

**HIGHER EDUCATION DEPARTMENT
GOVERNMENT OF ODISHA**

HE-MC—MISC-0048-2025 Letter No.: 39731 /HE, Dated: 21.07.26

From

Sri Kaliprasanna Mahapatra, IAS

Director, Higher Education Department

To

**The Controller of Examinations,
All State Public Universities/Autonomous Colleges, Odisha. (list attached)**

Sub: Submission of nine (09) Apprenticeship Embedded Degree Programme (AEDP) Courses for approval by the statutory academic bodies of the University and circulation to affiliated institutions.

Madam/Sir,

In enclosing herewith, the finalized syllabi of nine (09) Apprenticeship Embedded Degree Programme (AEDP) Courses developed by the Odisha State Higher Education Council (OSHEC) in alignment with the National Education Policy (NEP), for implementation in the eligible Higher Education Institutions listed under AEDP Programme.

You are, therefore, requested to place the enclosed AEDP Courses before the appropriate Board(s) of Studies and other competent statutory academic bodies of your university for necessary approval as per University Statutes and Regulations.

You are further requested to complete the requisite formalities on priority and ensure that the approved syllabi are circulated to all constituent and affiliated colleges under the jurisdiction of your University for timely implementation from the ensuing academic session 2026-27.

An action taken report regarding approval and circulation of the courses may kindly be furnished to this office dheodishamisc@gmail.com and Odisha State Higher Education Council (OSHEC) oshec.hed@gmail.com at an early date.

Yours faithfully,

Director, Higher Education, Odisha

39732
Memo No. _____/HE,

Dated: 21.07.26

Copy forwarded to P.S. to Commissioner-cum-Secretary for kind information of
Commissioner-cum-Secretary.

Director, Higher Education, Odisha

39733
Memo No. _____/HE,

Dated: 21.07.26

Copy forwarded to the Vice-Chancellors/Registrars of all State Public Universities,
Odisha for kind information and necessary intervention to facilitate expeditious approval of
the enclosed AEDP Courses by the statutory academic bodies of their respective Universities.

Director, Higher Education, Odisha

39734
Memo No. _____/HE,

Dated: 21.07.26

Copy forwarded to the Principals of ~~Concerned~~ Colleges, Odisha for kind
information and necessary intervention to facilitate expeditious approval of the enclosed
AEDP Courses by the statutory academic bodies of their respective ~~Universities~~ Colleges.

Director, Higher Education, Odisha

LIST of HEIs for AEDP	
District	Name of the College
Angul	Government Autonomous College, Hakimpada, Angul
	Athamallik (Degree) College, Athmallik
Balasore	K.K.S. Women's College, Balasore
	Gopalpur (Degree) College, Gopalpur, Balasore
	Rural (Degree) Institute of Higher Studies, Bhogarai
	Khaira (Degree) College, Khaira
	Simulia Degree College, Markona
	Remuna (Degree) College, Remuna
	F.M. Autonomous College, Balasore
	Swarnachud College, Mitrapur, Balasore
	Nilamani Degree Mahavidyalaya, Rupsa
Bargarh	Panchayat (Degree) College, Bargarh
	Anchala College Padmapur
	Attabira (Degree) College, Attabira
	Barapali Degree College, Barapali
	Mahatma Gandhi (Degree) College, Bhukta
Bolangir	D. A. V. Autonomous College, Bhatipara, Titlagarh
	Jawaharlal (Degree) College, Patnagarh
Boudh	Boudh Panchayat (Degree) College, Boudh
Cuttack	Shailabala Women's College, Cuttack
	Salipur Autonomous College, Cuttack
	Banki Autonomous College, Banki, Cuttack
	Govindpur (Degree) College, Govindpur
	Ravenshaw University
	Devi Kandal Nityananda (Degree) College, Eranch
	Christ (Degree) College, Cuttack
	UN Autonomous College, Adaspur, Cuttack
Dhenkanal	Janata (Degree) College
	Hindol (Degree) College, Khajuriakota
Gajapati	S.K.C.G. College Paralakhemundi,
	Indira Memorial (Degree) College, Chandiput
Ganjam	Shashi Bhushan Rath Government Women's College, Ganjam, Berhampur
	Ganjam (Degree) College, Ganjam
	Kabisurya Baladev Vigyan (Degree) Mahavidyalaya, Kabisuryanagar
	Mahamaye Mahila (Degree) Mahavidyalaya, Gandhinagar
	Khemundi (Degree) College, Digapahandi
	Gopalpur College, Ganjam
	Kabi Samrat Upendra Bhanja (Degree) College, Bhanjanagar
	Chikiti (Degree) Mahavidyalaya, Chikiti
	Polasara Science (Degree) College, Polosara
	Laxminarayan Degree College, Kodala
	Science (Degree) College, Konkorada

	Ramjee (Degree) Mahavidyalaya, Bhisimagiri
	Saheed Bhagat Singh (Degree) College, Khandadeuli
Jajpur	Narsingha Choudhury Autonomous College, Jajpur
	Bishnu Samantaray (Degree) College, Nuahat
Jharsuguda	Brajarajnar (Degree) College, Brajarajnar
	Laxmi Narayan (Degree) College, Jharsuguda
Kanadhamala	Government College, Phulbani
Kendrapada	Pattamundai College. Kendrapada
	Derabish (Degree) College, Derabish
Khurdha	B. J. B. Autonomous College, Bhubaneswar
	Rama Devi University
	Raja Madhusudan Dev Degree college of science and education
	DAV School of Business Management, Bhubaneswar
	Godavarish (Degree) Mahavidyalaya, Banapur
Mayurbhanja	Maharaja Purna Chandra Autonomous College, Mayurbhanja
	Baigan Badia (Degree) College, Baiganbadia
	Kaptipada (Degree) College, Nuasahi
	Karnjia Autonomous College, Mayurbhanja
	Kaptipada (Degree) College, Kaptipada
	Laxmikanta College, Bangripasi
	Panchpir Women's Degree College, Mayurbhajan
	Khunta (Degree) Mahavidyalaya, Khunta
Nayagarh	Nayagarh Autonomous College Nayagarh
	Brundabana Subudhi (Degree) College, Daspalla
	Sarankul (Degree) College, Sarankul
Nuapada	Khariar Autonomous College, Nuapada
	National (Degree) College, Nuapada
Puri	Nimapada (Autonomous) College, Nimapada
Rayagada	Rayagada Autonomous College, Rayagada
	Gunupur (Degree) College, Gunupur
	Women's (Degree) College, Rayagada
Sambalpur	Govt. Women's College, Sambalpur
	Gangadhar Meher University
	Bhim Bhoi (Degree) College, Rairakhol
	Gokul Parvati Rural (Degree) College, Kuntara
Sundergarh	Government (Degree) College, Sundergarh
	Government Women's (Degree) College, Sundergarh
	Govt. Autonomous College, Rourkela
	Sarbati Devi Women's (Degree) College, Rajgangpur

Name of Universities

Fakir Mohan University

Sambalpur University

Rama Devi Women's University

Utkal University

Berhampur University

MSCB University

Rajendra University

Ravenshaw University

Maa Manikeshwari University

Vikramdev University

Gangadhar Meher University

**Draft Model Curriculum for 3yr./4yr. Degree Course with
Apprenticeship Embedded Degree program**

**B.Sc. in Botany with Double Major in Tissue Culture & Vertical
Gardening**



**Higher Education
Department**
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Microbiology and Phycology	4
	MJ -1.2	Analytical techniques in plant sciences	4
	MJ -1.3	Cell biology	4
	MJ- 1.4	Mycology & Phytopathology	4
	MJ -2.1	Vertical garden: structure, management and landscaping	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	Archegoniatae	4
	MJ 1.6	Anatomy of Angiosperms and economic botany	4
	MJ 1.7	Genetics	4
	MJ- 1.8	Basic molecular biology	4
	MJ 2.2	Macro-propagation of plants	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / or any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	Plant ecology and phytogeography	4
	MJ 1.10	Plant systematics	4
	MJ 1.11	Reproductive biology of angiosperms	4
	MJ- 1.12	Basic plant physiology	4
	MJ 2.3	Micropropagation for horticultural crops	4
	MJ -2.4	Hardening and nutrition management of micro-propagated plants	4
	MDC (Multidisciplinary Course)	Botany/ or any other discipline	3
	SEC (Skill Enhancement Course)	Botany or/ any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	Basic plant biotechnology	4
	MJ- 1.14	Basic plant metabolites	4
	MJ- 1.15	Natural resource management	4
	MJ -2.5	Commercial floriculture through vertical gardening, hydroponic and aeroponic	4
	MJ -2.6	Irrigation, fertigation and disease control	4
	MDC (Multidisciplinary Course)	Botany/or any other discipline	3
	SEC (Skill Enhancement Course)	Botany/or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20
TOTAL			150

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Programme Objectives:

- To prepare the students for a career in Applied Botany
- To prepare the students for Higher Education and Research in Applied Botany
- To develop a conceptual understanding on vertical gardening and its application.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To promote wider reading on the subject and allied inter disciplinary subject.

Programme Outcome:

- To prepare the students for a career in Botany related Skill Based work Force.
- To prepare the students for Higher Education, Research and Technological interventions in Applied Botany.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject with practical training for company ready manpower.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills, to handle equipment's utilized to learn the subject and motivate for startup and agriculture and horticulture related company products.
- To generally promote wider reading on the subject and allied inter-disciplinary subjects for entrepreneurship and product development/technology.

Semester-I

1.1. Microbiology and Phycology

Course Objectives:

- To introduce the diverse group of microorganisms and their habitat relationship.
- To learn the discovery, nature and multiplication of virus particles.
- To know the characteristics, growth and physiology of bacteria and their role in agriculture, health and industry.
- To learn the general characteristics and ecological distribution of bacteria, algae and cyanobacteria and their immense importance to the mankind.
- To have knowledge about the habitats, distribution and diversity of algae in the soil, freshwater and marine environments.

Course Outcomes

- The students learn about the diverse nature of microbes and their interaction with other organisms.
- The students certainly get the opportunities to learn the basics of the nature and impact of viruses.
- The students shall be able to understand the potential of various microbes and the approaches to use them for human welfare.
- The students would be able to identify the important microbes including bacteria, cyanobacteria, and algae available in local environments and understand their beneficial roles.
- The students shall learn about the immense potential the algal resources and understand the methods of cultivation and use of algae.

Unit-I:

Learning Outcome: The learners are able to identify diverse group of microorganisms, general features of viruses and their economic importance.

- The microbial world, microbial nutrition, growth and metabolism.
- Viruses: Discovery, nature, physicochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (a general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV). Economic importance of viruses. Vaccine production, role in research, medicine and diagnostics. Viral plant diseases- symptoms, effect and control

Unit-II:

Learning Outcome: The students understand the growth, physiology and economic importance of bacteria and cyanobacteria.

- Bacteria: - Discovery, general characteristics, types- archaeobacteria, eubacteria, mycoplasma and spheroplasts, Cell structure, inclusions, nutrition, reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction). Economic importance of bacteria with reference to their role in agriculture, medicine and industry.
- Cyanobacteria:- Ecology, occurrence, cell structure, heterocyst, reproduction, economic importance; role in biotechnology. Morphology and life-cycle of *Nostoc*. General characteristics of prochlorophyceae, Evolutionary significance of Prochloron.

Unit-III:

Learning Outcome: The students able to grasp the general characteristics, ecological distribution and economic importance of algae.

- Algae: - General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigments, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction. Classification; criteria, system of Fritsch, and evolutionary classification of Lee (only up to groups); Role of algae in the environment, agriculture, biotechnology and industry.
- Chlorophyta: - General characteristics, occurrence, range of thallus organization, cell structure and reproduction. Morphology and life cycles of *Chlamydomonas*, *Volvox*, *Oedogonium* and *Coleochaete*.

Unit-IV:

Learning Outcome: The students will be able to understand the general characteristics, ecological distribution and economic importance of algae and cyanobacteria.

- **Charophyta:-** General characteristics; occurrence, morphology, cell structure and life-cycle of *Chara*; evolutionary significance.
- **Xanthophyta:-** General characteristics; Occurrence, morphology and life- cycle of *Vaucheria*.
- **Phaeophyta:-** Characteristics, occurrence, cell structure and reproduction. Morphology and life-cycles of *Ectocarpus* and *Fucus*.
- **Rhodophyta:-** General characteristics, occurrence, cell structure and reproduction. Morphology and life-cycle of *Polysiphonia*.

Practical:

1. Electron micrographs/Models of viruses –T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs.
3. Examination of bacteria from bacterial culture by Gram's staining method.
4. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule (live materials and photographs).
5. Bacterial growth measurement by turbidometry
6. Hemocytometry
7. Colony counting using colony counter
8. Phycology: - Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electronmicrographs), *Volvox*, *Oedogonium*, *Coleochaete*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus* and *Polysiphonia*, *Prochloron*, Diatoms through, temporary preparations and permanent slides

Textbooks:

- ✓ Singh, V., Pandey, P.C., and Jain, D.K. (2017). *Microbiology and Phycology*, Rastogi Publication, Meerut.
- ✓ Pandey BP (2022). *Botany for B.Sc. Students (Archigoniates & Plant Architecture)*, S. Chand publication, New Delhi
- ✓ Dubey RC & Maheshwari DK (2021) *A text book of Microbiology*, S. Chand publication, New Delhi
- ✓ Pandey BP (2023). *Botany for B.Sc. Students Semester I, NEP 2020*; S. Chand publication, New Delhi

Reference Books:

- ✓ Lee, R.E. (2008). *Phycology*, Cambridge University Press, Cambridge. 4th edition.
- ✓ Prescott, L.M., Harley J.P., Klein D. A. (2010). *Microbiology*, McGraw-Hill, India. 8th edition.
- ✓ Kumar, H.D. (1999). *Introductory Phycology*. Affiliated East-West Press, Delhi.
- ✓ Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). *Biology*, Pearson Benjamin Cummings, USA. 8th edition.
- ✓ Pelczar, M.J., Chan, E.C.S., Krieg, N.R. (2011) *Microbiology*, 8th edition, Tata McGraw-Hill Co, New Delhi.
- ✓ Willey, Sherwood and Christopher. *Laboratory exercises in Microbiology*. McGraw- Hill, India. 9th edition.
- ✓ Vasistha B.R. (2017) *Botany for Degree student, Algae*, S. Chand Publication, New Delhi.
- ✓ Mishra B. K. (2018) *Microbiology and Phycology*, Kalyani Publishers, New Delhi.

1.2 Analytical Techniques in Plant Sciences**Course Objective**

- To learn the principles and operations of microscopes of various complexity and their application in biological studies.
- To learn the techniques of centrifugation for separation of biological samples.
- To learn the methods of radioisotopes measurement in and their importance in study of biological materials and processes.
- To understand the principles and applications of spectrophotometry and to understand the basic structural design of a standard instrument.
- To learn about various chromatographic techniques in separation of plant extracts.
- To acquaint the students with the advanced methods for characterization of biomolecules

Course Outcomes:

- Proper understanding of the microscopy and knowledge to analyze plant samples using electron microscopy and flow Cytometer.
- Separation of biomolecules and cell organelle and appropriate application of the knowledge of centrifugation for the same.
- Basic knowledge on the use of radioisotopes for analysis of biological samples.
- Extraction and qualitative and quantitative analysis of extracts as well as the assay mixtures using spectrophotometer.
- Skilful application of chromatographic techniques for separation of amino acids, pigments and biomolecules.
- Proper method for characterizing protein and nucleic acids and skill on handling electrophoresis equipment for preparation of gels.

Unit-I:

Learning Outcomes: Students will be able to acquire knowledge about principles of microscopy and their types.

Imaging and related techniques: Principles of microscopy; Light microscopy; Fluorescence microscopy; Flow cytometry (FACS); Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit-II:

Learning Outcomes: Students will learn about the principles of centrifugation in biomolecule separation and importance of radiography in biological research

Cell fractionation: Centrifugation: Differential and density gradient centrifugation, Sucrose density gradient, CsCl₂ gradient, analytical centrifugation, ultracentrifugation. Radioisotopes: Use in biological research, auto-radiography, pulse chase experiment.

Unit-III:

Learning Outcomes: Students will learn about the components and working principle of different types of Spectrophotometer

Spectroscopy: Principles, Components and working mechanism of UV-Visible and Infra-Red spectroscopy, Fluorescence spectroscopy, Chlorophyll *a* fluorescence, Flame photometer, Bomb Calorimeter and Atomic Absorption Spectrophotometer.

Unit-IV:

Learning Outcomes: Students will learn about the separation methods for biomolecules using chromatography and electrophoresis instruments.

- **Chromatography:** Principle of chromatography, paper chromatography, column chromatography, TLC, HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.
- **Characterization of proteins and nucleic acids:** Electrophoresis: AGE, PAGE, SDS-PAGE. Mass spectrometry; X-ray diffraction, X-ray crystallography.

Practicals:

1. Study of different microscopic techniques observation through simple and compound microscope
2. Study of PCR using demonstration.
3. To separate pigments by paper chromatography.
4. To separate phytochemicals by thin layer chromatography.
5. Qualitative analysis of total Carbohydrates, Proteins & Lipids.
6. Demonstration of SEM/ Electrophoresis/ Chromatography.
7. Measuring OD using spectroscopy.
8. Beer Lombard's law and its validation

Textbooks:

- ✓ Patil, C. S. (2017). *Advanced Analytical Techniques*, ABE Books, New Delhi.
- ✓ Pandey BP (2023). *Botany for B.Sc. Students Semester I, NEP 2020*; S. Chand publication, New Delhi

Reference Books:

- ✓ Aneja, K. R. (2014). *Laboratory manual of microbiology and biotechnology*, Medtech, New Delhi
- ✓ Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). *Short Protocols in Molecular Biology*. John Wiley & Sons. 3rd edition.
- ✓ Plummer, D.T. (1996). *An Introduction to Practical Biochemistry*. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
- ✓ Ruzin, S.E. (1999). *Plant Micro technique and Microscopy*, Oxford University Press, New York. U.S.A.
- ✓ Pandey, B.P. (2023). *Botany for B.Sc. Students Semester I: NEP 2020*, S. Chand Publishing.

1.3 Cell Biology**Course Objectives:**

- To understand the basic components of prokaryotic and eukaryotic cells and the role of various macromolecules in the cells.
- Understand how the formation of cytoskeleton
- To have an understanding on nucleic acids as the genetic material;
- To learn the basic mechanism of replication of nucleic acids
- Understand how cells undergo mitosis & meiosis

Course Outcomes

- Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- Students will understand the components of cell wall & cytoskeleton
- Students will understand how these cellular components are used to generate and utilize energy in cells.
- Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes.
- Students will understand the cellular components underlying mitotic and meiotic cell division.

Unit-I:

Learning Outcomes: Students will understand the origin, growth and basic components of cell, cell wall & cytoskeleton.

- The Cell: Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory). Unique features of plant cells
- Plasmodesmata: Structure, role in movement of molecules & macromolecules, comparison with gap junctions.
- Plant Cell wall: Chemistry, structure and function.
- Cytoskeleton: The concept, structure and roles of microtubules, microfilaments and intermediary filament.

Unit-II:

Learning Outcomes: Students will recognize composition of Plasma Membrane and origin, structure, function of cell organelles

- Plasma Membrane: Overview of membrane structure and function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.
- Cell organelles: Endoplasmic Reticulum, Golgi apparatus, Lysosomes & plant Vacuole.

Unit-III:

Learning Outcomes: Students will realize the importance of photosynthesis and cellular respiration

- Cell organelles: Chloroplast, Mitochondria and Peroxisomes: Structural organization & Function.
- Biogenesis & semiautonomous nature of mitochondria and chloroplast.
- Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina & Function

Unit-IV:

Learning Outcomes: Students will understand the cellular units (DNA& RNA) underlying mitotic and meiotic cell division

- Nucleolus: Structure and function of nucleolus, Chromatin organization, its packaging role of nuclear matrix in chromosome organization and function, matrix binding proteins.
- Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA
- Cell division: Eukaryotic cell cycle, different stages of mitosis and meiosis. Cell cycle, Regulation of cell cycle.

Practical:

1. Study of plant cell structure with the help of epidermal peel mount of Onion/Rhoeo
2. Demonstration of the phenomenon of protoplasmic streaming in Hydrilla leaf.
3. Counting the cells per unit volume with the help of hemocytometer. (Yeast/pollen grains).
4. Study the phenomenon of plasmolysis and deplasmolysis.
5. Study of different stages of mitosis and meiosis using acetocarmine and acetoocine method from Onion root tip and bud respectively.
6. To find out the mitotic index

Textbooks:

- ✓ *Rastogi, V. B. (2016). Introductory Cytology, Kedar Nath & Ram Nath, Meerut*
- ✓ *Verma PS & Agarwal VK (2022) Cell Biology (Cytology, Biomolecules and Molecular Biology) S Chand Publication, New Delhi.*
- ✓ *Gupta, P. K. (2017). Biomolecules and Cell Biology, Rastogi Publication, Meerut.*
- ✓ *Kumar S. (2023). Cell biology, Pragati prakashan, Meerut*

Reference Books:

- ✓ *Sahoo, K. (2017) Biomolecules and Cell Biology, Kalyani Publishers, New Delhi.*
- ✓ *Tymoczko, J.L., Berg, J.M. and Stryer, L. (2012) Biochemistry: A short course, 2nd ed., W.H. Freeman*
- ✓ *Nelson, D.L. and Cox, M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.*
- ✓ *Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.*
- ✓ *Kumar HD, Molecular Biology 2ed Vikas Publication*
- ✓ *Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco*

1.4 Mycology and Phytopathology

Course Objectives

- To learn classification and diversity of fungi and their nutritional requirements.
- To learn the life cycle and ecology of some important genera of fungi and their pathogenicity.
- To understand the beneficial fungal interactions.
- To learn about edible fungi and their role in human nutrition.
- To learn the beneficial application of fungi in agriculture and medicine.
- To know the phyto-pathological processes and the method of their prevention and control.

Course Outcomes

- Have an idea on the vast fungal diversity in nature and method of their identification and culture.
- Know the life cycle of commonly occurring fungal genera and the disease caused by them.
- Have knowledge on the types of fungal associations and their importance.
- Have knowledge and skill on the application of fungi and fungal biomolecules in human welfare.
- Have skill to understand the host - parasite relationship and its role in establishment of viral, fungal and bacterial diseases in plants.
- Understand the causes and conditions for commonly occurring plant diseases and the methods of their control.

Unit-I:

Learning Outcomes: To introduce the students with the classification and diversity of fungi and their nutritional requirements.

- Introduction to true fungi: Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification; spore of fungi
- Zygomycota: General characteristics; Ecology; Thallus organization; Life cycle with reference to *Rhizopus*.
- Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces*, *Aspergillus*, *Penicillium*, and *Neurospora*.
- Basidiomycota: General characteristics; Ecology and Classification; Life cycle of *Puccinia* and *Agaricus*.

Unit-II:

Learning Outcomes: To introduce the students with the general characteristics, classification of allied fungi and the beneficial symbiotic associations.

- **Allied Fungi:** General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.
- **Oomycota:** General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora*, and *Albugo*.
- **Symbiotic associations:** Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Economic importance of Lichens, Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit-III:

Learning Outcomes: To introduce the students with the role of fungi in food industries, agriculture and medicine.

Applied Mycology: Role of fungi in biotechnology & research, Mushroom cultivation, Application of fungi in food industry (Flavor & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

Unit-IV:

Learning Outcomes: To introduce the students with the phytopathological processes and method for prevention and control of plant diseases.

- **Phytopathology:** Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; symptomology; Host- Pathogen relationships; disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. **Bacterial diseases** – Citrus canker and angular leaf spot disease of Cotton. Viral diseases – Tobacco Mosaic, Vein Clearing. Fungal diseases – Early blight of potato, Loose and covered smut.

Practical:

1. Introduction to the world of fungi (Unicellular, coenocytic/ septate mycelium, ascocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus*, *Penicillium* and *Saccharomyces*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Puccinia* : Study of different stages from temporary mounts and permanent slides.
5. *Agaricus*: Specimens of button stage and full-grown mushroom; sectioning of gills of *Agaricus*, and fairy rings are to be shown.
6. *Albugo*: Study of symptoms of plants infected with *Albugo*; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.
7. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Viral diseases: Mosaic disease of ladies' finger, papaya, cucurbits, moong, black gram, Fungal diseases: Blast of rice, Tikka disease of ground nut, powdery mildew of locally available plants and White rust of crucifers.

Text Books:

- ✓ Mishra, B. K. (2017), *Mycology and Phytopathology*, Kalynai Publishers, New Delhi.
- ✓ Pandey BP (2022). *Plant Pathology*, S. Chand publication, New Delhi

Reference Books:

- ✓ Sharma, P. D. (2017). *Mycology and Phytopathology* Rastogi Publication, Meerut.
- ✓ Agrios, G.N. (1997) *Plant Pathology*, 4th edition, Academic Press, U.K.
- ✓ Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*, John Wiley & Sons (Asia) Singapore. 4th edition.
- ✓ Webster, J. and Weber, R. (2007). *Introduction to Fungi*, Cambridge University Press, Cambridge. 3rd edition.
- ✓ Sethi, I.K. and Walia, S.K. (2011). *Text book of Fungi and Their Allies*, Macmillan Publishers India Ltd.

- ✓ *Mehrotra, R. S. (2011). Plant Pathology. Tata Mc Graw-Hill Publishing Company Limited, New Delhi*
- ✓ *Vashishta B.R, Sinha A.K & Kumar. A Botany For Degree Students : FUNGI (S chand Publica) New Delhi*
- ✓ *Dubey RC & Maheshwari DK (2021) A text book of Microbiology, S. Chand publication, New Delhi*

2.1 Vertical Gardening Structure, Management and Landscaping

Course Objectives:

- To train students on the structural design for establishing a vertical garden.
- To build up exposure on interiors and exterior vertical gardens.
- To understand the technologies, and have knowledge to establish vertical gardens for obtaining esthetic valences, benefit for environment and human health.
- To have knowledge on constructing and maintaining the vertical gardens.
- To have and understanding on modern concepts for landscape development for vertical gardens.

Course Outcomes:

On completion of the course the students will have

- A basic understanding on the concept, scope and applications of vertical gardens in the urban environment.
- The knowledge on the structural and space requirement for establishing a vertical garden.
- The skill to make benefit cost analysis for establishment and management of a vertical garden.
- The ability to establish a vertical garden to combat climate change related crop production.

Unit I

Origins and rise of vertical gardening through history, Green walls / Living walls; Living wall system structure for pre-vegetated panels, Material used in making panel; plastic, expanded polystyrene, synthetic fabric for supporting plants species; Modular green wall-components, structure and construction;

Vertical Garden Modules -detachable cups/pots, Green wall cup type/ Biowall cups. Vegetated mat wall: Building and installation of modular Green walls: Structures and components for green wall system.

Unit II

Light- General considerations; design for interior and exterior structures for proper lighting. Sun exposure and the surrounding context. Design as per growth habit of plant. Green facades, free standing systems for lighting- fences or columns, modular panels, geotextiles; Supporting structures,

Watering: selection for Succulent and hardy plants, Design for water circulation, and reuse. Cleaning and de-clogging system. Microclimate establishment.

Unit III

Vertical landscaping: concept and importance of landscaping, basic landscape designs; background, contrast, balance and rhythm. Landscaping for plant varieties, growth habits, light requirement. Light exposure and surrounding context.

Landscaping for ornamental, horticultural, foliage and green walls. Versatile applications of vertical gardening for both indoor and outdoor spaces

Unit IV

Management of vertical gardens-structural specifications, space, water, and nutrient management; benefit-cost analysis. Balance-sheet for a vertical garden; maintenance cost, environmental benefit, carbon footprint, temperature management.

Practical Syllabus:

1. The practical steps to design, install, and maintain vertical garden structures.
2. Identification and description of annuals, biennials, trees, shrubs, climbers, indoor plants, cacti and succulents, herbaceous perennials, grasses and bulbous ornamentals.
3. Study and identification of various Horticultural Tools, Planting tools and implements for vertical gardening Practices of various propagation techniques viz. cuttings, budding, grafting, layering, etc.
4. GI net, iron frame, and PVC pipe structure system for garden and wall.
5. The betel nut wood structure system
6. Visit to commercial nursery units for vertical gardening and hydroponic systems

Textbooks

- ✓ *Arora, J.S. 2006. Introductory Ornamental Horticulture. Kalyani Publishers, Ludhiana*
- ✓ *Bose, Chowdhury and Sharma. 1991. Tropical Garden Plants in colour. Horticulture and allied publishers, 3D Madhab Chatterjee street Kolkata.*
- ✓ *Bose, T.K. Mukherjee, D. 2004. Gardening in India. Oxford & IBH Publishers.*
- ✓ *Chadha, K.L. and Chaudhary, B. 1986. Ornamental Horticulture in India. Publication and Information division. ICAR, New Delhi.*
- ✓ *Chowdhury Bimal Das and Balai Lal Jana. 2014. Flowering Garden trees. Pointer publishers, Jaipur. India.*
- ✓ *Peter. K.V. 2009. Ornamental plants. New India publishing agency, Pitampura, New Delhi.*
- ✓ *Randhawa, G.S. Amitabha Mukhopadhyay, 2004. Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.*
- ✓ *Tiwari A.K. and R. Kumar. 2012. Fundamentals of ornamental horticulture and landscape gardening. New India*

Reference books

- ✓ *Jack Bake, 'Vertical Gardening' Kindle Edition*
- ✓ *The Green Wall (Learning more about vertical Gardening) by DUEEP Jyot Singh, JD_Biz Publishing*
- ✓ *DIY Vertical Gardens by Keri Algar*
- ✓ *Joy of Gardening (How to create and grew Herbs, Vegetables and Fruits in a container and Vertical Garden) by James and Janeen Brown*
- ✓ *Vertical Gardening: A Step-by-Step Guide to Container Gardening with Original Ideas for Your Green Project by Haines, Devon*
- ✓ *The Vertical Garden: From Nature to the City by Patrick Blanc and W.W. Norton, 2008*

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	• Communication, its Importance and Factors • Types of Communication • Verbal and Non-verbal Communication • Styles of Communication
2	English Language and Communication: Listening and Speaking	• Types of Listening • Speaking to communicate effectively • Style of speaking in Various Situations • English Pronunciation
3	English Language and Communication: Reading and Writing	• Reading methods and techniques. • Reading texts to Understand meaning • Writing Process • Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	• Grammar • Sentence structure • Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)
2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lightning)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

A. a) Environmental Ethics: Issues and possible solutions.

b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies

c) Environment Protection Act

d) Air (Preservation Control of Pollution) Act

e) Water (Preservation Control of Pollution) Act

f) Wildlife Protection Act

g) Forest Conservation Act

h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)

B. Human Population and the Environment

Population Ecology: Individuals, species, population, community

Human population growth, population control method

Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester II

Major I

Course Objectives

1.5 Archegoniate

Credit -04

- To know the principles, hypotheses and process of adaptation of plants to land habitat.
- To learn about the origin classification, and characteristics of bryophytes through some representative genera.
- To learn about the origin and distribution of vascular plants and stages of evolution of conducting tissues.
- To study the morphology, and characteristics of pteridophytes through some representative genera.
- To learn the characteristics, classification and importance of the gymnosperms.
- To have a general knowledge on the fossils and fossilization processes.

Course Outcomes:

- Able to understand the mechanism of the evolution of the higher plants and their adaptation to land habit.
- Knowledge on the diversity of archegoniates and their and their pattern of habitat specific distribution.
- Knowledge on the characteristics of bryophytes and skill to differentiate the genera on the basis of their morphology and anatomy.
- Ability to identify the members of pteridophytes and knowledge on their characteristic features.
- Understand the unique features and distribution of gymnosperms.
- Capacity to analyze various types of fossils on the basis of their characters.

Unit-I:

Learning Outcomes: The students will gain knowledge on the basic characteristics of Archegoniates.

- Introduction: Unifying features of archegoniates; Transition to land habit; Alternation of generations. General characteristics; Origin of land plants and Adaptations to land habit;
- Bryophytes: Origin and Classification; Range of thallus organization. Classification (up to family). Structure, Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* (developmental stages not included).
Ecological and economic importance of bryophytes.

Unit-II:

Learning Outcomes: The learners shall acquire an understanding on the origin, evolution and structural uniqueness of pteridophytes.

Pteridophytes: General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea*. Apogamy, and apospory, heterospory and seed habit, telome theory, stellar evolution and economic importance.

Unit-III:

Learning Outcomes: The learners shall have the skill to identify and evaluate the importance of gymnosperms in a habitat

Gymnosperms: General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus*, *Ginkgo* and *Gnetum*. (Developmental details not to be included).
Ecological and economic importance.

Unit-IV:

Learning Outcomes: The student will have knowledge to identify and analyze a fossil specimen.

Palaeobotany: Geological time scale, fossils and fossilization process. Morphology, anatomy and affinities of *Rhynia*, *Calamites*, *Lepidodendron*, *Lyginopteris*, *Cycadeoidea* and *Williamsonia*.

Practical:

1. Morphology, anatomy and reproductive structures of *Riccia*, *Marchantia*, *Anthoceros*, *Funaria*.
2. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
3. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
4. *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
5. Study of temporary preparations and permanent slides of *Marsilea*.
6. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
7. *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll and megaspore, T.S root, leaflet, rachis
8. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), T.S. Needle, stem, L.S. male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), L.S. of female cone.
9. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide).
10. Study of some fossil slides / photographs as per theory.

Textbooks:

- ✓ *Vasistha, B. R. (2017) Botany for Degree student, Bryophyta, S. Chand Publication, New Delhi.*
- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Archegoniate, Rastogi Publication, Meerut.*
- ✓ *Pandey B.P (2020) Botany For Degree Students NEP S Chand Publication New Delhi.*

Reference Books:

- ✓ *Acharya, B. S. (2017), Archegoniate, Kalyani Publishers, New Delhi.*
- ✓ *Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. New Delhi, India.*
- ✓ *Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.*
- ✓ *Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.*
- ✓ *Rashid. A. An Introduction To Archegoniate Plants (Vikas Publication) New Delhi.*

1.6 Anatomy of Angiosperms & Economic Botany**Course Objectives**

- To explain the tissues and tissue systems in plants.
- To explain the organization of shoot and root apices.
- To educate the students on the activity of meristems for primary and secondary growth of plants
- To explain about various types of woods in plants and their developmental pattern.
- To give a comprehensive idea about economic botany and its importance in human welfare.
- To provide knowledge on general account, cultivation, propagation and uses of common crops.

Course Outcomes:

- The ability to examine the internal anatomy of plant systems and organs.
- Develop a critical understanding of the evolution of the concept of organization of shoot and root apex.
- Evaluate the adaptive and protective morphological systems of plants.
- Be able to know the origin and evolution of crops and the importance of wild relatives in crop improvement.
- Develop a basic knowledge on germplasm and the basics for their conservation.
- Have an understanding of plants as a source of food, beverages, spices, and materials and its application in human welfare.

Unit-I:

Learning Outcomes: Students will learn about the plant tissues and their anatomical structures. They will also learn about adaptive modifications in plants to adjust at different environments.

- Introduction and scope of Plant Anatomy: Applications in systematics, forensics and pharmacognosy.
- Tissues: Classification of tissues; Simple and complex tissues (no phylogeny); cyto-differentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Cell wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances.
- Adaptive and Protective Systems: Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and non-glandular: two examples of each), stomata (classification); Anatomical adaptations of xerophytes and hydrophytes.

Unit-II:

Learning Outcomes: Students will learn about the leaf anatomical components. They will also learn about the organization of root and shoot system in plant.

- **Leaf:** Anatomy of dicot and monocot leaf, Kranz anatomy.
- **Stem:** Organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpustheory, continuing meristematic residue, cyto-histological zonation); Types of vascular bundles; Anatomy of dicot and monocot stem. Vascular Cambium: Structure, function and seasonal activity of cambium; secondary growth in stem(normal and anomalous). Root Stem transition.
- **Root:** Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Anatomy of dicot and monocot root; Endodermis, exodermis and origin of lateral root. Secondary growth in roots

Unit-III:

Learning Outcomes: Students will learn about the plant domestication and cultivation of important crop plants.

- **Origin of Cultivated Plants:** Concept of Centers of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.
- **Cereals:** Cultivation and brief account of Wheat, Rice and millets.
- **Legumes:** General account, importance to man and ecosystem.
- **Sugars & Starches:** Morphology, cultivation and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, cultivation, propagation & uses.

Unit –IV:

Learning Outcomes: Students will learn about the important timber, spice, oils and fats and drug yielding plants.

- **Timber plants:** General account with special reference to teak and pine. Fibers: Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses).
- **Spices:** Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper Beverages: Tea, Coffee (morphology, processing & uses).
- **Oils & Fats:** General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and *Brassica* (Botanical name, family & uses)
- **Drug-yielding plants:** Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis

Practical:

1. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
2. Root: monocot, dicot, secondary growth.
3. Stem: monocot, dicot - primary and secondary growth (normal and anomalous); periderm; lenticels.
4. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).
5. Ecological anatomy.
6. Cereals: Rice (habit sketch, study of paddy and grain, starch grains).
7. Legumes: Soya bean/moong bean/black gram, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
8. Spice and Beverages: clove, black pepper, Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
9. Fiber-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

Textbooks:

- ✓ Singh, V., Pandey, P.C. and Jain, D.K. (2017). *Anatomy of Angiosperms*, Rastogi Publication, Meerut.
- ✓ Pandey, B. P. (2017) *Plant Anatomy*, S. Chand Publication, New Delhi.
- ✓ Pandey, B. P. (2017) *Economic Botany*, S. Chand Publication, New Delhi.

Reference Books:

- ✓ *Eames, A.J. and Mc Daniels, L.H., (1953). An introduction to plant anatomy, Tata Mc Grow Hills, New Delhi*
- ✓ *Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.*
- ✓ *Tayal, M. S. (2012) Plant Anatomy Rajpal and Sons, New Delhi*
- ✓ *Mishra, B. K. (2017). Anatomy of Angiosperms, Kalyani Publishers, New Delhi.*
- ✓ *Pandey, B. P. (2017) Plant Anatomy, S. Chand Publication, New Delhi.*
- ✓ *Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.*
- ✓ *Samba Murty, A.V.S.S. and Subrahmanyam, N.S. (2011). Text Book of Modern Economic Botany, CBS Publishers and Distributors, New Delhi.*
- ✓ *Hill, Albert F. Economic Botany, Tata Mc Grow Hill Publishing Company, Ltd. New Delhi.*
- ✓ *Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.*
- ✓ *Singh, V., Pandey, P.C. and Jain, D.K. (2017). Economic Botany, Rastogi Publication, Meerut.*
- ✓ *Baruah, B. (2017). Economic Botany, Kalyani Publishers, New Delhi.*

1.7 Genetics**Course Objective**

- To know general organization, possible function, and frequency of genes and non-gene DNA sequences in a typical eukaryotic genome.
- Practical methodology for applying Mendelian laws (heavily reliant on problem solving).
- Extensions of Mendelian genetics, including different forms of allelic relationships.
- To know different types of mutations, affect genes and the corresponding mRNAs and proteins.
- Inheritance of linked genes, including recombination mapping, and the physical basis of these rules (chromosomal behaviour during meiosis)

Course Outcomes:

- Learn the basic principles of inheritance at the molecular, cellular and organismal levels.
- Understand the mechanism of inheritance and its relationship with the expression of morphological traits.
- Understand the relationships between molecule/cell level phenomena (“modern” genetics) and organism-level patterns of heredity (“classical” genetics)
- Know about the variations by polyploidy, chromosomal aberration and gene mutations.
- Test and deepen their mastery of genetics by applying this knowledge in a variety of problem-solving situations

Unit-I:

Learning Outcomes: To acquire the basic principles of inheritance at the molecular, cellular and organismal levels

- Mendelian genetics and its extension Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Interaction of genes, Pleiotropy, Recessive and Dominant traits, Polygenic inheritance.
- Extrachromosomal Inheritance: Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; cytoplasmic male sterility; Maternal effects- shell coiling in snail; Infective heredity- Kappa particles in Paramecium.

Unit-II:

Learning Outcomes: Relationships between modern genetics and classical genetics

Linkage, crossing over and chromosome mapping: Linkage and crossing over- Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numerical based on gene mapping; Sex Linkage.

Unit-III:

Learning Outcomes: To develop mutants using different mutagens

- Variation in chromosome number and structure: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy
- Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens - physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation. DNA repair mechanisms.

Unit-IV:

Learning Outcomes: Applying this knowledge in a variety of problem-solving situations of genetics

- The structure of gene: Classical vs. molecular concepts of gene; Cis-Transcomplementation test for functional allelism; Structure of Phage T4, rII Locus.
- Population and Evolutionary Genetics: Gene pool, Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation

Practical:

1. Analysis of allelic and genotypic frequencies.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis.
3. Chromosome mapping using test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Chromosome anomaly: Translocation Ring, Laggards and Inversion Bridge, break etc. (through photographs).

Text Books:

- ✓ *Singh B. D. (2017). Fundamental of Genetics, Kalyani Publishers, New Delhi.*
- ✓ *Gupta P. K. (2017). Genetics, Rastogi Publication, Meerut.*
- ✓ *Verma P. S (2022) Genetics Revised Ed. Schand Publication. New Delhi*

Reference Books:

- ✓ *Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & Sons, India. 8th edition.*
- ✓ *Sinnot, E.W., Dunn, L.C. and Dobzhansky, T. (1985) Principles of Genetics, Tata Mc Grow Hill, New Delhi*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. Benjamin Cummings, U.S.A. 10th edition.*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W.H. Freeman and Co., U.S.A. 10th edition.*
- ✓ *Strickberger, M.W. Genetics, Pearson Publishers, 3rd Edition*
- ✓ *Rastogi V. B. (2017). Genetics, Kedar Nath & Ram Nath, Meerut*

1.8 Basic Molecular Biology**Course Objectives**

- To understand the Historical perspective of DNA and DNA as the carrier of genetic information.
- To learn the Organization and structure of DNA and RNA in pro-and eukaryotes.
- To understand the structure and function organellar and nuclear genomes.
- To understand the General principles of replication and the relationship with genetic code.
- To study about Processing and modification of RNA in prokaryotes and eukaryotes for translation.

Course Outcomes:

On completion of the course the students shall

- Be able to describe Organization and structure and replication of DNA and RNA.
- Have theoretical and practical knowledge the prokaryotic and eukaryotic nucleic acids.
- Have a clear understanding on the structure and function of organellar genome.
- Understand the processes of bidirectional, semi-conservative and semi discontinuous mode of replication and the importance of the genetic code.
- Have ability to understand the mechanism of translation in prokaryotes and eukaryotes.

Unit- I:

Learning Outcomes: Students will gain knowledge about historical perspective and experimental proof of nucleic acids as genetic material.

Nucleic acids: Carriers of genetic information: Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod; McCarty), Types of genetic material, denaturation and renaturation, cot curves. Organization of DNA and structure of RNA- Prokaryotes, Viruses, Eukaryotes, Fraenkel-Conrat's experiment. Organelle DNA - mitochondria and chloroplast DNA. The Nucleosome – Chromatin structure - Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit-II:

Learning Outcomes: This is to gain knowledge about general principles and mechanism of replication of DNA and RNA processing

The replication of DNA: Chemistry of DNA synthesis (Kornberg's discovery); General principles–bidirectional, semi-conservative and semi-discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication. Central dogma and genetic code: Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features).

Unit-III:

Learning Outcomes: This is to learn the Mechanism of Transcription and transcriptional regulation in Prokaryotes and Eukaryotes

- Mechanism of Transcription: Transcription in prokaryotes and eukaryotes;
- Regulation of transcription in prokaryotes and eukaryotes: Principles of transcriptional
- Regulation; Prokaryotes: Operon concept- Regulation of lactose metabolism and tryptophan synthesis in E. coli. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing
- Processing and modification of RNA: Split genes-concept of introns and exons, removal of

introns, spliceosome machinery, splicing pathways, group I & group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes, exon shuffling; RNA editing and mRNA transport.

Unit-IV:

Learning Outcomes: Students will gain knowledge on Mechanism of Translation and Translation regulation in Prokaryotes and Eukaryotes.

Translation (Prokaryotes and eukaryotes): Ribosome structure and assembly; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; post-translational modifications of proteins.

Practical:

1. Preparation of LB medium and raising E. coli.
2. Isolation of genomic DNA from suitable plant material.
3. RNA estimation by orcinol method.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of Barr body from buccal smear preparation.

Textbooks:

- ✓ Gupta P. K. (2017). *Molecular Biology*, Rastogi Publication, Meerut.
- ✓ Verma P. S & Agarwal V. K (2022) *Molecular Biology Revised Ed. S. chand Publication. New Delhi*

Reference Books:

- ✓ Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007).
- ✓ *Molecular Biology of the Gene*, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
- ✓ Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*. John Wiley and Sons Inc., U.S.A. 5th edition.
- ✓ Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). *Concepts of Genetics*. Benjamin. Cummings. U.S.A. 9th edition.
- ✓ Sheeler, P. and Bianchi, D.E. (2009) *Molecular Biology of the Cell*, Willey Publisher, New Delhi
- ✓ Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). *Introduction to Genetic Analysis*. W.H. Freeman and Co., U.S.A. 10th edition.
- ✓ Alberts, B. et al. 2014. *Molecular Biology of the cell* Garland Science. 6 th Edition
- ✓ Power, C. B. (2017) *Cell Biology*, Himalaya Publishing House, New Delhi
- ✓ Sahu, A.C. (2017). *Essentials of Molecular Biology*, Kalynai Publishers, New Delhi.
- ✓ Kumar H. D *Molecular Biology 2nd Ed. Vikas Publication New Delhi*.

2.2 Macro-propagation of plants

Course Objectives:

- To provide basic knowledge on the concepts of micropropagation.
- To explain various processes of micropropagation of horticulture and garden plants.
- To train students on the layering techniques for various plant types.
- To understand the benefits of micropropagation of economically valuable plants.

Course Outcomes:

On completion of the course, the students will be able to

- Explain various methods plant propagation and their utilization.
- Understand advantages and disadvantages of vegetative, asexual and sexual plant propagation methods.
- Assess the benefits of asexual propagation of certain economically valuable plants.
- Demonstrate skills related to vegetative plant propagation techniques.
- Apply a specific macro-propagation technique for a given plant species.

Unit I

Basic concepts of macro-propagation: Definition, need and potentialities of macro-propagation; asexual and sexual methods of propagation - advantages and disadvantages. Propagation facilities: Mist chamber, humidifiers, greenhouses, glasshouses, cold frames, hot beds, poly-houses, phytotrons nursery - tools and implements. Identification and propagation by division and separation: Bulbs, pseudobulbs, corms, tubers and rhizomes; runners, stolon, suckers and offsets.

Unit II

Apomixis: Definition, facultative and obligate; types – recurrent, non-recurrent, adventitious and vegetative; advantages and disadvantages. Polyembryony: Definition, classification, horticultural significance; chimera and bud sport. Propagation of foliage and flowering plants using apomictic embryos.

Layering: Definition, principle and factors influencing layering. Plant propagation by layering: Ground layering – tip layering, simple layering, trench layering, mound (stool) layering and compound (serpentine layering). Air layering technique – application in woody trees.

Unit III

Cuttings: Definition, different methods of cuttings; root and leaf cuttings.

Stem cuttings: Definition of stem tip and section cuttings; plant propagation by herbaceous, soft -wood, semi hard wood, hard wood and coniferous stem cuttings. Physiological and bio chemical basis of rooting; factors influencing rooting of cuttings; Use of plant growth regulators in rooting of cuttings.

Unit IV

Grafting: Definition, principle, types, graft incompatibility, collection of scion wood stick, scion-stock relationship, and their influences, bud wood certification; micrografting. Propagation by veneer, whip, cleft, side and bark grafting techniques. Budding: Definition; techniques of 'T', inverted 'T', patch and chip budding.

Practical Syllabus

1. Preparation of nursery beds – flat, raised and sunken beds.
2. Propagation through apomictic process
3. Propagation by separation and division technique.
4. Propagation by cuttings.
5. Propagation by layering.
6. Propagation by grafting.
7. Propagation by budding

Textbooks

- ✓ Ramawat K G & Goyal S *Comprehensive Biotechnology 4th ed S chand Publication New Delhi.*
- ✓ Chawla, H. S. (2010). *Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ Singh, B. D. (2018). *Plant Biotechnology Kalyani Publishers, New Delhi.*

Reference Books

- ✓ Bhojwani, S.S. and Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.*
- ✓ Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.*
- ✓ Stewart, C.N. Jr. (2008). *Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.*
- ✓ Gupta, P. K. (2017). *Plant Biotechnology, Rastogi Publication, Meerut.*
- ✓ Dubey, R. C. (2017). *Advanced Biotechnology, S, Chand Publication, New Delhi*

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
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1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester -III

Major I

Credit 04

1.9 Plant Ecology & Phytogeography

Course objectives

- To learn the interaction of biotic components with non-living components of an ecosystem.
- To introduce to various natural ecosystems and how the interaction among different biotic and abiotic factors influencing the stability and diversity of an ecosystem.
- To study the physical, biological and chemical characteristics of factors influencing population.
- To know the experimental approach to determine the physical, chemical and organic matters of soil.
- To introduce the students to the characteristics and dynamism of population ecology.

Course Outcomes:

- Have ability to understand the ecological functioning of ecosystems and would certainly help students to maintain the local ecosystems.
- Have information on species' geographical range and how the size and life history influenced by the various components of ecosystems.
- An understanding of the factors that influence patterns of abundance and distribution in populations.
- Have knowledge on the process of soil formation and approaches to study the nature of soils.
- Have skill to evaluate the dynamics of change of population characteristics.

Unit-I:

Learning Outcomes: The students learn the concept of ecology and inter-relationships between the living world and its environment.

- Introduction and Concept of ecology, Autoecology, Synecology, System ecology: Levels of organization. Inter-relationships between the living world and the environment, the components of environment, concept of hydrosphere and lithosphere and dynamism, homeostasis.
- Light, temperature, wind and fire. Variations; adaptations of plants to their variation.

Unit-II:

Learning Outcomes: The students get idea on the formation, composition and profile of soil and state of water in environment.

Soil: Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

Water: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle

Unit-III:

Learning Outcomes: The students grasp about the dynamics of population ecology and plant communities.

- Biotic interactions and Population ecology: Characteristics and Dynamics.
- Plant communities: Concept of ecological amplitude; Habitat and niche; Characters: analytical

and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit-IV:

Learning Outcome: The students know about the ecosystem process and phytogeography of India.

- Ecosystems: Structure; Processes; Trophic organization; Food chains and Foodwebs; Ecological pyramids.
- Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.
- Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Phytogeographical division of India; Vegetation of Odisha.

Practical:

1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
3. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
4. Study of morphological adaptations of hydrophytes, xerophytes, halophiles (two each).
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
6. Quantitative analysis of herbaceous vegetation for frequency, density and abundance in the college campus.
7. Field visit to familiarize students with ecology of different sites.

Textbooks:

- ✓ Sharma, P.D. (2017). *Fundamentals of Ecology*. Rastogi Publications, Meerut, India.
- ✓ Shukla R.S. and Chandel P.S. (2016). *A Text Book of Plant Ecology*. S Chand Publication, New Delhi.

Reference Books:

- ✓ Odum, E.P. (2005). *Fundamentals of ecology*. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
- ✓ Singh, J.S., Singh, S.P., Gupta, S. (2006). *Ecology Environment and Resource Conservation*. Anamaya Publications, New Delhi, India.
- ✓ Wilkinson, D.M. (2007). *Fundamental Processes in Ecology: An Earth Systems Approach*. Oxford University Press. U.S.A.
- ✓ Kormondy, E.J. (1996). *Concepts of ecology*. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
- ✓ Santra, S. C. (2015) *Environmental Science*. New Central Book Agency (P) Ltd. Kolkata.
- ✓ Das M. C. and Das S. P. (2009). *Fundamental of Ecology*. Tata McGraw Hill, New Delhi.
- ✓ Shukla R.S. and Chandel P.S. (2016). *A Text Book of Plant Ecology*. S Chand Publication, New Delhi.
- ✓ Kumar H D by *Modern Concept of Ecology Revised Ed*. Vikas Publication.

1.10 Plant Systematics

Course Objectives

- A comprehensive presentation of the rules, regulations and codes of governing principles of the International Code of Nomenclature of Algae, Fungi and Plants (ICN)
- To provide knowledge on basic concepts of plant nomenclature and the tools used for naming the taxa.
- To impart knowledge on the traditional and advanced systems of classification of lower and higher plants.
- To acquaint the students with the modern approaches for developing systematic relationships in the plant kingdom.
- To enlighten the students about the phylogeny and the methods for building phylogeny among taxa of various angiosperms.
- To educate the students on the specific taxonomic characteristics of some angiosperm families and the method to make morphological studies of plant materials.

Course Outcomes:

- Knowledge on various levels of taxonomic hierarchy and the relationships among various hierarchical levels with respect to their similarities and variations of characters.
- The skill to use various taxonomic literature, Flora and herbaria, keys of both physical and digital types for plant identification and floristic studies.
- Critical thinking on the ancient, traditional and modern classification systems and evaluation of their applicability in taxonomic placement of taxa.
- Knowledge on the evolution of the concepts in classifying plants and weighing the potential of various tools.
- Ability to build the phylogeny among various taxa of different levels of hierarchy and identifying the apomorphy and plesiomorphy.
- Critical observations of the morphology of plant materials for taxonomic description and identification to the family, genus and species level.

Unit I:

Learning Outcome: The students shall gain knowledge on the importance of specimens, herbaria and flora for study of plant taxonomy.

Plant identification, Classification, Nomenclature; Biosystematics. Identification: Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access

Unit-II:

Learning Outcome: The learners shall have basic understanding on the application of rules of ICN for plant identification and nomenclature.

- Taxonomic hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).
- Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

Unit-III:

Learning Outcome: The students shall be able to classify a plant as per the correct taxonomic hierarchy.

- Systematics- an interdisciplinary science: Evidence from palynology, cytology, phytochemistry

and molecular data.

- Systems of classification: Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (up to series) and Hutchinson (up to series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit-IV:

Learning Outcome: The student shall have the skill to apply modern taxonomic tools in plant taxonomy.

- Phylogeny of Angiosperms: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin & evolution of angiosperms; co- evolution of angiosperms and animals; methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).
- Families of Angiosperms: Descriptive studies of *Magnoliaceae*, *Rosaceae*, *Rubiaceae*, *Poaceae*, *Orchidaceae*, *Musaceae*, *Acanthaceae*, *Apocynaceae*, *Asclepiadaceae*, *Lamiaceae*.

Practical:

1. Study of vegetative and floral characters of available materials of the families included in theory syllabus (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification).
2. Field visit, plant collection and herbarium preparation and submission. Mounting of properly dried and pressed specimen of at least fifteen wild plants with herbarium label (to be submitted in the record book)

Textbooks:

- ✓ *harma O. P. (2009) Plant Taxonomy, Tata Mc Grow Hill, New Delhi*
- ✓ *Sharma A. K, Sharma R, Taxonomy of Angiosperms and Utilisation of plants, Pragati Prakasan, Meerut*

Reference Books:

- ✓ *Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.*
- ✓ *Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.*
- ✓ *Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.*
- ✓ *Saxena, H. O. and Brahman, M. The Flora of Orissa, CSIR Publication.*
- ✓ *Bose T. K. (2009). Trees of the World, Regional Plant Resource Centre, Bhubaneswar, Odisha, India*
- ✓ *Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.*
- ✓ *Hanes, H. H. (2009). Botany of Bihar and Orissa,*
- ✓ *Mohanty, C. R. (2017). Textbook of Plant Systematics, Kalynai Publisher, New Delhi.*
- ✓ *Subrahmainayam, M. S. (2011) Modern Plant Taxonomy, Vikash Publishing House, New Delhi*

1.11 Reproductive Biology of Angiosperms**Course Objectives**

- To give a comprehensive idea about economic botany and its importance in human welfare.
- To know the origin, introduction, domestication and evolution of new crops / varieties of crop plants.
- To create awareness about importance of germplasm diversity.
- To provide knowledge on general account, cultivation, propagation and uses of common crops and processing of the materials.
- To know the extraction and uses of different oils as well as essential oils.

Course Outcomes:

- Have an understanding on the fundamental concepts of Economic Botany.
- Develop a basic knowledge on the evolution of crops/varieties.
- be aware about the importance of germplasm diversity and learn the methods for their conservation.
- Increase appreciation of diversity of plants and plant products used in everyday life of human and the methods for their enhanced production.
- Have an understanding of plants as a source of food, beverages, spices, and materials.

Unit-I:

Learning Outcome: Learn about structure and function of anther and pollen as well as their abnormalities

- Introduction: History and scope.
- Anther: Anther wall: Structure and functions, micro-sporogenesis, callose deposition and its significance.
- Pollen biology: Micro-gametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit-II:

Learning Outcome: Learn about the structure and function of ovule and embryo sac.

Ovule: Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte— mega-sporogenesis and mega-gametogenesis; Types and ultrastructure of different mature embryo sacs (Details of *Polygonum* type), Developmental pattern of mono-, bi- and tetrasporic embryo sacs.

Unit-III:

Learning Outcome: Develop knowledge about process of pollination, fertilization and self-incompatibility.

- **Pollination and fertilization:** Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.
- **Self-incompatibility:** Basic concepts; Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intraovarian and *in vitro* pollination; Modification of stigma surface.

Unit-IV:

Learning Outcome: Students will be aware of the details of endosperm, embryo, seed, polyembryony and apomixes.

- **Endosperm:** development, structure and functions
- **Embryo:** Types of embryogeny; General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo- endosperm relationship; Nutrition of embryo; Embryo development in *Paeonia*.
- **Seed:** Structure, importance and dispersal mechanisms
Polyembryony and apomixes: Introduction; Classification; Causes and applications

Practical:

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehiscent anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test, Germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/ campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs). Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
4. Embryogenesis: Study of development of dicot embryo through permanent slides/photographs; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.
5. Tracing the path of pollen tube.
6. Study of haustorial endosperm

Textbooks:

- ✓ Singh, V., Pandey, P.C, and Jain, D.K. (2017). *Reproductive Biology of Angiosperms*, Rastogi Publications, Meerut
- ✓ Bhojwani SS/S P Bhatnagar and Dantu PK (2015) - *The Embryology of Angiosperms* 6th ed Vikas Publication.

Reference Books:

- ✓ Maheswari, P. (2009). *Embryology of Angiosperms*.
- ✓ Shivanna, K.R. (2003). *Pollen Biology and Biotechnology*. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
- ✓ Raghavan, V. (2000). *Developmental Biology of Flowering plants*, Springer, Netherlands.
- ✓ Johri, B.M. I (1984). *Embryology of Angiosperms*, Springer-Verlag, Netherlands.
- ✓ Mishra, B. K. (2017). *Reproductive Biology of Angiosperms*, Kalyani Publishers, New Delhi.
- ✓ Pandey, B. P., (2017). *Taxonomy of Angiosperm*. S. Chand Publication New Delhi

1.12 Basic Plant Physiology**Course Objectives**

- About the mechanism and physiological activities in plants.
- On nutrient uptake and translocation to different plant parts.
- On the nature and physiological roles of various plant hormones on plant growth and development.
- On the physiological requirements for plant morphogenesis and flowering
- On the role of light responsive pigments in plant morphogenesis.

Course Outcomes

- The governing principles behind various physiological processes in plants.
- About various uptake and transport mechanisms (water and solutes) in plants and the factors governing these processes.
- The role of various plant hormones, signaling compounds, and stress responses.
- The skills to manipulate the plant hormones in plants for desired morphological and physiological responses.
- The climatic and physiological requirements for molecular signaling of plants for growth, differentiation, maturity.

Unit -I:

Learning Outcome: The learners shall have the knowledge on importance of water for basic physiological processes of plants.

- Structure and properties of water; pH and buffers; cellular buffering systems; Cell water Potential and its components, plasmolysis and imbibition, soil water potential.
- Water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, trans-membrane pathways.
- Ascent of sap—cohesion-tension theory. root pressure; water movement to leaves.
- Transpiration: Processes; mechanism of stomatal movement; factors affecting transpiration; guttation.
- Translocation in the phloem: experimental evidence in support of phloem as the site of sugar translocation. pressure–flow model; phloem loading and unloading; source–sink relationship.

Unit-II:

Learning Outcome: The students shall know about the nutrient uptakes and hormonal regulation of plant growth and metabolism.

- Mineral nutrition: essential and beneficial elements, macro and micronutrients, mineral deficiency symptoms, chelating agents.
- Nutrient Uptake: Transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, Symport and antiport.
- Plant growth regulators: Auxin: Biosynthesis, transport, distribution and function
- Gibberellins: Biosynthesis, transport, distribution and function
- Cytokinin: Biosynthesis, transport, distribution and function
- Absciscic acid: Biosynthesis, transport, distribution and function
- Ethylene: Biosynthesis, transport, distribution and function

Unit-III:

Learning Outcome: The students shall know about photosynthesis and storage of metabolites by plants.

- Photosynthesis: general concept; photosynthetic apparatus; photosynthetic pigments and photosystems; Red drop and Emerson's enhancement effect.
- Primary photochemical reactions: photon, exciton and electron transfer.
- Non-cyclic electron flow: role of tyrosine and phaeophytin, quinine cycle, oxygen evolving complex and water splitting. Cyclic electron flow: process and function; role of ferredoxin-quinone reductase
- C3, C4 and CAM pathways of carbon fixation.
- Photorespiration
- Synthesis and Catabolism of Sucrose and Starch.

Unit-IV:

Learning Outcome: The learners shall have the skill to understand the photomorphogenesis.

- Physiology of flowering: Photoperiodism, flowering stimulus, floral meristems, external and internal factors of flower evocation; florigen concept; ABC model of floral organ identity; chemical signals for floral evocation.
- Seed dormancy: causes, effects, breaking of seed dormancy.
- Senescence: Types and causes, biochemical basis
- Phytochrome: Discovery, chemical nature, role of phytochrome in photo- morphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Practical:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the induction of amylase activity in germinating barley grains
8. To demonstrate suction due to transpiration.
9. Measurement of relation between transpiration and transpiring surface
10. Measurement of cuticular resistance to transpiration.
11. Measurement of primary photochemical reactions by fluorescence.
12. Jain V K Fundamental of Plant physiology, 20th ed. S chand publication ,New Delhi

Text Books:

- ✓ *Pandey and Sinha (2011). Plant Physiology, Vikash Publishing House, New Delhi*

Reference Books:

- ✓ *Sinha, R. K. (2015). Modern Plant Physiology, Narosa Publishing House, New Delhi.*
- ✓ *Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.*
- ✓ *Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.*

- ✓ *Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.*
- ✓ *Salisbury, F. B. and Ross, C. W. Plant Physiology Wadsworth Publishing Company, California*
- ✓ *Sahoo, A. C. (2018). Outlines of Plant Physiology Kalyani Publishers, New Delhi.*
- ✓ *Srivastava, N. K. (2017). Plant Physiology, Rastogi Publications, Meerut.*

2.3 Micropropagation for horticultural crops

Course Objectives:

- To have a basic idea on principles and methods of Plant Tissue culture and in vitro tissue differentiation.
- To have theoretical and practical knowledge on direct and indirect regeneration of plants for vertical gardens.
- To study on genetic fidelity and true to type plant regeneration for quality plant production.
- To train the students on commercial plant regeneration for vertical gardens.

Course Outcomes:

On completion of the course the students will have the ability to

- Understand the methods of micropropagation and its advantages.
- Describe the true to type plant regeneration of desired variety
- Have skill to prepare explant, establishment of aseptic culture and mass production of planting materials.
- Establish micropropagation for self-employment.

Unit I

Laboratory design and equipment's for micropropagation; Composition of media; Nutrient and hormone requirements; sterilization of the seeds, explants and calli; Organogenesis (Callus mediated and direct adventitious); Shoot multiplication, rooting,

Unit II

Tissue culture mediated plant regeneration protocols of Orchids, Rose, ferns, Chrysanthemum, Gladioli, gerbera; Micropropagation of foliage plants- Philodendron, Aglaonema, Dieffenbachia.

Unit III

Micropropagation of banana, strawberries, grapevines, and dwarf papaya-Media preparation, explant collection, hormone composition, Organogenesis; Shoot multiplication, rooting,

Unit IV

Somatic Embryogenesis-scope, methods and limitations; somatic embryo, synthetic seeds-media, production, storage; Protoplast isolation, purification and storage; media for protoplast culture and fusion; suspension culture. Hybrid protoplast analysis, isolation and callus generation. Chemical and physical mutation. *Agrobacterium*-mediated gene transfer for improvement.

Practical:

1. Tissue Culture: laboratory setup (drawing component wise)
2. Demonstration and operation of instruments for Plant tissue culture (Autoclave, Laminar air flow cabinet, and Hot air oven, pH meter, Micro-balance,
3. Preparation of tissue culture (MS) medium / stock solutions.
4. Demonstration of surface sterilization techniques.

5. Collection of explants of banana, rose, orchid,
6. Surface sterilization of different explants.
7. Culture of Demonstration of aseptic inoculation of nodal, shoot apical meristem or floral or pod explants of banana, rose and orchid, plant species.
8. Synthetic seed formation and germination.
9. Gel electrophoresis and visualization (demonstration/photography)
10. Microscopic observations, data recording for callusing, regeneration, rooting and photograph

Textbooks:

- ✓ Chawla, H. S. (2010). *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- ✓ Ramawat, K. G. & Goyal, S. *Comprehensive Biotechnonology 4thed* Schand Publication New Delhi.

Reference Books:

- ✓ Bhojwani, S.S. and Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice*. Elsevier Science Amsterdam. The Netherlands.
- ✓ Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications of recombinant DNA*. ASM Press, Washington.
- ✓ Stewart, C.N. Jr. (2008). *Plant Biotechnology & Genetics: Principles, Techniques and Applications*. John Wiley & Sons Inc. U.S.A.
- ✓ Singh, B. D. (2018). *Plant Biotechnology* Kalyani Publishers, New Delhi.
- ✓ Gupta, P. K. (2017). *Plant Biotechnology*, Rastogi Publication, Meerut.
- ✓ Dubey, R. C. (2017). *Advanced Biotechnology*, S, Chand Publication, New Delhi

2.4 Hardening and nutrition management of micro-propagated plants

Course Objectives:

- To have a basic idea on principles and methods of hardening and acclimatization.
- To study green house and net house organization of commercial tissue culture.
- To have theoretical and practical knowledge on standardization of hardening environment.
- To study on net pot for long term transport of tissue culture plants and genetic fidelity and true to type plant regeneration.
- To study the acclimatization of plants in green house.

Course Outcomes:

On completion of the course the students shall be able to

- Have knowledge the about methods of hardening of micro-propagated plants.
- Describe the true to type plant regeneration of desire variety.
- Have skill to handle the in vitro grown plants produced in aseptic culture
- Prepare the required conditions for proper hardening of plantlets
- Gain knowledge on methods for measuring biochemical, and physiological changes of plants during hardening.

Unit I

Washing of media, methods of washing of plantlets. Artificial media used for net pot, liquid media in green house transfer, Control of humidity, temperature and light conditions; Plant performance analysis.

Unit II

Primary hardening medias-composition, nutrient management, sterilization, maintenance. Secondary hardening media-types, preparation, nutrient balance, microbial load management. Light regime during hardening; light source, intensity and duration; acclimatization, green house, net house.

Unit III

Liquid fertilizer use, types of liquid fertilizer during hardening; fertilizer dose commitment. Growth management and control; Liquid fertilizer application, Foliar spray, media fertigation, media nutrition management.

Unit IV

Irrigation during hardening-frequency, and duration; moisture management; moisture management of plantlets and hardening chamber; fungal and bacterial load management; antifungal and antibacterial agents; anti-transpirants during hardening. Metabolic and Stomatal Regulators; Film-Forming Compounds; stress hardening, Liquid fertilizer use, mirco-irrigation application

Practical:

- 1.Demonstration of hardening chamber.
- 2.Demonstration of techniques of hardening
- 3.Hardening experiments for rose plantlets
4. Hardening experiments for banana plantlets

5. Hardening experiments for orchid plantlets
6. Experiment with Application of anti-transpirants.
7. Hardening in different media
8. Demonstration of micro-irrigation, foliar spray, micronutrient management
9. Demonstration of net shed house, secondary hardening in net pot and poly bags.

Textbooks:

- ✓ *Bhojwani S.S., Razdan M. K (2005) Plant tissue culture: Theory and practice, Studies in plant science 5, North Holland, Elsevier, New Delhi*
- ✓ *Adrian, J and Assoumani M (1983) Gums and hydrocolloids in nutrition. In: M. Rechcigl (Ed), hand book of nutritional supplements, Vol. II. Agricultural use. CRS Press, Boca Raton, FL.*
- ✓ *Kyte et al. (2013). Plants From Test Tubes: An Introduction to Micropropagation. fourth Edition, Timber Press, London.*
- ✓ *Paiva R. & Reis M V. Micropropagated Plants Production and Establishment. International Society for Horticulture Science, Leuven, Belgium.*
- ✓ *Chawla, H. S. (2010). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.*
- ✓ *Ramawat K G & Goyal S Comprehensive Biotechnology 4th ed Schand Publication New Delhi.*

Reference Books:

- ✓ *Aiken M.M and Yeoman M.M (1986) A rapid screening technique for the selection of high yielding capsaicin cell line of Capsicum frutescens Mill. In: P. Morris et al (Eds.) Secondary Metabolism in Plant Cell Cultures. Cambridge University Press, London*
- ✓ *Anderson S.B, Christiansen I and Faresveit B (1990) Carrot (Daucus carota L.): In vitro production of haploids and field trials. In: Y.P.S. Bajaj (Ed.) Biotechnology in Agriculture and Forestry, Vol. 12. Haploids in crop improvement I. Springer, Berlin.*
- ✓ *Cervelli R and Senaratna T (1995) Economic aspects of Somatic embryogenesis. In: J. Aitken-Christie et al. (Eds.) Automation and environment control in plant tissue culture. Kluwer, Dordrest*
- ✓ *Smith R.H (2000) Plant Tissue Culture: techniques and Experiments, Second edition, Academic Press, USA*

Semester IV

1.13 Basic Plant Biotechnology

Course Objectives:

- To have a basic idea on principles and methods of Plant Tissue culture and in vitro tissue differentiation.
- To study about Somatic embryogenesis; Embryo culture and embryo rescue
- To have theoretical and practical knowledge on Protoplast isolation, fusion, culture and Selection of hybrid cells for regeneration of hybrid plants.
- To study about Recombinant DNA technology and its application.
- To study various techniques of gene transfer and its application in plant improvement.

Course Outcomes

- Have knowledge the about methods of Plant Tissue culture and its application.
- Be able to describe the Somatic embryogenesis; Embryo culture and embryo rescue
- Have skill to isolate plant Protoplast and differentiate the normal and hybrid protoplasts
- Have knowledge the Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries
- Gain knowledge on methods for developing transgenic plants and application of transgenics for human welfare.

Unit -I:

Learning Outcome: Understanding of the various process of tissue culture mediated plant regeneration protocols.

Plant Tissue Culture: Historical perspective; Aseptic tissue culture techniques; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones). Totipotency; Micropropagation (using nodal explant); Organogenesis (Callus mediated and direct adventitious); Somatic Embryogenesis; Protoplast isolation, culture and fusion, plant acclimatization

Unit-II:

Learning Outcome: Gain knowledge about the fundamental aspects of recombinant DNA technology.

Recombinant DNA technology-I: Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC and briefly PAC, MAC, HAC). Gene Cloning (Recombinant DNA, Bacterial transformation and selection of Recombinant clones, PCR mediated gene cloning).

Unit-III:

Learning Outcome: Gain knowledge about the recombinant DNA technology, gene transfer technology and production of transgenic plants.

Recombinant DNA technology-II: Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; Probes-oligonucleotide, heterologous, Methods of gene transfer- *Agrobacterium*-mediated, Direct gene transfer by Polyethylene Glycol (PEG) Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Kanamycin, Luciferase, GUS, GFP).

Unit-IV:

Learning Outcome: Have knowledge on chloroplast transformation and biosafety concerns of GM crops.

Chloroplast Engineering: Chloroplast genome, chloroplast transformation: rationale, methods used for generation of transplastomic plants, vectors for chloroplast transformation, transplastomics without antibiotic resistant gene, applications of chloroplast transformation. Biosafety concerns of genetically modified (GM) crops.

Practical:

1. Tissue Culture: laboratory setup (drawing component wise)
2. Demonstration of instruments for Plant tissue culture like Autoclave, Laminar air flow cabinet, and Hot air oven.
3. Demonstration of sterilization techniques for glassware
4. Preparation of tissue culture (MS) medium.
5. Demonstration of surface sterilization techniques.
6. Demonstration of aseptic inoculation of nodal or leaf explants of any available plant species.
7. Isolation of plasmid DNA.
8. Gel electrophoresis and visualization (demonstration/photography)

Textbooks:

- ✓ Chawla, H. S. (2010). *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- ✓ Ramawat K G & Goyal S *Comprehensive Biotechnonology 4th ed* Schand Publication New Delhi.

Reference Books:

- ✓ Bhojwani, S.S. and Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice*. Elsevier Science Amsterdam. The Netherlands.
- ✓ Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications of recombinant DNA*. ASM Press, Washington.
- ✓ Stewart, C.N. Jr. (2008). *Plant Biotechnology & Genetics: Principles, Techniques and Applications*. John Wiley & Sons Inc. U.S.A.
- ✓ Singh, B. D. (2018). *Plant Biotechnology* Kalynai Publishers, New Delhi.
- ✓ Gupta, P. K. (2017). *Plant Biotechnology*, Rastogi Publication, Meerut.
- ✓ Dubey, R. C. (2017). *Advanced Biotechnology*, S, Chand Publication, New Delhi

1.14 Basic Plant Metabolites**Course Objectives:**

- To learn the anabolic and catabolic cellular processes and their regulations.
- To understand the mechanism of signal transduction in plants and the major signalling pathways.
- To learn the photochemical and biochemical mechanisms for photosynthetic carbon fixation.
- To learn the mechanism of carbon oxidation and ATP synthesis.
- To understand the pathways of synthesis and oxidation and of lipids and fatty acids.
- To understand the role of enzymes and enzyme action.

Course Outcomes:

- The students shall be able to explain the importance of biochemical pathways and regulatory pathways.
- The students can explain the role of enzymes in metabolic activities.
- The students shall have ability to differentiate various carbon metabolic pathways.
- The students shall have proper level of knowledge on carbon oxidation and energysynthesis.
- The students can explain the processes of lipid metabolism and its importance in thegerminatin g seeds.
- The students shall be able to understand and explain the amino acid metabolic pathways.

Unit-I:

Learning Outcomes: Students will learn about the cellular metabolism and understand metabolic pathways and regulation of glycolysis, TCA cycle, ATP synthesis

- Concept of metabolism: Introduction, anabolic and catabolic pathways
- Glycolysis and its regulation, Fate of pyruvate, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate; regulation of PDH, NADH shuttle.
- TCA cycle, amphibolic role, anaplerotic reactions, regulation of the TCA cycle,
- Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase enzyme
- Boyers conformational model, Racker's experiment, Jaggendorf's experiment
- Role of uncouplers in ATP synthesis and their application.

Unit-II:

Learning Outcomes: Students will learn about fatty acid synthesis, breakdown and their regulation in plants.

- Fatty acid biosynthesis: Synthesis, and breakdown of triglycerides and their importance.
- Fatty acid Breakdown: β -oxidation, α oxidation, glyoxylate cycle
- Regulation of fatty acid metabolism. Gluconeogenesis and its role in mobilization of lipids during seed germination

Unit-III:

Learning Outcomes: The learner will understand the amino acid biosynthesis, degradation along with their regulation in plants.

- Amino acid biosynthesis and degradation in plants and its importance (proteasomal pathway) Synthesis of amino acid of alpha-ketoglutarate family, 3-phosphoglycerate precursor family, oxalo-acetate and pyruvate family, PEP erythrose-4-phosphate precursor family, Ribose-5-phosphate precursor family.
- Feedback control of amino acid biosynthesis: sequential, concerted and cumulative feedback control

Unit- IV:

Learning Outcomes: Students will learn about the enzymes and their classification, kinetics, inhibition and regulation.

- Enzymes: General properties, nomenclature and classification,
- Energetics of enzyme reactions, free energy change, forward and reverse reactions.
- Michaelis-Menten kinetics of enzyme reactions and its significance, Reciprocal plot, Brigg's-Halden modification, determination of V_{max} and K_m
- Enzyme inhibition: competitive, non-competitive inhibition, determination of K_i ,
- Role of regulatory enzymes: allosteric, covalent modulation

Practical:

1. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples.
2. Detection and quantification of protein from plant samples following Bradford method using spectrophotometer/colorimeter.
3. Detection/Estimation of the nature of carbohydrate – glucose, fructose, sucrose and starch from laboratory samples.
4. Detection of Ca, Mg, Fe, S from plant ash sample
5. Estimation of amino-nitrogen by formol titration method (glycine)
6. Estimation of titratable acidity from lemon.

Textbooks:

- ✓ Gupta, S. K. (2017). *Plant Metabolism*, Rastogi Publication, Meerut.
- ✓ Pandey B P (2019) *Botany For Degree Student* S Chand Publication. New Delhi

Reference Books:

- ✓ Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). *Plant Physiology and Development*. Sinauer Associates Inc. USA. 6th edition.
- ✓ Heldt, Hans-Walter. *Plant Bio-Chemistry* (3rd ed.), 2005. Elsevier Academic Press.

1.15 Natural Resource Management

Course Objectives:

- To introduce the types of natural resources and the concept of sustainable development.
- To understand the status of biological diversity and their management.
- To know the contemporary tools such as EIA and GIS for assessment and conservation of natural resources.
- To know about the non-conventional energy resources and their application.
- To learn the concept of resource accounting for better natural resource management

Course Outcomes:

- Be able to understand importance of each component of natural resources and try to use the available resources judiciously.
- Know about different biological conventions and treaties emphasizing the conservation of biological diversities.
- Clearly understand the importance of sustainable use of natural resources and procedures for their assessment.
- Have skill to use renewable energy sources for the betterment of the human civilization and actively participate in popularization of the methods of energy and resource conservation.
- Know the national and international efforts for management and accounting of natural resources.

Unit-I:

Learning Outcome: The learners shall gain knowledge about the importance of natural resources.

- **Natural resources:** Definition and types.
- **Sustainable utilization:** Concept, approaches (economic, ecological and socio-cultural).
- **Land:** Utilization (agricultural, horticultural, silvicultural); Soil degradation and management.
- **Water:** Fresh water (rivers, lakes, groundwater, water harvesting technology, rainwater storage and utilization).

Unit-II:

Learning Outcome: The students shall be able to know the processes for maintaining sustainability.

- Biological Resources: Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).
- Forests: Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.

Unit-III:

Learning Outcome: The students shall have skills to use modern tools for effective resource assessment and utilization.

- Energy: Renewable and non-renewable sources of energy-solar, wind, tidal, geothermal and bioenergy resources.
- Contemporary practices in resource management: EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint

Unit-IV:

Learning Outcome: The learners shall gain accounting skills for management and conservation of natural resources.

Resource Accounting; Waste management. National and international efforts in resource management and conservation

Practical

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collections of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. Estimation of soil moisture content and soil texture.
7. Estimation of soil porosity
8. Estimation of soil water-holding capacity.
9. Estimation of soil organic matter and soil carbon

Textbooks:

- ✓ *Pandey, B. W. 2005. Natural Resource Management. Mittal Publication, New Delhi*
- ✓ *Singh J S & Singh S P (2017) Ecology, Environmental science, Conservation. (Revised Ed) S Chand Publication New Delhi*

Reference Books:

- ✓ *Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.*
- ✓ *Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.*
- ✓ *Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.*

2.5 Commercial floriculture through vertical gardening, hydroponic and aeroponic**Course Objectives:**

- To make aware the students on the importance of commercial floriculture
- To train on the production techniques in floriculture.
- To Explain the breeding techniques of some flowering plants.
- To provide training on post-harvest operations in floriculture.
- To provide hands-on experience on various hydroponics and aeraponics.

Course Outcomes:

After completing the course, the learners will be able to:

- Understand basics of hydroponics and aeraponics.
- Develop basic facilities for commercial soilless floriculture at pilot scale and/or commercial scale.
- Devise and implement a strategy for marketing of the product.
- Establish themselves as entrepreneurs (Hydroponic cultivator).

Unit I

Floriculture - Importance, area and production in India. Importance, morphology and taxonomy, varieties, climate and soil, seeds and sowing, manuring, irrigation, intercultural operations, diseases and their control, harvesting and yield of: (a) Rose, (b) Fern, (c) Orchids, (d) Crossandra (e) Dahlia (f) aroids (g) Philodendron

Unit II

Morphology and taxonomy, varieties, climate and soil, seeds and sowing, manuring, irrigation, intercultural operations, diseases control, harvesting and yield of: (a) gladiolus (b) gerbera (c) carnation, (d) marigold, (e) anthurium.

Postharvest handling of cut and loose flowers-marigold, orchids, tuberose, rose, gerbera, carnation. Post-harvest handling of foliage-Philodendron, ferns, *Cycas*, palms, broad leaves, grasses and fillers.

Unit III

Growing of flowering plants under protected environments- glass house, plastic house, net house, infrastructure for epiphytic culture-construction, cost, operation and maintenance.

Unit IV

Hydroponic techniques; Circulating methods - Nutrient Film Technique (NFT), Deep Flow Technique (DFT), Dutch bucket; Non circulating methods - Root dipping, Floating, Capillary action; substrate, media, plantation, irrigation, fertigation and care; disease control. Factors affecting hydroponics

Aeroponics techniques; root mist and fog feed methods; Aeroponic units (including greenhouse facilities); Growth media; Nutrients dynamics (NPK, DO, TDS, pH); growth conditions-quality, light intensity, photoperiod and temperature; irrigation, fertigation and care; disease control. Factors affecting aeroponics.

Practical

1. Identification of commercially important floricultural crops.
2. Propagation technique in Hibiscus/Rose/Chrysanthemum/tuberose.
3. Propagation technique in Gladiolus/ carnation Petunia
4. Training and pruning of rose/Jasminum.
5. Use of chemicals and other compounds for prolonging the vase life of cut flowers.
6. Flower arrangement practices, Preparation of bouquets, garland.
7. Study of techniques used in hydroponics (Circulating methods such as Nutrient Film
8. Technique (NFT), Deep Flow Technique (DFT),
9. Dutch bucket; Non circulating methods such as Root dipping, Floating,
Capillary action; Aeroponics such as root mist and fog feed techniques).
10. Study of various instruments used in hydroponics (Pressure gauge, Filters, PVC
Tanks, Venturi/Reciprocating Pump/Mixing tank, EC meter, pH meter, TDS meter,
water pump, net cups, air pump, thermometer, lux meter, drip irrigation system.
11. Construction of sustainable hydroponic and aeroponic units (including greenhouse facilities)
12. Preparation of growth media for Hydroponics.
13. Estimation of NPK, DO, TDS, pH of growth media.
14. Study of suitable conditions for Hydroponics-quality, light intensity, photoperiod and temperature.
15. Growing a leafy vegetable/fruity vegetable/medicinal herb /aromatic plant in
Hydroponics /Aeroponic solution
16. Study of safety measures, certification standards and government policies. 01 Week
17. Visit to Hydroponic/Aquaculture/Aeroponic farm/Institute.

Textbooks

- ✓ Meier Schwarz. (1995). *Soilless Culture Management. Advanced Series in Agricultural Sciences, vol 24. Springer, Berlin.*
- ✓ Hasan, M.; Sabir, N.; Singh, A.K.; Singh, M.C.; Patel, N.; Khanna, M.; Rai, T.; and Pragnya, P. (2018). *Hydroponics Technology for Horticultural Crops, Tech. Bull. TBICN 188/2018. Publ. by I.A.R.I., New Delhi.*
- ✓ Misra, R.L., Misra S. (2017). *Soilless Crop production. Daya Publishing House, Astral*

Reference Books

- ✓ Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). *Aquaponics Food Production Systems. Springer Cham.*
- ✓ Meier Schwarz. (1995). *Soilless Culture Management. Advanced Series in Agricultural Sciences, vol 24. Springer, Berlin.*

2.6 Irrigation, fertigation and disease control

Course objectives:

- To develop students with proficiency in plant protection
- To employ students and implement their acquired knowledge in basic and applied aspects of plant protection.
- To enhance students' ability of in-depth thinking, development of scientific attitude,
- To manage the problems of disease in gardening and generating solutions

Course Outcome:

- Acquire a critical knowledge of care of plants of vertical garden.
- Identify and explain methods for proper irrigation and fertigation in an ornamental garden.
- Acquire skills on identification of diseases of various ornamental plants.
- Take proper care of the plants.

Unit I

Importance, design values, propagation, planting of flowering annuals, biennials and perennials: location of plants as per water and light requirement and availability; plant types for vertical garden: (a) Climbers (b) Creepers (c) Palms (d) Ferns (e) Grasses (f) Cacti, (g) Succulents.

Unit II

Automated, remotely controllable irrigation systems, frequency or duration of irrigation. Irrigation monitoring-volume, pressure, frequency. Types of irrigation: spray, drip, root zone, foliage irrigation. Green wall irrigation systems. Recycled irrigation.

Plant nutrition: fertilizer injection, media fertigation, nutrient addition to loose media, mat media and structural media, Weightless media, High Nutrient holding system for fast growing plants. Use of Cocopeat, Perlite, Sphagnum moss, vermiculite, vermicompost, shredded bark and leaf molds for slow nutrition.

Unit III

Comprehensive definition, causes of pest outbreak, losses caused by insect pests, Categories of pests: Major pests, minor pests, Monophagous pests, Polyphagous pest, Pathogenic Pests,

Regular Pests, and Sporadic Pests with examples. Concept of vectors with examples. Symptoms: Major types of plant disease symptoms caused by fungi, bacteria and viruses.

Unit IV

Root rot (*Pythium*, *Phytophthora*), Powdery Mildew (*Podosphaera pannosa*), Downy Mildew (*Peronospora sparsa*); Bacterial and fungal leafspot, pest and vector borne diseases-spider mites and mealy bugs, nematodes. Viral mosaic.

Disease prevention, management and control, pesticides-equipment, handling, application and precautions. Cultural practices for disease management

Practical Syllabus

1. Identification and description of various plants grown in ornamental gardens.
2. Tools, implements and containers used in ornamental gardening.
3. Demonstration and use of irrigation equipment
4. Demonstration of types and styles of irrigation using photos or videos.
5. Planting, designing and establishment of plant as per their light and water requirement.
6. Demonstration and use of fertilizers for vertical garden
7. Study of various instruments for fertigation
8. Experiments for standardization of fertigation of media

Textbooks

- ✓ Atwal, A. S. 1986: *Agricultural Pests of India and South-East Asia*. Kalyani Publishers, Ludhiana
- ✓ Dasgupta, M K 1988: *Principles of Plant Pathology*. Allied Publishers Pvt. Ltd., Calcutta
- ✓ Mandahar, C L, 1987: *Introduction of Plant Virus*. Chandan Co. (Pvt.) Ltd., New Delhi
- ✓ Basu, A N and Giri, B K 1993: *The Essentials of Viruses, Vectors and Plant Diseases*. Wiley Eastern Ltd., New Delhi
- ✓ Agarios, GN 1988: *Plant Pathology* Academic Press Inc, New York
- ✓ Prasad. T.V. *Hand book of Entomology*. New Vishal Publications, New Delhi Minor

Reference Books

- ✓ Matthews, G.A. 1979, *Pesticide Application Method*. Longman, London.
- ✓ Bindra, O.S and Singh, H. 1977. *Pesticide Application Equipment* Oxford and IBH Publishing Co.; New Delhi
- ✓ Chatterjee, P.B. 1997. *Plant Protection Techniques*. Bharati Bhawan (Publishers and Distributors), Patna. Brent, K.J and Atkin, R.K. (Eds), 1987. *Rational Pesticide Use*. Cambridge University Press, Cambridge

Syllabus for
**Apprenticeship Embedded Degree 3 or 4 Year Programme
(AEDP)**
in
**Bachelor of Science (B.Sc.) with Double Major in Industrial Chemistry
and Chemistry**
(NEP-2020)
To be implemented from June 2026 onwards



**Department of Higher Education, Government of
Odisha**

Semester	Subjects
I	Core-I 1.1.1 Atomic Structure, Periodicity and Chemical Bonding 1.1.2 Fundamental Organic Chemistry 1.1.3 Mineral Processing, Extractive Metallurgy, and Nonaqueous Solvents 1.1.4 Introduction to Polymer Science and Polymer Processing
	Core –II 1.2.1 Fuels, energy storage devices and cleaning agents
II	Core I 2.1.1 States of matter, and Ionic equilibrium 2.1.2 Chemical thermodynamics, equilibrium, and Colligative property 2.1.3 Organic Spectroscopy 2.1.4 Analytical Chemistry
	Core-II 2.2.1 Industrial Chemical and Environment
III	Core I 3.1.1 Acids and Bases and Chemistry of main group elements 3.1.2 Chemistry of halogen, oxygen and sulphur containing organic compounds 3.1.3 Phase equilibrium, Chemical dynamics, catalysis and surface chemistry 3.1.4 Chemistry of Organometallic Compounds
	Core II 3.2.1 Pharmaceutical, Fermentation, and Pesticides 3.2.2 Inorganic chemicals of industrial importance
	MDC1: Nuclear and Radiation Chemistry/ any paper from other discipline
	SEC1: Corrosion and Prevention
IV	Core I 4.1.1 Coordination Chemistry, Chemistry of d- and f-block elements, Inorganic Reaction Mechanism and electron transfer reactions 4.1.2 Natural Products, Heterocyclic Compounds, Nitrogen containing compounds, Dyes and Polynuclear Hydrocarbons 4.1.3 Conductance, electrochemistry, electrical properties of atoms and molecules
	Core II 4.2.1 Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry 4.2.2 Solid and porous materials, and magnetochemistry
	MDC2: Nanoscience and Nanotechnology/ any paper from other discipline
	SEC2: Biochemistry
V	Apprenticeship
VI	Apprenticeship
VII	Core I 7.1.1 Polymer Chemistry 7.1.2 Green Chemistry 7.1.3. Research Methodology
	Core II 7.2.1 Oxidation, Reduction, Reagents, Rearrangement and Name Reaction 7.2.2 Chemistry of Biomolecules
VIII	8.1.1 Quantum Chemistry and Statistical Thermodynamics 8.1.2. A. Pericyclic reaction, Photochemistry and Retrosynthesis 8.1.2 B. Chemical Group Theory electronic spectra of Metal complex and Nuclear chemistry

AEDP Programme Outcomes

- To prepare the students for a career in Chemistry.
- To prepare the students for Higher Education and Research in Chemistry.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To generally promote wider reading on the subject and allied inter disciplinary subject.

SEMESTER I

1.1.1 Atomic Structure, Periodicity of Elements and Chemical Bonding

Credit-04

Full mark-100

Course Objectives:

To provide the fundamental knowledge on the structure of atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. Various types of periodic properties and bondings have been reviewed to strengthen students for grasping this tricky topic and effectively tackle exam questions. The basics of acid-base titrimetric analysis has been incorporated in order to develop the analytical skills of the students.

Course Outcomes:

1. Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom.
2. Learn the various atomic properties of atoms and their variations in the periodic table.
3. Gain the idea of different types of bonding and their associated properties.
4. Understand the theory and applications of various acid-base titrations.

Unit – I: Atomic structure

Rutherford's nuclear model of atom, Bohr's theory and the origin of hydrogen spectrum, Sommerfeld's extension of Bohr's theory, de-Broglie equation, Heisenberg's Uncertainty Principle and its significance. Postulates of wave mechanics, Derivation of Schrödinger's wave equation for hydrogen atom, significance of ψ and ψ^2 . Radial and angular wave functions, Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of s-, p-, d- and f-orbitals, Relative energies of orbitals. Slater's rule and its limitations, Quantum numbers and their significance. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity and Aufbau principle.

Unit – II: Periodicity of elements:

Introduction to long form periodic table, Cause of periodicity, Division of elements into s-, p-, d- and f-blocks. Atomic radius, ionic radius, covalent radius and Van der Waals radius. Periodic trends in ionic and covalent radii. Ionization energy, electron affinity, electronegativity, and their variations in the periodic table. Applications of electronegativities. Pauling's/Mulliken's scale of electronegativity, Sanderson's electron density ratio.

Unit – III: Chemical bonding

Ionic bond-General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Haber cycle and its application, Born-Landé equation, Madelung constant, importance of Kapustinskii equation for lattice energy. Solvation energy, Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Unit – IV: Chemical bonding

Covalent bond-Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: CH_4 , H_2O , NH_3 , PCl_3 , PCl_5 , SF_6 , ClF_3 , I_3^- , BrF_2^+ , PCl_6^- , ICl_2^- , ICl_4^- , NH_4^+ , PO_4^{3-} and SO_4^{2-} . Valence Bond theory (Heitler-London approach). Hybridization, equivalent and non-equivalent hybrid orbitals. Ionic character in covalent compounds: Dipole moment. Percentage ionic character from dipole moment and electronegativity difference, Molecular orbital diagrams of homo- & hetero-diatomic molecules (N_2 , O_2 , C_2 , B_2 , F_2 , CO , NO) and their ions. Calculation of bond order. Concept of bent rule.

Metallic bond and Hydrogen Bond

Concept of metallic bond, The free electron model, The valence bond model, The band model (molecular orbital approach), semiconductor and insulators. Concept of hydrogen bond, nature of hydrogen bonding, consequences of hydrogen bonding and its importance.

List of experiments

A. General Experiments

1. Calibration and use of apparatus
2. Preparation of solutions of different Molarity/Normality.

B. Acid-Base Titration

1. Estimation of oxalic acid using a standard NaOH solution
2. Estimation of sodium carbonate using standard HCl.
3. Estimation of carbonate and hydroxide present together in a mixture.
4. Estimation of carbonate and bicarbonate present together in a mixture.

Text Books:

1. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Co., 33rd Ed., 2017.
2. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons, 1989.

Reference Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2010.
2. B. E. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, John Wiley & Sons, 1994.
3. P. W. Atkins, T. L. Overton, J. P. Rourke, M. T. Weller, F. A. Armstrong, Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press, 2010.
4. P. Chndra, C. Gupta, Chemical Dynamics and Coordination chemistry, 1st Ed., 2022.
5. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd., 2014.
6. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education, 2009.

1.1.2 Fundamental Organic Chemistry

Credit-04
Full mark-100

Course Objectives:

To provide the fundamental knowledge on organic chemistry to comprehend other organic chemistry courses in the coming semesters with greater depth. The purpose of this core paper is to review the basic concepts of electron displacement and the chemistry of aliphatic and aromatic hydrocarbons. Stereochemistry is also introduced to help students to visualise the organic molecules and their spatial arrangement in three-dimensional spaces, and hands-on experience on the detection of organic molecules.

Course Outcomes:

1. Understanding the basic concepts of electronic displacement phenomena in organic molecules, various bond-breaking processes and types of organic reactions.
2. Fundamental knowledge on symmetry and asymmetry aspect of organic molecules and their spatial arrangements in two-dimension and three-dimension with their stereochemistry.
3. Learning the synthesis, structure and stability of unsaturated hydrocarbons, understanding the concept of aromaticity and chemical reactions of unsaturated hydrocarbons and aromatic hydrocarbons.
4. Knowledge on selection of suitable solvents for purification and separation of organic compounds and detection of various elements present in it.

Unit-I: Basics of Organic Chemistry

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications in dipole moment; organic acids and bases; their relative strength. Homolytic and heterolytic fission with suitable examples. Curly arrow rules; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stability of carbocations, carbanions, free radicals and carbenes.

Introduction to types of organic reactions with suitable examples: Addition, Elimination, Substitution, Rearrangement and Pericyclic reactions.

Carbon-carbon sigma bonds, chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Corey-House Reactions, Free radical substitutions: Halogenation –relative reactivity and selectivity.

Unit-II: Stereochemistry

Concept of Chirality/Asymmetry, Geometrical isomerism and Optical Isomerism: Optical Activity, Specific Rotation. Determination of Relative and absolute configuration in chiral molecules using D/L, R/S, cis/trans, Syn/Anti and E/Z descriptors using C.I.P rules. Representation by Fischer Projection, Newmann and Sawhorse Projection formulae in molecules containing one and two chiral-centres. Enantiomers, Distereoisomers, meso- structures, Racemic mixture and their resolution.

Stability and Conformational analysis: types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of alkanes (ethane and n-butane): Relative stability with energy diagrams. Energy diagrams of cyclohexane: Chair, Half chair, boat and twist boat forms.

Unit–III: Chemistry of Unsaturated Hydrocarbons

Carbon-Carbon Pi Bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E₁, E₂, E₁cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/AntiMarkownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, syn and anti- hydroxylation (oxidation). 1,2- and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Unit–IV: Chemistry of Aromatic Hydrocarbons

Aromaticity: Hückel's rule, aromaticity in benzenoid and non-benzenoid compounds, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples.

Electrophilic aromatic substitution with mechanism: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the functional groups.

List of Experiments

1. Detection of extra elements (N, Cl, Br, I and S) in organic compounds by Lassaigne's test.
2. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid groups in known organic compounds.
3. Separation and purification of any one component of following binary solid mixture (Benzoic acid/*p*- Toluidine; *p*-Nitrobenzoic acid/*p*-Aminobenzoic acid; *p*-Nitrotoluene/*p*-Anisidine) based on the solubility in common laboratory reagents/solvents like water (cold, hot), ethanol (cold, hot), dil. HCl, dil. NaOH, dil. NaHCO₃ etc. and using chromatographic techniques.
4. Determination of melting point and boiling point of different organic compounds

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., Pearson Education India, 2010.
2. Bahl, B. S. Bahl, *Advanced Organic Chemistry*, 5th Ed., S. Chand, 2012.
3. A.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel'*
4. *Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India, 2003.

Reference Books:

1. T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, *Solomons' Organic Chemistry*, Global Ed., Wiley, 2024.
2. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., Oxford Publisher, 2012.
3. R. K. Bansal, *Organic Reaction Mechanism*, 3rd Ed., Tata McGraw-Hill Publications, 1998.
4. D. Nasipuri, *Stereochemistry of Organic compounds*, 4th Ed., New Age International Publisher, 2020.
5. P. Sykes, *A Guidebook to Mechanism in Organic Chemistry*, 6th Ed., Pearson Education, 2003.
6. F. A. Carey, R. J. Sundberg, *Advanced Organic Chemistry, Part-A and Part-B*, 5th Ed., Springer 2007.
7. N. K. Vishnoi, *Advanced Practical Organic Chemistry*, 3rd Ed., Vikas Publishing House, 2009.

8. O. P. Agarwal, *Advanced Practical Organic Chemistry*, Krishna Prakashan, 2014.
9. V. K. Ahluwalia, R. Aggarwal, *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press, 2004.
10. H. T. Clarke, *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers, 2021

1.1.3 Mineral Processing, Extractive Metallurgy, and Nonaqueous Solvents

Credit-04

Full mark-100

Course objective:

To equip students with fundamental knowledge and practical understanding of metallurgy, metal extraction, and nonaqueous solvent systems, for effective application in scientific and industrial contexts.

Course Outcomes:

1. To understand the basic principles involved in the processing of minerals, and their beneficiation.
2. Explain different extractive metallurgical processes for the extraction of metals from ores.
3. To understand the different refining methods of metals
4. To develop knowledge of solvent systems beyond water and their applications in chemical reactions.

UNIT-I: Occurrence of minerals and beneficiation

Occurrence of metal-bearing minerals in nature (based on standard electrode potentials), Mineral wealth of Odisha and India, mineral mining (open and underground mining), General mineral beneficiation processes before extraction (crushing/grinding, froth flotation, gravity, electrostatic separation, and magnetic separation).

Unit-II: Extractive metallurgy

Pyrometallurgy: Calcination and roasting, Ellingham diagram, use of carbon and carbon monoxide for reduction of metal oxides, electrolytic reduction, smelting and converting. Examples of the pyrometallurgical route for extracting metals from their ores (iron and copper).

Unit-II: Extractive metallurgy

Hydrometallurgy: Different leaching processes, Concentration/purification by solvent extraction (liquid-liquid extraction), ion exchange and precipitation processes. Electrowinning, Methods of purification of metals: electrolytic process, parting process, van Arkel-de Boer Process, Mond's process, and Zone refining. Example of the hydrometallurgical route for extracting aluminium from bauxite ore (Bayer process).

Unit-IV: Non-aqueous solvents

Introduction, classification of solvents, physical properties of solvents, general characteristics of solvents: self-ionization and levelling effect, reactions in non-aqueous solvents: liquid ammonia, liquid sulphur dioxide, anhydrous sulphuric acid, anhydrous HF, liquid N_2O_4 , Failure of auto-ionization theory and coordination model.

List of experiments

1. Analysis of iron content in iron ore (by acid leaching/dichromate titration)
2. Analysis of aluminium content in bauxite ore (By acid leaching/EDTA titration)
3. Separation of Fe(III)-Cu(II) mixture solution by solvent extraction (Ethyl acetate/HCl) and estimation of Cu(II) present in the aqueous medium.
4. Virtual laboratory experiments: Students should explore the virtual labs for the following experiment and prepare reports for each experiment.

- (a) Mineral beneficiation process (froth floatation, Magnetic separation)
 - (b) Solvent extraction of mixtures of metals
 - (c) Acid-base titration in non-aqueous media
5. Visit to the nearby mining site/research laboratories/industrial units, etc., to familiarise with different kinds of minerals, their mining, beneficiation and extraction processes.

Text/Reference Books

1. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
2. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
3. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut
4. H.S. Ray, A. Ghosh, Principles of extractive metallurgy, New Age Publication, New Delhi.
5. T.R. Rosenquist, Principles of Extractive Metallurgy, (2004), McGraw Hill
6. Swayam-NPTEL: Principles of Extractive Metallurgy
7. Virtual lab experiment sites: Virtual Labs India, Amrita Virtual Lab, YouTube for specific experiments.

1.1.5 Introduction to Polymer science and Polymer processing

Credit-04
Full mark-100

Objectives:

The course aims to provide an overall view of the fundamentals of polymers, polymeric processes, and polymeric products of industrial importance. Also, to provide the students with practical exposure to polymer industries with hands-on training on Polymer processing

Course Outcomes:

On completion of the course, the students should be able to

1. Explain the classification of polymers, fibres, resins, etc.
2. Acquire knowledge on various techniques of polymerisation
3. Explain reactions of polymers and polymer processing from raw materials to finished products.
4. Acquire knowledge on important polymeric products
5. Acquire hands-on training on the synthesis of simple polymeric compounds and polymer testing

UNIT-I: Introduction to Polymer Science:

Monomers, polymers and macromolecules, nomenclature and classification of polymers, functionality of monomers. Brief outlines of types of polymerisation and important properties of polymers. Techniques of polymerization: Bulk, solution, emulsion and suspension polymerization. Plastics and Fibres, Epoxies and Silicones: amino polymers, phenol formaldehyde resins.

UNIT-II: Fillers and additives

Types of fillers: organic and inorganic fillers, fillers, cellulosic fibres; applications and uses.

Polymer additives: plasticisers - classification, mechanism, properties, methods of plasticization, effects on physical and chemical properties, stability; flexibilizers; colourants; antioxidants; antistatic agent.

Unit-III: Polymer processing Techniques:

Moulding, moulding powder, processing of moulding powder, mixing, curving, types of moulding:- compression moulding, extrusion moulding, injection moulding, blow moulding, process parameters and defect analysis.

Unit-IV: Rubbers and adhesives:

Classification of rubber, latex, processing of latex (concentration, coagulation), compounding of rubber, vulcanizations of rubber. Synthetic rubbers: Preparation and applications of SBR, Butyl rubber, Nitrile rubber, Neoprene and Silicone rubber

Adhesives: theory, surface treatment, joint designs, physical nature of adhesives, types of adhesives, natural glue- application- elastomer adhesive: synthetic adhesives, olefinic polymer adhesives, types of epoxy adhesives

List of experiments:

1. Preparation of nylon-6,6 / Polyaniline
2. Preparations of phenol-formaldehyde resin-novalac / phenol-formaldehyde resin resold.
3. Preparation of urea-formaldehyde resin
4. Synthesis of Poly Methyl Methacrylate (PMMA)
5. Determination of molecular weight of polystyrene and polyvinyl alcohol by viscometry
6. Identification of polymers from solubility tests.
7. Identification of Polymers by Flame Tests

In addition, the student should acquire some practical experience from the following activities:

1. Visit any plastic/ polymer industry and prepare a lab report.
2. Students may visit some of the virtual lab experiments on polymer processing and prepare lab reports.

Recommended Text Books:

1. V. R. Gowarikar, Jayadev Sreedhar, N. V. Viswanathan, Polymer Science 1st Edition, New Age International Publishers, 1986.
2. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rd Edition, McGraw-Hill Education, 2010.
3. P. Bahadur & N.V.Sastry, Principles of polymer science, Narosa Publishing House, New Delhi, 2002.
4. Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)

Reference books

5. L.H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
6. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)
7. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).
8. Nayak P.L., Polymer Chemistry, Kalyani Publisher (2017).
9. Hundiware G.D., Athawale V.D., Kapadi U.R. and Gite V. V., Experiments in Polymer Science, New Age Publications (2009).
10. Online materials

1.2.1 Fuels, energy storage devices and cleaning agents

Credit-04

Full mark-100

Course Objectives:

This course is designed to provide an overview on fundamental scientific knowledge of energy resources such as coal and fuels; to make students learn the principles, design and working of energy storage devices with reference to batteries and supercapacitors; to impart scientific and technical know-how of cleaning agents such as soaps and detergents.

Course Outcomes:

On completion of the course, the student shall be able to:

1. Explain the chemistry of fuels and classification of fuels based on the calorific values
2. Understand the importance of coal as a fuel and for non-fuel purposes.
3. Learn about the refining and different types of petroleum products
4. Explain the function of a battery, its components and fundamental electrochemical processes in common battery systems.
5. Learn about the composition, preparation, and cleaning actions of soaps and detergents.

UNIT-I: Fuel Chemistry and Introduction to Coal

Conventional and non-conventional energy sources, classification of fuels and their calorific values. Introduction of coal, uses of coal (fuel and non-fuel) in various industries, its types and composition, carbonization of coal. Coal gas, producer gas and water gas: composition and their uses; uses of coal-tar based chemicals, requisites of a good metallurgical coke, coal gasification (hydro gasification and catalytic gasification), coal liquefaction and solvent refining.

UNIT-II: Petroleum and Petrochemicals

Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

UNIT-III:

Energy storage devices: batteries and supercapacitors

Primary and secondary batteries and their role in the energy system, battery components and their role, characteristics of batteries. Working of the following batteries: lead-acid and lithium-ion batteries and solid-state electrolyte batteries (SSBs). Fuel cells, solar cells, and polymer cells. Supercapacitors-introduction, types of supercapacitors: Electrical double layer, pseudo and hybrid supercapacitors.

UNIT – III: Cleaning agents - Soaps and detergents

Chemistry of soap and detergents, raw materials for soaps (oil/fats) and detergents (surfactants, binders and builders), saponification of fats/oils, surfactants from petroleum hydrocarbon (alkyl benzene sulfonates, linear alkyl benzene sulfonates, sodium lauryl sulphate). Different types of soap and their composition, synthetic detergents-classification. Preparation of soaps and detergents, cleansing action of soap and detergents. Advantages and disadvantages of soaps and detergents.

List of experiments:

1. Determining the viscosity of liquid fuels
2. To determine the moisture content of coal samples.
3. Determination of alkali in water samples and soaps.
4. Determination of iodine value of the oils/ fats.
5. Determination of saponification value of the oils/ fats.
6. Determination of acid value of the oils/ fats.
7. Preparation of soap
8. To determine the aniline point of a fuel (From virtual lab)

Text books:

1. O. P. Vermani, A. K. Narula: *Industrial Chemistry*, Galgotia Publications, Pvt. Ltd., New Delhi.
2. S. C. Bhatia: *Chemical Process Industries*, Vol. I & II, CBS Publishers, New Delhi.
3. P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
4. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi.
5. B. K. Sharma: *Engineering Chemistry*, Goel Publishing House, Meerut.
6. S. Verma and R. K. Goyal, Fuel Chemistry Theory and Practical, 1st Edition Aaryush Publications, Muzaffarnagar (U.P.), 2021.
7. Energy storage devices: batteries and supercapacitors, Book Chapter-4, IWA Publishing (2023).
doi: https://doi.org/10.2166/9781789063592_0061

SEMESTER-II

2.1.1. States of matter, and Ionic equilibrium

Credit-04

Full mark-100

Course Objectives:

The objective of this course is to develop basic and advanced concepts regarding gases and liquids. It aims to study the similarities and differences between the two states of matter and the reasons responsible for these. The objective of the practical is to develop skills for working in physical chemistry laboratory:-

Course Outcomes:

1. Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
2. Apply the concepts of gas equations and liquids while studying other chemistry courses and understand the importance of pH in everyday life.
3. Understand different lattice systems and apply the working principles of XRD for understanding crystal structure by powder and single crystal method.
4. Handle the stalagmometer and Ostwald viscometer properly and determine the density of aqueous solutions. Data reduction, interpretation using numerical and graphical methods.

Unit-I: Gaseous state

Kinetic molecular model of a gas, Collision frequency, Collision diameter, Collision cross section, Mean free path and viscosity of gases, including their temperature and pressure dependence, Relation between mean free path and coefficient of viscosity, Maxwell distribution of molecular velocities (no derivation); average, root mean square and most probable velocities and average kinetic energy, Law of equipartition of energy, Behaviour of real gases: Deviations from ideal gas behavior, Causes of deviation from ideal behavior, Vander Wall equation and its application, Compressibility factor Z, and its variation with pressure for different gases, Critical Phenomenon and critical constant derivation.

Unit-II: Liquid state

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Capillary action in relation to cohesive and adhesive forces, Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Unit- III: Solid state

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non- stoichiometric).

Unit-IV: Ionic equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono- and diprotic acids. calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions;

derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts and its application.

List of experiments:

1. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration and the determination of CMC
3. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
4. Study the variation of viscosity of sucrose solution with the concentration of solute.
5. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
6. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide
7. Determination of the dissociation constant of a weak acid.
8. Determination of solubility product of PbI_2 by titrimetric method.

Text Books:

1. P. W. Atkins, J. de Paula, *Elements of Physical Chemistry*, Oxford University Press, 6th Ed., 2006.
2. G. W. Castellan *Physical Chemistry* 4th Edn. Narosa 2004.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi 2011.

Reference books:

1. Puri, Sharma & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co, 47th Edn., 2017.
2. R. G., Mortimer *Physical Chemistry*, Elsevier (Academic Press), 3rd Ed, 2008.
3. T. Engel & P. Reid *Physical Chemistry*, 3rd Ed. Pearson 2013
4. Kapoor K. L., *Text Book of Physical Chemistry*, McGraw Hill, 3rd Edn. 2017
5. Hrishikesh Chatterjee, *Understanding PHYSICAL CHEMISTRY Through Theories and Problems, Nonlinear insights (opc) pvt. ltd. Publication division*, 1st Ed., 2023

2.1.2 Chemical thermodynamics, Equilibrium, and Colligative property

Credit-04

Full mark-100

Course Objectives:

The learners should be able to apply principles and laws of thermodynamics to reversible and irreversible systems. The students will understand the change in thermodynamic properties, equilibrium constants, partial molar quantities, and chemical potential.

Course Outcomes:

By the end of the course, the students will be able to:

- Discuss the laws of thermodynamics and applications to natural phenomena.
- Acquire a strong foundation of partial molar properties, its variation with temp and pressure for different systems and able to apply on the thermodynamics of simple mixtures.
- Inculcate firm foundations in the fundamentals and application of chemical equilibrium, and ΔG derive the relationship between different equilibrium constants.
- Understand the basic concept of Solutions of non-volatile solutes, colligative properties. Calculate various thermodynamic properties ($\Delta H_{\text{neutralization}}$, $\Delta H_{\text{hydration}}$ & C_v) for chemical reactions using calorimeter.

Unit-I: Chemical thermodynamics

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, q , work, w , internal energy, U , and statement of **first law**; enthalpy, H , relation between heat capacities, calculations of q , w , U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions. Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Unit-II

Carnot cycle, efficiency of heat engine, Carnot theorem; **Second Law**: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. **Third Law**: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Free Energy Functions: Gibbs and Helmholtz energy; variation of S , G , A with T , V , P ; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters, inversion temperature, Gibbs-Helmholtz equation, Maxwell relations, thermodynamic equation of state.

Unit-III: Systems of variable composition

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **Chemical equilibrium**: Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient (van Hoff's

reaction). Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p , K_c and K_x . Le Chatelier principle (quantitative treatment) and its applications.

Unit-IV: Solutions and Colligative Properties

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

List of experiments

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. Determination of heat of solution (ΔH) of oxalic acid/benzoic acid from solubility measurement.

Text Books:

1. P. W. Atkins & J. de Paula, *Elements of Physical Chemistry*, Oxford University Press, 6th Ed., 2006.
2. D. A. McQuarrie, & J. D Simon. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi 2004.
3. K. L. Kapoor, *Text Book of Physical Chemistry*, Mac Grow Hill, 3rd Edn. 2017
4. B. D. Khosla, V. C. Garg, & A. Gulati, *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi 2011.

Reference Books:

1. T. Engel & P. Reid, *Physical Chemistry* 3rd Ed. Pearson 2013.
2. S.C. Kheterpal Pradeep's *Physical Chemistry*, Vol. I & II, Pradeep Publications 2011.
3. Puri, Sharma & Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co, 47th Edn., 2017.

2.1.3 Organic Spectroscopy

Credit-04
Full mark-100

Course Objectives:

To provide knowledge on the principles of different advanced spectroscopic methods such as UV-Visible, FTIR, NMR and Mass-spectrometry and to develop analytical aptitude for the interpretation of structure of the organic compounds by applying these spectroscopic methods. Imparting practical knowledge on UV-visible spectroscopy and colour of compounds.

Course Outcomes:

1. Gaining knowledge on the principles of UV-visible and Infrared Spectroscopic techniques.
2. Gaining knowledge on the principles of NMR Spectroscopic techniques.
3. Gaining knowledge on the principles of Mass Spectrometry techniques.
4. Understanding and interpretation of different spectra of organic molecules.

Unit-I: UV-Visible Spectroscopy

Types of electronic transitions, λ_{max} , Lambert-Beer's law and its limitations, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Instrumentation (brief idea only), Application of Woodward rules for calculation of λ_{max} for the following systems: α , β - unsaturated carbonyl compounds, acids and esters; Conjugated dienes, distinction between cis and trans isomers.

Unit-II: FTIR Spectroscopy

Fundamental and non-fundamental molecular vibrations; IR absorption positions of O and N containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in simple functional group analysis

Unit-III: NMR Spectroscopy

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Equivalent and non-equivalent protons, Spin-spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics; Interpretation of NMR spectra of simple organic compounds. ^{13}C NMR spectroscopy, chemical shift values and interpretation of NMR spectra. preliminary idea on NMR of ^{15}N , ^{19}F , ^{31}P nuclei.

Unit-IV: Mass Spectrometry

Introduction, Basic principle, Fragmentation pattern, instrumentation, Determination of molecular formulae, molecular ions, Parent peak, Base peak, isotopic peak and metastable ion peak. Use of molecular fragmentation, McLafferty rearrangement, Mass spectra of some classes of compounds (hydrocarbons, alcohols, phenols, ketones, aldehydes, acids and esters). Problems involving identification of organic compounds using UV, IR, NMR spectroscopy and Mass spectrometry.

List of Experiments

- 1) Using an UV-visible spectrophotometer, obtain the uv-visible spectrum, determine the λ_{max} value and, after comparing the spectra of the following molecules, predict the effect of auxochrome and conjugation on absorption maxima.

- (a) Take and analyze the spectra of benzene, aniline, and 4-methoxyaniline using a suitable solvent. Then, compare the results after adding dil hydrochloric acid to it.
- (b) Take and analyze the spectra of salicylic acid, benzoic acid and *p*-amino benzoic acid, cinnamic acid in neutral and then compare the result after adding dil NaOH to it.
- (c) Take and analyze the spectra of o-nitrophenol, p-nitrophenols and nitrobenzene in neutral and then compare the result after adding dil NaOH to it.
- 2) Identification of labelled peaks in the ^1H NMR spectra of the known organic compounds and to explain their δ -values and splitting pattern on supplied NMR spectra.
- 2) Identification of labelled peaks in the IR spectrum of a compound and to explain the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C $\equiv$ C, C $\equiv$ N) of a supplied spectrum.

Text Books:

- ✓ W. Kemp, *Organic Spectroscopy*, 2nd Ed., Macmillan, 2019.
- ✓ P. S. Kalsi, *Spectroscopy of Organic Compounds*, 9th Ed., New Age International Publishers, 2022.
- ✓ D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, *Introduction to Spectroscopy*, 5th Ed., Cengage India Private Limited, 2015.

Reference Books:

- ✓ Y. R. Sharma, *Elementary Organic Spectroscopy*, 5th Ed., S. Chand, 2013.
- ✓ Jag Mohan, *Organic Spectroscopy: Principles and Applications*, 2nd Ed., Narosa Publishers, 2009.
- ✓ J. Singh, J Singh, *Organic Spectroscopy: Principles, Problems and their Solutions*, Pragati Prakashan, 2019.
- ✓ R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, *Spectrometric Identification of Organic Compounds*, 8th Ed., Wiley, 2022.

2.1.4 Analytical Chemistry

Credit-04
Full mark-100

Course Objectives:

The objective of this course is to provide a sound physical understanding of the principles of analytical chemistry and to show how these principles are applied in chemistry and related disciplines-especially in life sciences and environmental science. Students should gain hands-on experience with analytical instrumentation commonly used in chemical analysis, such as spectrophotometers, chromatographs, and mass spectrometers.

Course Outcomes:

1. Perform calibration and standardization procedures to ensure the accuracy and precision of analytical measurements, adhering to established protocols and standards.
2. Apply a variety of analytical techniques, such as spectroscopy, chromatography, electrochemistry, and titrimetry, to quantitatively and qualitatively analyze chemical substances.
3. Collect, analyze, and interpret experimental data accurately using appropriate statistical methods and error analysis techniques.
4. Develop critical thinking and problem-solving skills and Implement quality control and assurance practices, including the use of control charts and validation of analytical methods, to ensure the reliability and reproducibility of analytical results.

Unit I – Tools and Data Handling

Calibration of tools, sampling. Errors and Statistics: significant figures, rounding off, accuracy and precision, determinate and indeterminate errors, standard deviation, propagation of errors, confidence limit, test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit II – Separation Techniques

Solvent Extraction: distribution Coefficient, distribution ratio, solvent extraction of metals, multiple batch extraction, counter-current distribution. - Chromatographic Techniques: classification, theory of chromatographic separation, distribution coefficient, retention, sorption, efficiency and resolution.

-Column, ion exchange, paper, TLC & HPTLC: techniques and application. - Gas Chromatography: retention time or volume, capacity ratio, partition coefficient, theoretical plate and number, separation efficiency and resolution, instrumentation and application.

Unit III – Spectroscopic Techniques

Electromagnetic radiation, absorption, and emission of radiation – instrumentation: sources, monochromators, detectors. - Flame spectrometry: flame emission, AAS, ICP, instrumentation and application. - Absorption spectrometry: UV-VIS, IR, instrumentation, techniques and applications.

Unit IV – Thermal and Electroanalytical Techniques

Thermogravimetry: instrumentation and techniques, TGA curves, DTA and DSC,

applications. Electrogravimetry, coulometry, voltammetry, polarography, conductometry, instrumentation, techniques and application.

List of Experiments:

1. Determination of R_f values of organic compounds by thin layer chromatography
2. Separation organic mixture by column and thin layer chromatography
3. Determination of dissociation constant of an indicator using UV-Vis spectroscopy
4. Determination of molecular composition of ferric salicylate by Job's method (Using UV-Vis spectroscopy)
5. Potentiometric titration of potassium dichromate versus Mohr's salt
6. Determination of critical micellar concentration of a soap/detergent using conductometry.
7. Paper chromatographic separation of Fe^{3+} , Al^{3+} , and Cr^{3+} .

Textbooks:

1. D. C. Harris, *Quantitative Chemical Analysis*, 4th Edn., W. H. Freeman, 1995.
2. G. D. Christian & J. E. O'Reilly, *Instrumental Analysis*, 2nd Edn., Allyn & Balon, 1986.
3. Skoog, Holler and Crouch, *Principles of Instrumental Analysis*, Cengage Learning, 6th Indian Reprint 2017.

Reference books

1. W. H. Hobert: *Instrumental Methods of Analysis*, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
2. O. Mikes, & R.A. Chalmers, *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Ltd. London. 2001
3. Pavia, Lamman, Kriz and Vyvyan, *Introduction to Spectroscopy*, Cengage Learning, 3rd Indian Reprint 2017.

2.2.1 Industrial Chemicals and Environment

Credit-04

Full mark-100

Course Objectives:

The objectives of a course are to make the student aware about the intricate relationship between the industrial process, the production and uses of chemicals/gases and their profound impact on the environment; manufacturing, application, analysis and hazards of inorganic chemicals; air and water pollution, control measures for air and water pollutants, effluents, wastewater treatment and environment.

Course Outcomes:

By studying this course, the student will be able to

1. Understanding manufacturing processes, handling and storage of inorganic chemicals.
2. Realise the hazardous effects of the inorganic chemicals on human beings and vegetations.
3. Understand the composition of air, various air pollutants, effects and control measures of air pollutants.
4. Understand different sources of water pollutants, water quality parameters, impacts of water pollution, industrial effluents and water treatment.
5. Develop analytical skills in environmental chemistry, and apply a range of analytical techniques for the detection and characterization of environmental pollutants.
6. Apply the principles of environmental chemistry for mitigating environmental pollution, promoting environmental conservation.

UNIT-I

Industrial Gases and Inorganic Chemicals

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, hydrogen, acetylene, carbon monoxide, chlorine, sulphur dioxide.

Inorganic Chemicals: Manufacture, applications and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, potassium dichromate and potassium permanganate.

UNIT-II

Environment and its segments

Ecosystems: Biogeochemical cycles of carbon and nitrogen and aquatic ecosystems

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere.

Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone and Ozone depletion. Major sources of air pollution. Pollution by SO₂, CO₂, CO, NO_x, and H₂S and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and global warming.

UNIT-III

Water Pollution: Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Aquatic pollution: inorganic, organic, pesticide agricultural, industrial and sewage, detergents, oil spills and oil pollutants. Water treatment and purification (reverse osmosis, ion exchange). Effluent treatment (primary, secondary and tertiary treatment). Industrial effluents treatment (textile, dairy and agrochemicals). Water quality parameters for wastewater, industrial water and domestic water.

UNIT-IV

Energy and Environment

Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management. **Biocatalysis:** Introduction to biocatalysis: Importance in green chemistry and chemical industry.

List of experiments:

1. Determination of Dissolved Oxygen (DO) in water.
2. Acid Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by the simple titration method (AgNO_3 and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-} , HCO_3^-) using double titration method.
7. Determination of hexavalent chromium concentration in the supplied solution/wastewater by spectrophotometry.
8. Preparation of borax/boric acid
9. Study of some of the common bio-indicators of pollution.
10. Estimation of SPM in air samples.

Text Books:

1. De, A. K. *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi, 2010.
2. Stocchi E., *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

Reference Books:

1. Felder R.M. and Rousseau R.W., *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
2. Dara S. S., *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
3. Miller G.T., *Environmental Science*, 11th edition. Brooks/ Cole (2006).
4. Mishra, *Environmental Studies*, Selective and Scientific Books, New Delhi (2005).

SEMESTER-III

3.1.1 Acids and Bases and Chemistry of main group elements

Credit 4

Full mark 100

Course Objectives:

To provide the basic knowledge on general principles of acids and bases, chemistry of s- and p-block elements. Students can learn about chronological developments of the concepts of acids and bases. It will help students to get aware of the pH scale and classify a substance as acidic, basic, or neutral based on their pH or hydrogen ion concentration. Students can achieve the knowledge regarding volumetric analysis and preparation of metal complex.

Course Outcomes:

1. Know how the various theories of acid and base, and understand the occurrence and purification of metals
2. Learn the different properties of s- and p-block elements
3. Understand the preparation and properties of inorganic polymers.
4. Achieve knowledge on how to standardize, estimate and prepare inorganic compounds/metal ions.

Unit – I: Acids and Bases

Different concepts of acids and bases: Arrhenius theory, Bronsted-Lowry theory, Lewis theory, The Lux- Flood definition, The Usanovich definition, acids and bases in proton solvents, Concept of conjugate acid and conjugate base, Concept of pH, Pearson's classification of Lewis acid and Lewis bases into Hard and Soft Acids and Bases (HSAB), HSAB principle, application of HSAB principle.

Unit – II: Chemistry of s-Block Elements

General characteristics: melting point, flame colour, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, and sulphates. Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; Hydride and their classifications: ionic, covalent and interstitial, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties.

Unit – III: Chemistry of p-Block Elements

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, catenation, allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behavior of first member of each group. interhalogen and pseudo halogen compounds, Structure, bonding and properties (acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat) of the following:

- **Hydrides:** hydrides of Group 13 (only diborane), Group 14, Group 15, Group 16 and Group 17.
- **Oxides:** oxides of phosphorus, sulphur and chlorine
- **Oxoacids:** oxoacids of phosphorus and chlorine; per oxoacids of sulphur

- **Halides:** halides of silicon and phosphorus

Unit – IV: Noble gases

Occurrence and uses, rationalization of inertness of noble gases, clathrates; preparation and properties of XeF_2 , XeF_4 and XeF_6 . Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic polymer: Preparation, properties, structure and uses of the following compounds: Borazine, Silicates, silicones, phosphonitrilic halides $\{(\text{PNCl}_2)_n \text{ where } n = 3 \text{ and } 4\}$, and concept of carbophosphazene.

List of experiments

1. Standardization of sodium thiosulphate solution by standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution.
2. Estimation of copper using standard sodium thiosulphate solution (Iodometrically).
3. Estimation of available chlorine in bleaching powder iodometrically.
4. Preparation of Cuprous chloride (Cu_2Cl_2)
5. Preparation of Manganese (III) phosphate ($\text{MnPO}_4 \cdot \text{H}_2\text{O}$)
6. Preparation of Lead chromate (PbCrO_4)

Text Books:

1. A. J. Elias, *The Chemistry of the p-Block Elements-Syntheses, Reactions and Applications*, University Press (India) Pvt Ltd., 2009.
2. J. D. Lee, *Concise Inorganic Chemistry* Wiley India, 5th Edn., 2008.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry – Principles of structure and reactivity*, Pearson Education, 4th Ed. 2002.

Reference Books:

1. A. K. Das, *Fundamentals of Inorganic Chemistry*, Vol. I, CBS Publications, 2nd Ed., 2010.
2. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, *Advanced Inorganic Chemistry*, Vol. I, 7th Ed., S. Chand & Company Pvt. Ltd., 2021.
3. Puri, Sharma, Kalia, *Principles of Inorganic Chemistry*, Vishal Publication Co., 33rd Ed., 2017.
4. D. E. Shriver, P. W. Atkins, *Inorganic Chemistry*, Oxford University Press, 5th Ed., 2010.
5. G. L. Miessler, P. J. Fischer, D. A. Tarr, *Inorganic Chemistry*, 5th Ed., Pearson, 2014.
6. J. Mendham, *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.
7. V. K. Ahluwalia, S. Dhingra, A. Gulati, *College Practical Chemistry*, University Press, 2005.

3.1.2 Chemistry of halogen, oxygen and sulphur containing organic compounds

Credit 4

Full mark 100

Course Objectives:

To provide the knowledge on organic compounds containing halogen, alcohol, phenol, thiol, ether, thioether, aldehydes, ketones, carboxylic acids and its derivatives as functional groups. Further to know their preparation, properties and reactivity for developing the skills required for synthesizing a target molecule from a given molecule.

Course Outcomes:

1. Understanding on preparation, properties and reactions of haloalkanes, haloarenes, and organic compounds containing C, H, O and S functional groups.
2. Basic knowledge on various name reactions and their mechanisms involving substitution, addition, elimination and condensation.
3. Knowledge on functional group interconversion and synthetic applications of different organic compounds.
4. Knowledge on various functional group detection in organic compounds and preparation of derivatives of functional groups.

Unit-I: Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent and nucleophiles. substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Unit-II: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer– Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, Ammonia derivatives and LiAlH₄.

Sulphur containing compounds: Preparation and reactions of thiols and thioethers

Unit-III: Carbonyl Compounds

Structure, reactivity and preparation. Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann rearrangements, α halo-form reaction and Baeyer-Villiger oxidation, - substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH₄, NaBH₄, MPVO.; Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethylaceto acetate.

Unit-IV: Carboxylic Acids and Derivatives

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

List of Experiments

1. Functional group tests for amines (*p*-, *sec*- *tert*-), nitro, amide and imide groups in known organic compounds.
2. Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β -naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
3. Bromination of any one of the following:
 - a) Acetanilide by conventional methods
 - b) Acetanilide using green approach (Bromate-bromide method)
4. Nitration of any one of the following:
 - a) Acetanilide/nitrobenzene by conventional method
 - b) Salicylic acid by green approach (using ceric ammonium nitrate).
5. Identification of unknown organic compounds containing one functional group in CHO or CHN systems and their derivative preparation.

Text Books:

- ✓ R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., Pearson Education India, 2010.
- ✓ A. Bahl, B. S. Bahl, *Advanced Organic Chemistry*, 5th Ed., S. Chand, 2012.
- ✓ N. K. Vishnoi, *Advanced Practical Organic Chemistry*, 3rd Ed., Vikas Publishing House, 2009.
 - Reference Books:
- ✓ T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, *Solomons' Organic Chemistry*, Global Ed., Wiley, 2024.
- ✓ J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., Oxford Publisher, 2012.
- ✓ R. K. Bansal, *Organic Reaction Mechanism*, 3rd Ed., Tata McGraw-Hill Publications, 1998.
- ✓ P. Sykes, *A Guidebook to Mechanism in Organic Chemistry*, 6th Ed., Pearson Education, 2003.
- ✓ F. A. Carey, R. J. Sundberg, *Advanced Organic Chemistry, Part-A and Part-B*, 5th Ed., Springer 2007.
- ✓ B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India, 2003.
- ✓ O. P. Agarwal, *Advanced Practical Organic Chemistry*, Krishna Prakashan, 2014.
- ✓ V. K. Ahluwalia, R. Aggarwal, *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press, 2004.
- ✓ H. T. Clarke, *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers, 2021.

3.1.4 Phase equilibrium, Chemical dynamics, catalysis and surface chemistry

Credit 4

Full mark 100

Course Objectives:

This course is offered by School of Chemistry as a core subject for the B.Sc. programme, with an emphasis on fundamental understanding phase equilibrium and chemical kinetics. The objective of this course is to develop basic and advance concepts regarding of Surface chemistry and catalysis. It aims to study the similarity and differences between adsorption isotherms and reasons responsible for these. The objective of the practical is to develop skills for working in physical chemistry laboratory pertaining to kinetics & adsorption isotherms. The student will perform experiments based on the concepts learnt in Physical chemistry-III course.

Course Outcomes:

By the end of the course, the students will be able to:

1. Establish the phase rule for one, two component systems, eutectics; and its thermodynamic derivation; fundamentals of physical transformation of pure materials.
2. Interpret chemical kinetics of chemical reactions and its impact on reaction mechanism.
3. Differentiate between homogenous and heterogenous catalysis & Acid Base Catalysis, differentiate between Physical adsorption, chemisorption and various adsorption isotherms.
4. Determine distribution coefficients of solution mixtures, Interpret and use data generated from kinetic studies by graphical and experimental methods.

Unit-I: Phase Equilibria-I

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid- vapour equilibria, phase diagram for one component systems, with applications (H₂O and sulphur system). Phase diagrams for systems of solid-liquid equilibria involving eutectic (Pb-Ag system, desilverisation of lead), congruent (ferric chloride-water) and incongruent (sodium sulphate- water) melting points.

Unit-II: Phase Equilibria-II

Three component systems, water-chloroform-acetic acid system, triangular plots.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Unit-III: Chemical Kinetics

Order and molecularity of a reaction, derivation of rate laws (Zero, first, and second order) and its differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of orders. Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions (HBr chain reaction).

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates.

Unit-IV: Catalysis

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis- Menten mechanism, acid-base catalysis. Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibb's isotherms), nature of adsorbed state.

List of experiments

- Determination of distribution coefficients of:
 - Iodine between water and carbon tetrachloride.
 - Acetic/ benzoic acid between water and cyclohexane.
- Study the equilibrium of at least one of the following reactions by the distribution method:
 - $I_2(aq) + I^- \rightarrow I_3^-(aq)$
 - $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$
- Study the kinetics of the following reactions.
 - Integrated rate method:
 - Acid hydrolysis of methyl acetate with hydrochloric acid.
 - Saponification of ethyl acetate.
 - Compare the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of methyl acetate.
- Verify the Freundlich and Langmuir isotherms for the adsorption of acetic acid on activated charcoal.

Text Books:

- ✓ P. W. Atkins, J. de Paula, *Elements of Physical Chemistry*, Oxford University Press, 6th Ed., 2006.
- ✓ K. J. Laidler, *Chemical kinetics*, New York: Harper & Row 1916
- ✓ J. Rajaram, J. C. Kuriacose *Kinetics and Mechanisms of Chemical Transformations*, Penguin Books Ltd, 2000.

Reference Books:

- ✓ T. Engel, P. Reid, *Physical Chemistry* 3rd Ed. Pearson 2013.
- ✓ D. A. McQuarrie, J. D. Simon, *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi 2004.
- ✓ K. L. Kapoor, *Text Book of Physical Chemistry*, Mac Grow Hill, 3rdEdn. 2017

3.1.4 Chemistry of Organometallic Compounds

Credit 4

Full mark 100

Course Objectives

To provide the basic knowledge and cutting-edge developments in the field of organometallic chemistry. This includes the classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species. Specific organometallic compounds are studied in detail to understand the basic concepts. It familiarizes the versatility of phosphine/NHC ligands as well as metathesis reactions. It provides much fundamentals about the qualitative inorganic analysis having multiple radical mixtures.

Course Outcomes:

1. Understand the basic concepts of organometallic compounds pertaining to their synthesis, structure and bonding
2. Understand the mechanistic phenomena of organometallic based catalytic reactions
3. Get knowledge on the versatility of phosphine/NHC ligands, and industrially important metathesis reactions.
4. Understand and explain the basic principles of qualitative inorganic analysis

Unit – I: Organometallic Compounds-I

Definition of organometallic compound, classifications, nature of metal-carbon bond, nomenclature, the 18-electron rule, Concept of hapticity of organic ligands. Metal carbonyls: electron counting of metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear metal carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls

Unit – II: Organometallic Compounds-II

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethyl aluminium in the polymerisation of ethene and propylene (Ziegler – Natta Catalyst). Ferrocene: preparation and reactions (acetylation, alkylation, metallation, Mannich condensation, nitration, halogenation, silylation, borylation, sulphonation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene. Fluxional molecules. Concept of coordinative unsaturation, oxidative addition, reductive elimination, insertion reaction, migratory insertion, intramolecular hydrogen transfer reaction, agostic interaction.

Unit – III: Organometallic Catalysis

General idea of catalysis, turnover number (TON), turnover frequency (TOF), hydrogenation of alkenes using Wilkinson's catalyst, Tolman catalytic loop, hydroformylation of alkenes (using cobalt catalyst), enantioselective hydroformylation, wacker process, Monsanto acetic acid synthesis, Cativa process, hydrosilylation reactions, reduction of carbon monoxide by hydrogen (Fischer-Tropsch reaction). Concept of Pd-catalyzed cross-coupling reactions.

Unit – IV: Neutral Spectator Ligands and Metathesis Reactions

Steric and electronic structure of phosphine ligands, basicity of phosphine, monodentate and multidentate phosphines, cone angle, bite angle, N-heterocyclic carbenes (NHC), synthesis of NHC,

alkene metathesis, mechanism of alkene metathesis, classification of metathesis reactions, significance of metathesis reactions.

Lists of Experiment

1. Qualitative analysis of mixtures containing 4 radicals (2 anions and 2 cations). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} , F^- , Cl^- , Br^- , I^- , NO_3^- , PO_4^{3-} , NH_4^+ , K^+ , Pb^{2+} , Cu^{2+} , Cd^{2+} , Bi^{3+} , Sn^{2+} , Sb^{3+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+} .

Mixtures may contain one insoluble component (BaSO_4 , SrSO_4 , PbSO_4 , CaF_2 or Al_2O_3) or combination of interfering anions e.g., CO_3^{2-} and SO_3^{2-} ; NO_2^- and NO_3^- ; Cl^- , Br^- , I^- ; Br^- and I^- ; NO_3^- , Br^- , I^- .

Text Books:

1. B. D. Gupta, A. J. Elias, *Basic Organometallic Chemistry*, 2nd Edn., University Press (2013).
2. R. C. Mehrotra, A. Singh, *Organometallic Chemistry*, New Age International Publishers, 2nd Edn, 2000.
3. *Vogel's Qualitative Inorganic Analysis*, 7th Ed, Revised by G. Svehla, 4th Ed., Person, 2007.

Reference Books:

1. A. K. Das, *Fundamentals of Inorganic Chemistry*, Vol. II, CBS Publications, 2nd Ed. 2010.
2. D. E. Shriver, P. W. Atkins *Inorganic Chemistry*, Oxford University Press, 5th Edn.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry – Principles of structure and reactivity*, Pearson Education, 4th Ed. 2002.
4. B. R. Puri, L. R. Sharma, K. C. Kalia, *Principles of Inorganic Chemistry*, Vishal Publishing Co., 33rd Ed., 2017.
5. J. F. Hartwig, *Organotransition Metal Chemistry: From Bonding to Catalysis*, University Science Books, 2010.

3.2.1 Pharmaceutical, Fermentation, and Pesticides

Credit 4
Full mark 100

Course Objectives:

The objectives are to introduce students to a basic understanding of drugs and pharmaceuticals with a synthetic approach to some representative drugs; to introduce the foundational principles of fermentation processes, and to develop an understanding of pesticide formulation and impact. This course also aimed to prepare students for careers in applied science and industrial manufacturing.

Course Outcomes:

1. To describe the systematic approach involved in the design and development of drugs.
2. Acquire a critical knowledge of the synthetic techniques of drugs.
3. Explain the fermentation processes for the synthesis of antibiotics and natural products.
4. To explain the synthesis, properties, uses and adverse effects of pesticides

Unit-I: Drugs & Pharmaceuticals – I

Drugs & Pharmaceuticals, sources and classification of drugs, drug discovery, design and development, drug-target interaction, therapeutic action of different classes of drugs.

Basic Retrosynthetic approach, synthesis of the representative drugs of the following classes: analgesic agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, ibuprofen)

Unit-II: Drugs & Pharmaceuticals - II

Synthesis of some more representative drugs: Antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glycerol triturate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT-Zidovudine).

Unit-III: Fermentation:

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Unit-IV Pesticides

Introduction, types of pesticides (Insecticides, Herbicides), natural and artificial pesticides, benefits and adverse (toxic) effects, structure-activity relationship. Biopesticides, uses and future perspectives. Synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines: Gammexene, Organophosphates (Malathion, Parathion, pyrethroids), Carbamates (Carbofuran and carbaryl); Quinones. Pheromones, repellents and rodenticides.

List of experiments:

1. Preparation of Aspirin
2. Estimation of aspirin.
3. Preparation of magnesium bisilicate (Antacid)
4. Determine the acid-neutralising capacity of a commercial antacid tablet. (By back titration method)

5. Determination of metal content (Mg and/or Al) in a commercial antacid tablet by complexometric titration
6. Estimation of ascorbic acid in Vitamin C tablet (by iodometric method)

Text/Reference Books:

1. Engineering Chemistry P.C. Jain, M. Jain:, Dhanpat Rai & Sons, Delhi.
2. Industrial Chemistry, Sharma, B.K. & Gaur, Goel Publishing House, Meerut(1996)
3. Introduction to Medicinal Chemistry, G.L. Patrick: Oxford University Press, UK.
4. Medicinal and Pharmaceutical Chemistry, Hakishan, V.K. Kapoor:, Vallabh Prakashan, Pitampura, New Delhi.
5. Principles of Medicinal Chemistry, William O. Foye, Thomas L., Lemke, David A. William: B.I. Waverly Pvt. Ltd. New Delhi.
6. Industrial Microbiology, 3rd Edition, JR Casida L.E. (2015) New Age International (P) Limited Publishers, New Delhi, India.
7. Industrial Microbiology: An Introduction. 1st Edition, Waites M.J., Morgan N.L., Rockey J.S. and Higon G. (2001) Blackwell Science, London, UK.

3.2.2 Inorganic chemicals of industrial importance

Credit 4

Full mark 100

Course Objectives: The aim is to teach the students about fertilizers, surface coating, silicate industries, etc. They will also be provided with knowledge of the characterization of some industrial compounds and their preparations.

Course Outcomes: Students will gain an understanding of

- Properties and the types of different glasses, ceramics, and cement.
- Different types and manufacture of fertilizers, and composition of paint pigments.
- Alloy formulation, elements present in alloys, different types of steel, etc.
- They will be able to prepare some industrial chemical compounds.
- Able to analyse the components in some of the industrial products.

Unit I: Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses).

Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick-setting cements.

Unit II: Fertilizers

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

Unit III: Surface Coatings

Objectives of coating surfaces, preliminary treatment of surfaces, classification of surface coatings.

Paints and pigments: formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.

Unit IV: Alloys

Classification of alloys, ferrous and non-ferrous alloys, and Specific properties of elements in alloys.

Manufacture of Steel (removal of silicon, decarbonization, demanganization, desulphurization, dephosphorization) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

List of Experiment

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

Recommended Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

MDC1: Nuclear and Radiation Chemistry

Credit 3

Full mark 100

Learning objectives:

The objective of this course is to provide a comprehensive understanding of the foundational principles of nuclear chemistry and nuclear reactions, to study the different types of nuclear reactors, measurement of radioactivity, and to provide the elementary ideas of radiation chemistry. Additionally, this course covers some real-world applications to emphasise the importance of nuclear and radiation chemistry in various sectors.

Outcome

1. Explain the basics of nuclear chemistry, radioactive decays, and nuclear reactions.
2. Acquaint with the principles and working of different types of nuclear reactors.
3. Understand the principles and working of different radioactivity detector systems.
4. Illustrate an elementary idea of radiation chemistry and radiolysis of water
5. Comprehends the scientific and industrial applications of radioactive elements and isotopes

Unit-1: Fundamentals of nuclear chemistry

Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half-life, mean life period), units of radioactivity, Transient and secular equilibria,

Nuclear reactions: Bethe notation, types of nuclear reactions (n , p , α , d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions.

Unit-II:

Nuclear reactors: Types of nuclear reactions, nuclear fission, nuclear fusion, nuclear reactor: classification of reactors, the natural uranium reactor, breeder reactor. nuclear fusion and stellar energy.

Measurement of radioactivity: idea about accelerators and detectors, Van de Graaf and linear accelerators, synchrotrons, Geiger-Muller detector, Scintillation detectors,

Unit-III:

Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's imeter), units of radiation energy (Rad, Gray, Rontgen, RBE, Rcm, Sievert).

Nuclear pollution and safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry, disposal of nuclear waste.

Unit IV: Applications of nuclear chemistry in selective fields:

Energy Generation: Nuclear fusion and fission

Analytical Methods: Radioactive isotopes, Isotope dilution analysis, Neutron Activation Analysis (NAA), charged particle activation analysis, radiocarbon dating and geological dating

Medicine and healthcare: Medical isotopes, diagnostic imaging, and radiation therapy.

Agriculture and Food Science: Food irradiation, pest control, crop mutation breeding

Recommended Books/References:

1. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience, 2008
2. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice – Hall, 2010
3. Overman R. T, Basic concept of Nuclear Chemistry, Chapman & Hall. 2009.
4. A. N. Nesmeyanov, Radiochemistry, MIR Publication, Moscow. 2008
5. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry, Wiley, 2010
6. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, Second Edition. 2012.

Online Resources:

1. <https://nptel.ac.in/courses/115/104/115104043/>
2. https://onlinecourses.nptel.ac.in/noc20_me40/preview

SEC-I: Corrosion and Prevention

Credit 3

Full mark 100

Course Objectives:

Most of the industries such as chemical, mining and petroleum industries are facing the corrosion problems. In a recent survey made in India it was estimated that the annual loss due to corrosion is approximately 3 – 4% loss of the GDP. The course is offered to impart: Knowledge about the problem faced by industries, Develop understanding about the mechanism and process of corrosion, Knowledge about various methods for protection against corrosion. The scientific principles and methods that underlie the cause, detection, measurement, and prevention of many metal corrosion problems in engineering practice.

Course Outcomes:

1. To obtain detailed understanding of corrosion science and technology, basic theory and correlation with materials degradations
2. Students should able to solve the problems related to corrosion analysis and to design a suitable material for causes
3. To examine corrosion reliability issue in industry using corrosion instrument and standards
4. Corrosion data interpretation, analysis, and integration and Understand the criteria for determining corrective action for high-level corrosion problems within various industrial systems

UNIT-I:

Definition of corrosion, Corrosion Damage, Classification of corrosion, Electrochemical Aspects, Electrochemical Reactions, Mixed Potential Theory

UNIT-II:

Polarization, Passivity, Environmental Effects, Effect of Oxygen and Oxidizers, Effect of Temperature, Effects of Corrosive Concentration, Effect of Galvanic Coupling Using Mixed Potential Theory

UNIT-III:

Corrosion Testing: Standard Expressions for Corrosion Rate, Galvanic corrosion, Erosion Corrosion, Crevice Corrosion, Intergranular Corrosion, Pitting, Stress Corrosion. Tafel and Linear Polarization, AC Impedance, Small-Amplitude Cyclic Voltammetry. Paint Tests, Sea Water Tests. Interpretation of Results

UNIT-IV

Materials Selection, Alteration of Environment, Design, Cathodic and Anodic Protection, Coatings, High-Temperature Corrosion and Mechanisms and Kinetics, High-Temperature Materials, Corrosion problems in selected industry

Text Books:

1. Mars G. Fontana, Corrosion Engineering, 3rd edition, McGraw-Hill Book Company, 1986
2. David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, New York, 1998
3. H. H. Uhlig and R. W. Revie, Corrosion and Corrosion Control, Wiley (NY) (1985)

Reference Books:

1. K.E. Perumal and V.S. Raja, Corrosion Failures: Theory, Case Studies, and Solutions” 1st edition, John Wiley & Sons, USA
2. ASM Handbook Vol-13 (A, B & C)

3. ASTM and NACE standards for corrosion testing
4. R. G. Kelly, John R. Scully, D. W. Shoesmith, and R. G. Buchheit “ Electrochemical Techniques in Corrosion Science and Engineering” 1st edition, CRC Press
5. Neil Birks, Gerald H. Meier, Frederick S. Pettit “High Temperature Oxidation and Corrosion of Metals” Cambridge University Press

SEMESTER-IV

4.1.1 Coordination Chemistry, Chemistry of d- and f-block elements, Inorganic Reaction Mechanism and electron transfer reactions

Credit 4

Full mark 100

Course Objectives:

To provide the knowledge on the coordination compounds which find manifold applications in the diverse fields such as industrial catalysis, metallurgy, pharmaceutical industry, paints and pigments. Students will achieve the knowledge about the diverse kinetic aspects of the coordination compounds. They will also be familiarized with the chemistry of d- and f-block elements and get an idea about horizontal similarity in a period in addition to vertical similarity in a group. Besides, the idea of inorganic reaction mechanism and the importance of electron transfer reactions have been reviewed. Synthesis and estimation of inorganic compounds have been included to enhance the practical skill of students in this regard.

Course Outcomes:

1. Understand the chemistry of coordination compounds, and d- and f-Block elements.
2. Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory.
3. Understanding the fundamental importance of inorganic reaction mechanism and electron transfer reaction
4. Achieved the knowledge of the preparation of inorganic complex, estimation by EDTA method and gravimetric method.

Unit – I: Coordination Chemistry

Werner's Coordination theory, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds with coordination numbers 4 and 6. A brief idea about chelate effect, and labile and inert complexes. Valence bond theory and its application to complexes of coordination numbers 4 and 6. Examples of inner and outer orbital complexes. Crystal field theory and its application, measurement of Δ_o . Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δ_o . Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field theory, and MO Theory (bonding and antibonding interactions, idea about σ , σ^* , π , π^* , $n-p$ MO).

Unit – II: Chemistry of d- and f-Block Elements

Chemistry of transition metals: General group trends with special reference to electronic configuration, colour, variable valency, magnetic properties (no temperature dependence), catalytic properties, and ability to form complexes. Distinction among the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy). Some important compounds of Cr, Mn, Fe and Co and their roles as laboratory reagents; Potassium dichromate, potassium permanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside and sodium cobaltinitrite. Chemistry of Lanthanides and Actinides: electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanide contraction (causes and effects), separation of lanthanides by ion exchange method.

General features of actinides, separation of Np, Pm, Am from U.

Unit – III: Inorganic Reaction Mechanism

Thermodynamic and kinetic stability, Stepwise and overall formation constants and their relationship, factors affecting stability, Substitution reactions in square planar complexes, trans-effect, theories of trans- effect (electrostatic polarization and π -bonding theory), Substitution reactions in octahedral complexes, acid hydrolysis of octahedral Co(III) complexes with reference to effect of charge, chelation, steric crowding & effects of leaving group, base hydrolysis of octahedral Co(III) complexes: Conjugate base mechanism, test of conjugate base mechanism, anation reaction.

Unit– IV: Electron transfer reaction

Redox reactions: electron tunneling hypothesis, concept of Marcus-Hush theory, atom transfer reactions, one and two electron transfer, complementary and non-complementary reactions, inner sphere and outer sphere reactions, electron transfer through extended bridges, concept of hydrated electron.

List of experiments

1. Synthesis of hexamine nickel (II) complex, $[\text{Ni}(\text{NH}_3)_6] \text{Cl}_2$
2. Synthesis of tetraamminecopper (II) sulphate, $[\text{Cu}(\text{NH}_3)_4] \text{SO}_4 \cdot \text{H}_2\text{O}$
3. Estimation of Ca and Mg from cement by EDTA method
4. Estimation of nickel (II) using dimethylglyoxime (DMG)

Text Books:

- ✓ J. D. Lee, *Concise Inorganic Chemistry*, Wiley India, 5th Edn., 2008.
- ✓ J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry– Principles of structure and reactivity*, Pearson Education, 4th Ed. 2002.
- ✓ F. A. Cotton, G. Wilkinson, *Advanced Inorganic Chemistry* Wiley-VCH., 1999.

Reference books:

- ✓ A. K. Das, *Fundamentals of Inorganic Chemistry*, Vol. II, CBS Publications, 2nd Ed. 2010.
- ✓ G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley and Sons, 1989.
- ✓ Puri, Sharma, Kalia, *Principles of Inorganic Chemistry*, Vishal Pub. Co., 33rd ed., 2017.
- ✓ D. E. Shriver, P. W. Atkins, *Inorganic Chemistry*, Oxford University Press, 5th Edn.
- ✓ V. K. Ahluwalia, S. Dhingra, A. Gulati, *College Practical Chemistry*, University Press (2005).
- ✓ S. Gulati, J. L. Sharma, S. Manocha, *Practical Inorganic Chemistry*, 1st Edn., CBS Publishers & Distributors Pvt Ltd., (2017).

4.1.2 Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons

Credit 4

Full mark 100

Course Objectives:

Imparting information on natural products, nitrogen based organic compounds, heterocyclic compounds and polynuclear hydrocarbons with their chemical properties and structural elucidation. Imparting hands on training in estimation and analysis of organic compounds.

Course Outcomes:

1. Gaining knowledge on preparation, properties and synthetic application of nitrogen containing compounds including diazonium salts.
2. Understanding on isolation and structural elucidation of natural products and heterocyclic compounds and their chemical reactions.
3. Knowledge on structure and properties of fused aromatic compounds.
4. Learning on various procedures of estimation of organic compounds.

Unit-I: Nitrogen Containing Functional Groups

Amines: Effect of substituent and solvent on basicity; Preparation from nitro and nitriles and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

Unit-II: Dyes and Polynuclear hydrocarbon derivatives

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and applications of: *Azo dyes* – Methyl orange and Congo red (mechanism of Diazo coupling); *Triphenylmethane dyes*- Malachite Green, and crystal violet; *Phthalein dyes*- Phenolphthalein and Fluorescein. Edible dyes with example.

Preparation of Polynuclear Hydrocarbons: Reactions of naphthalene, anthracene, phenanthrene, acenaphthene, pyrene. Preparation and their structure elucidation (naphthalene) and important derivatives of naphthalene and anthracene.

Unit-III: Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom, Reaction and mechanism of substitution reactions of: Furan, Pyrrole, Thiophene and Pyridine. Synthesis of Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis), Furan (Paal Knorr synthesis, Fieser-Benary Synthesis), Derivatives of Furan: Furfural and Furoic acid (preparation only) Pyridine (Hantzsch synthesis). Pyrimidine (synthesis from β -keto acid), Bicyclic Heterocyclic compound: Indole (Fischer indole synthesis and Madelung synthesis) Quinoline (Skraup synthesis, Friedlander Synthesis).

Unit IV: Natural Products

Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation, synthesis and medicinal importance of Hygrine, Nicotine, Quinine and Morphine, Terpenes: Occurrence,

classification, isoprene rule; Elucidation of structure and synthesis of Citral, and α -terpineol.

List of Experiments

- 1) Qualitative analysis of unknown organic compounds containing bifunctional groups
- 2) Estimation of Phenol/ Aniline
- 3) Estimation of Methyl Ketone
- 4) Determination of percentage purity of carbonyl compound.

Text Books:

- ✓ R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., Pearson Education India, 2010.
- ✓ I. L. Finar, *Organic Chemistry*, Vol-2, 5th Ed., Pearson Publisher, 2002.
- ✓ N. K. Vishnoi, *Advanced Practical Organic Chemistry*, 3rd Ed., Vikas Publishing House, 2009.

Reference Books:

- ✓ T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, *Solomons' Organic Chemistry*, Global Ed., Wiley, 2024.
- ✓ J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., Oxford Publisher, 2012.
- ✓ J. A. Joule, K. Mills, *Heterocyclic Chemistry*, 5th Ed., Wiley Blackwell, 2010.
- ✓ R. K. Bansal, *Heterocyclic Chemistry*, 5th Ed., New Age International, 2017.
- ✓ O. P. Agarwal, *Organic Chemistry: Natural Products*, Vol. I, Krishna Prakashan Media, 2015.
- ✓ H. T. Clarke, *A Handbook of Organic Analysis: Qualitative and Quantitative*, 4th Ed., CBS Publishers, 2021.

4.1.3 Conductance, electrochemistry, electrical properties of atoms and molecules

Credit 4

Full mark 100

Course Objectives:

This course offers in introductory knowledge of electrolytic conductance depth knowledge of electrochemical cells. Students are expected to have background knowledge in physical chemistry and mathematics up to the +2 level for this course. The objective of the practical is to develop skills for working in physical chemistry laboratory.

Course Outcomes:

By the end of the course, the students will be able to:

1. The text provides an in-depth analysis of the conductance nature of electrolytic solutions, their thermodynamics, Debye-Huckel theory, ionic strength, mean ionic activity coefficient, and the Debye- Huckel limiting law.
2. Explain dynamic electrochemical processes and skill development to analyse it.
3. Understand the dynamic electrochemical processes and skill development to analyse it.
4. Develop skill to solve problems on Electrochemical Cells, electrode potentials, emf & solubility product measurements, potentiometric titrations, pK and pH measurements.

Unit-I: Conductance-I

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Unit-II: Conductance-II

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

Unit-III: Electrochemistry-I

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes.

Unit-IV: Electrochemistry-II

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). **Electrical properties of atoms and molecules:** Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no derivation), Dipole moment and molecular polarizabilities and their measurements.

List of experiments

- I. Determination of cell constant.
- II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- III. Perform the following conductometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Strong acid vs. weak base
- I Perform the following potentiometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Dibasic acid vs. strong base

Text Books:

- ✓ *P. W Atkins. & J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.*
- ✓ *J. O. Bockris & A. Reddy. Modern Electrochemistry, Kluwer Academic, 2002.*
- ✓ *S. Glasstone, An Introduction to Electrochemistry: Affiliated East West Press Private, Limited. 1960*

Reference Books:

- ✓ *T. Engel & P. Reid, Physical Chemistry 3rd Ed. Pearson 2013.*
- ✓ *McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi 2004.*
- ✓ *Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications. 2002.*

4.2.1 Basic quantum chemistry, Molecular & electronic spectroscopy and photochemistry

Credit 4

Full mark 100

Course Objectives:

This course is offered by School of Chemistry as a core subject for the B.Sc. programme, with an emphasis on fundamental understanding of Quantum chemistry, molecular spectroscopy, and photochemistry. Students are expected to have background knowledge in mathematics up to the +2 level for this course. The objective of the practical is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-V course.

Course Outcomes:

By the end of the course, the students will be able to:

1. Understand the postulates of quantum mechanics. Construct the Schrödinger wave equations for 1-D box, 3-D box, Rigid rotor, and SHO and able to interpret the solution of Schrödinger equation.
2. Understand LCAO-MO compare with VBT of H₂ molecule. Apply the fundamentals of Quantum mechanics to interpret molecular spectroscopy.
3. Calculate quantum yield of photochemical reactions.
4. Interpret the data obtained from graphical methods of Lambert-Beer's law experiments and correlate with UV-Vis spectroscopy.

Unit-I: Quantum Chemistry-I

Quantum mechanical operators, Postulates of quantum mechanics, Schrödinger equation and its application to particle in one-dimensional box (complete solution) - quantization of energy levels, zero-point energy, normalization of wave functions, probability distribution functions, nodal properties. Extension to three-dimensional boxes.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Rigid rotator model of rotation of diatomic molecule: Schrödinger equation, transformation to spherical polar coordinates. Derivation of rotational energy expression of diatomic molecule.

UNIT-II Chemical Bonding

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H₂⁺. Bonding and antibonding orbitals. Qualitative extension to H₂. Comparison of LCAO-MO and VB treatments of H₂ (only wave functions, detailed solution not required) and their limitations. Localized and non-localized molecular orbitals treatment of triatomic (BeH₂, H₂O) molecules.

Unit-III: Molecular Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

UNIT-IV: Molecular Spectroscopy-II

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. **Electronic spectroscopy:** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Photochemistry Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching, chemiluminescence.

List of experiments

1. Study of absorption spectra (visible range) of KMnO_4 and determine the λ_{max} value.
Calculate the energies of the transitions in kJ mol^{-1} , cm^{-1} , and eV.
2. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration.
3. Determine the dissociation constant of an indicator (phenolphthalein).
4. Determine the concentration of HCl against 0.1 N Na OH spectrophotometrically.
5. To find the strength of given ferric ammonium sulfate solution of (0.05 M) by using EDTA spectrophotometrically.
6. To find out the strength of CuSO_4 solution by titrating with EDTA spectrophotometrically.
7. To determine the concentration of Cu (II) and Fe (III) solution photometrically by titrating with EDTA.

Text Books:

- ✓ D. A. McQuarrie, *Quantum Chemistry*, Viva Books, Indian Student Edition, Reprint, 2011
- ✓ R.K. Prasad, *Quantum Chemistry*, New Age International, 2006
- ✓ I. Levine, *Quantum Chemistry*, 7th Edition, Pearson, 2000

4.2.2 Solid and porous materials, and magnetochemistry

Credit 4
Marks 100

Course Objectives:

To provide a basic understanding of the solid and porous materials with their diverse applications. Students will learn about some inorganic solids of technological importance, in addition to synthesis, characterisation and applications of different porous materials. It is also aimed to provide a basic understanding of magnetochemistry and molecular magnetism.

Course Outcomes:

1. Learn about the different inorganic solid materials, including theory and methods for the development of new materials with desired properties.
2. Know how pores can influence the properties of materials
3. Demonstrate an increased knowledge and understanding of magnetochemistry with critical thought and achieve the ability to analyze magnetochemical studies and data
4. Explain the principles that underlie the ability of various power cells and develop new idea of constructing power cell
5. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave). (Similarly other materials synthesis can be designed).

Unit – I: Inorganic solids of technological importance

Semiconducting and superconducting oxides: Introduction, general characteristics, and applications

Solid electrolytes: Introduction, fast ion transport; classification, synthesis, and properties of solid electrolytes. Specific applications in solid-State batteries, fuel cells, and gas sensors.

Silicate materials: Clays: Introduction, types with examples, characteristics and major applications.

Unit – II: Porous materials

Introduction, classification of pores (micro-, meso-, and macro-porous materials with examples),

Introduction, types, synthesis, and key properties of some advanced porous materials: Zeolites, Mesoporous silica, Metal organic frameworks (MOFs), Covalent organic frameworks. Characterization of porous materials: Surface and porosity analysis by gas adsorption (BET method).

Unit-III: Applications of porous materials

Some special applications of the above porous materials in the fields: Petroleum refining, catalysis, energy storage and conversion, gas storage (H_2/CO_2), gas/solvent separation, water treatment, targeted drug delivery, etc.

Unit-IV: Magnetochemistry

Magnetic substances: Terminology related to magnetic properties, classification, cooperative magnetism, ferromagnetic substances and related aspects, application of hard and soft ferromagnetic substances. Para-, ferro- and antiferro-magnetism: Temperature dependence of magnetic susceptibility, Curie's Law and Curie-Weiss Law, Pathways of ferro- and antiferromagnetism, magnetic properties of an electron, paramagnetism and thermal energy, spin-orbit coupling. Magnetic properties of compounds of d- and f-block elements: concentrated and dilute systems, magnetically frustrated systems, single

molecule magnet (SMM), single ion magnet (SIM), single chain magnet (SCM)

List of Experiments:

1. Preparation of ZnO from zinc nitrate salt.
2. Preparation of ZnS by the reaction of zinc nitrate and sodium sulphite.
3. Adsorption of hexavalent chromium on kaolinite clay in aqueous medium
4. Adsorption of methylene blue dye on kaolinite clay/Zeolite in aqueous medium
5. Water Softening via Ion Exchange: Removal of Ca(II) or Mg(II) from hard water using zeolite (Zeolite A) and estimation by EDTA

Virtual lab experiments

1. Determination of magnetic susceptibility a sample by Gouy method (<https://ep2-iitb.vlabs.ac.in/exp/gouys-method/procedure.html>)
2. Synthesis of zeolite and MOF samples

Text Books:

1. F. Gomez-Granados, J. C. Moreno-Pirajan, L. Giraldo-Gutierrez, Porous Materials: Theory and Its Application for Environmental Remediation (Engineering Materials), Springer Nature Switzerland AG; 1st Ed. 2021.
2. R. L. Dutta, A. Syamal, Elements of magnetochemistry, 2nd Ed, Affiliated East-West Press Pvt. Ltd, 2010.
3. J. N. Lalena, D. A. Cleary, O. B. M. H. Duparc, Principles of Inorganic Materials Design, 3rd Ed, Wiley, 2020.

Reference Books:

1. C. N. R. Rao, K. Biswas, Essentials of Inorganic Materials Synthesis, John Wiley & Sons, Inc., 2015.
2. C. Julien, A. Mauger, A. Vijh, K. Zaghib, Lithium Batteries: Science and Technology, Springer, 2015.
3. C. S. Solanki, Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Prentice Hall India Learning Pvt. Ltd., 2013.
4. D. Pavlov, Lead-Acid Batteries: Science and Technology, Elsevier Science, 2015.
5. S. P. Jiang, Q. Li, Introduction to Fuel Cells: Electrochemistry and Materials, Springer, 2022
6. Ramanan, G. R. Desiraju, J. J. Vittal, Crystal Engineering: A Textbook, World Scientific Publishing Co. Pte. Ltd., 2011.
7. A. Earnshaw, Introduction to Magnetochemistry, Academic Press, 2013.

MDC-2 Nanoscience and Nanotechnology

Credit 3

Full mark 100

Course Objectives:

This course aims to introduce the fundamental concepts and importance of the emerging fields of nanoscience and nanotechnology, with a focus on materials at the nanoscale, their preparation, characterization and applications.

Course Outcomes:

1. Understand the fundamental concept of nanodimensional materials.
2. Learn the various synthetic methods of nanomaterials.
3. Know different characterization techniques of nanomaterials and their principles.
4. Understand the important properties nanomaterials and stabilization of nanoparticles.
5. Appreciate the recent applications of nanomaterials.
6. Appreciate the recent applications of nanomaterials and gain interest in conducting research in the field of nanoscience

Unit-I: Basics of nanomaterials

Nanoscale regime and its importance, nano versus bulk, quantum confinement and its consequences, nanoscale in 0D, 1D, 2D and 3D with examples, quantum dots, nanoparticles, nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), nanocomposites. Concepts of magnetic- and superparamagnetic nanoparticles. Properties of nanomaterials due to the effect of size and surface energy. Concept of stabilization of nanoparticles (Electrostatic and steric).

Unit-II: Synthesis of nanomaterials

Concept of top-down and bottom-up approaches, synthesis of nanomaterial by top-down method: high-energy ball milling and lithograph, bottom-up methods: Physical vapour deposition (PVD), chemical vapour deposition (CVD), Ion sputtering, Electro-deposition. Solution-based chemical methods of synthesis: chemical reduction, precipitation and co-precipitation, sol-gel synthesis, reverse micelles, hydrothermal and solvothermal synthesis with examples. Bio-mediated synthesis. Stabilization of nanoparticles.

Unit-III: Properties and characterization of nanomaterials

Properties of nanomaterials: Optical, Magnetic, Electronic and mechanical. Use of the following characterization techniques for nanomaterials (Basic working principles and experimental data obtained without instrumental details are to be covered): Powder X-ray diffraction, UV-visible spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive X-ray Spectroscopy (EDX), X-ray Photoelectron Spectroscopy (XPS), Zeta potential and Dynamic light scattering (DLS)

Unit-IV: Selected applications of nanomaterials

Nanomaterials as catalysts and photocatalysts, Nanomaterials in medical (Biosensing, drug delivery, dendrimer-based nanomedicine, MRI contrast agent), energy storage and energy conversion devices, wastewater treatment. Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

Text Books:

1. K. Das, M. Das, An Introduction to Nanomaterials and Nanoscience, 1st Ed., CBS Publishers & Distributors Pvt. Ltd., 2017.
2. F. J. Owens, C. P. Poole Jr, The Physics and Chemistry of Nanosolids, Wiley-Interscience, 2008.
3. N. Kumar, S. Kumbhat, Concise Concepts of Nanoscience and Nanomaterials Scientific Publishers, 2023.
4. T. Pradeep, A textbook of Nanoscience and Nanotechnology, MsGraw-Hill Education, 2015.

Reference Books:

1. Nanomaterials-Synthesis, Properties and Applications, Edited by A. S. Edelstein and R. C. Cammarata, Institute of Physics Publishing, London, 1998.
2. G. A. Ozin, A. C. Arsenault, L. Cademartiri, C. A. Mirkin, Nanochemistry: A Chemical Approach to Nanomaterials, RSC Publishing, 2005
3. E. L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley-VCH, 2nd Reprint, 2005.
4. D. C. Agrawal, Introduction to Nanoscience and Nanomaterials, World Scientific, 2020.
5. B. S. Murthy, P. Shankar, B. Raj, B. B. Rath, J. Murday, Textbook of Nanoscience and Nanotechnology, 1st Ed., Orient Blackswan Pvt. Ltd., 2012.
6. CNR Rao et.al., Chemistry of nanomaterials: Synthesis, properties and applications by Wiley VCH Verlag GmbH & Co, Weinheim

SEC-II: Biochemistry

Credit 3

Full mark 100

Course Objectives:

The objective of this course is to familiarize the student with various biomolecules interacting with metal ions, biomolecular catalysis, and to get knowledge about the metabolism of various biomolecules.

Course Outcomes

1. Imparting knowledge on various metal ions involved in biological processes.
2. Understanding the principle of catalysis and energetics in complex biochemical reactions.
3. Understanding of various enzymes and their functions in biology.
4. Gaining knowledge on metabolism of dietary and endogenous bio-macromolecules.

Unit-I:

Metal ions in biology:

General introduction to important metal ions (Na, K, Mg, Ca, Cu, Fe, Zn, Co and Mo) and their functions, passive and active transport processes, Na⁺ /K⁺ pump, calcium pump, ionophores. Storage and transport of iron, copper and zinc. Siderophores, ferritin and transferrin in regard to iron-storage and transportation. Chemistry of porphyrin, iron porphyrins (heme proteins): hemoglobin (Hb), myoglobin (Mb) and their behavior as oxygen carrier, O₂ affinity, cooperativity and Bohr's effect, heme protein as electron carrier with particular reference to cytochrome-c and cytochrome-450, and cytochrome oxidase. Non-heme iron-sulphur protein as electron carrier (rubredoxins and ferredoxin). Non-heme oxygen uptake protein (hemerythrin and hemocyanin). Chemistry of chlorophyll: Photosynthesis, the light and dark reaction.

Unit-II:

Biomolecular Catalysis:

Metal-activated enzyme and metalloenzyme. Biological significance and mechanistic aspects of carboxypeptidase, carbonic anhydrase, blue-oxidases, non-blue oxidases, superoxide dismutase, Catalases, peroxidases, structure and biological functions of molybdenum nitrogenease.

Unit-III:

Basic Bioorganic chemistry (11 hrs)

Basic considerations, proximity effects in organic chemistry, molecular adaptation- Bio-isosterism, molecular recognition at the supra molecular level. Examples of some typical enzyme mechanism: chymotrypsin, ribonuclease, lysozyme. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, Thiamine pyrophosphate, pyridoxal phosphate, NAD⁺, NADP⁺, FMN, FAD, lipoic acid, Vitamin B₁₂.

Mechanism of reactions catalyzed by cofactors. A Nucleophilic displacement on a phosphorous atom, multiple displacement reaction and coupling of ATP cleavage to endergonic processes, transfer of sulphate, addition and elimination reactions, enolic intermediates in the isomerization reactions, β cleavage and condensation, isomerization, rearrangement, carboxylation, decarboxylation.

Unit-IV:

Metabolism of biomolecules:

Nutritive roles of carbohydrates, lipids, amino acids and proteins and their sources in various foods. Digestion, absorption, transportation and metabolism of carbohydrates (glycolysis, citric acid cycle, glycogenesis, glycogenolysis, gluconeogenesis, hexose monophosphate pathway, Blood sugar level and equilibrium), lipids (oxidation of fatty acids, fatty acid synthesis), proteins (transamination and deamination of protein, urea cycle, nitrogen balance, biosynthesis of proteins) Importance of cholesterol, phospholipids and lipoproteins in human health. Energy metabolism energy requirement, respiratory quotient, calorific value of food, standard calorific content of food types.

Textbooks

1. A. Das, A. K. Das, Mahua Das, Bioinorganic Chemistry, Books and Allied Pvt. Ltd., 2017.
2. P. S. Kalsi and J. P. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age Publications 3rd Edition 2017
3. Bio-organic Chemistry, Harish Kumar and Parmjit S. Panesar, published by Narosa Publishing House Pvt. Ltd., New Delhi, 2012.

Reference Books:

1. John E. McMurry and Tadhg P. Begley, The Organic Chemistry of Biological Pathways, 2nd Editions
2. Kurt Faber, Bio-transformations in Organic Chemistry, 7th Edition, Springer
3. An Introduction to Medicinal Chemistry- Vth Edition Graham L Patrick (Qxford 2013).
4. Burger's Medicinal Chemistry & Drug discovery, Vol 1-3, 15th Ed, 2014.
5. Bioorganic Chemistry, A chemical Approach to Enzyme action, Hermann Dugas and C. Penny Springer Verlag

SEMESTER-V and SEMESTER-VI

APPRENTICESHIP

SEMESTER-VII

7.1.1 Polymer Chemistry

Credit 4

Full mark 100

Course Objectives:

This course an emphasis on fundamental understanding of the type of bond in a polymer and rationally design the monomers for a given polymer. To describe various methods used for synthesizing polymers. To use analytical methods to characterize a polymer. To study the properties of polymers.

Course Outcomes:

5. The learners will be able to classify the polymers based on nature, occurrence, mode of synthesis, thermal properties etc.
6. To differentiate between methods and mechanism of polymerization process.
7. Calculate molecular weights of polymers and study the applications & properties.
8. The learners will be able to design the monomers for the preparation of polymers of interest, characterize and understand the properties polymers.

Unit-I: Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi- functional systems, Poly-functional systems.

Unit-II: Mechanism & Kinetics of Polymerization

Polymerization reactions – addition and condensation, mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques. **Crystallization and crystallinity:** Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Unit-III: Molecular weight of polymers and their determination

(M_n , M_w , M_v , M_z) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature (T_g) and its determination: WLF equation, outlines of factors affecting glass transition temperature (T_g).

Unit-IV: Properties of polymers

(physical, thermal and mechanical properties). Preparation, structure, properties and applications of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6,6). Thermosetting polymers - phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, conducting polymers (polyacetylene, polyaniline). Brief outline of biodegradable polymers.

List of experiments

1. Preparation of nylon-6,6 / Polyaniline
2. Preparations of phenol-formaldehyde resin-novalac / phenol-formaldehyde resin resold.
3. Preparation of urea-formaldehyde resin
4. Redox polymerization of acrylamide
5. Precipitation polymerization of acrylonitrile
6. Determination of molecular weight by viscometry:
 - a. Polyacrylamide / Polystyrene
 - b. (Polyvinyl pyrrolidone (PVP)
7. Determination of acid value/saponification value of a resin.
8. Determination of hydroxyl number of a polymer using colorimetric method.
9. Estimation of the amount of HCHO in the given solution by sodium sulphite method
10. Analysis of some IR spectra of polymers – Identification of labelled peaks in IR spectra of known polymer.

Text Books:

- ✓ V. R. Gowarikar, Jayadev Sreedhar, N. V. Viswanathan, *Polymer Science 1st Edition*, New Age International Publishers, 1986.
- ✓ Premamoy Ghosh, *Polymer Science and Technology: Plastics, Rubber, Blends and Composites*, 3rd Edition, McGraw Hill Education, 2010.
- ✓ P. Bahadur & N.V.Sastry, *Principles of polymer science*, Narosa Publishing house, New Delhi 2002

7.1.2 Green Chemistry

Credit 4
Full mark 100

Course Objectives:

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry, Principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles.

Course Outcomes:

1. Discuss about the role of principles of green chemistry.
2. Explain the importance of green synthesis.
3. Interpret the knowledge of prevention of hazardous chemicals in reactions.
4. Evaluate the efficiency of green catalysts & interpret the use of biocatalysts.

Unit-I: Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis-I

Twelve principles of Green Chemistry. Explanations of principle with special emphasis on- Designing green synthesis processes: Prevention of Waste/ by-products; maximize the incorporation of the materials used in the process into the final products (Atom Economy) with reference to rearrangement, addition, substitution and elimination reactions; Prevention/ minimization of hazardous/ toxic products; Designing safer chemicals; Use of safer solvents and auxiliaries (e.g. separating agent) - green solvents (supercritical CO₂, water, ionic liquids), solventless processes, immobilized solvents.

Unit-II: Principles of Green Chemistry and Designing a Chemical synthesis-II

Explanation of green chemistry principles with special emphasis on: Energy efficient processes for synthesis - use of microwaves and ultrasonic energy. Selection of starting materials (use of renewable feedstock); avoidance of unnecessary derivatization (e.g. blocking group, protection groups, deprotection); Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products use of chemically safer substances for prevention of chemical accidents, inherent safer design greener - alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol); real-time, in-process monitoring and control to prevent the formation of hazardous substances; development of green analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Unit-III: Examples of Green Synthesis/ Reactions and some real-world cases-I

Green Synthesis of the following compounds: adipic acid, catechol, methyl methacrylate, urethane, disodium iminodiacetate (alternative to Strecker synthesis), paracetamol, furfural.

Microwave assisted reactions: Applications to reactions (i) in water: Hofmann Elimination, hydrolysis (of benzyl chloride, methyl benzoate to benzoic acid), Oxidation (of toluene, alcohols);

(ii) reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction.

Ultrasound assisted reactions: Applications to esterification, saponification, Simmons-Smith Reaction (Ultrasonic alternative to Iodine).

Unit-IV: Examples of Green Synthesis/ Reactions and some real-world cases-II

Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments; Designing of Environmentally safe marine antifoulant; Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments; Synthesis of a compostable and widely applicable plastic (poly lactic acid) from corn; Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting
Future Trends in Green Chemistry
Oxidizing and reducing reagents and catalysts; multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Green chemistry in sustainable development. (Bio- diesel, bio-ethanol and biogas).

List of experiments

1. Acetylation of primary amine (Aniline to N-phenylacetamide) using Zn dust.
2. Nitration of salicylic acid by green method (Using calcium nitrate and acetic acid).
3. Bromination of acetanilide using ceric ammonium nitrate/KBr.
4. Microwave assisted nitration of Phenols using Cu(NO₃)₂.
5. Detection of elements in organic compounds by green method (Sodium carbonate fusion)
6. Base catalyzed Aldol condensation (Synthesis of dibenzalpropanone)
7. Vitamin C clock reaction using vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch. Effect of concentration on clock reaction.
8. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9. Diels Alder reaction in water: Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
10. Preparation and characterization of nanoparticles (Cu,Ag) using plant extract.

Text Books:

- ✓ P.T. Anastas & J.K. Warner, *Green Chemistry- Theory and Practical*, Oxford University Press 2000.
- ✓ V.K. Ahluwalia & M. Kidwai.: *New Trends in Green Chemistry*, Anamalaya Publishers, New Delhi 2004.
- ✓ V. Kumar *An Introduction to Green Chemistry*, Vishal Publishing Co., 2015.

Reference Books:

- ✓ A.S. Matlack. *Introduction to Green Chemistry*, Marcel Dekker 2001.
- ✓ A K. Das and M. Das, *Environment Chemistry with Green Chemistry*, Books and Allied (P) Ltd. 2010.
- ✓ R.K. Sharma, I.T. Sidhwani & M.K Chaudhari. I.K. *Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN978-93- 81141-55-7, 2013.*

- ✓ **E-Contents:** The supporting materials can be found on the **website of the Berkeley Center for Green Chemistry** (<http://bcgc.berkeley.edu/>).
- ✓ **Case Study:** <https://shorturl.at/cjuHI>

7.1.3 Research Methodology

Credit 4

Full mark 100

Course Objectives:

To make the students aware of fundamental but mandatory ethical practices in chemistry. To introduce the concept of data analysis. To learn to perform literature survey in different modes. To make the students aware of safety handling and safe storage of chemicals. To make students aware about plagiarism and how to avoid it. To teach the use of different e-resources.

Course Outcomes:

By the end of the course, the students will be able to:

1. Follow ethical practices in chemistry
2. Do Data analysis
3. Literature survey in different modes
4. Use e-resources.
5. Avoid plagiarism, understand the consequences and how to avoid

Unit-I: Scope of Research, Research Databases and Metrics

Define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, importance and future scope. **Print Database (traditional):** Sources of information: Primary, secondary, tertiary sources; **Digital: Databases (modern source):** Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; **EBSCO:** e-Resources Gateway for Universities of Odisha (odisha university | OSHEC | e-Resources for Universities and Colleges of Odisha); **Research metrics:** Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index; **Author identifiers/profiles:** ORCID, Publons, Google Scholar, ResearchGate, VIDWAN.

Unit-II: Statistical tools and validation for chemists

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation. Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS.

Unit-III: Research and Publication ethics:

Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Drillbit/Urkund etc), redundant publications; **Publication Ethics:** Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, **publication misconduct:** problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals; **IPR** - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

Unit-IV: Science Communications:

Types of scientific documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis; Thesis writing – Windows and/or linux operating system, programming fundamentals, basics of high level programming language-C:

editing, compilation and running a programme, storing data, elementary numerical methods, different steps and software tools (Word processing, LaTeX, Chemdraw, Chems sketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes; Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

Text Books:

- ✓ *Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.*
- ✓ *Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.*
- ✓ *Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London*

Reference Book:

- ✓ *Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.*
- ✓ *Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.*
- ✓ *Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992. OSU safety manual 1.01*

E-Contents:

1. [Google Scholar](#)
2. [Scopus preview - Scopus - Welcome to Scopus](#)
3. [Web of Science](#)
4. [CAS Insights | CAS](#)
5. [Reveal online attention to research - Altmetric](#)
6. [odisha university | OSHEC | e-Resources for Universities and Colleges of Odisha](#)

7.2.1 Oxidation, Reduction, Reagents, Rearrangements and Name Reactions

Credit 4

Full mark 100

Objectives: This course focusing on advanced organic reaction mechanisms and synthetic tools. It helps students in understanding the mechanism, scope, and limitations of important oxidation, reduction, and rearrangement reactions used in organic synthesis. It also helps students preparing competitive exam in Chemistry

Course Outcomes:

After completing the course, students will be able to:

1. Explain the mechanism and synthetic application of oxidation reactions using different oxidising agents KMnO_4 , CrO_3 , PCC, PDC, SeO_2 , OsO_4 , and peracids.
2. Describe selective reductions using NaBH_4 , LiAlH_4 , catalytic H_2 , Wolff-Kishner, Clemmensen, and dissolving metal reductions.
3. Select and justify the use of specific reagents for functional group interconversion, protection/deprotection, and C-C bond formation. Include organometallics, coupling agents, and Lewis acids.
4. Illustrate mechanisms of different rearrangement and name reactions

Unit-I: Oxidation Reactions

Oxidation of (a) alcohols to carbonyls by chromium, manganese, aluminium, silver, ruthenium, DMSO, hypervalent iodine and TEMPO based reagents, (b) alkenes to epoxides by peroxides/peracids, Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation (c) alkenes to carbonyls with bond cleavage by Manganese, Osmium, Ruthenium and lead based oxidants and ozonolysis (d) alkenes to alcohols/carbonyls without bond cleavage, Wacker oxidation, selenium, chromium based allylic oxidation process.

Unit-II: Reduction Reactions

Reduction reactions (a) in heterogeneous medium by Palladium/Platinum/Rhodium/Nickel (Resenmund reduction) and in homogeneous medium (Wilkinson reaction). Noyori asymmetric hydrogenation. (b) Metal based reductions using Li/Na in liquid ammonia (Birch reduction), Sodium, Magnesium, Zinc, Titanium and Samarium. (c) Reduction by hydride transfer reagents: Aluminium alkoxide, Sodium borohydride (NaBH_4), di-isobutylaluminium hydride (DIBAL-H), Sodium cyanoborohydride, Lithium trialkylborohydride, reduction with hydrazine (Wolff-Kischner reduction), reduction with trialkyltinhydride.

Unit-III: Reagents in Organic Synthesis

Functionalized Grignard reagents, organozinc, organo-lithium, organocopper, organopalladium, lithium diisopropylamide (LDA), Dicyclohexylcarbodiimide (DCC), organosilicon, organoborane, organotin, crown ethers, Dichlorodicyano benzoquinone (DDQ), Osmium tetroxide, 1,3-Dithiane, Trimethyl silyl iodide, Tri-n-butyl tin hydride.

Unit-IV: Rearrangement and Name Reactions

Nature of migration and migratory aptitude of groups in rearrangements reaction, Wagner-Meerwein, Favorskii, Fries, Benzil-Benzilic acid, Arndt-Eistert synthesis, Neber, Beckmann, Hofmann, Schmidt, Lossen, Shapiro reaction, Von-Richter, Sommelet-Hauser rearrangement, Wolff, Stevens reaction.

Recommended Textbooks:

- ✓ S. N. Sanyal, Reactions, Rearrangements and Reagents, 4th Ed., Bharati Bhawan Publishers & Distributors, 2019.
- ✓ R. K. Bansal, Organic Reaction Mechanism, 3rd Ed., Tata McGraw-Hill Publications, 1998.
- ✓ R. K. Bansal, Synthetic Approaches in Organic Chemistry, Narosa Publishing House, India, 1996.

Reference Books:

- ✓ W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, 2015.
- ✓ F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part-A and Part-B, 5th Ed., Springer 2007.
- ✓ J. March, M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Ed., Wiley, 2013.
- ✓ I. L. Finar, Organic Chemistry, Vol-2, 5th Ed., Pearson Publisher, 2002.
- ✓ R. O. C. Norman, J. M. Coxon, Principle of Organic Synthesis, 3rd Ed., CRC Press, 2017.

7.2.2 Chemistry of Biomolecules

Credit 4

Full mark 100

Course Objectives:

The objective of this course is to familiarize the student with biomolecules such as carbohydrates, amino acids, proteins, peptides, lipids and enzymes. The student will comprehend the structure, nomenclature, and properties of various biomolecules and their functions in biological systems. It will also help the learners to build the concept of metabolism by studying the chemistry and energetics of biomolecules in biochemical reactions.

Course Outcomes

1. Imparting knowledge on various biomolecules with their detailed classification, structure, nomenclature and functions.
2. Understanding the chemistry and energetics of food to energy conversion in biological systems.
3. Gaining knowledge on type of enzymes and their roles in metabolism of biomolecules in various biochemical reactions.
4. Practically determine saponification value and iodine number of fat and oil and determine the reducing and non-reducing sugars by Benedict's reagent.

Unit-I:

Carbohydrate

Occurrence, classification (mono-, di- and poly- saccharides), chemical structure, constitution and absolute configuration of glucose and fructose, epimers and anomers relationships, mutarotation, determination of ring size of glucose and fructose, Haworth projections and Fischer projection conformational structures, interconversions of aldoses and ketoses. Chemical properties of monosaccharides and Killiani-Fischer synthesis and Ruff degradation; Synthesis of Disaccharides – (Sucrose, Lactose and maltose) by condensation reactions.

Unit-II: Amino Acids, Peptides, Proteins and Nucleic acids

Amino acids: Classification, Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis.

Peptides: Classification, Determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups-Solid-phase synthesis.

Proteins: Structure of proteins, protein denaturation and renaturation.

Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Unit-III: Lipids

Introduction to oils and fats, common fatty acids present in oils and fats, role of lipids in our body, structure and classification, importance of omega-3 and omega-6 fatty acids and their sources. Physical and chemical properties of oils and fats, acid value, saponification value, iodine value, smoke point, flash point, fire point, and specific gravity. Chemical reactions of oil and fat, rancidity, conversion of oil to fat through hydrogenation, Baudouin test, Halphens test, Hexabromide test.

Unit-IV: Enzymes

Introduction to enzyme nomenclature, classification and characteristics. Salient features of active site of enzymes. Enzyme-substrate formation theory. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action, enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive including allosteric inhibition).

List of Experiments

- (1) Qualitative analysis of carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
- (2) Quantitative estimation of sugars:
 - a) Estimation glucose by titration with Fehling's solution.
 - b) Estimation glucose and sucrose in a given mixture.
- (3) Estimation of glycine by Sorenson's formalin method.
- (4) Study of the titration curve of glycine
- (5) Separation and identification of amino acids by paper chromatography
- (6) Separation of blue and orange dyes from methyl orange by paper chromatography
- (7) Separation and identification of food dyes by paper chromatography

Textbooks

- ✓ *D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 7th Ed., W. H. Freeman Co., 2017.*
- ✓ *J. L. Jain, S. Jain, N. Jain, Fundamentals of Biochemistry, S. Chand, 2016.*
- ✓ *E. J. Wood, Wilson and Walker Principle and Techniques of Practical Biochemistry, Cambridge University Press, 2009.*

Reference Books:

- ✓ *D. Das, Biochemistry, 14th Ed., Academic Publishers, 2015.*
- ✓ *A. V. S. S. Rao, A Textbook of Biochemistry, 9th Ed., UBS, 2002.*
- ✓ *R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Ed., Pearson Education India, 2010.*
- ✓ *G. P. Talwar, L. M. Srivastava, Textbook of Biochemistry and Human Biology, 3rd Ed., Prentice Hall India, 2002.*
- ✓ *J. M. Berg, J. L. Tymoczko, L. Stryer, Biochemistry, 6th Ed., W. H. Freeman, 2006.*
- ✓ *P. J. Kennelly, K. M. Botham, O. McGuinness, V. W. Rodwell, P. A. Weil, Harper's Illustrated Biochemistry, 32nd Ed., Lange-McGraw-Hill, 2022.*
- ✓ *T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, Solomons' Organic Chemistry, Global Ed., Wiley, 2024.*

SEMESTER VIII

8.1.1 Quantum chemistry & Statistical Thermodynamics

Credit 4

Full mark 100

Course Objectives:

This course is offered with an emphasis on fundamental understanding of Quantum chemistry, molecular spectroscopy, and photochemistry. Students are expected to have background knowledge in mathematics up to the +2 level for this course. The objective of the practical is to develop skills for working in physical chemistry laboratory.

Course Outcomes:

By the end of the course, the students will be able to:

1. Understand the approximation method encompassing Linear variation principle, perturbation theory.
2. Apply HMO to different conjugated systems.
3. Acquire a firm knowledge of statistical methods, Ensembles, and apply the concept of molecular partition functions to macroscopic systems.
4. Compare the thermodynamic properties of different statistics.

Unit-I:

Approximation Methods: The variation theorem, linear variation principle, Perturbation theory (first order and non-degenerate). Applications of variation method and perturbation theory to the Helium atom.

Unit-II:

Huckell theory of conjugated systems, Calculation of π -bond energy, delocalization energy, electronic & charge density calculation, and bond order. Applications to ethylene, butadiene, cyclopropanol radical, and cyclobutadiene.

Unit-III:

Fundamentals of Statistical methods, Starling's approximation, Statistical Thermodynamics: mathematical & thermodynamic probability. Maxwell Boltzman distribution between partition function. Types of Partition functions: translational, rotational, vibrational and electronic partition functions.

Unit-IV:

Types of Statistics- Bose-Einstein statistics, Maxwell-Boltzman, Fermi-Dirac statistics. Calculation of results of three types of statistics.

Text Books:

- ✓ *D. A. McQuarrie, Quantum Chemistry, Viva Books, Reprint, 2011, Indian Student Edition*
- ✓ *Statistical Thermodynamics: M. C. Gupta, New Age Pvt Publication*
- ✓ *Statistical Mechanics and Thermodynamics, C. Garrod, Oxford Univ. Press, New York.*

Reference Book:

- ✓ *Atkin's Physical Chemistry: P. W. Atkins, J. D. Paula, Oxford University Press*
- ✓ *Statistical Mechanics, D. A. McQuarrie, University Science Books, California.*

- ✓ *Statistical Mechanics - A Concise Introduction for Chemists* B. Widom, Cambridge University Press

Reference books

- ✓ L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons (2005)
- ✓ Malcolm P. Stevens, *Polymer Chemistry: An Introduction*, 3rd ed. Oxford University Press (2005)
- ✓ Seymour/Carraher's *Polymer Chemistry*, 9th ed. by Charles E. Carraher, Jr. (2013).
- ✓ Nayak P.L., *Polymer Chemistry*, Kalyani Publisher (2017).
- ✓ Hundiwale G.D., Athawale V.D., Kapadi U.R. and Gite V. V., *Experiments in Polymer Science*, New Age Publications (2009).

8.1.2.A Pericyclic reactions, Photochemistry and Retrosynthesis

Credit 4

Full mark 100

Course Objective

Imparting knowledge in the theory and applications of various aspects of pericyclic reactions and photochemistry and synthetic aptitude of organic molecules. It will also help to understand the synthesis and mechanisms of various reactions.

Course Outcomes:

1. Understand the concepts related to organic synthesis, mechanisms.
2. Apply their understanding about the photochemical reactions of industrial significance.
3. Evaluate the photochemical reactions based on the influence of the substituents on substrate molecules.
4. Design new photochemical reactions in order to achieve the required product(s).

Unit-I: Pericyclic Reaction-I:

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann rules, Correlation diagrams, FMO and PMO approaches. Electrocyclic reactions - Conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl systems.

Unit-II: Pericyclic Reaction-II:

Cycloaddition reactions - suprafacial and antarafacial additions, $4n$ and $4n+2$ systems, Correlation diagrams and FMO method, Allowed and forbidden reactions. Diels-Alder reactions: retro Diels-Alder reaction- FMO mechanism for endo- and exo-selectivity, stereochemistry, inter- and intramolecular reactions.

Sigmatropic rearrangements: $[i,j]$ H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations, Sommelet-Hauser, Claisen, thio-Claisen, Cope, Oxa and aza-Cope rearrangements, Ene reaction.

Unit-III: Photochemistry:

First order Photochemical processes Light absorption, Fluorescence and Phosphorescence. Photochemistry of Alkene: Isomerization, Intramolecular reactions of the olefinic bond, di- π -methane, oxa di- π - and aza di- π -methane rearrangements, Photochemistry of vision. Photochemistry of Carbonyl compounds: Norrish type I and II reaction, Paterno-Buchi reaction, Photoreduction. Photochemistry of Arenes: Photochemical aromatic substitution, addition and isomerisation reaction. Photo-Fries reactions of anilides, Barton reaction, the mechanisms of reactions involving free radicals- Sandmeyer, Gomberg-Bachmann, Pschorr, Ulmann and Hunsdiecker reactions. Singlet molecular oxygen reactions.

Unit-IV: Retrosynthesis:

An introduction to synthons and synthetic equivalents, disconnection approach, functional group interconversions, the importance of the order of events in organic synthesis. one group C-X and two group C-X disconnections, chemo selectivity, reversal of polarity, cyclisation reactions. One Group C-C disconnection: Alcohols and carbonyl compounds, regioselectivity, Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. Two group C-C Disconnections: Diels-Alder reaction, 1,3-difunctionalised compounds, α , β - unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Michael addition and Robinson annulation.

Protecting Groups, Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

List of Experiments

- (1) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
- (2) Diels Alder reaction in water: Reaction between furan and maleic acid in water at room temperature rather than in benzene under reflux condition.
- (3) Preparations of the following compounds: Aspirin/Paracetamol/Barbituric acid/
- (4) Synthesis of methyl orange.
- (5) Synthesis of amide derivative from carboxylic acid and amine or from esters
- (6) Synthesis of esters by refluxing glacial acetic acid and ethanol in presence of sulphuric acid.
- (7) Retrosynthetic analysis of biomolecules.

Textbooks

- ✓ S. Warren, P. Wyatt, *Organic synthesis, the disconnection approach*, 2nd Ed., Wiley, 2012.
- ✓ J. Singh, J Singh, *Photochemistry and Pericyclic Reactions*, New Age Science, 2009.
- ✓ B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education India, 2003.

Reference Books:

- ✓ S. Kumar, V. Kumar, S. P. Singh, *Pericyclic Reactions: A Mechanistic and Problem- Solving Approach*, Academic Press, 2015.
- ✓ W. Carruthares, I. Coldham, *Modern Methods of Organic Synthesis*, 4th Ed., Cambridge University Press, 2015.
- ✓ J. March, M. B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Ed., Wiley, 2013.
- ✓ R. K. Bansal, *Organic Reaction Mechanism*, 3rd Ed., Tata McGraw-Hill Publications, 1998.
- ✓ R. K. Bansal, *Synthetic Approaches in Organic Chemistry*, Narosa Publishing House, India, 1996.
- ✓ J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., Oxford Publisher, 2012.
- ✓ T. L. Gilchrist, R. C. Storr, *Organic Reactions and Orbital Symmetry*, 2nd Ed., Cambridge University Press, 1979.
- ✓ F. A. Carey, R. J. Sundberg, *Advanced Organic Chemistry, Part-A and Part-B*, 5th Ed., Springer 2007.
- ✓ I. L. Finar, *Organic Chemistry Vol. I & Vol. II*, Longman, Cambridge, 2011.

8.1.2.B Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry

Credit 4

Full mark 100

Course Objectives:

To provide basic knowledge on symmetry of molecules applied through mathematical group theory. Gives idea about the electronic transitions between d-orbitals, L-S coupling, qualitative Orgel diagrams for different d^n systems, selection rules for electronic spectral transitions, charge transfer phenomena, Nuclear chemistry has been introduced to inculcate students about the chemistry of inner core of atoms. Lab work has been designed for preparing key inorganic compounds and estimating important ingredients of day-to-day use in a product in order to make students competent in this regard.

Course Outcomes:

1. Learn a significant knowledge on formal group theory for understanding molecular spectroscopy.
2. Explore the fundamentals of electronic spectra of coordination complexes.
3. Understand the stability of nucleus and its reactions, and the applications of radioisotopes in different fields.
4. Achieve the knowledge on quantitative estimation of important ingredients in various commonly used products, and also get the synthetic skills of preparing key inorganic compounds

Unit – I: Fundamentals of group theory

Symmetry operation, symmetry element, classification of symmetry elements, definition of group, subgroup, cyclic groups, molecular point groups, group multiplication table, group generators, symmetry of platonic solids, conjugacy relation and classes, matrix representation of symmetry elements.

Unit – II: Character table and normal modes

Character of a representation, reducible and irreducible representation, Great orthogonality theorem (qualitative description only), properties of irreducible representation. Character table (explanation and significance), construction of character tables for C_{2v} and C_{3v} point groups, direct product, standard reduction formula, Normal modes for C_{2v} and C_{3v} molecules.

Unit – III: Electronic spectra of metal complexes

Electronic transitions between d-orbitals, L-S coupling, Orgel diagrams for $3d^1$ to $3d^9$ ions. Selection rules for electronic spectral transitions, relaxation in selection rules. spectrochemical series of ligands, nephelauxetic series, Evaluation of Dq , B and β parameters for the complex, charge transfer spectra (elementary idea). Significance of Tanabe-Sugano diagram.

Unit – IV: Nuclear Chemistry

Nuclear stability, magic numbers, radioactivity, general characteristics of radioactive decay particles, decay kinetics, nuclear reaction, Bethe's notation, types of nuclear reaction, nuclear cross section, compound nuclear theory, nuclear fission, liquid drop model, shell model, hard core preformation theory, fission fragments and their mass distribution, charge distribution, ionic charge of fission fragments, working principle of nuclear reactor, concept of boron-neutron capture therapy, concept of nuclear fusion.

List of experiments:

1. Estimation of iodine in iodized common salt iodometrically
2. Estimation of phosphoric acid in cola drinks by molybdenum blue method
3. Preparation of potash alum from scrap aluminum
4. Preparation of potassium of trioxalatoferrate (III) trihydrate, $K_3[Fe(C_2O_4)_3] \cdot 3H_2O$
5. Determination of alkali content in antacid tablet using HCl
6. Determination of acetic acid in commercial vinegar

Text Books:

- ✓ K. V. Ready, *Symmetry and Spectroscopy of Molecules*, New Age Int. Publishers, 2nd Ed, 2009.
- ✓ H. J. Arnikar, *Essentials of Nuclear Chemistry*, New Age International Pvt. Ltd., 4th Ed. 2011.
- ✓ A. Sakthivel, D. T. Masram, M. Sathiyendiran, S. Kaur-Ghumaan, *Electronic and Magnetic Properties of Transition and Inner Transition Elements and Their Complexes*, Publish with Nova Science Publishers, 2017.

Reference Books:

- ✓ F. A. Cotton, *Chemical Applications of Group Theory*, Wiley India (P) Ltd., 3rd Ed, 2009.
- ✓ G. L. Miessler, P. J. Fischer, D. A. Tarr, *Inorganic chemistry*, 5th Ed., 2014.
- ✓ D.E. Shriver, P. W. Atkins, *Inorganic Chemistry*, Oxford University Press, 5th Edn.

- ✓ *D. Gabel, R. Moss, Boron Neutron Capture Therapy: Toward Clinical Trials of Glioma Treatment, Springer-Verlag New York Inc., 1st Ed, 2012.*
- ✓ *A. J. Elias, General Chemistry Experiments, University Press, 2007.*
- ✓ *Y. R. Sharma, Modern Approach to Practical Chemistry, Kalyani Publishers, 2008.*
- ✓ *Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed., Person, 2007.*

**Draft Model Curriculum for 3yr./4yr. Degree Course with
Apprenticeship Embedded Degree program**

B.Sc./B.A. with Double Major in Economics and Data Analytics



**Higher Education
Department**
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Basic economics -I	4
	MJ -1.2	Indian Economy -I	4
	MJ -1.3	Mathematical Methods for Economics-I	4
	MJ- 1.4	Money and Banking	4
	MJ -2.1	Computational methods in Economics	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	Basic economics -II	4
	MJ 1.6	Indian Economy -II	4
	MJ 1.7	Statistical methods for Economies	4
	MJ- 1.8	Public Economics	4
	MJ 2.2	Introductory Econometrics	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship /or Any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	Microeconomics-I	4
	MJ 1.10	Macroeconomics-I	4
	MJ 1.11	Mathematical Methods for Economics-II	4
	MJ- 1.12	Development Economics	4
	MJ 2.3	Fundamentals of Data Analytics	4
	MJ -2.4	Excel application in Data Analytics	4
	MDC (Multidisciplinary Course)	Economics or /any other discipline	3
	SEC (Skill Enhancement Course)	Economics or/ any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	Microeconomics-II	4
	MJ- 1.14	Macroeconomics-II	4
	MJ- 1.15	Environmental Economics	4
	MJ -2.5	Data Analytics using “R”	4
	MJ -2.6	Data Analytics using Python	4
	MDC (Multidisciplinary Course)	Economics /or any other discipline	3
	SEC (Skill Enhancement Course)	Economics /or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20
TOTAL			150

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Semester-I

1.1 Basic economics-I

Course Description

This course is designed to expose the students to the basic principles of how the economy works at the microeconomic level with some basic concepts like markets, and consumer choice. in macroeconomics. The emphasis will be on thinking like an economist and the course will illustrate how microeconomic concepts can be applied to analyze real-life situations. This course also discusses the preliminary macroeconomic concepts associated with the determination and measurement of aggregate macroeconomic variables like savings, investment, and GDP.

Course Outcomes (COs)

- To expose the students to the introductory micro and macro-economic concepts.
- To explain how to think like an economist and illustrate how microeconomic concepts can be applied to analyses of real-life situations.
- To introduce preliminary macroeconomic concepts associated with the determination and measurement of aggregate macroeconomic variables like savings, investment, and GDP.
- To examine the circular flow of income and expenditure in a 2, 3, and 4-sector economy.

Unit I: Exploring the Subject Matter of Economics, Markets and Welfare

The Ten Principles of Economics; How people make decisions; Working of the economy as a whole; Thinking Like an Economist: The Economist as Scientist – The scientific method: Observation, Theory and more observation; Role of Assumptions; Economic Models; Why economists disagree; Graphs in Economics; The Market Forces; Markets and Competition; The Demand and Supply curves – Market vs Individual curves, Shifts in Demand and Supply Curves; Market Equilibrium and changes therein; Price Elasticity of Demand – determinants and computation; Income and Cross Elasticity of Demand; The Price Elasticity of Supply – determinants and computation; Consumer and Producer Surplus.

LO: Upon completion of this module, students will get a basic idea about the basic underlying principles followed in economics and get a formative perspective to concepts of elasticity of demand and supply.

Unit II: Theory of Consumer Choice

The Budget Constraint; Preferences – representing preferences with indifference curves; Properties of Indifference Curves; Two extreme examples of indifference curves; Optimization – Equilibrium; Change in equilibrium due to changes in income, changes in price; Income and Substitution Effect; Derivation of Demand Curve; Three applications – Demand for Giffen goods, Wages and Labour Supply, Interest rate and Household saving.

LO: Upon completion of this module, the students can understand the problem of choice and decision-making by consumers and have a vivid understanding of optimization and equilibrium.

Unit III: Basic Concepts in Macroeconomics

Macro vs. Microeconomics; Limitations of Macroeconomics; Stock and Flow variables, Equilibrium and Disequilibrium, Partial, and General Equilibrium Statics – Comparative Statics and Dynamics; National Income Concepts – GDP, GNP, NDP, and NNP at market price, factor cost, real and nominal; Disposable Personal Income.

LO: Upon completion of this module, the students will be introduced to concepts of macroeconomic variables and the basic concept of National Income Accounting.

Unit IV: Measurement of Macroeconomic Variables

Output, Income and Expenditure Approaches; Difficulties of Estimating National Income; National Income Identities in a simple 2-sector economy and with government and foreign trade sectors; Circular Flows of Income in 2, 3 and 4-

sector economies; National Income and Economic Welfare; Green Accounting.

LO: Upon completion of this module, the students will be familiarized with the estimation of National Income and understand the circular flow of income and expenditures in a closed and open economy.

Textbook:

- ✓ *Gregory N Mankiw: Principles of Economics, 6th Edition, Cengage Learning India Private Limited, New Delhi*
- ✓ *Gregory N. Mankiw (2010): Macroeconomics, 7th edition, Cengage Learning India Private Limited, New Delhi*
- ✓ *Government of India (2012): National Accounts Statistics Sources and Methods, CSO, MOSPI*

Reference Book:

- ✓ *Karl E. Case and Ray C. Fair (2007): Principles of Economics, 8th Edition, Pearson Education Inc.*
- ✓ *Richard T. Froyen (2005): Macroeconomics, 2nd Edition, Pearson Education Asia, New Delhi.*

1.2 Indian Economy- I

Course Description

Using appropriate analytical frameworks, this course reviews major trends in economic indicators and policy debates in India in the post-independence period, with particular emphasis on paradigm shifts and turning points. Given the rapid changes taking place in India, the reading list should be updated annually.

Course Outcomes

1. To have an understanding of the evolution of the Indian economy from pre-colonial to modern times, and its current state as a developing economy.
2. To be able to explain the relationship between population growth, human development, and economic development in India.
3. To be able to assess the national income trends in India, including sectoral composition, regional disparities, and challenges like poverty, inequality, and unemployment.
4. To gain the ability to critically analyze the role of economic planning in India's development, including the evolution from Five-Year Plans to NITI Aayog.

Unit I: Basic Characteristics of Indian Economy as a Developing Economy

Indian Economy in the Pre-British Period; The Structure and Organization of Villages and Towns; Industries and Handicrafts in Pre-British India; Colonialism; Economic Consequences of British Rule; Decline of Handicrafts and Progressive Ruralization; The Land System and Commercialization of Agriculture; Industrial Transition; Colonial Exploitation and Impacts – Underdevelopment; Colonization and Modernization; State Policies and Economic Underdevelopment; The Current State of Indian Economy

LO: This module shall enable the students to gain an in-depth understanding of the pre-British Indian economy, including its structure, industries, colonial impacts, and modernization, and evaluate state policies and current economic conditions.

Unit II: Population and Human Development

Population Growth and Economic Development – size, growth and Future of Population; Causes of rapid Population Growth; Population and Economic Development; Population Policy; Demographic Issues– Sex and Age Composition of Population; Demographic Dividend; Urbanization and Migration; Human Resource Development – Indicators and importance of Human Resource Development; Education policy; Health and nutrition.

LO: Upon completion of this module, students will analyze the population trends and policies in India, understand their impact on economic development, and evaluate the importance of human development (education, health) for India's future.

Unit III: National Income in India: The Growth Story and Current Challenges

Trends in national and per capita income; Changes in sectoral composition of national income; Regional disparities in Growth and Income; Savings and Investment and Economic Growth – The Linkage; Poverty – Estimation and Trends, Poverty Alleviation Programs– MGNREGA, NRLM, SJSRY; Inequality – Measures and trends in India; Unemployment– Nature, Estimates, Trends, Causes and Employment Policy.

LO: Upon completion of this module, students will have an understanding of national income trends, sectoral contributions, regional inequalities, and challenges that India faces like poverty, inequality, and unemployment.

Unit IV: Economic Planning in India

Rationale, Features, Objectives, Strategies, Achievements and Assessment of Planning in India; Eleventh Five Year Plan– Objectives, Targets and Achievements; Twelfth Five Year Plan – Vision and Strategy;

From Planning to NITI– Transforming India’s Development Agenda.

LO: Upon completion of this module, students will be able to appreciate the rationale and features of economic planning in India, its objectives and strategies, evaluate its achievements, and describe the transition to NITI Aayog.

Textbook:

- ✓ Misra, S. K. and Puri V. K. *Indian Economy — Its Development Experience*. Himalaya Publishing House, Mumbai

Reference Books:

- ✓ Dutt R. and Sundharam K. P. M: *Indian Economy*. S. Chand & Company Ltd., New Delhi.
- ✓ Datt and Sundharam, Gaurav Datt and Ashwani Mahajan, S Chand: *Indian Economy*, Publications, 7th Revised Edition
- ✓ *Indian Economy Since Independence*, ed by Uma Kapila, Academic Foundation, Revised Nineteenth Edition 2008-09
- ✓ Government of India (Current Year): *Economic Survey*, Ministry of Finance, New Delhi Basu, K. (2008): *Oxford Companion to Economics in India*, Oxford University Press

1.3 Mathematical Methods for Economics I

Course Description

This is the first of a compulsory two-course sequence. The objective of this sequence is to transmit the body of basic mathematics that enables the study of economic theory at the undergraduate level, specifically the courses on microeconomic theory, macroeconomic theory, statistics and econometrics set out in this syllabus. In this course, particular economic models are not the ends, but the means for illustrating the method of applying mathematical techniques to economic theory in general. The level of sophistication at which the material is to be taught is indicated by the contents of the prescribed textbook.

Course Outcomes:

- To use mathematical techniques in analyzing economic problems
- To get a fair idea about the number system, set theory, and different types of functions.
- Evaluate and use the concept of derivative of functions involving single variables to link the total and marginal concepts in Economics.
- Understand major concepts of Linear Algebra

Unit I: Preliminaries and Functions of One Real Variable

Sets and set operations; Cartesian product; relations; functions and their properties; Number systems. Types of Functions: constant, polynomial, rational, exponential, logarithmic; Graphs and graphs of functions; Limit and Continuity of functions; Limit theorems.

LO: *This module will enable the students to know the theory of sets, ordered pairs, and Cartesian products; and learn the concepts of relation and function and limit and continuity of functions.*

Unit II: Derivative of a Function

Rate of change and derivative; Derivative and slope of a curve; Continuity and differentiability of a function; Rules of differentiation for a function of one variable; Application- Relationship between total, average and marginal functions.

LO: *This module will enable the students to know the concept of the derivative and the rules for derivatives; and about the economic applications of differentiation in establishing the relationship between total, marginal, and average functions in Economics.*

Unit III: Functions of two or more Independent Variables

Partial differentiation techniques; Geometric interpretation of partial derivatives; Partial derivatives in Economics; Elasticity of a function – demand and cost elasticity, cross and partial elasticity.

LO: *This module will enable the students to find out partial derivatives of multivariate functions; and calculate elasticities of multivariate functions.*

Unit- IV: Matrices and Determinants

Matrices: concept, types, matrix algebra, transpose, inverse, rank; Determinants: concept, properties, solving problems using properties of determinants, solution to a system of equations - Cramer's rule and matrix inversion method.

LO: *This module will enable the students to understand different types of matrices and determinants; and learn about the matrix operations and solve systems of linear equations using matrices.*

Textbook:

- ✓ C. Chiang and K. Wainwright (2005): *Fundamental Methods of Mathematical Economics*, McGraw Hill International Edition

Reference Book:

- ✓ *K. Sydsaeter and P. J. Hammond (2002): Mathematics for Economic Analysis. Pearson Educational Asia*
- ✓ *Edward T Dowling (2004): Introduction to Mathematical economics, Tata McGeaw-Hill, Third Edition.*
- ✓ *Taro Yamane (1995): Mathematics foe Economists: An elementary survey. New Delhi Prentice Hall. Second Edition*

1.4 Money and Banking

Course Description

This course exposes students to the theory and functioning of the monetary and financial sectors of the economy. It highlights the organization, structure and role of financial markets and institutions. It also discusses interest rates, monetary management and instruments of monetary control. Financial and banking sector reforms and monetary policy with special reference to India are also covered.

Course Outcomes:

- Understanding money and its types along with their functions and different measures of money supply.
- Understanding the basic concepts of banking, and its functions and to examine the banking scenario in India.
- To gain knowledge of the functions of central banks and monetary policies and how they have evolved.
- Get an understanding of the conceptual framework of the financial market and institutions of India.

Unit I: Money

Definition and functions of money; Types of money: legal tender money and bank money, near money; Value of money and index number; construction of index number; WPI, CPI, PPI, GDP deflator, Cost of living index. Demand for money- Classical and Keynesian approaches, Patinkin and the Real Balance Effect; Friedman's Quantity theory of money. Supply of Money- Measures of money supply: M_1 , M_2 , M_3 and M_4 ; High powered money and money multiplier.

LO: This module will enable students to understand various concepts of money and money substitutes, functions of money, and monetary aggregates.

Unit II: Commercial Banking

Meaning and types; Functions of commercial banks; the process of credit creation and its limitations; Balance sheet and portfolio management, Banking sector reforms in India; Lessons from Global Financial Crisis and Policy Response in India.

LO: This module will make the students aware of basics of commercial Banking and Finance.

Unit III: Central Banking

Functions of a central bank; Quantitative and qualitative methods of credit control; Central Bank's Supervision and prudential measures for financial stability; current monetary policy of India, liquidity adjustment facility (LAF) through Repo and reverse repo operation, MSF.

LO: Upon completion of this module, students will be able to appreciate the effects of the major policy tools and understand how central banks affect the financial system of the economy.

Unit IV: Financial Markets

Financial Market, Meaning, Types, Money market and Capital Market, Primary and Secondary Market, Stock Exchanges, SEBI; Role of Financial Markets for Economic Development. Financial Instruments: Government securities, derivatives, futures and options, bond, debentures.

LO: This module shall help students to understand the nature of financial instruments and their usage.

Textbook

- ✓ *Bhole, L. M. (2017): Financial institutions and Market, 6th Ed, Tata McGraw hill, New Delhi.*
- ✓ *Mishkin, F. S. & Eakins S. G (2017): Financial Market and Institutions, 8th Ed, PE, New Delhi.*

Reference Book

- ✓ *Suraj. B. Gupta (2010): Monetary Economics: Institution, Theory and Practice, S. Chand.*
- ✓ *Gorden & Natrajan (2023): Financial Market and institutions, 3rd Ed, Himalaya Publishing house*

2.1 Computational Methods in Economics

Course Description

This course introduces the students to understand uses of computers and their applications in economics. After completion of the course, students will develop professional competency in working with MS Office.

Course Outcomes:

- To understand the uses of computers and their applications in Economics.
- To develop professional competency in working with MS Office.
- To get hands-on use of Microsoft Office applications- Word, Excel, PowerPoint, and Access.
- To gain basic soft skills in handling data, creation, and formatting of Word documents, and making presentations.

Unit-I: Computer Fundamentals

The basic architecture of CPU and its functions – Input device and output device – Primary and secondary memory. Operating systems - concept and types, Windows- concepts and components; Basics of a computer network: LAN, WAN, and MAN; Introduction to internet and its applications; booting process, Machine language, and assembly language; Applications of computer in Economics, other fields.

LO: This module shall make the students understand the basics of computers – parts, memory, network, and internet.

Unit II: MS Word, PowerPoint, and Access Applications

MS Word: Word basics, creation of a document, use of tables, pictures, and charts; editing, formatting, and printing documents; MS PowerPoint: Features, Creation of Slides for presentation, Types of view, Slide master, Templates and Slide transition; MS-Access: Data Field, Record, Database file, Types of files, Types of records, Data type, Database evolution, Data transfer from Excel to Access

LO: Upon completion of this module, students shall be able to create text documents using MS Word, create interesting and appealing presentations using MS PowerPoint, and apply Database Management Software (DBMS) like MS Access to manage data of businesses and enterprises.

Unit III: Worksheet & MS Excel

Basics of worksheet –creating a worksheet, entering data into a worksheet, sorting data, autofill, saving & protecting a worksheet, Formatting of a worksheet. Previewing & Printing worksheet; Create an Excel chart; Drawing charts: Area, Bar, Column, Line, Pie, Scatter, etc. Move and Resize your chart; Charts Styles and Layouts; Chart Titles and Series Titles; Format chart Panel; Add labels to a Chart; Format chart segments; Format Axis titles; Format your Axis titles

LO: Upon completion of this module, students shall develop the ability to arrange data in spreadsheets using graphing tools, pivot tables, and formulas.

Unit IV: MS-Excel Basic Function

Basic calculations: Sum, Sqrt, Max, Min, Count, Averages, Rank; Conditional and logical functions: IF, AND, OR; Estimation of correlation and regression; Hypothesis testing: t-test, F-test and Z-test Excel Pivot Tables; The LOOKUP Function; The VLOOKUP Function in Excel; Hyperlinks in Excel

LO: This module shall enable the learner to analyze data using MS Excel functions.

Textbooks:

- ✓ *New Perspectives Microsoft Office Excel 2016, Comprehensive Enhanced Edition, by Parsons, et al, Nelson Publisher.*
- ✓ *Sinha, P. K. (2004): Computer Fundamentals, 6th Ed, BPB Publications, New Delhi.*

Reference Book

- ✓ *Raja Raman.V. (2014): Fundamentals of Computers, 6th Ed, PHI, New Delhi.*
- ✓ *Kerns R. L.(1992): Essentials of Microsoft Windows, Word and Excel, PHI.*
- ✓ *Alexis Leon & Mathews Leon: Introduction to Computers with Ms-Office, TMH.*

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	● Communication, its Importance and Factors ● Types of Communication ● Verbal and Non-verbal Communication ● Styles of Communication
2	English Language and Communication: Listening and Speaking	● Types of Listening ● Speaking to communicate effectively ● Style of speaking in Various Situations ● English Pronunciation
3	English Language and Communication: Reading and Writing	● Reading methods and techniques. ● Reading texts to Understand meaning ● Writing Process ● Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	● Grammar ● Sentence structure ● Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)
2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lightning)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force (NDRF) and Odisha Disaster Rapid Action Force (ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightning), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

- A. a) Environmental Ethics: Issues and possible solutions.
 - b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
 - c) Environment Protection Act
 - d) Air (Preservation Control of Pollution) Act
 - e) Water (Preservation Control of Pollution) Act
 - f) Wildlife Protection Act
 - g) Forest Conservation Act
 - h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
 - B. Human Population and the Environment
- Population Ecology: Individuals, species, population, community
- Human population growth, population control method
- Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester-II

1.5 Basic Economics II

Course Description

This course is designed to expose the students to the basic principles of how the economy works at the microeconomic level with some basic concepts like production, firms and input markets. This course also aims to introduce the students to the basic macroeconomic concepts of money, inflation, and the theories of determination of income and employment in the aggregate economy.

Course Outcomes

- ✓ To have a clear idea about the principles that govern the economy's running at the micro and macro levels.
- ✓ To understand about the working of the input market.
- ✓ To gain clarity about dynamic concepts of Inflation, Employment, money, and income.
- ✓ To understand of the theories of determination of income and employment in the aggregate economy.

Unit I: The Firm and Market Structures

Cost concepts; Production and Costs; The various measures of cost – Fixed and Variable cost, Average and Marginal cost; Cost curves and their shapes; Costs in the short run and the long run; Economies and diseconomies of scale. Firms in Competitive Markets – What is a competitive market; Profit maximization and the competitive firm's supply curve; The marginal cost curve and the firm's supply decision; Firm's short-run decision to shut down; Firm's long-run decision to exit or enter a market; The supply curve in a competitive market – short run and long run

LO: Upon completion of this module, the students will have a clear understanding of the traditional theory of cost and different cost concepts, and be able to distinguish between short-run and long-run costs, and relate them to a firm's decision-making under competitive markets.

Unit II: The Input Markets

The Demand for Labour – The production function and the marginal product of labour; Value of the marginal product of labour and demand for labour; Shifts in labour demand curve; The supply of labour – the trade-off between work and leisure; Shifts in the labour supply curve; Equilibrium in the Labour Market; Other factors of production: Land and Capital; Linkages among factors of production

LO: Upon completion of this module, the students will get an insight into the analysis of demand and supply of inputs and the linkages among the factors of production.

Unit III: Money and Changes in its Value

Evolution and Functions of Money, Quantity Theory of Money – Cash Transactions, Cash Balances and Keynesian Approaches, Value of Money and Index Number of Prices

Inflation – Meaning, Causes, and Anti-Inflationary Measures; Classical, Keynesian, Monetarist and Modern Theories of Inflation, Inflationary Gap, Deflation- Meaning, Causes, and Anti-Deflationary Measures, Depression and Stagflation; Inflation vs. Deflation

LO: Upon completion of this module, the students shall understand the evolution of money and the classical theories of money supply and be able to explain the causes of inflation and deflation in an economy and the impact and solution thereto.

Unit IV: Determination of National Income

The Classical Approach - Say's Law, Theory of Determination of Income and Employment with and without saving and Investment; Basics of Aggregate Demand and Aggregate Supply and Consumption- Saving – Investment Functions, The Keynesian Approach – Basics of Aggregate Demand and Aggregate Supply and Consumption, Saving, Investment Functions; The Principle of Effective Demand; Income Determination in a Simple 2-Sector Model; Changes in Aggregate Demand and Income- The Simple Investment Multiplier

LO: Upon completion of this module, the students shall get to know the classical and Keynesian theories of income and employment determination.

Textbook:

- ✓ *Gregory N Mankiw: Principles of Economics, 6th Edition, Cengage Learning India Private Limited, New Delhi*
- ✓ *Gregory N. Mankiw (2010): Macroeconomics, 7th edition, Cengage Learning India Private Limited, New Delhi*
- ✓ *Government of India (2012): National Accounts Statistics Sources and Methods, CSO, MOSPI*

Reference Book:

- ✓ *Karl E. Case and Ray C. Fair (2007): Principles of Economics, 8th Edition, Pearson Education Inc.*
- ✓ *Richard T. Froyen (2005): Macroeconomics, 2nd Edition, Pearson Education Asia, New Delhi.*

1.6 Indian Economy II

Course Description

This course examines sector-specific policies and their impact in shaping trends in key economic indicators in India. It highlights major policy debates and evaluates the Indian empirical evidence. Given the rapid changes taking place in the country, the reading list should be updated annually.

Course Outcomes

- To analyze the current state of Indian agriculture, including production trends, factors influencing production, and policy initiatives like land reforms and the green revolution.
- To evaluate the development of Indian industries, including historical industrial policies, challenges faced by small-scale industries, and the role of labor.
- To assess the contribution of the tertiary sector to the Indian economy, and understand the concept of Human Resource Development (HRD) and its role in India's development.
- To explain India's foreign trade scenario, including trade composition, export promotion strategies, and the role of foreign capital.
- To analyze the environmental policies implemented in India and the global response to climate change, considering India's specific situation.

Unit I: Agricultural Development in India

Indian Agriculture: nature, importance, trends in agricultural production and productivity, factors determining production, land reforms, new agricultural strategies and green revolution, rural credit; Agricultural marketing and warehousing.

LO: Students will be able to analyze the structure, challenges, and advancements in Indian agriculture, including policies, credit, and marketing.

Unit II: Industrial Development in India

Trends in industrial output and productivity; Industrial Policies of 1948, 1956, 1977, and 1991; Industrial Licensing Policies – MRTP Act, FERA, and FEMA; Growth and problems of SSIs, Industrial sickness; Industrial finance; Industrial labor.

LO: Students will know about industrial output and productivity trends, industrial policies, the impact of licensing policies, small-scale industries' growth, industrial finance, and labor issues in India.

Unit III: Tertiary Sector, HRD, and the External Sector

Tertiary Sector: growth and contribution of the service sector to GDP of India, share of services in employment; Human development – concept, evolution, measurement; HRD: indication, importance, education in India, Indian educational policy; Health and Nutrition. Foreign Trade: role, composition, and direction of India's foreign trade, trends of export and import in India, export promotion versus import substitution; Balance of Payments of India; India's Trade Policies; Foreign Capital – FDI, Aid and MNCs.

LO: Students will have an understanding of the growth of India's service sector, human development strategies (education & health), and international trade dynamics (exports, imports, foreign investment)

Unit IV: Indian Economy and Environment

Environmental Policies in India: The Environment (Protection) Act 1986, The Environment (Protection) Rules 1986, The National Forest Policy 1988, Policy statement for Abatement of Pollution 1992, National Conservation Strategy and Policy Statement on Environment and Development

1992, The National Environment Appellate Authority Act 1997, National Environmental Policy 2006; Global deal with Climate Change: Introduction, Intergovernmental Panel for Climate Change (IPCC), Impact of Climate Change on India, Global Response on Climate Change, Possible Role of India.

LO: Students will be able to analyze key environmental policies in India, the global deal on climate change, IPCC's role, climate change impacts, and global responses to India's role.

Textbook:

- ✓ *Mishra, S. K. and Puri V. K. Indian Economy — Its Development Experience. Himalaya Publishing House, Mumbai*

Reference Books:

- ✓ *Dutt R. and Sundharam K. P. M.: Indian Economy. S. Chand & Company Ltd., New Delhi.*
- ✓ *Datt and Sundharam, Gaurav Datt and Ashwani Mahajann: Indian Economy, S Chand Publications, 7th Revised Edition*
- ✓ *Indian Economy Since Independence, ed by Uma Kapila, Academic Foundation, Revised Nineteenth Edition 2008-09*
- ✓ *Government of India (Current Year): Economic Survey, Ministry of Finance, New Delhi*

1.7 Statistical Methods for Economics

Course Description:

This is a course on statistical methods for economics. It begins with some basic concepts and terminology that are fundamental to statistical analysis and inference. It is followed by a study and measure of the relationship between variables, which are the core of economic analysis. This is followed by a basic discussion on index numbers and time series. The paper finally develops the notion of probability, followed by probability distributions of discrete and continuous random variables, and introduces the most frequently used theoretical distribution, the Normal distribution.

Course Outcomes:

- To summarize data effectively using measures of central tendency, dispersion, and graphical techniques.
- To analyze relationships between variables through correlation and regression analysis.
- To understand and interpret time series data by identifying trends and seasonality.
- To apply probability theory and sampling techniques to solve statistical problems and assess data validity.

Unit I: Data Collection and Measures of Central Tendency and Dispersion

Basic concepts: population and sample, parameter and statistics; Data Collection: primary and secondary data, methods of collection of primary data; Presentation of Data: frequency distribution; cumulative frequency; graphic and diagrammatic representation of data; Measures of Central Tendency: mean, median, mode, geometric mean, harmonic mean, their relative merits and demerits; Measures of Dispersion: absolute and relative - range, mean deviation, standard deviation, coefficient of variation, quartile deviation, their merits, and demerits; Measures of skewness and kurtosis.

LO: *At the end of this module, students will be able to distinguish between population and sample, collect and organize data, and calculate measures of central tendency and dispersion to understand a data set's characteristics.*

Unit II: Correlation and Regression Analysis

Correlation: scatter diagram, sample correlation coefficient - Karl Pearson's correlation coefficient and its properties, probable error of correlation coefficient, Spearman's rank correlation coefficient. Two variable linear regression analysis - estimation of regression lines (Least square method) and regression coefficients - their interpretation and properties, standard error of estimate.

LO: *This module shall help students master the techniques to measure the strength and direction of relationships between variables (correlation) and use linear regression analysis to model and predict those relationships.*

Unit III: Time Series and Index Number

Time Series: definition and components, measurement of the trend- freehand method, methods of semi-average, moving average and method of least squares (equations of first and second degree only), measurement of the seasonal component; Index Numbers: Concept, price relative, quantity relative and value relative; Laspeyres's and Fisher's index, family budget method, problems in construction and limitations of index numbers, test for ideal index number.

LO: *Upon completion of this module, students will be able to analyze time series data for trends and seasonality, and construct and interpret index numbers to measure price and quantity changes.*

Unit IV: Probability Theory and Sampling

Probability: Basic concepts, addition, and multiplication rules, conditional probability; Meaning of Sampling, Types of Sampling: Probability Sampling versus Non-Probability Sampling; Simple Random Sampling and its selection, Systematic Sampling, Multi-stage Sampling, Quota Sampling; Error: Sampling and Non-sampling.

LO: Upon completion of this module, students will be able to calculate probabilities, understand different sampling methods (probability vs. non-probability), and identify potential errors associated with sampling.

Basic Readings and Textbooks:

- ✓ S. C. Gupta (2017): *Fundamentals of Statistics*, Himalaya Publishing House, Delhi

Reference Book:

- ✓ Murray R. Spiegel (2017): *Theory & Problems of Statistics*, Schaum's publishing Series.
- ✓ A L Nagar & R K Das (1983): *Basic Statistics*. Oxford University Press.

1.8 Public Economics

Course description:

Public economics is the study of government policy from the points of view of economic efficiency and equity. The paper deals with the nature of government intervention and its implications for allocation, distribution and stabilization. Inherently, this study involves a formal analysis of government taxation and expenditures. The subject encompasses a host of topics including public goods, market failures and externalities.

Course Outcomes:

- The course will familiarize the students with the relevance, responsibilities, and sources of receipts of the government.
- Students will be able to understand the rationale behind the public provision of specific goods and services and what can be left to market for provision.
- Students will be able to understand the normative ideas behind public expenditure, taxation, and public debt as well as the budget of government and its impact on the economy.
- Students will be able to understand the methods of fiscal management by the government in India.

Unit I: Introduction to Public Finance and Public Budgets

The concept of Pareto Optimality. Pareto improvement and potential Pareto improvement. Public good versus private good; Free riding and public Good provision. Maximum Social advantage. Market failure and role of government; Public Budget: kinds of budget, economic and functional classification of the budget; Balanced and unbalanced budget; Balanced budget multiplier; Budget as an instrument of economic policy

LO: *This module will give an idea of the goods to be provided by the government and market and the challenges faced by the government to provide public goods; and will also teach about different types of budgets and their implications for the economy.*

Unit II: Public Expenditure

Meaning, classification, principles, cannons and effects, causes of growth of public expenditure, Wagner's law of increasing state activities, Peacock-Wiseman hypotheses. Pareto Optimality Criterion, social Allocation

LO: *This module will educate on the principles behind public expenditure and the causes behind the rise in the public expenditure.*

Unit III: Public Revenue

Sources of Public Revenue; Taxation - meaning, cannons and classification of taxes, impact and incidence of taxes, division of tax burden, the benefit and ability to pay approaches, taxable capacity, effects of taxation, characteristics of a good tax system, major trends in tax revenue of central and state governments in India, Introduction of GST in India. Issues and Challenges relating to GST.

LO: *This module will educate on the sources of receipts for the government, theoretical ideas behind taxation, and implementation of GST in India.*

Unit IV: Public Debt

Sources, effects, debt burden – Classical/ Ricardian views, Keynesian and post-Keynesian views; shifting - intergenerational equity, methods of debt redemption, debt management, tax versus debt.

LO: *This module will give a fair idea of different aspects of the implications of public debt on the economy*

Textbooks:

- ✓ J. Hindriks and G. Myles (2006): *Intermediate Public Economics*, MIT Press.

Reference Book:

- ✓ R. A. Musgrave and P. B. Musgrave (1989): *Public Finance in Theory and Practices*. McGraw Hill
- ✓ Bhatia H L (2018): *Public Finance*. Vikas Publishing House.

2.2 Introductory Econometrics

Course Description:

This course provides a comprehensive introduction to basic econometric concepts and techniques. It covers statistical concepts of hypothesis testing, estimation and diagnostic testing of simple and multiple regression models. The course also covers the consequences of and tests for misspecification of regression models.

Course Outcomes:

- To have a comprehensive introduction to basic econometric concepts and techniques.
- To gain an understanding of the statistical concepts of hypothesis testing, estimation, and diagnostic testing of simple and multiple regression models.
- To gain knowledge about the consequences, tests, and remedies of violation of Least Square assumptions.

Unit I: Introduction

Definition, Nature and scope of econometrics; Theoretical Probability Distributions: Binomial, Poisson and Normal distributions: their properties. Theory of Estimation: Estimation of parameters; properties of estimators – small sample and asymptotic properties; point and interval estimation.

LO: *This module will enable the students to know about some common discrete and continuous theoretical probability distributions; and to know about estimators, point and interval, and the desirable properties of point estimators.*

Unit II: Hypothesis Testing

Testing of hypotheses: defining statistical hypotheses; Simple and composite hypotheses; Null and alternative hypothesis; Type I and Type II errors, Critical region; Neyman-Pearson lemma; Power of a test; Test statistics: z, chi square, t and F.

LO: *This module will enable the student to gain knowledge about statistical hypotheses and the procedure of testing of hypothesis; and have an understanding of type I and type II errors in the procedure of hypothesis testing.*

Unit III: Linear Regression Analysis

Two variable linear regression model – Assumptions; Least square estimates, Variance and co- variance between Least square estimates; BLUE properties; Standard errors of estimates; Co- efficient of determination; Inference in a two variable linear regression model; ANOVA; Forecasting. Introduction to multiple regression models.

LO: *This module will enable the students to understand the concept and usefulness of regression analysis and differentiate between Linear and non-linear relations; understand the difference between simple & multiple linear regression models and their estimation as well as inference drawn therefrom.*

Unit IV: Violation of Classical Assumptions

Heteroscedasticity, Multicollinearity and Auto-correlation: Meaning, consequences, tests and remedies.

LO: *This module will enable the student to understand the consequences, tests, and remedies of violation of Least Square assumptions.*

Textbook:

- ✓ Gujarati, D & Sangeetha (2007); —*Basic Econometrics*l, McGraw Hill Book Co.

Reference Book:

- ✓ Wooldrige, J. M. (2022): *Introductory Econometrics: A modern Approach*, 7th Ed, Cengage Publication

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester-III

1.9 Microeconomics I

Course Description

The course is designed to provide sound training in microeconomic theory to formally analyze the behavior of individual agents. Since students are already familiar with the quantitative techniques in the previous semesters, mathematical tools are used to facilitate understanding of the basic concepts; this course looks at the behavior of the consumer and the producer and also covers the behavior of a competitive firm.

Course Outcomes:

- To develop an understanding of preferences and consumer choice and formally analyze the behavior of individual agents
- To be able to use mathematical tools to facilitate understanding of the basic concepts of Economics.
- To understand the behavior of the consumer and the producer.
- To understand the behavior of a competitive firm.

Unit I: Consumer Theory I

Preferences and Utility, Axioms of Rational Choice, Utility, Trades and Substitutions, Indifference curves; Mathematics of Indifference curves, Utility functions for specific preferences, the many good cases; Utility Maximization and choice: the 2-good case (graphical analysis), the n-good case, Indirect utility function, the Lump sum principle, Expenditure minimization, properties of the expenditure function.

LO: *This module will enable the students to understand the basic concepts in consumer behavior like utility, choice, optimization, and Indifference curves using mathematical tools; and differentiate between direct and indirect utility, and explain expenditure function and its properties.*

Unit II: Consumer Theory II

The Income and Substitution Effects: Demand function, changes in income, changes in goods price- Direct and Indirect Approaches (Slutsky), the Individual's Demand Curve, Compensated (Hicksian) demand curves and functions, demand elasticity, Consumer Surplus, Demand relationships among goods, the 2-good case, substitutes and complements, Net (Hicksian) substitutes, and Complements, Substitutability with many goods.

LO: *This module will enable the students to analyze the effects of changes in income and prices on demand; differentiate between Ordinary and compensated demand; explain the concepts of price and income elasticities, and substitutability between goods; and understand the concept of Consumer Surplus*

Unit III: Production Theory and Costs

Production Functions: Marginal productivity, Production with One Variable Input (labour) and with Two-Variable Inputs, Isoquant Maps and the Rate of Technical Substitution, Returns to Scale, Elasticity of Substitution, Some Simple Production Functions: Linear, Fixed Proportions; Technical Progress. Definition of Cost and its properties, Cost minimizing input choices (Optimization principles, Expansion Path), Cost Functions and Shift in Cost Curves, Long-Run versus Short-Run Cost Curves.

LO: *This module will enable the students to understand concepts like production function in the short run and the long run, isoquants, and substitution between inputs; and explain concepts of cost, and optimization in the short run and long run*

Unit IV: Profit Maximization

The Nature and Behaviour of Firms, Marginal Revenue – Relationship between Average and marginal revenue, Short-Run Supply by a Price-Taking Firm, Profit Functions and its Properties, Profit maximization – General conditions, Input demands

LO: *This module will enable the students to understand the behavior of the competitive firm and concepts like average and marginal revenue; and learn the conditions for profit maximization, properties of profit function*

Textbook:

- ✓ *C. Snyder and W. Nicholson (2012): Microeconomic Theory: Basic Principles and Extensions, 11th Edition, Cengage Learning, Delhi, India*

Reference Books:

- ✓ *H. R. Varian (2010): Intermediate Microeconomics: A Modern Approach, 8th Edition, W.W. Norton and Company/Affiliated East-West Press (India). The workbook by Varian and Bergstrom may be used for problems*

1.10 Macroeconomics- I

Course Description

This course introduces the students to formal modelling of a macro-economy in terms of analytical tools. It discusses various alternative theories of output and employment determination in a closed economy in the short run as well as long run, and the role of policies in this context.

Course Outcomes:

- To understand the basics of consumption function and its relation with income, and factors influencing consumption function.
- To get a knowledge about various types of investment spending and evaluate the impact of investment through multiplier and accelerator in economies.
- Discuss the various approaches to demand and supply of money.
- Analyse and interpret the IS-LM model as a step toward understanding economic fluctuations.

Unit I: Consumption

Consumption – Income Relationship, Propensities to Consume and the Fundamental Psychological Law of Consumption; Implications of Keynesian Consumption Function; Factors Influencing Consumption Function; Measures to Raise Consumption Function; Absolute, Relative, Permanent, and Life-cycle hypothesis

LO: *This module shall enable the students to find out how consumption is affected by income and other factors.*

Unit II: Investment

Autonomous and Induced Investment, Residential and Inventory Investment, Determinants of Business Fixed Investment, Decision to Invest and MEC, Accelerator and MEI, Theories of Investment: The Accelerator and Tobin's theory

LO: *Students will gain an understanding of different forms of investment spending and theories of investment*

Unit III: Demand for and Supply of Money

Demand for Money – Classical, Neoclassical, and Keynesian Approaches, The Keynesian Liquidity Trap and its Implications, Supply of Money – Classical and Keynesian Approaches, The Theory of Money Supply Determination and Money Multiplier, Measures of Money Supply in India, RBI approach to money supply, Determination and Money multiplier. High-powered money and money multiplier

LO: *Students will be able to understand the workings of money in an economy.*

Unit IV: Aggregate Demand and Aggregate Supply

Derivation of Aggregate Demand and Aggregate Supply Curves in the IS-LM Framework; Nature and Shape of IS and LM curves; Interaction of IS and LM curves and Determination of Employment, Output, Prices and Investment; Changes in IS and LM curves and their Implications for Equilibrium

LO: *This module shall help to gain knowledge about the way the goods market and money market serve as a basis for the determination of employment, output, price, and investment.*

Text Readings:

- ✓ *N. Gregory Mankiw (2010): Macroeconomics, 7th edition, Cengage Learning India Private Limited, New Delhi.*
- ✓ *Richard T. Froyen (2005): Macroeconomics, 2nd Edition, Pearson Education Asia, New Delhi.*

Reference Book:

- ✓ *Snowdon, B. and Vane H. R. (2005). Modern macroeconomics –its Origins, Development and Current State. Edward Elgar Publishing Limited, Cheltenham, UK.*
- ✓ *Ahuja H. L. (2019). Macroeconomics- Theory and Policy. 20th Edition, S Chand publication.*
- ✓ *Dwivedi, D. N. (2018): Macroeconomics -Theory and Policy. 5th Edition, Tata McGraw Hill.*

1.11 Mathematical Methods for Economics II

Course Description:

This course is the second part of a compulsory two-course sequence. This part is to be taught in Semester II following the first part in Semester I. The objective of this sequence is to transmit the body of basic mathematics that enables the study of economic theory at the undergraduate level, specifically the courses on microeconomic theory, macroeconomic theory, statistics and econometrics set out in this Syllabus. In this course, particular economic models are not the ends, but the means for illustrating the method of applying mathematical techniques to economic theory in general. The level of sophistication at which the material is to be taught is indicated by the contents of the prescribed textbook.

Course Outcomes:

- To use mathematical techniques to analyze economic problems.
- To have an understanding of the input-output models.
- To be able to use second and higher-order derivatives and integration to analyze the nature of functions.
- To develop the ability to optimise objective functions subject to satisfaction of constraints.

Unit I: Linear models:

Input-Output Model: Basic concepts and structure of Leontief's open and static Input-Output model; Solution for equilibrium output in a three-industry model; The closed model.

LO: *This module will enable the students to get an idea of the static input-output model in its closed and open versions, which are of great practical importance in Economics.*

Unit II: Second and Higher Order Derivatives and Integration:

Technique of higher order differentiation; Interpretation of second derivative; Second order derivative and curvature of a function; Concavity and convexity of functions; Points of inflection, Derivative of Implicit Function; Higher Order Partial Derivative. Indefinite Integrals; Rules of Integration; Techniques of Integration: Substitution Rule, Integration by parts, and Partial Fractions; Definite Integral – Area Interpretation.

LO: *This module will enable the students to know the concept of higher-order derivatives and integration, definite and indefinite; and the applications of higher-order derivatives and integration in Economics.*

Unit III: Single and Multivariable Optimization:

Optimum values and extreme values; Relative maximum and minimum; Necessary versus sufficient conditions – First and Second derivative tests (using Hessian Determinants); Economic applications thereof, First and second order condition for extrema of multivariable functions; Convex functions and convex sets.

LO: *This module will enable the student to learn the concept of optimization of single and multi-variable functions.*

Unit IV: Optimization with Equality Constraints:

Effects of a constraint; Finding stationary value – Lagrange-Multiplier method (Two variable single constraint case only); First and second order condition; The Bordered Hessian determinant.

LO: This module will enable the student to understand the meaning and definition of constraint optimization, and the use of the Lagrange multiplier method and the Bordered Hessian determinant to optimize an objective function with respect to a constraint.

Text Reading:

- ✓ *A. C. Chiang and K. Wainwright (2005): Fundamental Methods of Mathematical Economics, McGraw Hill International Edition.*

Reference Book:

- ✓ *K. Sydsaeter and P. J. Hammond (2002): Mathematics for Economic Analysis. Pearson Educational Asia*
- ✓ *Edward T Dowling (2004): Introduction to Mathematical economics, Tata McGeaw-Hill, Third Edition.*
- ✓ *Taro Yamane (1995): Mathematics for Economists: An elementary survey. New Delhi Prentice Hall. Second Edition.*

1.12 Development Economics I

Course Description:

This is the first part of a two-part course on economic development. The course begins with a discussion of alternative conceptions of development and their justification. It then proceeds to aggregate models of growth and cross-national comparisons of the growth experience that can help evaluate these models. The axiomatic basis for inequality measurement is used to develop measures of inequality and connections between growth and inequality are explored. The course ends by linking political institutions to growth and inequality by discussing the role of the state in economic development and the informational and incentive problems that affect state governance.

Course Outcomes:

- The course will enhance the understanding of concepts of development and the need for it.
- It helps students learn about aggregate models of growth.
- It examines the axiomatic basis for inequality measurement and explores the connections between growth and inequality.
- It familiarizes the students with the socio-economic and political institutions while showing their contribution to economic development.

Unit I: Study of Economic Development

Conceptions of Development economic growth and economic development; Alternative measures of development, documenting the international variations in these measures, comparing development trajectories across nations and within them measures of economic development – national and per capita income, basic needs approach, capabilities approach, three core values of development, PQLI, HDI, HPI, MDPI, GDI; Happiness Index

LO: Upon completion of this module, students learn the alternative concepts associated with the development and the changes in the measurement of development over time.

Unit II: Theories of Economic Growth and Development

Classical theory, Marxian theory; Schumpeterian theory; Rostow's stages of economic growth; Harrod-Domar model, Solow model and convergence with population growth and technical progress.

LO: Upon completion of this module, students gain an elaborate knowledge about the growth theories put forth by different Schools of Economics.

Unit III: Poverty, Inequality, Agriculture, Industry and Development:

Measuring poverty: Head Count Ratio, Poverty Gap Ratio, Squared Poverty Ratio, FGT Ratio; Measuring Inequality – Lorenz curve and Kuznets' inverted U hypothesis; Growth, poverty and inequality; Policy options – some basic considerations

Agriculture, Industry and Economic Development: Interdependence between agriculture and industries – A model of complementarities between agriculture and industry; terms of trade between agriculture and industry; functioning of markets in agrarian societies; interlinked agrarian markets

LO: This module shall help the learners to understand different measures of poverty and inequality in an economy and gain an insight into the role of agriculture and industry in economic development and the dynamic complementarity between the two sectors.

Unit IV: Institutions and Economic Development:

Role of institutions in economic development; Characteristics of good institutions and quality of institutions; The pre-requisites of a sound institutional structure; Different measures of institutions – aggregate governance index, property rights and risk of expropriation; The role of democracy in economic development; Role of markets and market failure; Institutional and cultural requirements for operation of effective private markets; Market facilitating conditions; Limitations of markets in LDCs; Corruption and economic development – tackling the problem of corruption

LO: Upon completion of this module, students get to know the importance and role of institutions in the process of economic development.

Textbook:

- ✓ *Todaro, Michael P and Stephen C Smith (2006): Economic Development, 8th Edition, Pearson*

Reference Books:

- ✓ *Debraj Ray (2009): Development Economics, Oxford University Press.*
- ✓ *Thirlwall, A P (2011): Economics of Development, 9th Edition, Palgrave Macmillan*

2.3 Fundamentals of Data Analytics

Course Description:

This course provided an introduction to the principles, techniques and application of Data Analytics. It familiarises a student with the process of data collection, organization, analysis and interpretation so as to generate meaningful insights.

Course Outcomes:

- Understand the fundamental concept and foundation of Data analytics in Economics
- Identify the significance of data analytics in various spheres of study.
- Preprocess data from various sources using appropriate techniques for analysis and interpretation of data sets including accessing the confidence level.
- Demonstrate about data privacy, visualization tools and limitation of data analytics in real world situation.

Unit I:

Foundations of Data Analytics: Data, information, knowledge - types of data: structured, unstructured, time-series, cross-section, panel. Types of data analytics: descriptive, diagnostic, predictive, prescriptive.

Unit II:

Data analysis process: problem definition, data collection, data cleaning, data analysis, modelling, interpretation, reporting. Role of data analytics in economics, business and policy making. Analytics vs Statistics vs ML

Unit III:

Analytics Methods for Economics: Statistical inference basics: sampling distributions, confidence intervals, hypothesis testing - t, z, f chi-square and Regression analysis, interpretation for policy

Unit IV:

Time series analytics: trend, seasonality, smoothing, ARIMA basics, Data visualization & dashboards. Index numbers and growth rate, CAGR (compound annual growth rate). Data visualisation ethics: data privacy, bias, reproducibility, communicating results to technical and non-technical audience.

Suggested Readings

Textbooks

- ✓ Kumar, U. D. (2017). Business Analytics: The Science of Data-Driven Decision Making Wiley India
- ✓ Gupta, S. P. (2022). Statistics for Economics. Sultan Chand & Sons.

References

- ✓ C.R. Kothari – Research Methodology: Methods and Techniques
- ✓ Maheshwari, A. (2017). Data Analytics: The Science of Data Analytics Made Accessible. McGraw Hill Education (India).
- ✓ Wheelan, C. (2021). Naked Statistics: Stripping the Dread from the Data (Updated Edition). W. W. Norton & Company.
- ✓ Hyndman, R. J., & Athanasopoulos, G. (2021). Forecasting: Principles and Practice (3rd ed.). OTexts

2.4 Excel Application in Data Analytics

Course Description

Microsoft excel course is a versatile tool for data analytics. It facilitates students in developing practical's skills with data sets using formulas, functions, and data validation techniques. Excel is extensively used for data analysis in economics, social sciences, research and helps in developing advanced analytics tools and techniques.

Course Outcomes

- It introduces students to Microsoft excel as a tool for Data Management and analysis
- It develops the ability to organise preprocess data using excel: its functions and features
- Equip and enable students to create data visualization, dashboard for decision making
- Promotes critical thinking and problem-solving skills through hands on exercise and case studies

Unit 1: Introduction to MS Excel and Data Entry

Overview of Spreadsheet Applications, Features of Microsoft Excel, Excel Interface and Navigation, Workbook, Worksheet, Rows, Columns, and Cells, Creating, Saving, and Opening Files, Entering and Editing Data, Cell Formatting, Number Formats for Economic Data, Tables and Borders, Conditional Formatting

Unit 2: Charts and Graphical Representation and Managing Economic Data

Line Charts, Bar Charts, Pie Charts, Combo Charts, Sparklines and Dashboards, Sorting and Filtering, Data Validation, Removing Duplicates, Importing CSV and External Data, Organizing Economic Datasets, Creating PivotTables, Pivot Charts

Unit 3: Descriptive Statistics and Formulas in Excel

Mean, Median, and Mode, Variance and Standard Deviation, Correlation Analysis, Frequency Distribution, Histograms, Arithmetic Operations, Cell References (Relative and Absolute), SUM, AVERAGE, COUNT, MIN, MAX, IF and Logical Functions, Percentage Calculations

Unit 4: Economic and Financial Calculations

Growth Rate Analysis, Inflation Rate Calculation, Compound Growth, Index Numbers, Trend Analysis, Trend Lines, Moving Averages, Forecast Sheet, Scenario Analysis, Introduction to Regression Analysis, Interpreting Regression Output, Formatting Reports, Exporting and Printing Reports

Practical Work

1. Calculate GDP growth rates
2. Compute inflation percentages
3. Analyze household consumption expenditure
4. Prepare a GDP dataset, Format inflation and unemployment tables, Import and clean economic data
5. Create inflation trend charts
6. Analyze wage distribution
7. Compare regional unemployment data
8. Regional GDP analysis using PivotTables
9. Forecast inflation trends
10. Analyze relationship between income and consumption

Key Formulae

- $\text{Growth Rate} = ((\text{Current Value} - \text{Previous Value}) / \text{Previous Value}) \times 100$

- $FV = PV(1 + r)^n$
- Variance: $s^2 = \Sigma(x_i - \bar{x})^2 / (n - 1)$
- Linear Regression: $y = a + bx$

Suggested Practical Project

- Inflation Analysis of India
- GDP Growth Comparison
- Unemployment Trend Analysis
- Trade and Export Dashboard
- Household Consumption Survey Analysis

Suggested References

- ✓ *Excel Data Analysis for Dummies* by Stephen McDaniel
- ✓ *Microsoft Excel Training*: <https://support.microsoft.com/excel>
- ✓ *World Bank Data Portal*: <https://data.worldbank.org>

Semester-IV

1.13 Microeconomics II

Course Description

This course is a sequel to Microeconomics I. The emphasis will be on giving conceptual clarity to the student coupled with the use of mathematical tools and reasoning. It covers the Market, general equilibrium and welfare, imperfect markets, and topics under information economics.

Course Outcomes:

- To understand short-run and long-run supply decisions of a competitive firm & industry equilibrium
- To have a basic understanding of concepts of Pareto efficiency in consumption & production; general equilibrium, and welfare theorems
- To develop an understanding of imperfect markets such as Oligopoly
- To understand basic concepts of game theory.

Unit I: Firm Supply and Equilibrium

Supply decision of a competitive firm and Exceptions; Inverse Supply Function; Profits and Producer's Surplus; Long Run Supply Curve of a Firm; Long Run Average Costs; Short Run and Long Run Industry Supply; Industry Equilibrium in Short and Long Run; Meaning of Zero Profits; Economic Rent

LO: Upon completion of this module, students will understand the short-run and long-run supply decisions of a competitive firm and the concept of industry equilibrium; and gain an idea about long-run average costs, zero profit, and economic rent

Unit II: General Equilibrium, Efficiency and Welfare

The Edgeworth Box; Trade; Pareto Efficient Allocations; Existence, Stability and Uniqueness of equilibrium; Walras Law; The Welfare Theorems and their implications; The Firm; Production and the Welfare Theorems; Production possibilities, comparative advantage and Pareto efficiency

LO: This module shall help to understand concepts like Pareto efficiency, and general equilibrium in consumption and learn welfare theorems, comparative advantage, production possibilities, and general equilibrium in production

Unit III: Market Imperfections: Monopoly and Monopolistic Competition

Barriers to Entry, Profit Maximization and Output Choice, Monopoly and resource Allocation, Price Discrimination, Degrees of Price Discrimination, Regulation of Monopoly, Dynamic Views of Monopoly. Monopolistic competition – product differentiation, Selling costs and excess capacity

LO: This module shall aid in understanding the nature of monopoly markets and the role of barriers to entry and explain price discrimination; and to explain features of monopolistic competition and the question of economic inefficiency in equilibrium

Unit IV: Oligopoly and Game Theory

Non-collusive oligopoly models: Cournot, Bertrand, Stackelberg, Sweezy, Chamberlin, Collusive oligopoly models: Cartels, Price leadership. The Payoff Matrix of a Game; Nash Equilibrium, Pure and Mixed Strategies, The Prisoner's Dilemma, Repeated Games, Tit-for tat strategy, Enforcing a cartel, Sequential Games, A Game of entry deterrence

LO: Upon completion of this module, students will be able to understand and explain the features of oligopoly and learn different models thereof; and the meaning and use of game theory in oligopoly; understand concepts like Nash equilibrium and different types of games, especially Prisoner's dilemma.

Textbook:

- ✓ *H. R. Varian (2010): Intermediate Microeconomics: A Modern Approach, 8th Edition,*
- ✓ *W.W. Norton and Company/Affiliated East-West Press (India). The workbook by Varian and Bergstrom may be used for problems.*
- ✓ *Koutsoyiannis, A (1979): Modern Microeconomics, 2nd Ed, ELBS/Macmillan*

Reference Book:

- ✓ *C. Snyder and W. Nicholson (2012): Microeconomic Theory: Basic Principles and Extensions, 11th Edition, Cengage Learning, Delhi, India.*
- ✓ *Robert S. Pindyck and Daniel Rubinfeld: Microeconomics, 8th Edition, Pearson*
- ✓ *H. L. Ahuja (2018): Advanced Economic Theory. Twenty-First Edition, Sultan Chand Publication*

1.14 Macroeconomics II

Course Description

This paper deals with growth models and the classical school of thought, and its evolution into Keynesian economics. The students are introduced to long-run dynamics in growth and technical progress. This paper also familiarizes about the open economy and its dynamics.

Course Outcomes:

- To emphasize on conceptual understanding and some applications of important growth models.
- To enable critical appreciation of the classical school of thought and the evolution of Keynesian economics.
- To understand the theoretical underpinnings of economic policy in open economies, such as monetary and fiscal policy, the basic Mundell-Fleming model, and nominal and real exchange rate determination.
- To understand the trade-off between Unemployment and Inflation; get a critical understanding of Long-run and Short-run Phillips Curve, unemployment, and Expectations.

Unit I: Economic growth model:

Accumulation of capital in the basic Solow model; supply and demand for goods, growth in the capital stock and the steady state, Golden rule level of capital, comparing steady states, transition to the golden rule steady state with too much and too little capital, population growth technological progress – Solow version

LO: *The module shall enable the students to get conceptual clarity and strengthen theoretical foundations of the Solow growth model*

Unit II: Classical and Keynesian Macroeconomic thought

Classical macroeconomics, Employment and output determination: Say's law; the quantity theory of money, Keynes General theory: Keynes main propositions, Analysis of the labour market, Keynes critique of Says law and Quantity Theory of Money, the orthodox Keynesian school, underemployment equilibrium in the Keynesian model.

LO: *This module shall help students in developing a clear, comprehensive understanding of how and in what ways the Classical and Keynesian schools of economic thought differ from each other.*

Unit III: Open Economy and Macroeconomic policies

Balance of payments –concepts, meaning of equilibrium and disequilibrium in Balance of payments measures to correct disequilibrium. Determination of foreign exchange rate- the balance of payments theory, fixed versus flexible exchange rate; the short run open economy model: The basic Mundell-Fleming model: Macroeconomic policies – Fiscal policy - Crowding-out and Crowding-in; Monetary policy and instruments, the Transmission Mechanism, Effectiveness of macroeconomic policies in the open and closed economies.

LO: *This module will enable students to get clarity on macroeconomic theories and models in the context of open economies, the interdependent nature of key macroeconomic variables,*

sectors, and markets, and the dynamics of responses to exogenous domestic and international economic shocks

Unit IV: Inflation, Unemployment and Expectations

Inflation – Unemployment trade-off and the Phillips curve – short run and long run analysis, Adaptive and Rational expectation hypothesis. The policy ineffectiveness debate. Phillips curve and orthodox Keynesian school. Solow and Tobin's modified Philips curve.

LO: Upon completion of this module, students shall be able to derive the Phillips Curve from the Aggregate Supply Curve, the short-run and long-run Phillips curve, and understand the role of adaptive expectations and rationale expectations.

Text Readings:

- ✓ *Richard T. Froyen (2005): Macroeconomics, 2nd Edition, Pearson Education Asia, New Delhi.*
- ✓ *N. Gregory Mankiw (2010): Macroeconomics, 7th edition, Cengage Learning India Private Limited, New Delhi.*

Suggested References:

- ✓ *Levacic R and Rebmman A (1982): Macroeconomics –An introduction to Keynesian – neoclassical controversies*
- ✓ *Edward Shapiro (2001): Macroeconomics Analysis- Galgotia Publication Private Limited, 5th Edition, New Delhi.*
- ✓ *Dwivedi, D. N. (2018): Macroeconomics -Theory and Policy. 5th Edition, Tata McGraw Hill.*
- ✓ *Blanchard, O. (2013): Macroeconomics. 7th edition, Pearson Edn*

1.15 Environmental Economics

Course Description

This course introduces the students to the basics of environmental economics to understand the fundamentals of environmental concerns and develop insights into valuation of environment.

Course Outcomes:

- To understand the basic concepts/principles of Environmental Economics
- To be able to analyse and apply the concepts to understand specific case studies.
- To develop insights into the valuation of the environment.
- To become capable to execute/create the Project or field assignment as per the knowledge gained in the course.

Unit I: Economy and Environment

Concepts of Environmental Economics, Natural Resource Economics, and Ecological Economics. Important environmental Problems (Air pollution, water pollution, deforestation, climate change and global warming), Economy-Environment inter-linkages, Role of environment for economic development, Effect of economic development (industrialization, urbanisation, modernization of agriculture) on environment, Consequences of environmental degradation on the economy and the wellbeing of the people and other living beings, concept of Environment-Kuznets Curve hypothesis.

LO: This module will aid in acquiring knowledge of the concepts related to Environmental Economics and in understanding the Environment-Economy interlinkage.

Unit II: The Economics of Pollution and Climate change

Environment and Market Failure, Nature of environment quality (Non-rivalry and non-excludability), Pollution as public bad, Pollution as negative externality. Pigouvian tax for optimal pollution, Property rights and bargaining for optimal pollution (Coase Theorem), Government's Command and Control method for controlling pollution. Climate change as market failure (Greenhouse gas externality, lack of incentives for developing low carbon technology), policy measures for mitigations of climate change (carbon taxes and tradable carbon rights).

LO: This module will be useful for the students in understanding the nature of pollution and getting knowledge of pollution control and climate change mitigating tools.

Unit III: Valuation of Environment

Difficulties of valuation of eco-system services, Concepts of Economic value of environment (Use and non-use value, Option value, Existence value); Willingness to pay (WTP) and willingness to accept (WTA) compensation for improvement/deterioration of environment quality, Revealed Preference Method of valuation of environment (The hedonic price approach, Travel Cost approach) Contingent Valuation method.

LO: Upon completion of this module, the learner shall gain knowledge of the different methods of valuing environmental services.

Unit IV: Natural Resources and Sustainable Development

Natural resources; renewable and exhaustible; management of exhaustible resources and the Hotelling's rule; management of renewable resources (case of fishery only) optimally, Concept of carrying capacity of Environment (related to resource use and pollution), Issues of irreversibility, uncertainty in the natural resource use and waste disposal, Sustainable Development: Concepts and Components (Social, Economic and Environmental), Daly's operational principles for sustainability, Sustainable Development Goals (SDGs).

LO: This module shall initiate an understanding of the limits of the use of natural resources from the point of view of their sustainability and Sustainable development.

Textbook:

- ✓ *Bhattacharya, R. N. (2002): Environmental Economics: An Indian Perspectives, OUP, New Delhi*

Reference Book:

- ✓ *Kolstad, C.D (1999): Environmental Economics. Oxford University Press, New Delhi*

Course objectives

- Understand the fundamentals of R programming and its application in economic and social science data analysis.
- Develop skills for importing, cleaning, transforming, and managing datasets obtained from surveys, government reports, and economic databases.
- Apply descriptive statistical techniques and data visualization methods to explore and interpret economic and social data.

Course outcomes

- Demonstrate proficiency in basic R programming concepts, including data types, control structures, functions, and data structures for handling economic datasets.
- Import, clean, organize, and transform data from various sources using R and Tidyverse packages to prepare datasets for analysis.
- Apply descriptive statistics and probability concepts to summarize and interpret economic and demographic data.
- Create effective visualizations using ggplot2 and other R tools to communicate patterns, trends, and relationships in economic data.

Course Content

Unit I: Foundation of R Programming(15 Hours)

Introduction to R and RStudio, Installing and Setting Up R, Variables and Data Types, Operators and Expressions, Control Structures and Functions, Vectors, Lists, and Data Frames

Practical Activities: Writing simple R scripts, Basic arithmetic and statistical calculations, Creating and manipulating vectors

Unit II: Data Manipulation and Cleaning in R (15 Hours)

Importing Data from CSV and Excel Files, Introduction to Tidyverse, Data Frames and Tibbles, Data Cleaning Techniques, Handling Missing Values, Filtering, Sorting, and Transforming Data

Practical Activities: Cleaning survey datasets, Transforming economic and social datasets

Unit III: Data Visualization and Statistical Analysis (15 Hours)

Interpreting Statistical Results: Descriptive Statistics, Probability Distribution, Hypothesis Testing, Data Visualisation with ggplot2, creating histograms, boxplots, scatterplots

Practical Activities: Analyzing demographic datasets, Visualizing trends and distributions, Comparing datasets using graphs

Unit IV: Applied Data Analysis and Reporting (15 Hours)

Correlation and Regression Analysis, Introduction to Predictive Modeling, Time Series Analysis Basics, Creating Reports with R Markdown, Introduction to Reproducible Research

Practical Activities: Regression analysis using real-world data, Forecasting trends using time series

Suggested Readings

- ✓ *R for Data Science*
- ✓ *An Introduction to Statistical Learning with Applications in R*
- ✓ *Using R for Introductory Statistics*
- ✓ *Practical Statistics for Data Scientists*

Major II

Credit 04

2.6 Data Analytics using Python

Course Objectives

This course introduces students to Python-based data analytics with applications in economics and social sciences. Upon completion of the course, students will be able to:

- Understand the fundamentals of Python programming and data handling.
- Perform data cleaning, preprocessing, and transformation using Python.
- Apply data visualization and exploratory data analysis techniques to economic datasets.
- Conduct statistical inference and hypothesis testing using Python.

Course Learning Outcomes

After successful completion of the course, students will be able to:

- Import, clean, manage, and manipulate large datasets using Python.
- Create effective visualizations and perform exploratory data analysis to identify patterns and relationships.
- Develop, evaluate, and interpret regression and classification models.
- Use time-series techniques to analyse trends and generate forecasts.

Course Content

Unit I: Fundamentals (15 Hours)

Introduction to Data Analytics, Python Basics, NumPy and Pandas, Data Import and Export, Data Cleaning
Handling missing values

Unit II: Statistics and Visualization (15 Hours)

Applications of Central Tendency and dispersion, Histograms, Boxplots, Scatterplots, Correlation Analysis and Interpretation

Unit III: Applied Analytics (15 Hours)

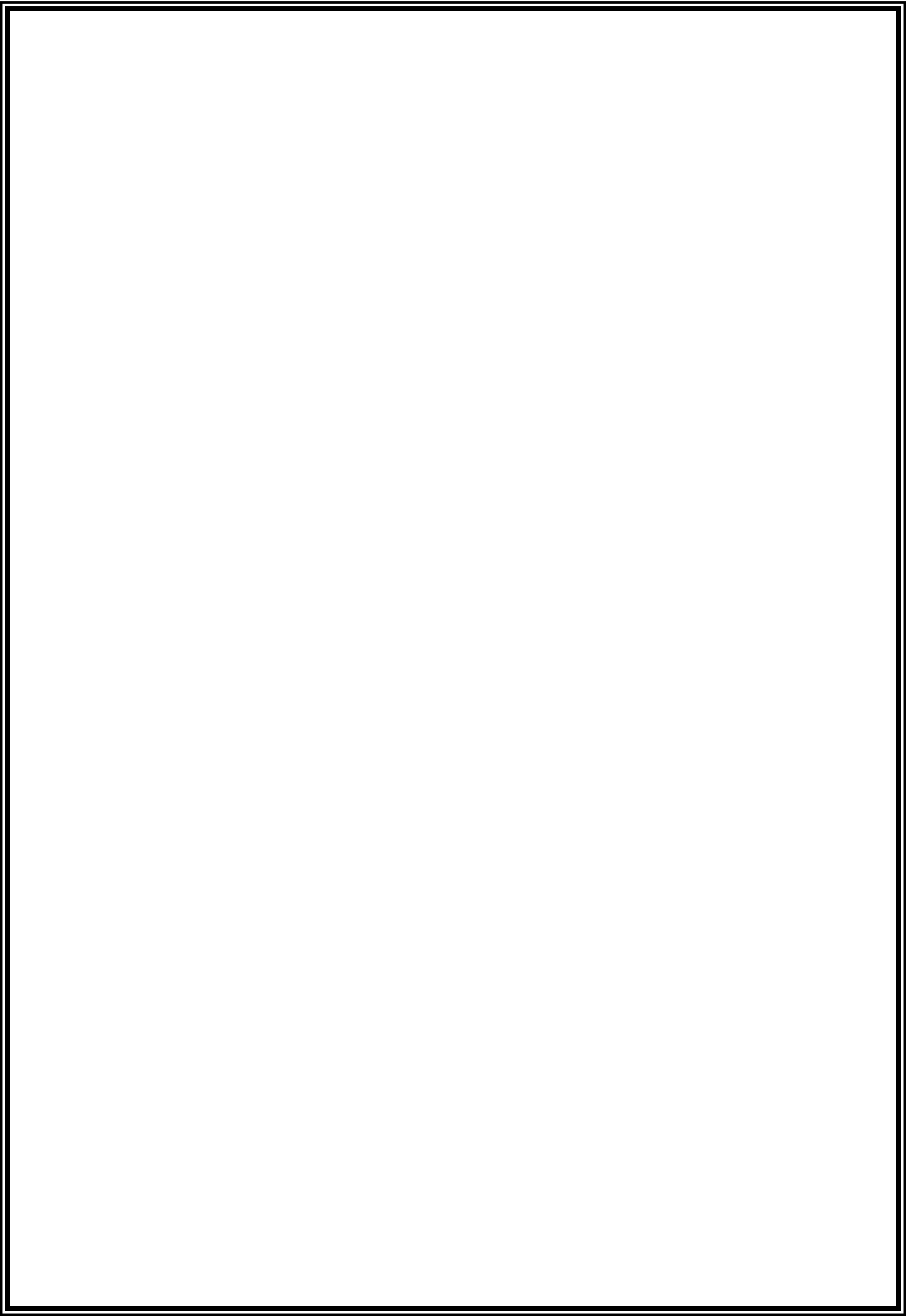
Hypothesis Testing, Chi-square Test, Simple Linear Regression, Logistic Regression, Case Studies from Census/Education/Economics

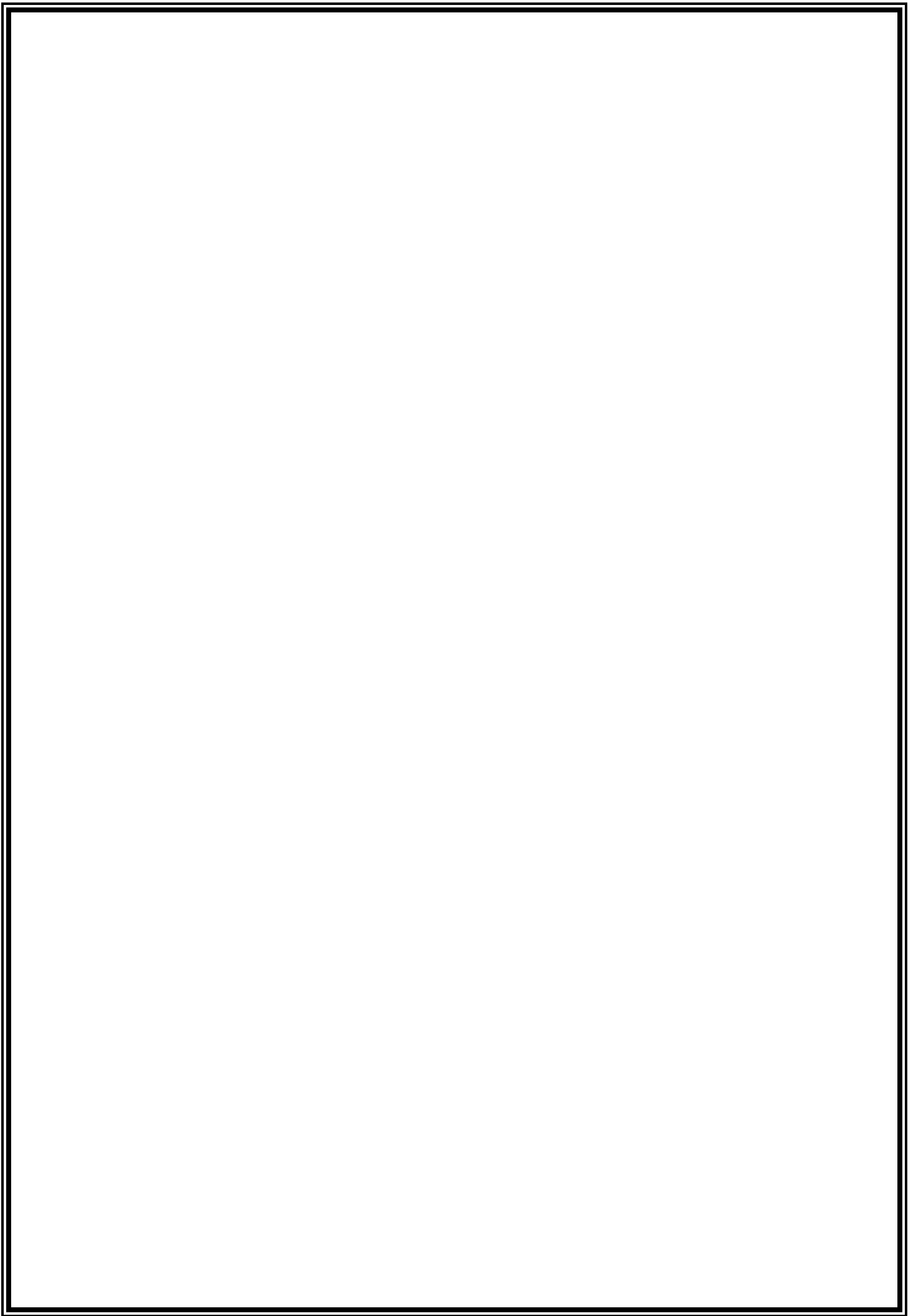
Unit IV: Time Series Analysis and Forecasting (15 Hours)

Time Series Analysis, Moving Averages, Exponential Smoothing, Introduction to Machine Learning, Data Ethics and Privacy

Suggested Readings

- ✓ McKinney, W. (2022). *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter* (3rd ed.). O'Reilly Media.
- ✓ Swaroop, C. H. (2016). *A Byte of Python*. Self-published.
- ✓ Black, K. (2019). *Business Statistics for Contemporary Decision Making* (10th ed.). Wiley.
- ✓ VanderPlas, J. (2016). *Python Data Science Handbook*. O'Reilly Media.
- ✓ Géron, A. (2022). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (3rd ed.). O'Reilly Media.





**Draft Model Curriculum for 3yr./4yr. Degree Course with
Apprenticeship Embedded Degree program**

**B.A. in English with Double Major in Translation &
Digital Humanities**



**Higher Education
Department**
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Introduction to Literary Studies	4
	MJ -1.2	British Poetry and Drama (14 th to 16 th c.)	4
	MJ -1.3	Introduction to Indian Writing in English	4
	MJ- 1.4	Introduction to Language and Linguistics	4
	MJ -2.1	Academic and Professional Writing	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	British Poetry and Drama (17 and 18 century) Indian Classical Literature	4
	MJ 1.6	British Prose (18 Century)	4
	MJ 1.7	Literary Criticism from Plato to Leavis	4
	MJ- 1.8	Literatures from the World-I	4
	MJ 2.2	Translation and Applied Language Practices	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / or any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	The Romantic Revival and English Literature of the Period	4
	MJ 1.10	The Victorian Era	4
	MJ 1.11	Modern English Literature (20th Century)	4
	MJ- 1.12	Indian Myths and Epics: New Perspectives	4
	MJ 2.3	Digitisation, Archiving, and Documentation Practices	4
	MJ -2.4	Public Humanities and Cultural Documentation (Focus: Odisha)	4

	MDC (Multidisciplinary Course)	English / or any other discipline	3
	SEC (Skill Enhancement Course)	English / or any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	European Classical Literature	4
	MJ- 1.14	Indian Classical Literature	4
	MJ- 1.15	Women’s Writings	4
	MJ -2.5	Text Analysis and Computing	4
	MJ -2.6	Digital Culture and Public Communication	4
	MDC (Multidisciplinary Course)	English /or any other discipline	3
	SEC (Skill Enhancement Course)	English /or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20
TOTAL			150

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Semester I

1.1 Introduction to Literary Studies

Course Objectives

- The course “An Introduction to Literary Studies” deals with questions concerning the nature of literature
- It will provide an understanding of the major literary genres and it gives an overview of the formation of the same.
- This beginner’s course has been designed for students who have opted for a major in English and it will benefit students with a general introduction to literature as well as induce them for a more serious pursuit going ahead in this programme.
- The course will enable students to improve their proficiency through reading, respond to texts, draw lessons and insights from those, understand and appreciate other cultures and relate to events, characters and their own lives.
- It will also to expose students to models of good writing.
- It will develop the potential of students in a holistic, balanced and integrated manner encompassing the intellectual, spiritual, emotional and physical aspects in order to create a balanced and harmonious human being with high social standards.

Unit-1

What is literature? Literature and Society, Literature and Life, Literature and Science, the literary canon, genre, literary theory and criticism

Poetry: Lyric, Sonnet, Ballad, Ode, Elegy, Epic, Mock-Epic, Dramatic monologue

Prose: Novel, Novella, Short Story, Essay, Biography, Autobiography

Drama: Comedy, Tragedy, Tragi-comedy, one act-play, Epic play

Unit-2

Poems to be read: Sonnet no 130 by William Shakespeare, ‘The Skylark’ by P B Shelley, ‘At Spring Time’ by John Keats, ‘The Brook’ by Lord Alfred Tennyson, “Because I could not stop for death” by Emily Dickinson, “Village Song” by Sarojini Naidu, “Love After Love” by Derek Walcott

Unit-3

Prose to be read: “The Bet” by Anton Chekhov, “The Verger” by Somerset Maugham, “The Fight between Leopards” by Jim Corbett, “The Night the Tiger came” by Manoj Das, “The Bicycle” by Dash Benhur, “The Man who Knew Too Much” by Alexander Baron, “The way to Equal Distribution” by Mahatma Gandhi, “A Call to Youth” by S. Radhakrishnan and “Miseries of the Rich” by G B Shaw

Unit-4

Drama to be read: *Doctor Faustus* by Christopher Marlowe Act-5, Scene-2, or *As You Like It* by William Shakespeare, Act-II, Scene-VII, (Forest of Arden scene), *Ghasiram Kotwal* (Act-I) by Vijay Tendulkar or One Act play *The Bear* by J.B. Priestly.

The teacher is supposed to acquaint the learners with the difference in tone, language and setting between a comedy, a tragedy and a tragi-comedy.

Prescribed Texts

Hillis Miller, "What Is Literature?" (Canvas); *The Norton Introduction to Literature*, Introduction (1-13)

"What is literature?" by Terry Eagleton in *An Introduction to Literary Theory* Blackwell Publication 1983, 1996

The Widening Arc: A Selection of Prose and Stories, Ed. Asima Ranjan Parhi, S Deepika, Pulastya Jani, Kitab Bhavan, Bhubaneswar, 2016.

"The Art of Fiction" by Henry James (available on the internet archive)

Melodious Songs and Memorable Tales, Gyanajuga, 2015.

Suggested Readings

- ✓ Kennedy, X.J. and Dana Gioia. *Literature: An Introduction to Fiction, Poetry, and Drama*. 11th ed. Portable ed. New York: Longman, 2009.
- ✓ Gardner, Janet E. et al ed. *Literature: A Portable Anthology*, 2nd ed. Bedford/St. Martin's, 2009. ISBN: 978-0-312-46186-7
- ✓ Shelley, Mary. *Frankenstein (Case Studies in Contemporary Criticism)*. Ed. Johanna M. Smith. Bedford/St. Martin's, 2000. ISBN: 978-0-312-19126-9
- ✓ Mays, Kelly J. *The Norton Introduction to Literature, Portable 13th Edition*. ISBN: 978-0-393-42046-3
- ✓ Miller, Hillis. "What Is Literature?" (Canvas); *The Norton Introduction to Literature*, Introduction (1-13)
- ✓ Forster, E. M. *Aspects of the Novel*
- ✓ <https://archive.org/stream/in.ernet.dli.2015.136479/2015.136479>.
- ✓ <https://www.thereader.org.uk/featured-poem-the-brook-by-alfred-lord-tennyson/>
- ✓ https://archive.org/stream/georgebernardsh00hendgoog/georgebernardsh00hendgoog_djvu.txt
- ✓ https://archive.org/stream/in.ernet.dli.2015.136479/2015.136479.The-Works-Of-J-B-Priestley_djvu.txt

1.2 British Poetry and Drama (14TH to 16th C.)

Course Objectives

- The course seeks to provide the students a historical background of the literature of the time.
- It aims to introduce to the students British poetry and drama from the 14th to the 17th centuries.
- It aims to offer the students an exploration of certain seminal texts that set the course of British poetry and plays.

Unit-1

A historical overview

The period is remarkable in many ways. 14th century poetry evokes an unmistakable sense of “modern” and the spirit of Renaissance is marked in the Elizabethan Drama. The Reformation brings about sweeping changes in religion and politics. A period of expansion of horizons; both intellectual and geographical.

Unit-2

Chaucer: “The Wife of Bath’s Tale”

Or

“Sir Gawain and the Green Knight” (Part 1, lines 1-490)

Unit-3

Thomas Campion: “Follow Thy Fair Sun, Unhappy Shadow”, Sir Philip Sidney: “Leave, O Love, which reachest but to dust”, Edmund Waller: “Go, lovely Rose”, Ben Jonson: “Song to Celia”, William Shakespeare: Sonnets: “Shall I compare thee to a summer’s day?”, “When to the seasons of sweet silent thought”, “Let me not to the marriage of true minds.”

Unit-4

William Shakespeare: *Macbeth* or *Twelfth Night*.

Marlowe: *The Jew of Malta* or Thomas Dekker: *The Shoemaker’s Holiday*

Prescribed Texts

The Short Oxford History of English Literature by Andrews Sanders. Oxford: OUP

Weller Series: *Macbeth & Twelfth Night*

The Jew of Malta by Christopher Marlowe

The Shoemaker’s Holiday by Thomas Dekker

Seventeenth-Century British Poetry, 1603-1660 edited by Rumrich and Chaplin. A Norton Critical Edition

The Broadview Anthology of Sixteenth-Century Poetry and Prose. Edited by Marie Loughlin; Sandra Bell; Patricia Brace

All prescribed pieces are available as digital copies at internet archive. www.archive.org

Suggested Readings

- ✓ *A History of English Literature: Traversing Centuries* by Chaudhury & Goswami. Orient Blackswan
- ✓ *Shakespeare: The Invention of the Human* by Harold Bloom
- ✓ 'Madness as Method: A Study of Shakespearean Tragic Hero', *Atlantic Critical Review*, Ed. Mohit K. Roy, Delhi,, Vol. 5, No.2, April-June 2006, pp.1-10.

- ✓ *Marlowe: A Critical Study* by J. B. Steane. Cambridge University Press
- ✓ *Critical Essays on Christopher Marlowe* by Emily Carroll Bartels. G.K. Hall

1.3 Introduction to Indian Writing in English**Course Objectives**

- The objective of this course is to give the students an understanding of the evolution of Indian Writing in English and appreciate its literature from the period of western colonization to the twenty-first century.
- It aims to introduce students to major movements and figures of Indian Literature in English through the study of selected literary texts, to create literary sensibility and emotional response to the literary texts and to implant a sense of appreciation of literary text.
- This course aims to expose students to the artistic and innovative use of language employed by the writers and to instill values and develop human concern in students through exposure to literary texts.

Unit-1

- “Our Casuarina Tree” by Toru Dutt
- “Coromandel Fishers” by Sarojini Naidu
- “Night of the Scorpion” by Nissim Ezekiel
- “Introduction” by Kamala Das
- “The Bus” by Arun Kolatkar
- “The Frog and the Nightingale” by Vikram Seth
- “Her Garden” by Meena Alexander
- “Narcissus” by Easterine Kire

Unit-2

- “The Secret of Work” by Swami Vivekananda
- “India and Greece” & “The Old Indian Theatre” by Jawaharlal Nehru (Selection from The Discovery of India)
- “Religion in a Changing World” by Dr. S. Radhakrishnan (Religion, Science and Culture)
- Passages from *The Autobiography of an Unknown Indian* by Nirad C. Chaudhuri
(*Picador Book of Modern Indian Literature* by Amit Chaudhuri)

Unit-3

- *Final Solutions* by Mahesh Dattani
Or
- *Silence: The Court* by Vijay Tendulkar

Unit-4

- Under the Banyan Tree by R.K Narayan
- The Little Gram Shop by Raja Rao
- The Night Train at Deoli by Ruskin Bond
- Unaccustomed Earth by Jhumpa Lahiri

Prescribed Texts

- ✓ *A Clutch of Indian Masterpieces: Extraordinary Short Stories from the 19th Century to the Present* edited by David Davidar
- ✓ *Interminable Tales: The Short Stories*. Published online by Cambridge University Press
- ✓ *The Golden Treasury of Indo-Anglian Poetry* by Gokak V.K, Sahitya Akademi, 2006
- ✓ *The Oxford India Anthology of Modern Indian Poets* by A. Mehrotra. OUP, 1993
- ✓ *Contemporary Indian Poetry in English*, Salem Peeradina, Macmillan 1972
- ✓ *The Discovery of India*, Jawaharlal Nehru, 1946
- ✓ *Karma Yoga* by Vivekananda, Advaita Ashrama Publication, 2012
- ✓ *Religion, Science and Culture* by Radhakrishnan, Orient Paperback

Suggested Readings

- ✓ Picador Book of Modern Indian Literature. Amit Chaudhuri, 2001
- ✓ *A Clutch of Indian Masterpieces* by David Davidar, Aleph Books, 2016
- ✓ Lahiri, Jhumpa, *Unaccustomed Earth*, Random House India, 2008
- ✓ *Collected Plays* by Mahesh Dattani, Penguin, India.

1.4 Introduction to Language and Linguistics

Course Objectives

- The course aims to familiarise students with the subject of linguistics and prepares them for further in-depth study of language-related issues.
- It will provide students an idea of language evolution, structure, and the way it functions.
- It aims to develop in the students the knowledge of linguistic sign, language structure, correlation of lingual and mental processes, language and speech, the structure of language, types of language units, systems of writing, linguistic diversity, etc.

Unit-1

- Language and Human Language
- Language and Society
- Nature and features of Human language; language and human communication; differences from other forms of communications
- Artificial intelligence and human language

Unit-2

- Linguistics and Language
- What is linguistics; development in the history of linguistic studies
- Contribution of linguistics to other areas of human inquiry
- Linguistics for jobs

Unit-3

- Phonetics and accuracy in pronunciation
- IPA
- Stress and Intonation
- Morphology

Unit-4

- Word formation processes
- Nature of sentences and connected texts
- Syntax and discourse
- Language and meaning: semantics

Prescribed Texts

An Introductory Text Book on Linguistics and Phonetics by R L Varshney

Global Englishes: A Resource Book for Students by Jennifer Jenkins, 3rd Edn, Special

Indian Edition, Routledge, 2016

An Introduction to Language and Communication by Ekmajian et al

Indian English through Newspapers, Concept Publishing Company, New Delhi, 2008 by A R Parhi

Suggested Readings

- ✓ Linguistics by David Crystal
- ✓ “Localising the Alien: Newspaper English and the Indian Classroom”, Asima Ranjan Parhi, English Studies in India, Springer, 2018. E Book-ISBN-978-981-13-1525-1.
- ✓ The Indianization of English (OUP) by Braj B Kachru
- ✓ Communicative Competence by Tanutrushna Panigrahi. Notion Press Publishing, India, Malaysia and Singapore

- ✓ David Crystal, English as a World Language
- ✓ A Course in Linguistics by Tarni Prasad. PHI
- ✓ Linguistics: A Very Short Introduction by P H Mathews. OUP

Students may be encouraged to refer to online resources

2.1 Academic and Professional Writing**Course Objectives (CO)**

- Identify and apply conventions of academic writing, citation, and ethical research communication.
- Produce professional documents i.e. emails, reports, minutes, and institutional texts.
- Develop content for digital platforms, public communication, and cultural institutions.
- Analyse and create media texts like news reports, reviews, interviews, and basic scripts.
- Assemble a professional communication portfolio demonstrating workplace and public writing competencies.

UNIT 1: Academic Writing Practices

- Features of academic writing: Formality, Objectivity, Evidence-Based, Structure and Organisation, Fallacies, Precision, Critical Thinking and Hedging
- Citation and referencing: APA, MLA, Chicago Style Manual, and IEEE Style Sheets (Latest Editions)
- Summarising and paraphrasing: Comprehension and sentence restructuring techniques
- Writing for research and institutions: Research Paper, Academic Proposal and Report, and White Paper

UNIT 2: Professional Communication

- Workplace communication: Operational clarity, project alignment, professional relationship building, and feedback
- Email and official correspondence: Formal Letters, Memo, Notice and Circular
- Official report writing, agenda and minutes
- Communication ethics: Factual accuracy, valuing diverse perspectives, and protecting proprietary information

UNIT 3: Content Development and Digital Writing

- Writing for websites and digital platforms: Company and brand messaging, product and service highlights, educational contents, blog posts/press release, and customer success stories
- Educational content preparation: Audience profile and need assessment, content structuring, format selection, search engine optimisation, and choice of language
- Public communication writing: Public announcements, campaigns, information about public policies, and CSR write-ups
- Writing for cultural institutions: Digital storytelling, interactive promptings, community outreach and advocacy

UNIT 4: Media and Journalistic Writing

- News and feature writing: Choice of a topic, structure and length, 5Ws and 1H, ABC, language and style, sourcing and credibility, and editorial decision-making
- Review writing and Interview writing: Pre, while and post-writing activities, structuring, attempts to explain with reference to fact and opinion
- Literary and cultural reporting: Factual reporting, thematic focus, immersive storytelling techniques, perspectives and voice
- Introduction to script writing for film, documentary, and digital media

Practical Components

- Preparation of communication portfolio (consisting of: one formal email, one institutional report, one feature article or review, one digital content piece for a website or social media platform, and a short script (3–5 pages) for a documentary film, interview-based video, or cultural short film based on a local theme, institution, festival, or community practice.
- Institutional writing exercises (such as: drafting notices and press releases, preparing event reports, documenting public lectures, writing cultural programme summaries, and preparing content for newsletters or institutional websites).

Students may undertake guided study visits and short observational assignments at nearby establishments such as:

- local newspaper offices,
- publication and printing units,
- media houses,
- community radio stations,
- film or documentary production groups,
- literary and cultural organisations,
- district information offices,
- university publication cells,
- or communication and documentation units of public institutions.

These visits may be linked to apprenticeship exposure in areas such as:

- publishing and editorial assistance,
- media communication,
- cultural reporting,
- institutional documentation,
- digital content development,
- public communication,
- and introductory script preparation for documentary and digital media production.

Learning Outcomes

- Demonstrate proficiency in academic writing conventions, including structure, tone, citation, and referencing.
- Produce clear, ethical, and effective professional communication such as emails, reports, minutes, and institutional documents.
- Develop content tailored for digital platforms, educational contexts, and public communication.
- Apply journalistic writing techniques in news, feature, review, interview, and cultural reporting.
- Create basic scripts for documentary, interview-based, and cultural digital media projects.
- Compile a professional communication portfolio integrating academic, institutional, media, and digital writing practices.
- Engage with real-world communication environments through guided study visits and apprenticeship-linked tasks.

Prescribed books

- 1) Belcher, W. L. (2019). *Writing your journal article in twelve weeks: A guide to academic publishing success* (2nd ed.). SAGE Publications.
- 2) Clark, R. P. (2006). *Writing tools: 50 essential strategies for every writer*. Little, Brown and Company.
- 3) Graff, G., & Birkenstein, C. (2021). *They say / I say: The moves that matter in academic writing* (5th ed.). W. W. Norton & Company.
- 4) Sanyal, J. (2006). *Indlish*. Viva Books.
- 5) Strunk Jr., W., & White, E. B. (2000). *The elements of style* (4th ed.). Longman.
- 6) Matt Swaine, H. Gilbert & Gavin Allen. (2022). *Writing for journalists*. (4th ed.). Routledge.

Learning Resources

- 1) “Soft Skills,” Prof. Binod Mishra, IIT Roorkee, NPTEL
- 2) “Developing Soft Skills and Personality,” Prof. T Ravichandran, IIT Kanpur, NPTEL
- 3) “Literature, Culture and Media,” Prof. Rashmi Gaur, IIT Roorkee, NPTEL
- 4) Film Appreciation, Prof. Aysha Viswamohan, IIT Madras, NPTEL
- 5) “Text, Textuality and Digital Media” by Arjun Gosh, IIT Delhi, NPTEL
- 6) “Effective Writing,” Prof. Binod Mishra, IIT Roorkee, NPTEL

Other online resources:

- 1) <https://writingit.fireside.fm/episodes> (podcast)
- 2) <https://ruralindiaonline.org/> (documentaries)
- 3) “Stylish Academic Writing” by Steven Pinker, <https://www.youtube.com/watch?v=IE-TTz13P7w> (FDP lecture)
- 4) “The Philosophy of Professional Writing: Brandon Sanderson’s Writing Lecture,” https://www.youtube.com/watch?v=MEUh_y1IFZY
- 5) “AI & Student Writing: Perils and Pedagogies” by Dr. Scott Graham, <https://www.youtube.com/watch?v=9cnfZ5n4ToE>
- 6) [Walking with Dan: Podcasting, Creativity, & AI](#)

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	● Communication, its Importance and Factors ● Types of Communication ● Verbal and Non-verbal Communication ● Styles of Communication
2	English Language and Communication: Listening and Speaking	● Types of Listening ● Speaking to communicate effectively ● Style of speaking in Various Situations ● English Pronunciation
3	English Language and Communication: Reading and Writing	● Reading methods and techniques. ● Reading texts to Understand meaning ● Writing Process ● Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	● Grammar ● Sentence structure ● Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)
2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lightning)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightning), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

- A. a) Environmental Ethics: Issues and possible solutions.
- b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
- c) Environment Protection Act
- d) Air (Preservation Control of Pollution) Act
- e) Water (Preservation Control of Pollution) Act
- f) Wildlife Protection Act
- g) Forest Conservation Act
- h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
- B. Human Population and the Environment
- Population Ecology: Individuals, species, population, community

Human population growth, population control method

Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester II

1.5 British Poetry and Drama (17th and 18th century)

Course Objectives

- The objective of this course is to acquaint students with the Jacobean and the 18th century British poetry and drama.
- It aims to familiarize students with the period of the acid satire and the comedy of humours.
- It will expose the students to the period of supreme satiric poetry and the comedy of manners.

Unit-1

John Milton: "Lycidas" or "L'Allegro and Il Penseroso"

John Donne: "A Nocturnal upon S. Lucie's Day", "Love's Deity"

Andrew Marvel: "To His Coy Mistress", "The Garden", "A Dialogue between the Soul and the Body"

Unit-2

Ben Jonson: *Volpone* or *The Alchemist*

Unit-3

Pope: "Ode on Solitude", "Summer", "Sound and Sense", "The Dying Christian to his Soul" Robert Burns: "A Red Red Rose", "A Fond Kiss", "A Winter Night", "My Heart's in the Highlands"

Unit-4

Dryden's *All for Love* or Congreve's *The Old Bachelor*

Prescribed Texts

- ✓ "Lycidas" by John Milton (Eds. Paul & Thomas), Orient Blackswan
- ✓ "L'Allegro and Il Penseroso" by John Milton (Eds. Paul & Thomas), Orient Blackswan
- ✓ *Seventeenth-Century Poetry: An Annotated Anthology* by Robert Cummings (Editor)
- ✓ *Ben Jonson: Volpone*
- ✓ *Ben Jonson: The Alchemist*
- ✓ *Dryden's All for Love*
- ✓ *Congreve's The Old Bachelor*
- ✓ *Selected Poetry: Alexander Pope. Edited with an Introduction and Notes by Pat Rogers. Oxford World's Classics*
- ✓ *Complete Poems and Songs of Robert Burns. by Robert Burns*

Suggested Readings

- ✓ A History of English Literature: Traversing the Centuries - Chowdhury & Goswami, Orient Black swan
- ✓ The Norton Anthology of English Literature, Vol. B: The Sixteenth Century & The Early Seventeenth Century
- ✓ The Norton Anthology of English Literature: The Restoration and the Eighteenth Century

1.6 British Prose (18 Century)

Course Objectives

- The objective of the paper is to acquaint the students with two remarkable forms of literature: Essay and novel.
- It will make the students aware of the shift of emphasis from reason to emotion in the literature of the period.
- It aims to expose students to the development of prose

Unit-1

Joseph Addison: "On Giving Advice", "Reflections in Westminster Abbey", "Defence and Happiness of Married Life"

Richard Steele: "Recollections", "On Long-Winded People"

Unit-2

Daniel Defoe: *Robinson Crusoe*

Unit-3

Oliver Goldsmith: "A City Night-Piece", "On National Prejudices", "Man in Black"

Samuel Johnson: "Expectations of Pleasure frustrated", "Domestic Greatness Unattainable", "Mischiefs of Good Company", "The Decay of Friendship"

Unit-4

Thomas Gray: "Elegy written in a country churchyard"

Prescribed Texts

- ✓ Readings in English Prose of the Eighteenth Century (Houghton Mifflin Company, 1911), by Raymond Macdonald Alden
- ✓ "Elegy written in a country churchyard" by Thomas Gray
- ✓ Robinson Crusoe by Daniel Defoe
- ✓ "A City Night-Piece", "On National Prejudices", "Man in Black" by Goldsmith
- ✓ "Expectations of Pleasure frustrated", "Domestic Greatness Unattainable", "Mischiefs of Good Company", "The Decay of Friendship" by Samuel Johnson
- ✓ The Macmillan Anthology of English Literature: The Restoration and Eighteenth Century. Edited by Ian McGowan.

Suggested Readings

- ✓ *A History of English Literature: Traversing the Centuries* - Chowdhury & Goswami, Orient Blackswan
- ✓ *The Norton Anthology of English Literature: The Restoration and the Eighteenth Century*
- ✓ *English Literature: William J. Long*

1.7 Literary Criticism from Plato to Leavis

Course Objectives

- This course seeks to introduce students to the tradition of Western Literary Criticism from Classical Antiquity to the Early Modern period.
- It aims to guide students through several centuries of critical writing.
- This paper is to be read in conjunction with a companion course in Literary theory in the following semester.

Unit-1

- Plato: *The Republic* (Book X)
OR
- Aristotle: *The Poetics* (Ch. 1, 2, 3, 4)

Unit-2

- Samuel Johnson: *Preface to Shakespeare*
OR
- S. T Coleridge: *Biographia Literaria* (Ch. 13 & 14)

Unit-3

- William Wordsworth: "*Preface*" to *Lyrical Ballads*
OR
- Matthew Arnold: "The Function of Criticism at the Present Time"

Unit-4

- T. S. Eliot: "To Criticize the Critic"
OR
- F. R. Leavis: "Under Which King, Bezonian?"

Prescribed Texts

- ✓ *Johns Hopkins Guide to Literary Theory and Criticism. Relevant chapters. Johns Hopkins University Press, US.*
- ✓ *Critical Approaches to Literature by David Daiches*
- ✓ *The Function of Criticism: From Spectator to Post-structuralism by Terry Eagleton (Chapter on Criticism from Norton Anthology)*

Suggested Readings

- ✓ *An Introduction to Literature, Criticism and Theory by Andrew Bennett and Nicholas Royle. Available online at <https://bookoblivion.com>*
- ✓ *The Norton Anthology of Theory and Criticism 2001, 2010 and 2018*
- ✓ *Literary Criticism: An Introduction to Theory and Practice by Charles E. Bressler*

1.8 Literatures from the World-I**Course Objectives**

- This paper proposes to introduce the students to the study of world literature through a representative selection of texts from around the world.
- It aims to read beyond the classic European canon by including defining literary texts from other major regions/countries, except the United States of America, written in languages other than English, but made available to the readers in English translation.
- It aims to provide students an idea of non-European canon in literary studies.

Unit-1

The idea of world literature: Scope, definition and debates Uses of reading world literature

Unit-2

- Albert Camus *The Outsider*
OR
- Fyodor Dostoevsky *Notes from Underground*

Unit-3

- V S Naipaul *In a Free State*
OR
- Chimamanda Ngozi Adichie *Purple Hibiscus*

Unit-4

- Pablo Neruda "Death Alone", "Furies and Suffering", "There's no Forgetting", "Memory"
OR
- Octavio Paz "from San Ildefonso Nocturne", "Between Going and Staying the Day Wavers", "Humayun's Tomb", "Motion"

Prescribed Texts

- ✓ *Like all prescribed texts these texts are available online in their respective names at*
- ✓ <https://www.poetryfoundation.org/poems/>
- ✓ Project Gutenberg <https://www.gutenberg.org/>
- ✓ *Additionally, teachers can help students to locate texts in other online valid websites.*

Suggested Readings

- ✓ *The Complete Stories by Franz Kafka:*
- ✓ http://www.vanderbilt.edu/olli/class materials/Franz_Kafka.pdf
- ✓ "What is world Literature?" (Introduction) David Damrosch
<http://press.princeton.edu/chapters/i7545.html>
- ✓ *Tagore's comparative world literature*

- ✓ https://www.academia.edu/4630860/Rabindranath_Tagores_Comparative_World_Literature
- ✓ Dostoevsky's *Notes from Underground*
- ✓ <http://www.gutenberg.org/files/600/600-h/600-h.htm>
- ✓ Margaret Atwood's "Stone Mattress" <http://www.newyorker.com/magazine/2011/12/19/stonemattress>
- ✓ Margaret Atwood's *Pretend Blood*
- ✓ <http://www.independent.co.uk/artsentertainment/books/features/first-lives-club-pretend-blood-a-short-story-by-margaret-atwood-1779529.html>
- ✓ Alice Munro's short Stories <http://www.newyorker.com/magazine/2013/10/21/the-bear-came-over> the mountain-2, <http://www.newyorker.com/magazine/2008/09/08/face>
- ✓ Poems of Octavio Paz : http://www.poetrysoup.com/famous/poems/best/octavio_paz
- ✓ *Weltliteratur: John Wolfgang von Goethe in Essays on Art and Literature Goethe: The Collected Works Vol.3*
- ✓ Rabindranath Tagore "World Literature": *Selected Writings on Literature and Language: Rabindranath Tagore Ed. Sisir Kumar Das and Sukanta Chaudhuri Damrosch*
- ✓ Goethe's "World Literature Paradigm and Contemporary Cultural Globalization" by John Pizer
- ✓ "Something Will Happen to You Who Read": Adrienne Rich, Eavan Boland' by Victor Luftig. JSTOR iv.
- ✓ *Comparative Literature University of Oregon.*
- ✓ David Damrosch, *What is World Literature?* Princeton University Press
- ✓ "WLT and the Essay" *World Literature Today* Vol. 74, No. 3, 2000. JSTOR *Irish University Review*, Vol.23 Spring 1, Spring-Summer.

2.2 Translation and Applied Language Practices**Course Objectives (CO)**

- Explain key principles and challenges of literary, non-literary, and cultural translation.
- Apply translation strategies to institutional, media, educational, and digital texts.
- Use basic translation technologies such as Unicode tools, OCR, machine translation, and workflows.
- Prepare small-scale parallel corpora and aligned bilingual texts.
- Produce a translation portfolio reflecting multilingual and applied language competencies.

UNIT 1: Translation Techniques and Practices

- Principles of translation: Source text analysis; linguistic equivalence; formal procedures like borrowing, calques, transposition, modulation and adaptation; CAT tools, QA methods, registral, discourse and domain specific features
- Literary and non-literary translation: Genre specific, aesthetic, artistic, cultural, and emotional values in literary translation; creative adaptations; concept of knowledge text; focus on translating objective facts, accuracy in translating specialised terminologies in non-literary translations; audience and target demography analysis
- Translation challenges: Cultural nuances and colloquialisms; literary components and stylistic equivalence in literary translation; factual correctness, structural coherence, and handling jargons in non-literary translation
- Cultural translation: Culturemes, domestication/foreignisation, and contextual mapping

UNIT 2: Technology in Translation

- Unicode and typing tools: Code points, character encoding schemes, Unicode normalisation, phonetic transliteration, keyman and keyboard mapping, candidate windows, preparing common locale data repository; and introduction to TMS
- OCR awareness: Error tolerance and correction; contextual repair; layout and formatting understanding; metadata recognition; and VLM prompting
- Machine translation tools: Camera translation; document translation; voice-to-speech; DeepL translator; translation memory; AI tools; and back-translation
- Translation software and digital workflows: Glossary and terminology database; fuzzy matching; MTPE; continuous localisation, GitHub and CMS; Application Programming Interface and connectors

UNIT 3: Specialised Translation

- Translation and Interpretation Techniques: Oblique techniques like transposition, modulation and adaption; simultaneous and consecutive interpretation
- Media translation: Multimodality and audio-visual translation; ideology, power and cultural mediation; and transmedia storytelling
- Educational/pedagogical translation: Contrast of linguistic features between SL and TL; strategic competence, and translation quality assessment (TQA)
- Public communication and localisation

UNIT 4: Parallel Corpora and Language Resources

- Introduction to corpus preparation: Purpose, target domain, representativeness, balance; sampling strategies; data collection and curation; machine readability and sanitation; transcription; metadata and annotation
- Bilingual text alignment: Sentence and sub-sentence alignment; linguistic discrepancies; and structural transformations
- Annotation basics: Semantic, morphological and syntactic alignment; annotation separability; inter-annotator agreement (IAA); diffing and merging
- Corpus applications in language technology: Language modelling; discourse and sentiment mapping; multimodal integration; downstream enterprise application; and forming dynamic web corpora

Practical Components

- Translation portfolio (may include: Literary translation of Poem, short prose passage; Institutional translation: Notice, circular, brochure; Cultural translation: Festival description, folk narrative; Digital translation: Website/social media content; Audiovisual translation: Subtitle; Media translation: News report, interview)
- Preparation of mini parallel corpus: (small, organised bilingual collection of aligned texts in two languages, for example: Odia-English, Hindi-English, or Odia-Hindi.)

Suggested Study Visit

Visit to:

- translation centre,
- publication office,
- language technology unit

Suggested Apprenticeship Linkages

- Translation and Interpreting services
- Localisation (Suppose a museum creates: an English exhibit description. Students may localise it for: Odia-speaking visitors, school students, tourists, or digital audiences. This may involve: simplifying terminology, explaining local cultural references, adjusting tone, adding pronunciation support, adapting layout for bilingual display.)
- Language documentation
- Corpus preparation (**Example 1:** Corpus of Folk Narratives from Western Odisha-Students collect: oral stories, transcriptions, translations, speaker details, audio clips. **Example 2:** Parallel Corpus of Tourism Texts-Students prepare: Odia tourism brochures, English translations, aligned bilingual files. **Example 3:** Literary Festival Corpus-Students compile: interviews, speeches, panel summaries, press releases, social media content from a literary event.)

Learning Outcomes

- Explain core principles, theories, and challenges of literary and non-literary translation.

- Translate texts across languages with cultural and contextual sensitivity.
- Use translation technologies such as Unicode tools, OCR, and machine translation.
- Perform specialised translation tasks including media, educational, and public communication translation.
- Prepare a small parallel corpus using bilingual alignment and annotation techniques.
- Produce a diversified translation portfolio across genres and formats.
- Understand professional translation workflows through study visits and apprenticeship exposure.

Prescribed Books

- 1) Kothari, Rita (2003). *Translating India*. Routledge.
- 2) Trivedi, Harish. Translation and transcreation [Audio recording]. Internet Archive. https://archive.org/details/dni.ncaa.SAK-92-AC/SAK-92-AC_SIDE_A.mp3
- 3) Pöchhacker, Franz (2022). *Introducing interpreting studies: Third Edition*. Routledge, Taylor & Francis.
- 4) Bellos, David (2011). *Is that a fish in your ear? Translation and the meaning of everything*. Particular Books. <https://doi.org/10.3366/tal.2012.0081>
- 5) *My Years with Gorbachev and Shevardnadze* by Pavel Palazhchenko
- 6) Hatim, B., & Munday, J. (2008). *Translation: An Advanced Resource Book*. Routledge.
- 7) O'Hagan, M. (Ed.). (2020). *The Routledge Handbook of Translation Technology*. Routledge.

Learning Resources

- 1) “Translation Studies and Theory” by Prof. Mini Chandran, IIT Kanpur, NPTEL
- 2) TED Translators Program (real-world exposure, <https://www.ted.com/participate/translate>)

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester III

1.9 The Romantic Revival and English Literature of the Period

Course Objectives

- The course aims at acquainting the students with the Romantic period and some of its representative writers.
- Another of its major objectives is to give the students a broad idea of the social as well as historical contexts that shaped this unique upheaval.
- It also aims to define what is romantic revival through the representative texts.

Unit-1

William Blake: “The Holy Thursday”, “The Chimney-Sweeper” (from Songs of Innocence) “London”, “A Poison Tree” (from Songs of Experience), ‘The Tger’

Unit-2

William Wordsworth: “Tintern Abbey”
Samuel Taylor Coleridge: “Kubla Khan”

Unit-3

John Keats “Ode to a Nightingale” and “Ode on Melancholy”
P.B. Shelley: “Ode to the West Wind” and “To a Skylark”

Unit-4

William Wordsworth: “Preface to Lyrical Ballads” (2nd Edition)
OR
P.B. Shelley: “A Defence of Poetry”

Prescribed Texts

- ✓ *The Project Gutenberg eBook of Songs of Innocence and of Experience by William Blake*
- ✓ <https://www.poetryfoundation.org/poems/> (for Coleridge, Wordsworth, Keats, Shelly's poems)
- ✓ “Preface to Lyrical Ballads” by William Wordsworth (2nd Edition)
- ✓ “A Defence of Poetry” P.B. Shelley
(<https://www.poetryfoundation.org/articles/69388/a-defence-of-poetry>)

Suggested Readings

- ✓ The Routledge History of Literature in English
- ✓ History of English Literature: Traversing the Centuries: Chowdhury & Goswami
- ✓ Romantic Imagination by C. M. Bowra
- ✓ Pelican Guide to English Literature. Vol.5. Edited by Boris Ford
- ✓ ‘Nature as Therapy: A Romantic Construct’. Rajiv Gandhi University Research Journal. Ed.Vol-10, No. 1-2, Jan-Dec 2011. pp.1-10.

1.10 The Victorian Era

Course Objectives

- The course seeks to expose students to the literature produced in Britain in the 19th century or of the politically known as the Victorian period.
- The focus of the course is mainly on prose (fictional and non-fictional) and criticism. The 19th century embraces three distinct periods of the Regency, Victorian and late Victorian.
- The course aims to provide to the students an understanding of the 19th century British literature which is mainly famous for the Romantic Movement, but was also a witness to major socio-political developments like industrialization, technological advancements and large-scale mobilization of people from the rural to the urban centers.
- It will allow students to explore much of the prosaic activities/developments needed for the time and the culture and society debate.

Unit-1

Charles Lamb: "Old China" Tennyson: "Ulysses"

Leigh Hunt: "A Few Thoughts on sleep" Browning: "My Last Duchess"

Unit-2

Mary Shelly: *Frankenstein*

OR

Jane Austen: *Pride and Prejudice*

Unit-3

Charles Dickens: *Hard Times*

OR

Elizabeth Gaskell: *Mary Barton*

Unit-4

Mathew Arnold: "Culture and Anarchy" (Chapter 1)

OR

William Hazlitt: "Lectures Chiefly on the Dramatic Literature of the Age of Elizabeth"
from *Lectures on English Poets*

Prescribed Texts

- ✓ *Like all prescribed texts these texts are available on line at*

- ✓ <https://www.poetryfoundation.org/poems/>
- ✓ Project Gutenberg <https://www.gutenberg.org/>
- ✓ *The Nineteenth Century: 1798-1900 (Anthologies of English Literature)* by Brian Martin

Suggested Readings

- ✓ *Chapter 4, 5 from a Short Introduction to English Literature* by Jonathan Bate
- ✓ *The English Novel* by Terry Eagleton
- ✓ *The Cultural Critics* by Leslie Johnson
- ✓ *The Nineteenth-century English Novel* by James Killroy
- ✓ https://onlinecourses.nptel.ac.in/noc21_hs28/preview
- ✓ *The Oxford Handbook of the Victorian Novel* ed by Lisa Rodensky

1.11 Modern English Literature (20th Century)

Course Objectives

- The course aims to present to the students a historical overview of the era
- It highlights the developments in society and economy, leading to a crisis in western society known as the First World War and the resultant change in the ways of knowing and perceiving.
- It presents the triggers for the modern consciousness, such as Marx's concept of class struggle, Freud's theory of the unconscious, Bergson's *durée*, Nietzsche's will to power and Einstein's theory of relativity.
- This also aims to familiarize the students with the new literature of Britain in the early decades of the 20th century. The course will mainly focus on the modernist canon, founded on Ezra Pound's idea of 'make it new', but will cover war poetry, social poetry of the 1930s and literary criticism.

Unit-1

- T.S. Eliot "The Love Song of J. Alfred Prufrock"
- W.B. Yeats "Sailing to Byzantium"
- Ezra Pound "In a Station of the Metro"
- T.E. Hulme "Autumn"
- Hilda Doolittle "The Mysteries Remain"

Unit-2

- Wilfred Owen: "Dulce Et Decorum Est"
- Siegfried Sassoon: "Suicide in the Trenches"
- W.H Auden: "The Unknown Citizen"
- Stephen Spender: "An Elementary Classroom in a Slum"
- Louis MacNeice: "Prayer before Birth"

Unit-3

Virginia Woolf: *Mrs. Dalloway* or James Joyce: Stories from *Dubliners* ("The Sisters", "Evelyn", "An Encounter", "Clay", "Two Gallants")

Unit-4

Literary Criticism: Henry James, "The Art of Fiction" or T.S. Eliot, "Tradition and Individual Talent"

Prescribed Texts

- ✓ *Like all prescribed texts these texts are available online in their respective names at*
- ✓ <https://www.poetryfoundation.org/poems/>
- ✓ Project Gutenberg <https://www.gutenberg.org/>
- ✓ *Additionally, teachers can help students to locate texts in other online valid websites.*

Suggested Readings

- ✓ *Pelican Guide to English Literature: The Modern Age (ed.) Boris Ford*
- ✓ *Jonathan Bate, English Literature: A Very Short Introduction, Oxford Paperback*
- ✓ *Peter Faulkner, Modernism. London: Methuen*
- ✓ *Peter Childs, Modernism, New Accents. Routledge*

1.12 Indian Myths and Epics: New Perspectives

Course Objectives

- This course aims to study the literary aspects of the ancient Indian myths and their living values along with the studies of the Indian epic literature.
- While the primary purpose of the course is to make students understand and appreciate how the Indian mythic and epic literature are being re-imagined and re-mapped in the contemporary time, through the reading of primary sources in translation, the course aims to cover the important mythological themes and students will be able to assess the role of mythology as a central component of society and the theories that have been developed to understand its role in meaning-making.
- It demonstrates a basic literacy in the mythology that includes explanations of basic narratives, major figures, and context of the myths, myths' cultural expressions and the relationships between the texts.
- To explore the blurred space of gender and bust the western theoretical frame of gender and sexuality while reading Indian epics in a philosophical, literary and aesthetic blend not alien to spirituality.

Unit-1

A historical and cultural overview on the ancient Indian Literature, myths and epics and their retellings and adaptations

“Three Hundred Ramayanas” by A K Ramanujan

“Introduction” in *The History of Indian Literature, Volume-I* by Maurice Winternitz (Motilal Banarasidass Publishers, New Delhi)

“A Passage to India” by Walt Whitman

Unit-2

“Ancient Ballads of Hindustan-I” (Savitri) by Toru Dutta

From *Mirabai* translated by Robert Bly, ‘The Dark one won’t speak to me’, ‘You pressed Mira’s seal of love’, ‘Dark One, how can I sleep?’, ‘O my friends, what can you tell me of Love’.

From *Sri Radha* by Ramakanta Rath, Section 1, 5, 13, 19 (‘Come take half of the remainder of my life’), 42.

From *Of Sons and Fathers* by Asim Ranjan Parhi,

“Another February”, “De-fathered”, “Fathers are but Sons under Stress”, “The Historic Burden” and “Crestfallen”

Unit-3

Drama

Vasavadutta by Sri Aurobindo

Unit-4

Shakuntala by Namita Gokhale

Prescribed Texts

- ✓ *A K Ramanujan's essay 'Three Hundred Ramayanas' The History of Indian Literature, Volume-I by Maurice Winternitz (Motilal Banarasidass Publishers, New Delhi)*
- ✓ *Love and the Turning Seasons, Ed. Andrew Schelling, page 165-166 and 173-174.*
- ✓ *Sri Radha by Ramakant Rath, translated by the poet, Grass Roots, Bhubaneswar.*
- ✓ *Of Sons and Fathers by Asim Ranjan Parhi Paksighara Prakashanee (Published by Bird Nest), Bhubaneswar.*
- ✓ *Plays by Sri Aurobindo: A Survey, S. Krishna Bhatta, Indian literature, Jan-Jun 1974, Sahitya Akademi.*

Suggested Readings

- ✓ *A K Ramanujan's essay 'Three Hundred Ramayanas' The History of Indian Literature, Volume-I by Maurice Winternitz (Motilal Banarasidass Publishers, New Delhi)*
- ✓ *The following essays provide reference material for the poems from Of Sons and Fathers:*
- ✓ *Ajanta Dutt in Indian Literature (UGC CARE), Vol.4, No.330. July-August 2022, Sahitya Akademi, New Delhi page, 180-182. <https://www.jstor.org> for the poems from Of Sons and Fathers.*
- ✓ *Mridul Bordoloi, Dibrugarh University Journal of English Studies (UGC CARE), Vol.31. 2022-2023.pp.89-98.www.dujes.co.in for the poems from Of Sons and Fathers.*
- ✓ *Vaisali, the last essay in BharatiyaManyaprad, An International Journal of Indian Studies, Ed. Neerja A Gupta, Vice Chancellor, Sanchi University of Buddhist Studies, Vol.-IX, May 2022. ISSN-2321-8444.*
- ✓ *Nanda Kishore Biswal, Pioneer, Bhubaneswar edition, 5.1.2023.*
- ✓ *B.Mohanta, Journal of Extension and Research, The Gandhigram Rural Institute, Tamilnadu, Vol. XVIII, No. I, 2024.*
- ✓ *R. Swain, Transcript: Journal of Literature and Cultural Studies, Research Journal of Bodoland University, Kokrajhar, Assam, Volume 10, December 2022, published in May 2024. Pg. 175-178. Print copy ISSN-2347-1743.e-journal ISSN-2582-9858.*
- ✓ *"Fathers are but Sons under Stress", Review paper on the anthology of poems Of Sons and Fathers, Special Issue of The Odisha Journal of English Studies, Vol.14, Issue-I, 2024(Santwana Haldar).*
- ✓ *"Locating 'Male' in Indian Mythopoeic Cultural Narratives: A Critical Evaluation of Asim Ranjan Parhi's Of Sons and Fathers. Research paper at International Conference in Social Sciences and Humanities in the 21st Century, Organised by ACAVENT, November 24-26, 2023, Vienna, Austria, (Salim and Parhi).*

- ✓ *Preface and Introduction (Suman kumar Ghai and Dinesh Kumar Mali respectively) of Pitaon aur Putron ki, Yash Publications, New Delhi, 2024. Page 7-30.*
- ✓ *Review article, page 291-294 and Research article, Page 310-324 in Byanjana, June-August 2024.*
- ✓ *Plays by Sri Aurobindo: A Survey, S. Krishna Bhatta, Indian literature, Jan-Jun 1974, Sahitya Akademi.*
- ✓ *Indian English Novelists: An Anthology of Critical Essays. Madhusudan Prasad*
- ✓ *Indian Literature, All Volumes by Sisir Kumar Das*

2.3 Digitisation, Archiving, and Documentation Practices

Course Objectives (CO)

- Describe the roles of libraries, archives, museums, and cultural institutions in knowledge preservation.
- Document oral traditions, manuscripts, and community knowledge using appropriate formats and ethics.
- Create fieldnotes and audio-visual documentation for cultural and research purposes.
- Apply basic principles of metadata creation, file organization, and digital preservation.
- Design and execute a small documentation or archiving project.

UNIT 1: Cultural and Knowledge Institutions

- Libraries: As hubs of knowledge; vital tangible and intangible cultural archives; information literacy and intellectual dialogues; institutional convergence (LAM)
- Archives: Core archival principles; the archival lifecycle; cultural heritage and collective memory
- Museums: Collection ethics, audience engagement, integration of digital technologies; and exploring how museums shape societal values and historical narratives
- Literary and cultural organisations: Knowledge formation through literary and cultural education; community, cultural and literary memories; curation and representation; and public engagement

UNIT 2: Knowledge Preservation and Community Memory

- Books and manuscripts: Codicology, palaeography and material culture; textual editing and philology
- Oral traditions: Indigenous epistemologies and traditional knowledge; performance theory; historical consciousness; orality and literacy; dynamics of memory change
- Folk knowledge: Narratives and mythologies; Traditional Ecological Knowledge (TEK); embodied knowledge in rituals, festivals, craft and material culture; cultural memory and identity construction
- Community archives: Alternative record formats; sustainability and technology; collaboration with mainstream institutions

UNIT 3: Documentation and Field Practices

- Documentation formats and templates: PDF, ODF, TXT, TIFF, JPG and PNG: descriptive metadata like Dublin Core; and digitisation specifications
- Fieldnotes and observation: Observer bias and positionality; methodological choices; and community protocols
- Audio/video documentation: Provenance and context; handling analog carriers; digitisation and technical standards; and metadata and annotation
Ethics of documentation

UNIT 4: Digital Preservation and Metadata

- File organisation: File naming conventions; directory and field structure; descriptive and technical data; format obsolescence and integrity
- Metadata preparation: Aligning with recognized standards; categorizing by core metadata types; guaranteeing authenticity and provenance; automation and extraction; and validation and consistency
- Digital archiving workflows: Ingest (Submission); preservation metadata, and storage, security and access
- Introduction to cataloguing: Title and responsibility, edition, material specifics, publication details, physical description, series, notes, and ISBN; OAIS model; PREMIS; and descriptive schemes; and navigational digital challenges

Practical Components

- Metadata preparation exercise (Refer: Dublin Core Metadata Initiative-
<https://www.dublincore.org/specifications/dublin-core/dcmi-terms/>)
- Documentation project

Suggested Study Visit

Visit to:

- archive,
- museum,
- manuscript library,
- or cultural institutions

Suggested Apprenticeship Linkages

- Archives
- Museums
- Documentation centres
- Digital preservation projects

Learning Outcomes

- Identify the roles of libraries, archives, museums, and cultural institutions.
- Document manuscripts, oral traditions, folk knowledge, and community memory.
- Conduct ethical field-based documentation using standard tools and formats.
- Prepare metadata and apply basic digital archiving workflows.
- Design and execute a small-scale documentation or digitisation project.
- Engage critically with digital archives and repositories.

Prescribed Books

- ✓ *Zaidi Nishat and Pue A. Sean (2024). Ed. Literary Cultures and Digital Humanities in India. Routledge.*
- ✓ *Mallik, Anupama, et al. (2018). Ed. Digital Hampi: Preserving Indian Cultural Heritage, Springer.*
- ✓ *Millar, Laura. (2017). Archives: Principles and Practices, 2nd ed. London: Facet Publishing.*

- ✓ Müller, Katja. (2024). *Digital Archives and Collections: Creating Online Access to Cultural Heritage*, NY: Berghahn.
- ✓ *Theory and Craft of Digital Preservation* by Trevor Owens. Baltimore, John Hopkins University Press, 2018.
- ✓ Legget, Elizabeth.R. (2021). *Digitization and Digital Archiving: A Practical Guide for Librarians*, 2nd Edition. Rowman & Littlefield.

Learning Resources

1. “Data Base Management System,” Prof. Partha Pratim Das Prof. Samiran Chattopadhyay, IIT Kharagpur, NPTEL
2. Voyant Tools Tutorial: <https://voyant-tools.org/docs/tutorial-start.html>
3. Programming Historian: <http://programminghistorian.org/en/lessons/>

Students may be introduced to archives through guided exploration of the following digital collections:

- Parliament of India Lok Sabha Digital Library <https://eparlib.sansad.in>
- Kala Nidhi Cultural Archives
- Bichitra Variorum
- Digital Thoreau (Introductory example of a digital literary archive.)
<https://digitalthoreau.org/>
- [The Canterbury Tales Project](#)
Useful for understanding manuscript traditions and digital textual editing.
- [The Victorian Web](#)
Large-scale humanities archive combining literature, history, and visual culture.
- [British Library – Endangered Archives Programme](#)
Important example of manuscript digitisation and endangered archive preservation.
- [Digital South Asia Library](#)
Major archive of South Asian texts, maps, and historical resources.

Other online Resources:

- 1) *The National Archives UK* Playlists (YouTube)
- 2) Digitization 101 Webinar series: <https://ccaha.org/digitization-101>: Episodes: Prioritization of Collections; File Storage for Digitization; File Specifications for Digitization; Metadata for Digitization; In-House vs. Outsourcing and Quality Control; Equipment Selection

2.4 Public Humanities and Cultural Documentation (Focus: Odisha)**Course Objectives (CO)**

- Investigate the cultural history, linguistic diversity, and public memory of Odisha.
- Document folk, performing, and storytelling traditions through field-based methods.
- Examine heritage institutions, festivals, tourism, and community practices in public culture.
- Produce community-focused documentation and cultural mapping outputs.
- Engage ethically with communities and institutions in public humanities projects.

UNIT 1: Cultural History of Odisha

- Regional diversity: Coastal, Western, and Hilly/Tribal; syncretic religious traditions; linguistic variations; indigenous tribal heritage; and localized art and architecture
- Language and identity: Historical evolution of Odia identity; language movements and regional nationalism; tribal languages and heteroglossia
- Cultural movements: Religious and philosophical movements; the Jagannath cult; and the Mahima cult
- Public memory: The legacy of Kalinga and Ashoka's transformation; maritime glory and cultural expansion; medieval literature and the Bhakti movement; the Paika rebellion and anti-colonial resistance; and formation of a separate Odisha state

UNIT 2: Folk and Performing Traditions

- Folk songs and narratives: Mythological performances on the basis of the Ramayana and the Mahabharat and the Puranas in the form of Pala, Daskathia, Sankirtan, Chhau, Odissi, Ghodanacha, Kendara Gita, Laudi, Dhuduki, Karma Geet, Sambalpuri Lokgita and Geet Khudia; celebration of seasonal and agricultural cycles like Dola, Makar Sankranti, Askhaya Tiritiya, Pana Shankranti, Raja, Dashera, Diwali and Manabasa; Annual Osha, Brata and Mela
- Theatre traditions: Bharat Leela, Moghul Tamsa, Danda Nata, Ramaleela, Desia Nata, Raasa Leela, Kaliya Dalan, Poetic play (Gitinatya) and modern opera
- Local festivals: Raja Purnima, Rath Jatra, Dola and Holi, Dashera and Diwali, Raasa Purnima and Baliyatra, Thakurani Parba, Nuakhai, Dhanujatra, Sitalasasthi, Mahashivratri, Magha Mela, and Chaiti Parba
- Storytelling practices: Abolkara Kahani, Shuasari Kahani, Bhagabat Tungji Stories, Pothi Bacha, Aimag Kahani and Tribal Tales

UNIT 3: Heritage and Public Culture

- Heritage institutions: Tangible and intangible components; Museums, Archives, Archaeological sites; religious and philosophical heritage of Odisha
- Pilgrimage and tourism: The golden triangle of faith; the diamond triangle; coastal and ecotourism; pilgrimage of western and southern Odisha
- Community participation & Cultural preservation: Public participation in rural and urban institutions; monument conservation; preservation of cultural and performing arts and crafts

UNIT 4: Contemporary Cultural Institutions

- Literary organisations: Literary, linguistic and cultural organizations of importance across Odisha both Government and private
- Festivals and public culture
- Knowledge institutions
- Community media initiatives

Practical Component

- Community documentation project
- Cultural mapping exercise

Suggested Study Visit

Students may undertake guided visits and apprenticeship-linked activities at nearby:

- museums,
- archives,
- literary organisations,
- theatre groups,
- cultural festivals,
- community media initiatives,
- pilgrimage centres,
- tourism offices,
- heritage institutions,
- and documentation projects.

Students may observe and participate in:

- event documentation,
- cultural reporting,
- oral history collection,
- festival archiving,
- public communication,
- and heritage documentation practices

Learning Outcomes

- Explain the cultural history of Odisha with reference to language and identity.
- Document folk, performing, and storytelling traditions.
- Analyse heritage institutions, pilgrimage, tourism, and community participation.
- Examine contemporary cultural institutions and public culture.
- Conduct community-based documentation and cultural mapping projects.
- Communicate cultural knowledge effectively to public audiences.

Prescribed Books

- ✓ *Dash, M. (2024). The big book of Odia literature. Penguin.*
- ✓ *Malla, B. (2019). Discovering Odia culture. Black Eagle Books.*
- ✓ *Nayak, J. K., & Mahapatra, A. (2022). Critical discourse in Odia. Routledge.*

- ✓ *Sahoo, S. R. (2024). Echoes of Odisha: Celebrating heritage and culture [Kindle edition]. Amazon.*

Learning Resources

- 1) “Introduction to Cultural Studies,” Prof. Avishek Parui, IIT Madras, **NPTEL**
- 2) “Folk and Minor Art in India,” Prof. Shatarupa Thakurta Roy, IIT Kanpur, **NPTEL**
- 3) IGNCA YouTube channel
- 4) TED talks on Culture and Storytelling
- 5) Sahapedia YouTube channel

Semester IV

1.13 European Classical Literature

Course Objectives

- The objective of this course is to introduce the students to European Classical literature, commonly considered to have begun in the 8th century BC in ancient Greece and continued until the decline of the Roman Empire in the 5th century AD.
- It seeks to acquaint the students with the origins of the European canon.
- It aims to provide a historical overview of classical antiquity like ancient Greece, the rise and decline of the Roman Empire
- It will lead to a discussion on the cultural history of the Greco-Roman world centered on the Mediterranean Sea.

Unit-1

Homer *Odyssey* (Book I)

OR

Virgil *Aeneid* (Book I)

Unit-2

Sophocles *Oedipus the King*

OR

Aeschylus *Prometheus Bound*

Unit-3

Aristophanes's *Frogs*

OR

Plautus *Asinaria*

Unit-4

Horace *Ars Poetica* or *Essay on Poetic Theory*

OR

Longinus *On the Sublime*, Chapter 7, 39

Prescribed Texts

All the texts are available for access on Project Gutenberg. <https://www.gutenberg.org>

And in Internet Archive at www.archive.org with the same titles. Students may be encouraged to browse the sites.

Suggested Readings

- ✓ European Classical Literature by Amit Ganguly and Jay Bansal
- ✓ Hand Book On European Classical Literature by Biplab Banerjee
- ✓ Mimesis: The Representation of Reality in Western Literature by Erich Auerbach. USA: Princeton University Press. 2013.
- ✓ Ancient Greek Literature and Society by Charles Rowan Beye, Ithaca, New York: Cornell University Press. 1987

1.14 Indian Classical Literature

Course Objectives

- This course aims at creating awareness among the students of the rich and diverse literary culture of ancient India.
- It purports to engage students with and discuss different genres of classical literature and their scope.
- It will introduce them to the Indian Epic tradition and show how they will assimilate the theory and practice of Sanskrit Classical drama, engage with Indian aesthetic theory such as Alankar and Rasa.
- It will enable students to understand the concept of Dharma and the heroic in Indian Classical Drama.

Unit-1

Vedic Literature: *SamjnanaSukta* Rig Veda X.19, *SivasankalpaSukta* Yajur Veda XXX.I.6 and *PurushaSukta* Yajur Veda XV. XXXI. 1-16

Unit-2

Selections from Epic Literature: Vyasa 'The Dicing' and 'The Sequel to Dicing,' 'The Book of the Assembly Hall', 'The Temptation of Karna', Book V 'The Book of Effort', OR 'Ayodhya Kanda' (Book II), 1st Canto of *The Ramayana of Valmiki*

Unit-3

Sanskrit Drama: Kalidasa, *Abhijnanasakuntalam*, Act IV.

Or

Bhavabhuti's *Rama's Last Act (Uttararamacharita*

Or

Mrcchakatikaby Sudraka, Act I.

Unit-4

Aesthetics and Maxims: Bharata's *Natyashastra*, Chapter VI on Rasa theory

Sahitya Darpana of Vishvanatha Kaviraja Chaps- I& II

Nitisataka of Bhartrhari 20 verses from the beginning

Prescribed Texts

- ✓ The New Vedic Selection Vol 1, Telang and Chaubey, Bharatiya Vidya Prakashan, New Delhi
- ✓ The Mahabharata: tr. And ed. J.A.B. van Buitenen (Chicago: Brill, 1975) pp. 106-69.
- ✓ The Ramayana of Valmiki. Gita Press Edition.
- ✓ *Abhijnanasakuntalam* by Kalidasa. tr. M.R Kale, Motilal Banarasi Dass, New Delhi.
- ✓ *Rama's Last Act (Uttararamacharita)* by Bhavabhuti. tr. Sheldon Pollock (New York: Clay Sanskrit Library, 2007)
- ✓ *Mrcchakatikaby* by Sudraka, Act I, tr. M.M. Ramachandra Kale (New Delhi: Motilal Banarasisidass, 1962)

- ✓ Bharata's Natyashastra. English Translation by M.M. Ghosh, Asiatic Society, Kolkata, 1950.
- ✓ Sahitya Darpana of Vishvanatha Kaviraja Chaps- I& II. English Translation by P.V. Kane, Motilal Banarsidass, New Delhi.
- ✓ The Satakatraya edited by D.D. Kosambi, Published in Anandashrama Series, 127, Poona, 1945. Also, English Translation published from Ramakrishna Mission, Kolkata

Suggested Readings

- ✓ Kalidasa. Critical Edition, Sahitya Akademi.
- ✓ B.B Choubey, New Vedic Selection, Vol 1, Bharatiya Vidya Prakashan, New Delhi
- ✓ H.H. Wilson (Tr.)-Rig Veda
- ✓ Bharata, Natyashastra, tr. Manmohan Ghosh, vol. I, 2nd edn. (Calcutta: Granthalaya, 1967) chap. 6: 'Sentiments', pp. 100–18.
- ✓ J.A.B. VanBuitenen, 'Dharma and Moksa', in Roy W. Perrett, ed., Indian Philosophy, vol. V, Theory of Value: A Collection of Readings (New York: Garland, 2000) pp.33–40.
- ✓ Vinay Dharwadkar, 'Orientalism and the Study of Indian Literature', in Orientalism and the Postcolonial Predicament: Perspectives on South Asia, ed. Carol A. Breckenridge and Peter van der Veer (New Delhi: OUP, 1994) pp. 158–95
- ✓ 'Pedagogy and Indian Poetics: The Case of Michael Henchard'. Dialogue. Ed. S. Hajela and R.Sharma. Vol-VI, No.I, June 2010, pp.90-94.
- ✓ Universals of Poetics by Haldhar Panda 16

1.15 Women's Writings*

Course Objectives

- The course aims to acquaint the students with the complex and multifaceted literature by women of the world.
- It proposes to provide students ideas reflecting the diversity of women's experiences and their varied cultural moorings.
- It has included different forms of literature by women authors: poetry, fiction, short fiction, and critical writings. In certain respects, it interlocks concerns of women's literary history, women's studies and feminist criticism.

Unit-1

In Defence of a Literature of Their Own and Discoursing at Par

Mary Wollstonecraft: "Introduction" from "A Vindication of the Rights of Women"

Virginia Woolf: "Chapter 1" from *A Room of One's Own*

Or

Simone de Beauvoir: "Introduction" from *The Second Sex*

Unit 2

Desiring Self: Fiction by Women from the Centre

Charlotte Bronte: *Jane Eyre*

Or

Emily Bronte: *Wuthering Heights*

Jean Rhys: *Wide Sargasso Sea*

or

Doris Lessing: *The Grass is Singing*

Unit 3

Desiring and Dissenting Self: Fiction by Women from the Periphery

Krupabai Sathianadhan: *Saguna* or *Kamala*

or

Prativa Ray: *Yajnaseni*

Unit-4

Tongues of Flame: Poetry by Women from Across the World

*Any Four Poets to be read

Kamala Das "An Introduction" & "The Sunshine Cat"

Eunice de Souza "Women in Dutch Painting" & "Remember Medusa?"

Tishani Doshi "Ode to the Walking Woman" & "What the Body Knows"

Maya Angelou "Phenomenal Woman" & "I Know Why the Caged Bird Sings"

Sylvia Plath "Mirror" & "Barren Woman"

Margaret Atwood "This is a Photograph of me" & "The Landlady"

Prescribed Texts

- ✓ Virginia Woolf, *A Room of One's Own*

<https://victorianpersistence.files.wordpress.com/2013/03/a-room-of-ones-own-virginia-woolf-1929.pdf>

- ✓ Mary Wollstonecraft, A Vindication of the Rights of Women: Introduction
<http://pinkmonkey.com/dl/library1/vindicat.pdf>
- ✓ Maya Angelou's Poems
http://www.poemhunter.com/i/ebooks/pdf/maya_angelou_2012_6.pdf
- ✓ Sylvia Plath's Collected Poems
https://monoskop.org/images/2/27/Plath_Sylvia_The_Collected_Poems_1981.pdf
- ✓ Margaret Atwood's Poems
<http://www.poemhunter.com/margaret-atwood/poems/>
- ✓ Eunice de Souza, "Remember Medusa?" & "Women in Dutch Painting"
<http://www.poetrynook.com/poem/remember-medusa>
<http://www.gallerie.net/issue14/poetry1.html>
- ✓ Tishani Doshi's Poems
http://www.poemhunter.com/i/ebooks/pdf/tishani_doshi_2012_6.pdf
- ✓ Simone de Beauvoir, The Second Sex
<http://burawoy.berkeley.edu/Reader.102/Beauvoir.I.pdf>

Suggested Readings

- ✓ Toril Moi, Sexual Textual Criticism
- ✓ Elaine Showalter, A Literature of Their Own
- ✓ Sandra Gilbert and Susan Gubar, The Mad Woman in the Attic
- ✓ Gill Plain and Susan Sellers, A History of Feminist Literary Criticism. Cambridge University Press. 2007.
- ✓ Essays to be read: Helen Carr, "A History of Women's Writing" and Mary Eagleton, "Literary Representations of Women"
https://mthoyibi.files.wordpress.com/2011/09/05-history-of-feminist-literary-criticism_gill-plain-and-sus.pdf

2.5 Text Analysis and Computing

Course Objectives (CO)

CO1. Explain foundational concepts of text-as-data, annotation, and corpus-oriented reading.

CO2. Apply distant reading approaches and basic computational methods to literary and cultural texts.

CO3. Use digital tools such as Voyant Tools and AntConc for text analysis and visualisation.

CO4. Evaluate digital archives and repositories for research and preservation purposes.

CO5. Carry out a short text analysis assignment; collaborating computational and interpretive tools.

UNIT 1: Introduction to Text Analysis

- Text as data
- Digital text preparation
- Annotation and markup basics
- Corpus-oriented reading

UNIT 2: Distant Reading and Computational Humanities

- Concepts of distant reading
- Frequency and pattern analysis
- Topic identification
- Computational literary studies

UNIT 3: Computational Tools for Text Analysis

- Voyant Tools
- AntConc
- Basic visualisation tools
- Text analysis workflows

UNIT 4: Digital Archives and Online Repositories

- Institutional repositories
- Open-access archives
- Digital collections
- Preservation and access

Practical Component

- Mini text analysis project
- Digital archive exploration

Suggested Study Visit

Visit to:

- digital library,
- ICT centre,
- archive digitisation unit,
- or digital humanities project centre.

Suggested Apprenticeship Linkages

- Digital humanities labs
- Research support
- Text processing
- Digital archives

Learning Outcomes

- Conceptualise text as data for computational analysis.
- Apply annotation, markup, and corpus-oriented reading techniques.
- Use distant reading methods to identify textual patterns and themes.
- Operate text analysis tools such as Voyant Tools and AntConc.
- Design and execute a mini text analysis project.
- Critically evaluate digital archives and repositories.

Prescribed Books

1. Feldman, R., & Sanger, J. (2007). *The text mining handbook: Advanced approaches*. Cambridge University Press.
2. Stoltz, D. S., & Taylor, M. A. (2023). *Mapping texts: Computational text analysis for the social sciences*. Oxford University Press.
3. Walsh, B., & Horowitz, S. (2016). *Introduction to text analysis: A course book*. Walshbr.com.

Learning Resources:

- 1) “Introduction to Digital Humanities” by Prof. Maya Dodd and Dr. Nirmala Menon, FLAME University, Pune, **SWAYAM**
- 2) “Natural Language Processing,” Prof. Pawan Goyal, IIT Kharagpur, **NPTEL**

2.6 Digital Culture and Public Communication

Course Objectives (CO)

- Validate digital literacy and accountable participation in online data ecosystems.
- Analyse digital publics, platforms, and networked communities.
- Use social media and digital tools for academic, professional, and cultural communication.
- Produce podcasts, blogs, videos, or digital stories for public communication.
- Assemble a digital content portfolio validating ethical and operative digital engagement.

UNIT 1: Digital Literacy and Online Culture

- Digital literacy concepts: Information literacy; protecting personal data, recognizing phishing scams, and managing privacy settings; content creation; and technical proficiency
- Online communication: Collaborating, sharing, and networking respectfully across various digital platforms
- Digital citizenship: Media and information literacy; safety and security; practicing empathy and preventing cyberbullying; and digital wellness
- Information ecosystems: Disinformation and misinformation; platform governance and power; media landscapes and journalism; and digital resilience

UNIT 2: Digital Public Sphere and Networked Communities

- Digital publics: Digital networks, platforms, and algorithmic architectures shape the modern public sphere
- Online participation: Engagement of stakeholders through digital platforms; collaboration, design and accessibility
- Public discourse: Misinformation and the post-truth era: algorithm mediation and platform power; polarisation and echo-chambers
- Platform cultures: Algorithmic governance and affordances; platform capitalism and commodification; fragmentation and the “Post-Public Sphere”

UNIT 3: Social Media for Learning and Professional Networking

- Academic networking: Scholarly visibility and public intellectualism; digital metrics; post-university and rational discourse
- Professional communication
- Knowledge dissemination: Open science and knowledge dissemination; commodification of knowledge; deliberation and civic engagements
- Digital collaboration: E-Governance and citizen co-creation; network governance; and knowledge sharing

UNIT 4: Content Creation and Digital Publishing

- Audio/video content creation
- Podcasting basics
- Blogging and digital storytelling
- Public-facing digital communication

Practical Components

- Digital content portfolio
- Podcast/blog/video assignment

Suggested Study Visit

Visit to:

- media lab,
- digital content studio,
- communication office,
- or cultural media organisation.

Suggested Apprenticeship Linkages

- Digital media
- Content development
- Educational technology
- Public communication

Learning Outcomes

- Demonstrate digital literacy and responsible digital citizenship.
- Analyse digital publics and networked communities.
- Use social media for academic and professional networking.
- Create blogs, podcasts, videos, and digital stories.
- Develop a digital content portfolio.
- Understand ethical dimensions of digital public communication.

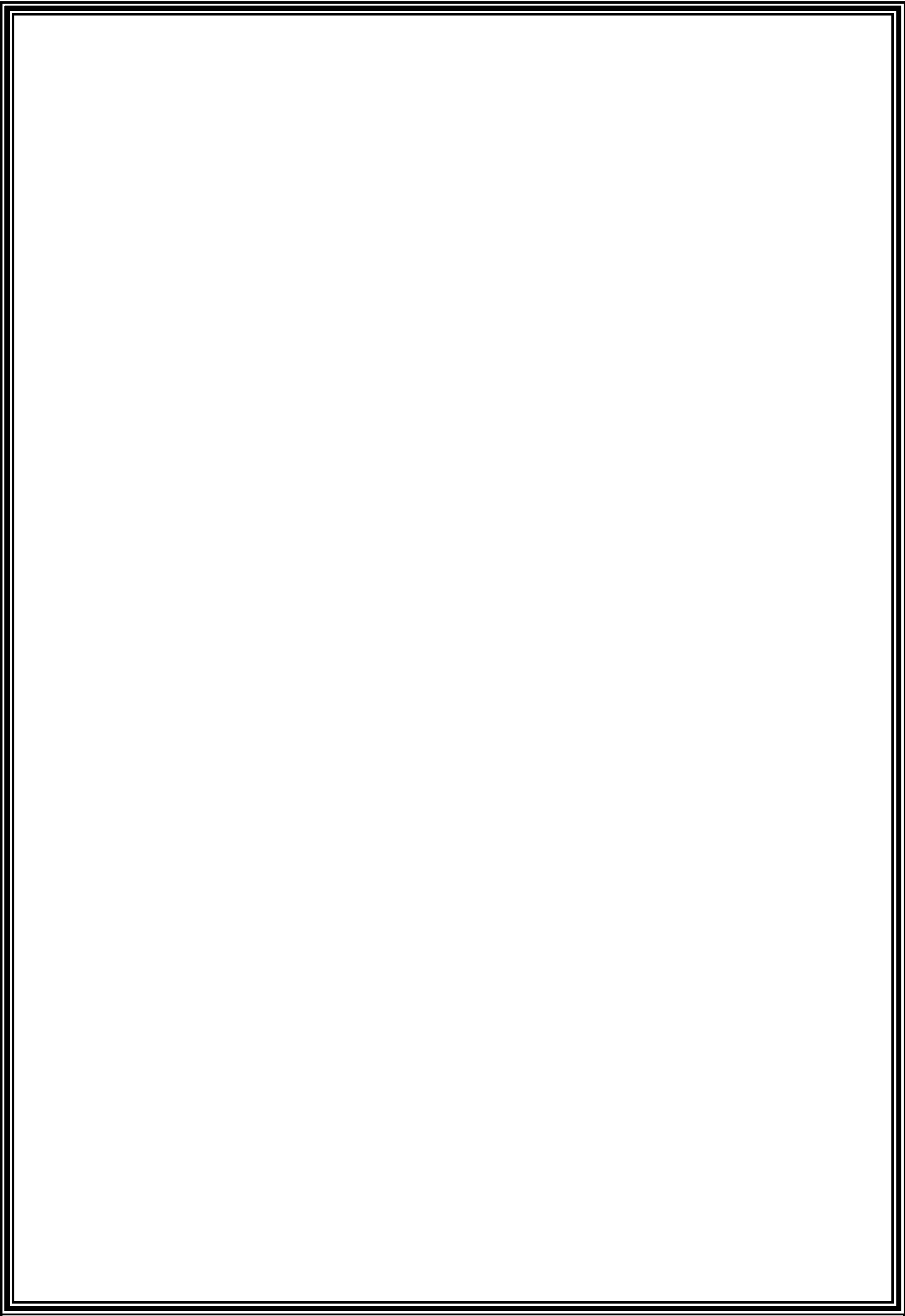
Prescribed Books

1. Delfanti, A., & Arvidsson, A. (2019). *Introduction to digital media*. Wiley-Blackwell.
2. Hartley, J. (2004). *Communication, cultural and media studies: Key concepts*. Routledge.
3. Miller, V. (2020). *Understanding digital culture* (2nd ed.). Sage Publications.
4. Uzelac, A., & Cvjetičanin, B. (Eds.). (1989). *Digital culture: The changing dynamics*. Culturelink.

Learning Resources:

- 1) “Text, Textuality and Digital Media” by Arjun Gosh, IIT Delhi, **NPTEL**
- 2) “Online Communication in the Digital Age” by Prof. Rashmi Gaur, IIT Roorkee, **NPTEL**

Note: The suggested readings and learning resources are indicative. Teachers may suitably supplement them with additional print, digital, audio-visual, and field-based resources according to student needs and local institutional contexts.



**Draft Model Curriculum for 3yr./4yr. Degree Course with
Apprenticeship Embedded Degree program**

**B.Sc. in Geology with Double majors in
Resource Exploration and Digital Mapping**



**Higher Education
Department**

Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	General Geology	4
	MJ -1.2	Historical Geology	4
	MJ -1.3	Crystallography	4
	MJ- 1.4	Mineralogy And Mineral Optics	4
	MJ -2.1	Field Geological Mapping	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	Palaeontology	4
	MJ 1.6	Geochemistry And Elementary Petrology	4
	MJ 1.7	Igneous Petrology	4
	MJ- 1.8	Elementary Economic Geology	4
	MJ 2.2	Ore Microscopy	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / or any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	Stratigraphy	4
	MJ 1.10	Sedimentary Petrology	4
	MJ 1.11	Metamorphic Petrology	4
	MJ- 1.12	Economic Resources of India	4
	MJ 2.3	Environmental Geology	4
	MJ -2.4	Laboratory Instrumentation and Analysis	4
	MDC (Multidisciplinary Course)	Geology or/ any other discipline	3
	SEC (Skill Enhancement Course)	Geology or/ any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	Structural Geology & Tectonics	4
	MJ- 1.14	Engineering Geology & Rock Mechanics	4
	MJ- 1.15	Hydrogeology	4
	MJ -2.5	Remote Sensing and GIS	4
	MJ -2.6	Exploration And Mining Geology	4
	MDC (Multidisciplinary Course)	Geology /or any other discipline	3
	SEC (Skill Enhancement Course)	Geology /or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20
TOTAL			150

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Semester-I

1.1 General Geology

(ORIGIN OF EARTH, ITS EVOLUTION AND LANDFORMS)

Course Objectives

- To introduce fundamental aspects of Earth and Planetary system and Geological time-scale
- To introduce the Internal Structure and processes of Earth.
- To associate the naturally occurring landforms with erosive and depositional action of the rivers, wind, glaciers and oceans.

Learning Outcomes:

- Understand the scientific theories and evidence supporting the origin of the Earth and the Solar system
- Analyze the processes involved in the early evolution of the Earth including differentiation, accretion, and the formation of the Earth's internal structure and processes.
- Understand the internal structure and processes within the earth which impacts surface processes like volcanism and earthquakes.
- Evaluate the surface processes and agents like water, wind, glacier and oceans in shaping the various landforms.

Unit - I: Earth as a planet

Geology - its perspective, scope and subdivisions; Solar System and its planets. The terrestrial and jovian planets. Origin of Earth in the solar system. About Earth (size, shape, mass, density, rotational and revolution parameters). Radioactivity and age of the earth.

Unit - II: Internal structure of the Earth

Seismology and internal structure of the earth; Formation of core, mantle, crust; Convection in Earth's core and its magnetic field. Volcanoes: Types, products and distribution. Earthquakes - intensity, causes and distribution.

Unit - III: Denudation and Geological Action of water

Weathering and Erosion, Mass wasting; Geological works of river. Types of drainage pattern. Geological action of underground water.

Unit - IV: Geological action of Wind, Glaciers & Ocean

Geological action of glacier, wind and ocean and landforms produced by them. Wave erosion and beach processes.

Suggested Practical:

- ✓ Topographic Maps and Interpretation.
- ✓ Contour Patterns and Drawing of Profiles
- ✓ Volcanoes and their Occurrences
- ✓ Earthquakes and Seismic Zones.

Textbook:

- ✓ Steven Earle (2015) *Physical Geology* (available online at <https://opentextbc.ca/geology/>)
- ✓ G B Mohapatra (2018) *Textbook of Physical Geology*, CBS Publishers

1.2 Historical Geology

(DYNAMIC EARTH, ITS ROCK AND FOSSIL RECORDS)

Course Objectives:

- To introduce crustal processes which shape the Earth's surface
- To explain the theory of plate tectonics and its evidences
- To provide the basis of Geologic time scale
- To introduce fossils and its use to establish evolution of life through geological time.

Learning Outcome:

- Analyze landforms and the causative crustal processes
- Understand the role of plate tectonics in shaping Earth's surface and its various landforms
- Appreciate the evolution of life through geological time through stratigraphy and its correlation
- Explain evolution of vertebrate and origin from fossil records

Unit - I: Crustal Processes & landforms

Diastrophism – Epeirogeny and orogeny; Isostasy – concept and theories; Geosynclines, Origin of oceans, continents, mountains and rift valleys.

Unit - II: Plate Tectonics

Plate tectonics—concept and types of plate margins; Continental drift—evidences and causes; Sea-floor spreading; Mid-oceanic ridge, trenches, transform faults; Island arc.

Unit - III: Geological Time Scale and Rock records

Geological Time Scale, Principles of Stratigraphy, Stratigraphic units; Stratigraphic correlation, and Indian equivalences; Geomorphologic and tectonic divisions of India.

Unit - IV: Fossils and Evolution of Life on Earth

Fossils, types and fossilization; Geological significance of fossils. Origin of life and evolution – ancient and modern concepts, evidences, theories and types, Types of fossil specimens.

Suggested Practical:

- Identification of Landforms from Tectonic Maps
 - Ring of Fire
 - Different types of plate boundaries
 - Triple junctions
- Identification of Vertebrate Fossils
- Identification of Invertebrate fossils
- Identification of Plant fossils

Textbook:

- ✓ *Wicander, Monroe (2012) Historical Geology, Cenage Learning.*

Suggested Readings:

- ✓ *Shah, S. K. (2018), Historical Geology of India, Scientific Publishers.*
- ✓ *Poort & Carlson (2005) Historical Geology: Interpretations and Applications, Pearson Prentice Hall*

1.3 Crystallography

Course Objectives

- To explain the principles of crystallography and crystal systems.
- To introduce crystallographic calculation using Miller's indices, Lattice parameters and crystallographic axes
- To provide a methodical approach to identification and classification of mineral crystals based on their crystallographic properties.

Learning Outcomes

- Understand the principles of crystallography and crystal systems.
- Explain the fundamental concepts of crystallography, including crystal lattice, unit cell, symmetry elements, and crystal systems.
- Identify and classify crystals based on their crystal systems and symmetry properties.
- Interpret crystallographic data, including crystal symmetry and crystallographic directions
- Analyze crystal structure and properties of minerals.

Unit - I: Elements of crystallography and isometric system

Crystalline and non-crystalline substances, Crystals - definition, characteristics, intercepts, parameters, indices and forms (Open and closed, General and Special). Symmetry elements and classification of crystals in to six systems. Hermann-Mauguin symbol; Holohedrim, hemihedrim, hemi morphism and enantiomorphism. Twinning zone and zonal laws.

Unit - II: Normal classes A

Study of axial relationship, symmetry elements and forms present in normal classes of isometric, tetragonal, hexagonal and Trigonal system.

Unit - III: Normal classes B

Study of axial relationship, symmetry elements and forms present in normal classes of orthorhombic, monoclinic and triclinic system.

Unit - IV: Lower crystal classes

Study of axial relationship, symmetry elements and forms present in lower classes of isometric system. Projection of crystals. Bravais lattice.

Practical:

- Identification of symmetry elements from crystallographic models
- Stereographic projection of crystals belonging to isometric and tetragonal normal class

Textbook

- ✓ *Crystallography by J D Dana.*

Suggested Books:

- ✓ *Practical approach to crystallography and mineralogy, R. N. Hota (2011), CBS Pub, New Delhi*
- ✓ *Flint, F. (1964): Essentials of Crystallography, Peace Pub., Russia.*
- ✓ *Babu, S. K. (1987): Practical Manual of Crystal Optics, CBS Pub. & Dist.*
- ✓ *Ford W. E., (2006) Dana's Text Book of Mineralogy CBS Pub. & Dist., New Delhi*

1.4 Mineralogy and Mineral Optics

Course Objective

- To introduce Minerals and their properties
- To provide the basis of mineral classification
- To provide an understanding of an optical microscope and how to observe optical properties of minerals in thin sections

Learning Outcome:

- Identify and classify minerals in hand specimens
- Observe optical properties and identify minerals under the microscope
- Describe the macro and micro properties of minerals and mineral groups

Unit – I: Elements of mineralogy

Chemical bonding and compound formation. Definition and classification of minerals. Physical properties of minerals, Silicate structure and its classification. Isomorphism, polymorphism and pseudo morphism.

Unit - II: Silicate groups

Study of atomic structure, chemistry, physical, optical properties and uses of minerals of Olivine, Pyroxene, Amphibole, Garnet, Feldspar, Feldspathoids, silica and Mica groups.

Unit- III: Principles of mineral optics

Nature of light rays and their propagation, internal reflection, double refraction, interference and polarization. Nicol Prism and polaroids. Petrological microscope - parts and their functions. Preparation of thin section of minerals and rocks.

Unit - IV: Optical properties

Behaviour of light in thin section and production of interference colours. Order of interference colour, twinkling, Optic axis, Uniaxial and biaxial minerals. Isotropism and anemotropism, Extinction and extinction angle. Pleochroism, pleochroic scheme, Birefringence; Outline of study of optical characters of minerals in thin sections.

Practical:

- Megascopic identification of Minerals
- Microscopic identification of Minerals;
- Measurement of extinction angle; sign of elongation and order of interference color.

Textbook:

- ✓ *Dexter Perkins (2002) Mineralogy, Prentice-Hall of India, New Delhi.*

Suggested Readings:

- ✓ *Klein, C., Dutrow, B., Dwight, J. & Klein. (2007). Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.*
- ✓ *Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.*
- ✓ *Verma, P.K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt. Ltd.*
- ✓ *Deer, W.A., Howie, R.A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.*
- ✓ *Hota, R. N. (2017) Practical approach to crystallography and mineralogy, CBS Publishers and Distributors, New Delhi.*

Field Geological Mapping

Course Objective:

- To be taught for the 1-year certificate program
- To introduce elements of Geological Maps and its components
- To interpret landforms on geological Maps
- To explain how geological features are represented in a geological map
- To use tools for preparing geological maps

Learning Outcome:

- Describe the elements of a geological map
- Explain the significance of map elements and legend items
- Field data Collection, sampling and representation in a geological map
- Prepare a geological map
- Use a geological map for field mapping

Unit - I: Introduction

Geological Map and map components, Scale and symbology, Toposheet numbering, map reading and locating self in field,

Unit - II: Field Measurements

Geological compass and field measurements, Measuring dip and strike, Mapping and representation of lithological contacts, Concept of V-rule and its significance

Unit - III: Mapping Structures

Folds and Faults and their mapping. Representation of different types of folds and faults. Unconformities and their representation. Techniques of litho-sections

Unit - IV: Geological Map

Anatomy of a Geological map. Map features and symbols. Legend and Scale. GIS Maps - Projection and scale, Map elements – Layout design, north arrow, representative ratio, symbology and legend. Map printing

Textbook:

- ✓ *C W Hayes Handbook for Field Geologists*
- ✓ *Maltair & Maltair, 20189, Concepts of Cartography, Remote Sensing & GIS*

Suggested readings:

- ✓ *Compton, R. R., 1985, Geology in the Field, Wiley, New York.*
- ✓ *Lisle, Braham, Barnes, 2011, Basic Geological mapping*

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	• Communication, its Importance and Factors • Types of Communication • Verbal and Non-verbal Communication • Styles of Communication
2	English Language and Communication: Listening and Speaking	• Types of Listening • Speaking to communicate effectively • Style of speaking in Various Situations • English Pronunciation
3	English Language and Communication: Reading and Writing	• Reading methods and techniques. • Reading texts to Understand meaning • Writing Process • Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	• Grammar • Sentence structure • Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-so conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)
2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lighting)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

- A. a) Environmental Ethics: Issues and possible solutions.
- b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
- c) Environment Protection Act
- d) Air (Preservation Control of Pollution) Act
- e) Water (Preservation Control of Pollution) Act
- f) Wildlife Protection Act
- g) Forest Conservation Act
- h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
- B. Human Population and the Environment
- Population Ecology: Individuals, species, population, community
- Human population growth, population control method
- Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural

- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester-II

Major I

Credit 04

1.5 Palaeontology

Course Objectives

- To introduce the principles and methods of paleontology
- To expose students to fossils, their mode of formation, classification and application in paleontological dating.
- To use fossil records for reconstruction of the evolutionary history of organisms.
- To discourse on ancient environments and climate change from fossil evidences including mass extinctions.

Learning Outcomes:

- Understand the principles of paleontology which include fossil identification, excavation techniques, and paleontological dating.
- Apply these techniques to analyze and interpret fossil records.
- Analyze and interpret the fossil record to reconstruct the evolutionary history of organisms and understand past ecosystems.
- Infer about ancient environments, climate change, and mass extinctions from fossil records.

Unit - I: Introduction to Paleontology

Fossilization – conditions, processes (Taphonomy) and modes. Taxonomic hierarchy and Nomenclature. Concept of biostratigraphy, geological time scale and organic evolution.

Unit - II: Invertebrate Fossils

Introduction to important invertebrate groups (e.g. Trilobita, Mollusca) and their biostratigraphy significance. Morphology and evolution of Brachiopods, Pelecypods, Cephalopods & Gastropods, Trilobites, Echinoids, Corals and Graptolites

Unit - III: Vertebrate Paleontology

Origin and division of vertebrates and major stages of evolution. Reptiles and mammals and their evolution from fossil records. Siwalik fauna, Evolution of horse, elephant and homo sapiens.

Unit - IV: Paleobotany & Palynology

Gondwana flora and their significance. Separation of spores and pollens. Utility of palynological studies in different fields.

Practical:

- Identification of important invertebrate and plant fossils;
- Drawing and labeling of fossils;
- Arrangement of fossils in geochronological order;

Textbook:

- Foote, M. and Miller, I.A. (2007) Principles of Paleontology. W. H. Freeman and company
- Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution, 4th Edition, Blackwell Publishing.

Suggested readings:

- ✓ Raup, D. M., Stanley, S. M. Freeman, W. H. (1971) Principles of Paleontology
- ✓ Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
- ✓ Shukla, A.C. & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
- ✓ Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
- ✓ Benton, M.J. and Harper, D.A.T. (2009) Introduction to Paleobiology and the Fossil Record. Wiley-

Blackwell

Major I

Credit 04

1.6 Geochemistry and Elementary Petrology

Course Objectives:

- To introduce the chemical characteristics and cosmic abundance of elements
- To explain the geochemistry of water and sediments
- To classify and name of the rocks based on their mineral composition and properties
- To explain the petrographic characteristics and petrographic features, such as mineral assemblages, textures, and structures, exhibited by rocks.

Learning Outcomes

- Explain the geochemistry of water and sediments
- Classify elements based on their geochemistry and mode of affinity.
- Elaborate on the cosmic abundance of elements
- Explain the petrographic characteristics and petrographic features of rocks.

Unit - I: Elements of geochemistry

Chemical bonding, states of matter and atomic environment of elements. Cosmic abundance of elements; composition of planets and meteorites. Structure and composition of earth. Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers.

Unit - II: Geochemical classification of elements

Geochemical classification of elements, Primary geochemical differentiation; Atomic substitution. Advection and diffusion; Solid solution, Chromatography; Elements of marine chemistry; Mineral reactions- diagenesis and hydrothermal reactions.

Unit - III: Cosmic abundance of elements

Distribution of elements in solar system; Chemical differentiation and composition of the Earth; General concepts about geochemical cycles and mass balance; Geo-chemical behaviour of major elements.

Unit – IV: Elements of petrology

Types of rocks, Physical properties, genesis, evolution and types of magma. Processes of formation of sedimentary rocks; origin of metamorphic rock.

Practical:

- Geochemical data analysis and interpretation of common geochemical plots.
- Geochemical phase variation diagrams and its interpretations.
- Rock classification and Megascopic identification of rocks

Textbook:

- ✓ *Principles of Geochemistry, Brian Mason*
- ✓ *Principles of Petrology: An Introduction to the Science of Rocks, Tyrrell, G.W.*

Suggested Readings:

- ✓ *Essentials of geochemistry, John V Walther*
- ✓ *Petrology of Igneous, Sedimentary and Metamorphic Rocks, Sachin Changotra*
- ✓ *Petrography, An Introduction to the Study of Rocks. Williams, H., F. J. Turner, and C. M. Gilbert.*

1.7 Igneous Petrology

Course Objectives

- To introduce Igneous processes and products
- To classify the various igneous rocks based on their genesis, mineral composition and texture
- To analyze the petrographic characteristics and processes of igneous rocks:
- To interpret rock characteristics to deduce the magmatic processes, including magma differentiation, fractional crystallization, assimilation, and magma mixing.

Learning Outcomes:

- Understand the basis for classification and nomenclature of igneous rocks:
- Identify igneous rocks based on their mineral composition, texture, and mode of occurrence.
- Evaluate the petrographic characteristics and interpret the igneous processes involved.
- Deduce the magmatic processes, including magma differentiation, fractional crystallization, assimilation, and magma mixing

Unit - I: Introductory Concepts

Magma generation in the crust and upper mantle. Physical properties of magma - temperature, viscosity, density and volatile content. Modes of emplacement of igneous rocks: volcanic, hypabyssal, plutonic

Unit - II: Forms, Texture and Microstructure

Mode of occurrence of igneous rocks. Forms of igneous rocks. Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of minerals in magma; Different textures and microstructures and their occurrence. Bowen's reaction series, differentiation and assimilation of magma and diversity of igneous rocks.

Unit - III: Classification and Petrographic Analysis

Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical and associational. Norm and mode. Standard classification schemes – Niggli, Hatch and Wells and IUGS. TAS diagram for volcanic rocks; Petrography of important igneous rocks (felsic, mafic, ultramafic and Alkaline)

Unit - IV: Phase Diagrams

Phase rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary and ternary systems under high dry and wet pressure with respect to their nature under low pressure, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, forsterite – diopside – silica and nepheline - kalsilite – silica.

Practical:

- ✓ *Megascopic identification of important igneous rocks.*
- ✓ *Microscopic identification of important igneous rocks*

Textbook:

- ✓ *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*
- ✓ *Hota, R.N.(2017) Practical approach to petrology, CBS Publishers and Distributors, New Delhi*

Suggested readings:

- ✓ *Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.*
- ✓ *Bose M.K. (1997). Igneous Petrology.*

✓ G W Tyrrell. (1926). *Principles of Petrology*. Springer

1.8 Elementary Economic Geology

Course Objective

- To explain the process of formation of ore deposits.
- To discourse on Indian distribution of metallic and non-metallic ore minerals
- To provide an understanding of the various economic minerals found in India.

Learning Outcomes:

- Understand the primary and secondary processes of ore formation
- Apply principles of ore genesis and geothermometry
- Appreciate the distribution of various metallic and non-metallic ores in India.

Unit - I: Ore Minerals & Primary Processes

Process of formation of ore bodies: Magmatic concentration, Hydrothermal processes, Wall rock alteration and Paragenesis, Zoning.

Unit - II: Secondary processes

Residual and mechanical concentration, Oxidation and Supergene enrichment, Sedimentation, Evaporation & Metamorphism.

Unit - III: Ore genesis

Ore genesis, Syngenetic & Epigenetic Ores, Formation of Magmatic, Hydrothermal, Metamorphic Fluids and their concentration. Geothermometry, definition, classification, methods for preparation of geological thermometry.

Unit - IV: Economic Minerals of India

Metallic and Non-metallic ores of India: Metallic ores, Non-metallic and industrial rocks and minerals, Atomic minerals, Gem & Gemstones.

Practical:

- Distribution of Economic Minerals by type in India and the world
- Problems in geothermometry.

Textbooks:

- ✓ Tiwari, S. K. (2010) *Ore Geology, Economic Minerals and Mineral Economics*, Atlantic Publishers & Distributors (P) Limited
- ✓ Laurence Robb. (2005) *Introduction to ore forming processes*. Wiley.

Suggested Reading:

- ✓ Guilbert, John M. and Charles Frederick Park (2007) *The Geology of Ore Deposits*, Waveland Press 4.
- ✓ Arogyaswamy R.N.P. (2017) *Courses in mining geology*, Oxford and IBH publishers
- ✓ Evans, A.M. (1993) *Ore Geology and Industrial minerals*. Wiley
- ✓ Ridley, J. (2013): *Ore Deposit Geology*. Cambridge University Press, UK. P398.
- ✓ Guilbert, J.M. and Park Jr., C.F. (1986) *The Geology of Ore deposits*. Freeman & Co.

2.2 Ore Microscopy

Course Objective

- To introduce students to optical examination of adsorbing (ore) minerals
- To educate students on the interaction of polarized light reflected from crystalline polished surface of ore minerals

Learning Outcome:

- Acquire the capability of basic determination of Ore minerals in reflected light
- Illustrate the capability to identify ore minerals and their stage of alteration
- Interpret mineral paragenesis from polished sections

Unit 1: Introduction to Ore Microscopy

Ore Microscope, and its parts and components. Polarization for reflected light, Sample preparation for ore microscopy

Unit 2: Optical Properties for Ore Mineral Identification

Qualitative methods for identification of Ore Minerals, Qualitative optical properties of ore minerals, Qualitative testing of hardness of ore minerals.

Unit 3: Morphological and Structural Properties

Morphological properties ore minerals. Structural properties, Ore mineral aggregates. and mineral aggregates.

Unit 4: Mineral Paragenesis

Basic classification, Systematic qualitative optical study of ore minerals, Native elements, sulphides, sulfosals, oxides, hydroxides and gangue minerals.

Practical:

- Ore Microscope
- Identification of Sulfides and Sulfosals
- Identification of Oxides and Hydroxides
- Gangue Mineral identification

Textbook:

- ✓ *Craig, J.R., Vaughan, D.J.: 1981. Ore Microscopy and Ore Petrography, John Wiley and sons Inc. New York.*

Suggested readings:

- ✓ *Castroviejo, R. (2023) A Practical Guide to Ore Microscopy – Volume 1, Springer*

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester-III

1.9 Stratigraphy

Course Objectives

- Introduce the principles of stratigraphy and geological time scale
- Exposure on Stratigraphic Nomenclature and Indian stratigraphic systems and their significance
- Describe the use of fossils for paleoecology, paleobiogeography, paleoclimate and paleoenvironmental study

Learning Outcome:

After completion of this course successfully, the students will be able to

- Explain the principles of advanced stratigraphy and details of geological time scale
- Assess Indian stratigraphic systems and their significance
- Discuss on the use of fossils for paleoecology, paleobiogeography, paleoclimate and paleoenvironmental study

Unit - I: Introduction

Definition and scope of Stratigraphy, Principles of Stratigraphy, Geological Time Scale. Stratigraphic Contacts and types (conformable contacts, unconformities), Stratigraphic correlation and types, Classification and nomenclature of units, Indian code of Stratigraphic Nomenclature, Elements of Paleogeography

Unit - II: Precambrian Stratigraphy of India

Precambrian stratigraphy of Karnataka, Odisha, Jharkhand, Rajasthan, Madhya Pradesh and Maharashtra. Stratigraphy of Cuddapah and Vindhyan basins, Delhi supergroup

Unit – III: Paleozoic, and Mesozoic Stratigraphy of India

Gondwana rocks with special emphasis on fossils, climate and economic importance. Triassic of Spiti, Jurassic of Kutch and Cretaceous of Trichinopoly..

Unit - IV: Cenozoic Stratigraphy of India

Deccan traps, , Tertiary of Assam, Siwalik (with special reference to mammal fossils).

Practical:

- Drawing of stratigraphic units in outline map of India and Odisha;
- Identification and interpretation of stratigraphic assemblages;
- Drawing of paleogeographic maps as mentioned in theory

Textbook:

- ✓ Ramakrishnan & Vaidyanadhan (2008) *Geology of India, Volumes 1 & 2*, Geological society of India, Bangalore.
- ✓ Boggs, S., 1995. *Principles of Sedimentology and Stratigraphy*, Prentice Hall, New Jersey.

Suggested readings:

- ✓ Krishnan, M.S. (1982) *Geology of India and Burma*, CBS Publishers, Delhi
- ✓ Doyle, P. & Bennett, M. R. (1996) *Unlocking the Stratigraphic Record*. John Wiley
- ✓ Valdiya, K. S. (2010) *The making of India*, Macmillan India Pvt. Ltd.

1.10 Sedimentary Petrology

Course Objectives:

- To introduce the concepts and principles of sedimentary processes and products
- To observe sedimentary rocks and their properties in hand specimen and under the petrographic microscope
- To introduce the different sedimentary environment, facies and their association
- To provide an overview of the different mechanisms of basin formation and provenance analysis

Learning Outcomes:

- Evaluate and identify various sedimentary rocks
- Analyze the sedimentary textures and deduce the depositional environment
- Determine the direction of younging in a succession by observing sedimentary structures.

Unit I: Sedimentary Processes

Weathering & Erosion. Fluid flow and Sediment transport. Deposition and lithification. Diagenesis and its type. Depositional Environments (Continental, Transitional and Marine).

Unit II: Texture, Fabric and Structures

Texture (grain size and shape) and its significance. Grain fabric and its interpretation, Sedimentary structures and determination of paleocurrent and direction of younging.

Unit III: Classification & Petrography

Clastic and Carbonate classification. Petrographic notes on sandstones, conglomerate, shale, limestone and breccia and their occurrences in India. Dolomite and dolomitisation.

Unit IV: Sedimentary Basins & Provenance Analysis

Sedimentary Basins and types, Sedimentary Provenance and provenance Analysis, Heavy mineral and their significance, Sedimentary Basins of India.

Practical:

- Megascopic and Microscopic identification of sedimentary rocks.
- Grainsize Analysis, Paleocurrent Analysis

Textbooks:

- ✓ *Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell*
- ✓ *Boggs, S., 1995. Principles of Sedimentology and Stratigraphy, Prentice Hall, New Jersey.*

Suggested readings:

- ✓ *Prothero, D.R., & Schwab, F. (2004). Sedimentary geology. Macmillan.*
- ✓ *Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.*
- ✓ *Hota, R.N. (2017) Practical approach to petrology, CBS Publishers and Distributors, New Delhi*

1.11 Metamorphic Petrology

Course Objectives

- To introduce the origin of metamorphic rocks in different geological environments.
- To discourse on the different physical and chemical processes affecting metamorphic rocks of various types.
- To Describe the effect of tectonism on metamorphism.

Learning Outcome:

- Identify metamorphic rocks by evaluating their properties
- Evaluate the stage of metamorphism from phase diagrams
- Analyze the effect of tectonism on metamorphism.

Unit - I: Metamorphism: Factors and Types

Introduction and definition of metamorphism. Factors controlling metamorphism: Agents and types of metamorphism, ACF and AKF diagrams.

Unit - II: Metamorphic facies and grades

Index minerals, Metamorphic zones and grades. Concept of metamorphic facies; Mineralogical phase rule of closed and open systems; Structure and textures of metamorphic rocks.

Unit - III: Metamorphism and Tectonism

Relationship between metamorphism and deformation; Metamorphic mineral reactions (prograde and retrograde); Migmatites and their origin; Metasomatism and role of fluids in metamorphism. Classification of metamorphic rocks; Metamorphic differentiation.

Unit - IV: Metamorphic Petrography

Petrographic notes on important rock types like schists, gneisses, granulite, marble, quartzite, slate, phyllites, khondalite, charnockite and eclogites and their Indian occurrences.

Practical:

- Megascopic identification of metamorphic rocks.
- Microscopic examination of metamorphic rocks.
- Metamorphic equations and phase diagrams

Textbook:

- ✓ Yardley, B. W., & Yardley, B. W. D. (1989). *An introduction to metamorphic petrology*. Longman Earth Science Series.

Suggested Readings:

- ✓ Philpotts, A., & Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
- ✓ Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.
- ✓ Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
- ✓ Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
- ✓ Hota, R. N. (2017) *Practical approach to petrology*, CBS Publishers and Distributors, New Delhi.

1.12 Economic Resources of India

Course Objectives

- To discourse on Metallic and non-metallic minerals and their Indian distribution
- To study on the mineralogy, occurrence and usage of Industrial minerals
- To explain the Describe the different methods of mineral beneficiation techniques

Learning Outcome:

- Learn about Metallic Minerals and their distribution in India
- Understand the mineralogy, occurrence and usage of Industrial minerals
- Describe the different methods of mineral beneficiation techniques

Unit - I: Introduction

Classification of Economic Minerals, Critical Minerals of India. Mineral provinces and state-wise reserves of major economic minerals of India.

Unit - II: Metallic Minerals

Indian distribution, mode of occurrence, properties, uses and reserves of ores of Iron, Aluminium, Chromium, Copper, Gold, lead and Zinc, Manganese, Titanium, Tin, Uranium, Lithium and Thorium.

Unit – III: Non-metallic Minerals of India

Indian distribution, mode of occurrence, properties, uses and reserves of Asbestos, Barites, Beryl, Corundum, Diamond, Dolomite, Fireclay, Graphite, Fluorite, Gypsum, Kyanite, Graphite, Mica Talc and Mineral fertilisers.

Unit – IV: Energy Resources

Geology (mode of occurrence, properties and usage) of Coal, Petroleum and Uranium and their Indian distribution.

Practical:

- Megascopic identification of Ore minerals
- Map study of Metallogenic provinces of India
- Coal, Petroleum and Uranium Deposits map

Textbooks:

- ✓ Gokhale, K.V.G.K. and Rao, T.C. (1978) *Ore deposits of India, their distribution and processing*, Tata-McGraw Hill, New Delhi.
- ✓ Umathay, R.M. (2006), *Mineral Deposits of India*
- ✓ Chandra, D. (2007). *Chandra's Textbook on Applied Coal Petrology*. Jijnasa Publishing
- ✓ Shelly, R.C. (2014). *Elements of Petroleum geology: Third Edition*, Academic Press

2.3 Environmental Geology

Course Objectives

- To be excluded for the 4 year honours with research program
- To introduce the role of geology to the environment
- To discourse av=bour the various environmental disasters
- To expose students to disaster management and the application of Remote sensing and GIS in the discipline.

Learning Outcome:

- Describe natural hazards and environmental disaster and their drivers.
- Illustrate application of remote sensing and GIS in disaster management.
- Interpret climate change and ensuing geomorphic responses.
- Describe natural hazards, and broad applied aspects of geomorphology.

Unit 1: Natural Disasters and Disaster Management

Drought, Flood, Cyclone, Tornado, Thunder storm; Earthquake, Land slide, Tsunami, Inundation of Coastlines

Unit 2: Elements of Climatology

Thermal Structure & Composition of Atmosphere; Elements of Climate and weather. Basis of classification; Koppen's classification; Thornthwaite's classification; Brief idea on Types of Climate found in India.

Unit 3: World Weather Circulation

Jet stream and its influence on world weather; Air Mass, their classification and influence on world weather; Fronts (Front classification). Mechanism of monsoon; Factors associated with monsoonal intensity; Effects of monsoon.

Unit 4: Climate Change

Milankovitch cycles and variability in the climate; Glacial-interglacial stages; The Last Glacial maximum (LGM). Glacial periods, sea-level rise, effects of sea level rise, Rise of carbon dioxide in the atmosphere, green-house gases, green-house effect and global warming, Desertification.

Practical:

Tutorials and Seminars

Textbook:

- ✓ *Bell, F.G., 1999. Geological Hazards, Routledge, London.*

Suggested readings:

- ✓ *Bryant, E., 1985. Natural Hazards, Cambridge University Press.*
- ✓ *Smith, K., 1992. Environmental Hazards. Routledge, London*

2.4 Laboratory Instrumentation and Analysis

Course Objectives

- To introduce laboratory based analytical instruments and their operation
- To explore how these instruments are used and what data sets are generated
- To introduce analysis and interpretation of lab generated data

Learning Outcomes:

- Explain the principles behind various analytical instruments
- Operate analytical instruments and produce data from samples
- Analyze and interpret data for various applications

Unit - I: Liquid Chromatography

Various sample preparation techniques, isolation of compounds from mixtures. The identification of compounds using various detectors, limitation and advantages of the technique

Unit - II: Gas Chromatography

Sample injection methods, Correlation of Theory and Practice through Van Deemter Plots, Important experimental variables, Quantitative separations of mixtures, limitation and advantages of the technique.

Unit - III: Mass Spectrometry

Various sample preparation techniques, acquisition of data, isolation of compounds from mixtures, identification of compounds from fragmentation patterns, limitation and advantages of the technique.

Unit - IV: X-Ray Diffraction and Atomic Absorption

Metal Analysis methods, detection limits, surface vs. Bulk Analysis, Destructive vs Non-destructive Analysis, Calculation of concentrations.

Practical/Tutorial:

- Mass spectroscope Instruments
- XRD and its operation
- Gas Chromatography instruments
- Liquid Chromatography instruments

Textbooks:

- ✓ *Mark F Vitha, Chromatography: Principles and Instrumentation, Wiley*
- ✓ *Kaimin Shih (eds) X-Ray Diffraction, Nova*
- ✓ *Welz and Sperling, (1999) Atomic Absorption Spectroscopy, Wiley*

Semester-IV

1.13 Structural Geology & Tectonics

Course Objectives

- To introduce structural geology and its relation to tectonics
- To explain the various deformations observed in rocks under different stress conditions
- To discourse on the mechanism of various geological structures like folds, faults & shear zones.
- To describe the tectonic evolution of continents and oceans, evolution of Himalaya

Learning Outcomes:

- Identify and describe the stress conditions from observing the deformations
- Evaluate geological structures like folds, faults, shear zones, etc.
- Analyze the conditions leading to the tectonic evolution of continents and oceans, evolution of Himalaya

Unit - I: Rock deformation

Introduction, Attitude of beds; V's rule; Deformation, concept of stress and strain; Strain ellipses of different types and their geological significances. Effects of topography on structural features, Topographic and structural maps; Outlier, Inlier, Nappe, Klippe and Fenster.

Unit - II: Folds

Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding; Recognition of folds in field and map, causes of folding, Top and bottom criteria of deformed strata.

Unit - III: Faults and joints

Fault- classification, mechanism, significance, recognition in the field and map, general effects of faulting on outcrops. Joints - geometry, classification and significance.

Unit - IV: Unconformities, Foliation and lineation

Unconformity - types, significance, recognition in the field and map, difference between fault and unconformity. Foliation - types and relation with major structures, Lineation - types and relation with major structures; Salt domes and diapirs.

Practical:

- Interpretation of structure, stratigraphy and geologic history from maps;
- Completion of outcrops and drawing of sections;
- Three-point problems;
- Thickness and depth problems;

Textbook:

- Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley

Suggested readings:

- ✓ Billings, M.P.(1987) Structural Geology, 4th edition, Prentice-Hall.
- ✓ Park, R.G.(2004) Foundations of Structural Geology. Chapman & Hall.
- ✓ Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
- ✓ Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
- Lahee, F. H. (1962) Field Geology. Mc Graw Hill

1.14 Engineering Geology & Rock Mechanics

Course Objectives

- To introduce the mechanical properties of rocks
- To expose students to the geological problems related to foundation, dam, tunnel, road and bridges.
- To evaluate rock mass and building materials and stability of slopes.

Learning Outcome:

- Define the mechanical properties of rocks
- Solve the geological problems related to foundation, dam, tunnel, road and bridge.
- Characterize rock mass and building materials
- Address issues related to stability of slopes.

Unit - I: Engineering properties and classification

Engineering properties of Rock and Soil. Rock strength and failure, Mohr circle. Building materials. Rock mass classification – Rock quality designation.

Unit - II: Slopes and Slope Stability

Soil - classification, erosion and conservation. Slopes and Slope failure, Geological factors, Slope history and examples of Slope failure. Landslides and its type.

Unit - III: Geology of Tunnels and Bridges

Tunnels and its types, Bridges and its types, Geological considerations of tunnel alignment and bridge site selection. Earthquake resistant structures.

Unit - IV: Reservoir & Dams

Types of dams; Geological considerations of Dam site and reservoir site selection. Case studies of Dams (e.g. Hirakud dam, Rengali dam).

Practical:

- Engineering properties of rocks.
- Structural maps and tunnel Alignment
- Topographic maps and Bridge site selection

Textbooks:

- ✓ *N Chena Kesavulu, Engineering geology*
- ✓ *S P Garg, Physical and Engineering Geology*

Suggested Readings:

- ✓ *Blyth & Frietas (1984) A Geology for Engineers. 7th Edition, Elsevier*
- ✓ *Verma, B. P. (2017). Engineering Geology and Rock mechanics. 4th Edition. Khanna Publishers.*

1.15: Hydrogeology

Course Objectives

- To introduce the properties of rocks which make them an aquifer
- To introduce the principles and processes of groundwater flow including Darcy's law, hydraulic conductivity, and aquifer properties.
- To elaborate on groundwater flow patterns, groundwater recharge and discharge mechanisms, and the factors influencing groundwater movement and contamination.

Learning Outcomes:

- Explain the principles and processes of groundwater flow including Darcy's law, hydraulic conductivity, and aquifer properties.
- Analyze and interpret groundwater flow patterns, groundwater recharge and discharge mechanisms, and the factors influencing groundwater movement and contamination.
- Apply hydrogeological techniques for groundwater assessment and management.
- Design and implement groundwater monitoring programs, evaluate aquifer properties, analyze groundwater quality, and propose appropriate strategies for sustainable groundwater use and protection.

Unit - I: Hydrological Properties of Rocks

Hydrological cycle, vertical zonation of ground water, Properties of water bearing formations -porosity, permeability, specific yield, specific retention, storativity. Aquifer types-Confined and unconfined aquifers, aquitard, aquiclude, aquifuge. Darcy's law.

Unit - II: Groundwater Quality and Pollution

Physical and chemical Quality of ground water and its use in domestic, agriculture and industries. Groundwater pollution and its mitigation. Arsenic and Fluoride contamination in ground water.

Unit - III: Groundwater Management

Groundwater basin, Water table fluctuation, Artificial recharge of groundwater, Rainwater Harvesting. Cone of depression. Sea-water intrusion.

Unit - IV: Groundwater Distribution and Exploration

Ground water provinces of India and Odisha. Ground Water exploration methods (Geological and Geophysical).

Practical:

- Solving numerical problems (as per theory)
- Groundwater prospect Mapping
- Laboratory records and viva voce.

Textbooks:

- ✓ *Groundwater Hydrology (3rd edition) (2005) by David Keith Todd and Larry W. Mays. John Wiley & Sons, Inc.*

Suggested readings:

- ✓ *C. W. Fetter (2014) Applied Hydrogeology, Pearson New International Edition.*
- ✓ *B. B. S. Singhal and R. P. Gupta (2010) Applied Hydrogeology of Fractured Rocks (2nd edition), Springer*

- ✓ *Groundwater Science (2nd edition) (2013) by Charles Fitts. Academic Press.*
- ✓ *Ground Water (3rd edition) (2007) by H. M. Raghunath. New Age International Publishers.*

2.5 Remote Sensing and GIS

Course Objective:

- To introduce the basic concepts of remote sensing.
- To discourse of satellite sensors, platforms and their products
- To utilize remote sensing images to interpret features and classify landcover
- To introduce the concept of modelling spatial objects in GIS

Learning Outcome:

- Identify the properties in a remote sensing imagery
- Process a digital image to enhance and derive indices
- Use GIS to model real world objects GIS
- Perform basic overlay analysis using GIS.

Unit-I: Energy Sources and Interactions

Energy sources and principles of radiation, Energy radiation, reflection, scattering and absorption, Black body radiation, Energy interaction in the atmosphere and with earth surface features, spectral reflectance curves

Unit-II: Satellites and Platforms

Types of platforms and sensors; resolution of sensors- spatial, spectral, radiometric and temporal. Satellites: Types and orbits. Earth Observation Satellites: LANDSAT, ASTER, SPOT, IRS, their sensor characteristics and application. Microwave and Hyperspectral remote sensing.

Unit-III: Image Corrections, Visualization and Interpretation

Geometric corrections, ground control points and co-registration, atmospheric corrections, concepts of colour, contrast stretching, filtering and edge enhancement, density slicing and thresholding. Image Interpretation

Unit-IV: Geographic Information Systems (GIS)

GIS Fundamentals, Geographic Coordinate Systems and Map Projections. Conceptual models of spatial information- raster and vector data models, advantages and disadvantages of raster and vector data models, non-spatial information and concept of database, GIS applications across disciplines.

Practical:

- Interpretation of various aeolian, glacial, fluvial and marine land forms from Satellite Imagery.
- Visualization of False Colour Composites
- GIS Layers and Spatial Interpolation

Textbooks:

- ✓ Reddy, A. (2014). *Textbook of Remote Sensing and Geographical Information Systems. Fourth Edition. B S Publications*

Suggested readings:

- ✓ Gupta R.P. *Remote Sensing Geology, Springer*
- ✓ Demers, M.N. (2012). *Fundamentals of GIS, 4th Edition, Wiley Blackwell*
- ✓ Burrough, P.A. (2016). *Principles of GIS. 3rd Edition, OUP*

2.6 Exploration and Mining Geology

Course Objectives:

- To introduce metallic and non-metallic ore minerals and their occurrence and distribution
- To elaborate on the various mineral exploration and extraction techniques
- To discourse on the methods of reserve estimation, mining and ore processing.

Learning Outcome:

- Explain the fundamental terminology like ore, tenor, gangue and grade
- Appreciate the Indian distribution of metallic and non-metallic ore minerals
- Analyze the various mineral exploration and extraction techniques and their suitability to a deposit
- Able to calculate reserve estimation

Unit - I: Mineral Exploration

Mineral deposits and Host rocks, Mineral prospecting methods – Geological (including remote sensing methods), Geochemical, Geophysical, Drilling (& Coring) methods.

Unit - II: Resource and Reserve Estimation

Concept and definitions of Resource and Reserves, Sampling and assaying, Deterministic and probabilistic methods of reserve estimation.

Unit - III: Mining

Elements of mining, its methods (alluvial mining, opencast mining and underground mining) for metallic and non-metallic ores. Shafting, ventilations, drainage and pumping. Mine safety and environment.

Unit - IV: Mineral Beneficiation

Elements of Mineral processing. Sizing (Crushing & grinding), Concentration (Gravity, magnetic and Froth Flotation) and separation methods

Practical:

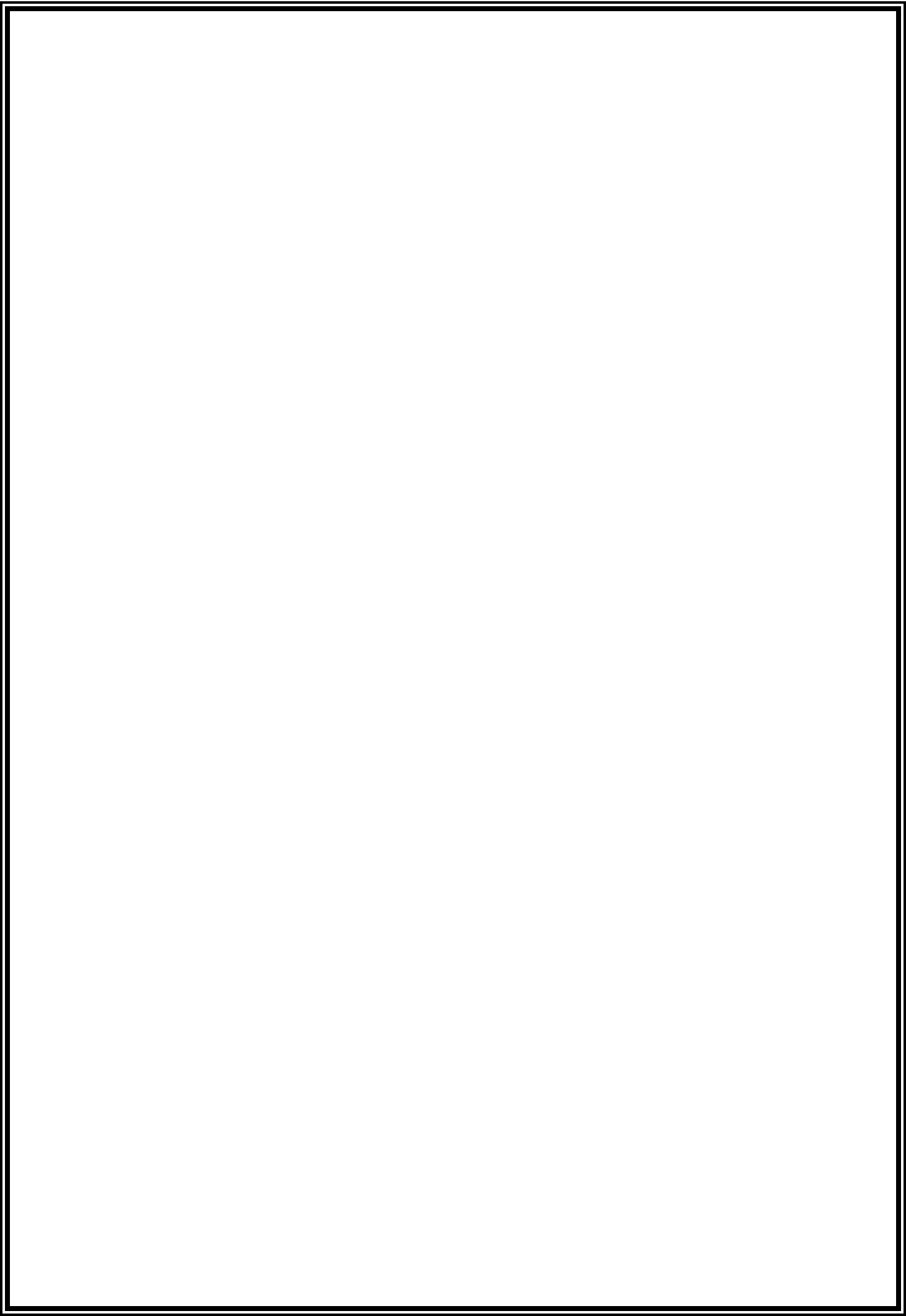
- Sampling and Geochemical assaying
- Calculation of reserves – deterministic
- Calculation of reserves - probabilistic.

Textbook:

- ✓ *Swapan Kumar Haldar, Mineral Exploration Principles and Applications, Elsevier*

Suggested Readings:

- ✓ *Roger Majoribanks, 2010 Geological methods in Mineral Exploration and Mining, Springer*
- ✓ *Subba Rao, Mineral beneficiation, CRC Press*



Draft Model Curriculum for 3yr./4yr. Degree Course with Apprenticeship Embedded Degree program

B.A History with Double Major in Tourism and Hospitality Operations



**Higher Education
Department**
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	History of India I (From Prehistory to Vedic Age)	4
	MJ -1.2	Tourism Concepts Principles and Practices	4
	MJ -1.3	Foundation Course in Front Office	4
	MJ- 1.4	Foundation Course in Accommodation Operation	4
	MJ -2.1	Social Formations and Cultural Pattern of Ancient World	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	History of India II	4
	MJ 1.6	Social Formations and Cultural Pattern of Ancient World II	4
	MJ 1.7	Basic Course in Front Office II	4
	MJ- 1.8	Basic Course in Accommodation Operations II	4
	MJ 2.2	Travel & Tourism Industry	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / or any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	History of India III	4
	MJ 1.10	Rise of Modern West	4
	MJ 1.11	Historical Theories and Methods	4
	MJ- 1.12	History of Orissa I	4
	MJ 2.3	Emerging Trends in Tourism	4
	MJ -2.4	Art Heritage of India	4
	MDC (Multidisciplinary Course)	Basic Principles of Management /or any other discipline	3
	SEC (Skill Enhancement Course)	Computer Skills for Hotel Professionals /or any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	History of Orissa: The Making of a Region	4
	MJ- 1.14	Accommodation Operations	4
	MJ- 1.15	Front Office Operations	4
	MJ -2.5	Tourism Marketing	4
	MJ -2.6	Temples and Biodiversity of Odisha	4
	MDC (Multidisciplinary Course)	Organization Behaviour /or any other discipline	3
	SEC (Skill Enhancement Course)	Organization of Event Meeting and Conferences /or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20
TOTAL			150

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Semester I

Major- I

Credit 4

1.1. History of India- I (From Prehistory to Vedic Age)

Course Objectives

- What were the major changes in Indian history and how did they come about?
- What were the particular institutions and cultural elements in Indian society which may be considered different from those in other societies?
- Students will acquire knowledge regarding the early life and socio-cultural status of the people of ancient India. They can gather knowledge about the society, culture, religion and political history of Ancient India. They will learn about trade and urbanization of ancient civilization, like Harappan Civilization, Vedic civilizations etc
- Students will be oriented to appreciate the changes and continuity in ancient India and also learn about how various sources which are corroborated in order to construct the history of Ancient India

Course Outcomes

- Describe the antiquity of India's past and methods of construction of past
- Describe the different sources which are scientifically corroborated to construct the past
- Describe the beginning of farming communities and scientific methods which have come up in recent years
- Understand the Vedic roots of Indic civilization

Unit-I: Reconstructing Ancient Indian History

1. Early Indian notions of History
2. Sources of Historical Writings and the Historiography concerned with this Period
3. Historical Geography (Major Harappan Sites and Sixteen Mahajanapadas).

Unit-II: Pre-historic Hunter-Gatherers and Food Production

1. Paleolithic Cultures: Upper, Middle and Lower; Tool Typologies in Three Phases, Distribution of Sites, Subsistence Pattern
2. Mesolithic Culture: Distribution of Sites, Tool typologies, Subsistence Pattern, Evidence of Foraging
3. Neolithic: Zones of Early Farming Cultures of Indian Subcontinent (Ash Mound sites of South India, Eastern India, Vindyan Fringe, North-Western India), Crops, Subsistence Pattern, Habitation Structure

Unit-III: The Harappan Civilization

1. Origin and nature; Harappa as Saraswati-Sindhu civilisation: Settlement Patterns and Town Planning (Study of Harappa, Mohenjodaro, Kalibangan, Dholavira and Lothal
2. Economic Life: Agriculture, Craft Productions and Trade (External and Internal)
3. Social and Political Organization; Religious Beliefs and Practices; Art

Unit-IV: Cultures in Transition

1. Early Vedic Age: Sources, Geography, Society, Polity, economy Religion and Literature

2. Later Vedic Age: Social Stratification (Varna and Gender), Polity, Religion, and Culture; Philosophy of Upanishads
3. Non-Harappan Chalcolithic Cultures and Megaliths: Malwa, Kayatha, Ahar, OCP, Eastern India, Megaliths in South India

Suggested Reading List:

- ✓ *BD Chattopadhyaya, A Survey of Historical Geography of Ancient India, Delhi, 1991* }
- ✓ *B. Subba Rao, Personality of India, Varoda, 1958.* }
- ✓ *BD Chattopadhyaya, The Concept of Bharatavarsha and Other Essays, Delhi, 2017* }
- ✓ *D.K. Bhattacharya, An Outline of India's Prehistory R. S. Sharma, Material Culture } and Social Formations in Ancient India, 1983.*
- ✓ *Upinder Singh, a History of Ancient and Early Medieval India.* } *V.N. Mishra, Prehistoric Colonisation of South Asia Free download* }
<https://www.ias.ac.in/article/fulltext/jbsc/026/04/0491-0531#:~:text=Human%20colonization%20in%20India%20encompasses,stone%2C%20bronze%20and%20iron%20ages>
- ✓ *Bridget and Raymond Allchin, (The Rise of Civilization in India and Pakistan. } Cambridge: Cambridge University Press, Part III. Pp. 229- 346, 1982.*
- ✓ *Tony Joseph, Early Indians, The Story of Our Ancestors and Where We Came From, } Delhi, Juggernaut Publciation.*
- ✓ *Romila Thapar, Early India: From Beginning to 1300 CE, Delhi Penguin, different } editions*
- ✓ *A.L. Basham, The Wonder that was India, Vol.1, Delhi, Penguin, Different editions }*
- ✓ *Romila Thapar: Cultural past, Delhi, OUP. 2004 edition, Section 1 only. }*
- ✓ *R.S.Sharma, Material Culture and Social Formation in Ancient India, Delhi, } Macmillan.*
- ✓ *The Vedic Age, Vol 1, Bharatiya Vidya Bhawan }*
- ✓ *Sreedharan, E., A Textbook of Historiography, 500 BC TO AD 2000, Hyderabad: } Orient Blackswan, Reprint 2009*

Major-I

Credits: 4

1.2 Tourism Concepts, Principles and Practices

Course Objective:

The objective of this course is to provide a comprehensive understanding of tourism, its fundamentals and operational framework.

Course outcome (CO):

- **CO1:** To define key concepts and structural components of the tourism industry.
- **CO 2:** To describe the historical evolution and socio-economic significance of the tourism industry.
- **CO 3:** To classify tourism services and products based on their unique features.
- **CO 4:** To assess the impact of tourism activities on the host communities and the environment.

Unit-I: Introduction

1. Introduction: What is Tourism? Significance of Tourism; Definitions and Concepts.
2. Tourism Systems, Visitor, Traveller, and Excursionist– Definition and differentiation.
3. Motivations and deterrents for travel.

Unit-II: Characteristics and Components of Tourism Industry

1. Tourism Industry- structure, and characteristics
2. Constituents of Tourism Industry: Primary, secondary, and tertiary
3. 5 A's – Introduction, Attraction, Accessibility, Accommodation, Amenities, Activities

Unit-III: Types and Forms of Tourism

1. Inbound, outbound Inter–regional and intra–regional tourism, domestic, international tourism,
2. Adventure, health, business, conferences, conventions, incentives, sports, religious, senior tourism
3. Special interest tourism like culture or nature oriented, ethnic or 'roots' tourism and VFR;

General Tourism Trends

Unit-IV: Role of Governments

1. Role of Ministry of Tourism in developing and promoting tourism in India;
2. Role of Central and State Government in Promoting Tourism,
3. Study of National Tourism Policy 2002
4. Case Study: Tourism Policy of Kerala, Rajasthan, and Odisha

Suggested Reading List

- ✓ *Mill & Morrison. The Tourism System- An Introductory Text (7th Edition). Dubuque, Iowa (USA): Kendall Hunt Publishing.*

- ✓ *Goeldner & Ritchie. Tourism, Principles, Practices, and Philosophies. New Jersey: Wiley and Sons.*
- ✓ *Coltman. Introduction to Travel and Tourism- An International Approach. New Jersey: John Wiley.*
- ✓ *Kamra & Chand. Basics of Tourism- Theory, Operation and Practice. New Delhi: Kanishka Publishers.*
- ✓ *Bhatia. International Tourism Management. New Delhi: Sterling Publishers*

1.3 Foundation Course in Front Office-I

Course Objective

The objective of this course is to provide students with a foundational understanding of the global hospitality landscape and the essential operational procedures for managing the hotel front office and the guest arrival cycle.

Course Outcomes (COs)

- **CO 1:** To classify hotels and hospitality establishments based on industry standards such as size, star rating, ownership, and target clientele.
- **CO 2:** To explain the organizational hierarchy, professional attributes, and inter-departmental coordination necessary for effective front office management.
- **CO 3:** To analyse room tariffs, meal plans, and guest profiles to effectively manage room allocation and occupancy trends.
- **CO 4:** To demonstrate proficiency in using front office equipment, managing documentation (vouchers), and executing the guest cycle from pre-arrival to key control.

Unit I: The Hospitality Landscape and Professional Standards

- Famous hotels worldwide and industry terminology.
- Classification of hotels (Size, Star, Location, Ownership, Niche types like Ecotels/Pod hotels).
- Organizational hierarchy of small, medium, and large establishments.
- Service departments and job opportunities in the sector.
- Essential attributes of a Front Office Professional.

Unit II: Operations and Layout of the Front Office

- Core functions and layout of the Front Office department.
- Professionalism: Importance of timely reporting and designated uniforms.
- Inter and intra-departmental coordination strategies.

Unit III: Guest Profiles, Room Management, and Tariffs

- Typology of rooms and hotel facilities.
- Tariff structures (BAR, Corporate, Contracted) and room rate categories.
- Meal plans applicable to the hotel industry.
- Analysis of guest types (Business, Leisure) and seasonal flow (Peak/Lean).

Unit IV: Pre-Arrival Logistics and the Guest Cycle

- Arrival preparation: Occupancy status, room allocation, and VIP confirmation.
- Operational tools: Usage of card machines, printers, and office equipment.
- Front office documentation: Vouchers (Petty cash, Visitor's paid out).
- The Guest Cycle and key control procedures.

Suggested Reading List

- ✓ **Bhatia, A. K.** (2006). *Tourism development: Principles and practices*. Sterling Publishers Pvt. Ltd.
- ✓ **Dix, C., & Baird, C.** (2006). *Front office operations*. Pearson Education.
- ✓ **Ministry of Tourism.** *Annual reports*. Government of India.
- ✓ **Tewari, J. R.** (2016). *Hotel front office: Operations and management*. Oxford University Press.

1.4 Foundation Course in Accommodation Operations

Course Objective

To equip students with a comprehensive understanding of professional housekeeping operations, administrative control procedures, and the application of cleaning science across diverse hospitality environments.

Course Outcome (CO)

- **CO 1: To identify** the organizational hierarchy, essential professional attributes, and varied career opportunities within the accommodation operations sector.
- **CO 2: To explain** the functional layout of the housekeeping department and the significance of inter-departmental coordination in achieving customer delight.
- **CO 3: To execute** administrative tasks at the housekeeping control desk, including the management of registers, guest room status reports, and lost and found procedures.
- **CO 4: To demonstrate** proficiency in cleaning science by selecting appropriate agents, equipment, and manual or mechanical methods while adhering to safety (PPE) protocols.

Unit I: Housekeeping Organization and Professionalism

- Hierarchy of housekeeping in small, medium, and large establishments.
- Essential attributes of a Housekeeping Professional and industry terminology.
- Job opportunities in accommodation operations.
- Functional layout of the housekeeping department.

Unit II: Role and Scope in Hospitality Operations

- Scope and significance of housekeeping in the hospitality industry.
- Working towards customer delight: Roles and responsibilities.
- Institutional housekeeping: Airlines, Hospitals, Hostels, and Corporate sectors.
- Inter and intra-departmental coordination strategies.

Unit III: The Housekeeping Control Desk

- The pivotal role of the Control Desk as a communication hub.
- Maintenance of forms, formats, records, and registers.
- Standard Operating Procedures (SOP) for Lost and Found.
- Importance of tracking guest room and event status before cleaning.

Unit IV: Cleaning Science and Linen Management

- Categorization of linens used in housekeeping.
- Selection and use of cleaning agents and equipment.
- Manual vs. Mechanical cleaning methods and frequency (Daily, Periodical, Special).

- Significance of Personal Protective Equipment (PPE) in cleaning activities.

Suggested Reading List

- ✓ **Andrews, S.** (2013). *Hotel housekeeping: A training manual*. Tata McGraw-Hill Education.
- ✓ **Kappa, M. M., Nitschke, A., & Schappert, P. B.** (2005). *Managing housekeeping operations*. American Hotel & Lodging Educational Institute.
- ✓ **Raghubalan, G., & Raghubalan, S.** (2015). *Hotel housekeeping: Operations and management*. Oxford University Press.
- ✓ **Tewari, J. R.** (2016). *Hotel front office: Operations and management*. Oxford University Press. (Note: Useful for inter-departmental sections).

Foundation Course in Accommodation Operations **Lab- I**

Sl. No.	Modules	Outcomes
1	Housekeeping Operations- Practical	• Explain Guest Room Supplies and demonstrate their Position in Standard Room, Suite Room, VIP and Single Lady Travelers' Room, Special amenities. • Demonstrate Maids' Trolley Setup, Contents with Placement • Draw Layout of housekeeping pantry • Demonstrate Placement of Equipment and Setup of Pantry • Identify Cleaning Equipment's- Manual and Mechanical • Identify cleaning agents. • Name various cleaning agents brand names. • Demonstrate the procedures for cleaning different areas/surfaces
2	Front office Operations- Practical	• Demonstrate Basic Manners, Attributes and Grooming Standards Required for accommodation operations. • Explain Different Types of Calls, Screening Practice. • Identify Equipment & Stationery used in front office and housekeeping. • Demonstrate Telephone Etiquettes and Telephone Handling • Practice on Cases Related to Front office & Other Departmental Communications • Mock Situations – Role – Plays

2.1 Social Formations and Cultural Pattern of Ancient World**Course Objectives:**

- Students will be able to understand the evolution of human society & how the society of agricultural and animal husbandry had begun in ancient times.
- They also learn how the human society had transformed from nomadic to civilized society in ancient history of the World.
- They can acquire knowledge about the Ancient Greek polities, society and cultural life.

Course Outcome

- Critical understanding on the interdisciplinary in understanding the evolution of homo sapiens
- Develop team spirit to make group presentation on Migration, evolution, tool technology Skill in developing prehistoric tool technology
- Develop appreciation of the global heritage
- Appreciate the difference between Senatorial democracy and popular democracy of Rome and Greece respectively

Unit-I: Evolution of Man

1. Evolution of Man: From Hominoid to Homo Sapiens
2. Paleolithic Cultures: Lower, Middle and Upper Paleolithic Cultures, Tool typologies and technologies, Migration of Homo Sapiens and Colonisation
3. Mesolithic Cultures, Tool Typology, Foraging, Rock Art, Religion

Unit-II: Neolithic Culture:

1. Food Production : Major Sites in Fertile Crescent, Food Production, Habitation Structure, Pottery, Neolithic Revolution
2. Development of Agriculture: Early Domesticated Plants in Fertile Crescent, • China, India
3. Animal Husbandry: Archaeological Evidence of Animal domestication, • Characteristics of Domesticated Animals

Unit-III: Bronze Age Civilizations

1. Egypt: (Natural and Cultural Settings, Major Developments in Old Kingdom, Middle Kingdom and New Kingdom, Society, economy, Religion, Art and Temple Architecture
2. Mesopotamia: Developments in Sumerian, Babylonian and Assyrian periods: Natural and Cultural Setting, Cultural Developments from Ubaid period to emergence of Uruk as a state, religion, society, economy and cultures of Sumer; Developments in Imperial Ur, Code of Hammurabi, and Babylonian expansion, Introduction of Iron and Neo-Assyrian Empire
3. China (Shang): Pre Shang Culture, Oracle Bones, Major Developments, Chinese Society

Unit-IV: Ancient Greece:

1. Athens and Sparta: Natural & Cultural Setting of Ancient Greece, Development of Polis, Evolution of Oligarchic Spartan State, its Institutional structure, and society;
2. Polity, Economy & Society: Evolution of Athenian Democracy from Solon to Peloponnesian War), Athenian Economy
3. Culture: Literature, Religion, Art and Architecture, Science

Suggested Text Books:

- ✓ *Brian Fagan and Nadia Durrani People of Earth, London, Routledge, 2019*
- ✓ *Brian Fagan* & *Chris Scarre, Ancient Civilisation, London Routledge, 2016*
- ✓ *Amar Farooqui, Early Social Formation, Delhi, Different editions*
- ✓ *Alex Castor, Between Two Rivers: The History of Ancient Mesopotamia, 2006, The Teaching Company*
- ✓ *History of Mankind Series, UNESCO*
- ✓ *V. Gordon Childe, What Happened in History?, 1942/2003 edition*
- ✓ *Bisman Basu, The Story of Man* | *H.Neil* & *M.C. Willam, A World of History, Oxford, New York, 1907.*
- ✓ *H.R. Hall, Ancient History of the Near East, 1932.*
- ✓ *H.S. Baghela, World of Civilization*
- ✓ *Wenke, R.J. and D. Olzewski. (2007). Patterns in Prehistory: Humankind's First Three Million Years. New York: Oxford University Press, pp. 228-268*
- ✓ *Whitehouse, R. (1977). The First Civilizations, Oxford: Phaidon, Chapters 3, 4, 5, pp 33-115.*
- ✓ *Chang, K.C. (1987). Shang Civilization. New Haven, Conn: Yale University Press, pp. 263-288.*
- ✓ *Feng, Li. (2013). Early China, Cambridge: Cambridge University Press, pp. 1-111.*

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	• Communication, its Importance and Factors • Types of Communication • Verbal and Non-verbal Communication • Styles of Communication
2	English Language and Communication: Listening and Speaking	• Types of Listening • Speaking to communicate effectively • Style of speaking in Various Situations • English Pronunciation
3	English Language and Communication: Reading and Writing	• Reading methods and techniques. • Reading texts to Understand meaning • Writing Process • Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	• Grammar • Sentence structure • Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

- a) Air pollution
- b) Water pollution
- c) Soil pollution
- d) Marine pollution
- e) Noise pollution
- f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

- a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
- b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
- c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
- d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.
- e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)

2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lighting)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

- A. a) Environmental Ethics: Issues and possible solutions.
 - b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
 - c) Environment Protection Act
 - d) Air (Preservation Control of Pollution) Act
 - e) Water (Preservation Control of Pollution) Act
 - f) Wildlife Protection Act
 - g) Forest Conservation Act
 - h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
- B. Human Population and the Environment
- Population Ecology: Individuals, species, population, community
- Human population growth, population control method
- Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester II

1.5 History of India-II: From State formation to early medieval (c.600BCE-c.750CE)

Course Objectives

- Understand the process of state formation and 2nd urbanism in the period of Buddha
- Analyse the relation of socio-economic changes in early historical period and rise of heterodoxy religions such as Buddhism, Jainism, Ajivakas, Lokayat
- To make students appreciate the emergence of Asokan empire and Critically understand socio-economic and political changes ushered by them
- Understand the emergence of state system in the Deccan and Odisha in the post Mauryan period
- Understand the expanding cultural arc of India by analysing the influence of India in Southeast Asia
- Make students appreciate the changes and excellences in various spheres in the Gupta period
- Understand the changes and continuities between ancient India and the beginning of early medieval, especially the beginning of Samanta system

Course Outcomes

- Students will be able to understand the linkages between social, political, economic and cultural processes of early Historical Development
- They will be able to appreciate the context and the structure of the Mauryan empire and the policy of Asoka in a multicultural past of India
- Able to identify various Indo Greek and Kushana Coins
- Students will be able to understand the nature of Puranic religion and how Puranic-agamic religion created a sacred geography of India

Unit-I: Economy and Society (circa 600 BCE to circa CE 300):

1. Urban growth: Material conditions such as agricultural expansion, Janapada nivesa, Sixteen Mahajanapada, Urban centres: Trade & Commerce, Organisation of Production (Srenis), Trade Routes
2. Social stratification: Class, Varna, Jati, Gender
3. Buddhism and Jainism: Material milieu of Heterodoxies , Social Significance, Buddhist Sects,, Major Principles of Jainism,

Unit-II: Changing Political Formations (circa 300 BCE to circa CE 300):

1. The Mauryan Empire: Asoka's Policy of Dhamma, Reading Asokan inscriptions, Administration, economy, Decline
2. Post-Mauryan Polities: Kushanas, and Satavahanas and Sangam in deep South
3. Indic Cultural Arc: India's contact with China, Central Asia and Southeast Asia; Silk route and expansion of Buddhism

Unit-III: The Guptas:

1. Political Developments: Expansion, Fragmentation and Huna Invasion from Samudra Gupta to Skanda Gupta
2. Literary and Scientific Developments during the Guptas; education in Nalanda
3. Development of Puranic Religions: Temples, Tirthas, Hindu pantheon

Unit-IV: Towards Early Medieval India [circa CE fourth century to CE 750]:

1. Agrarian Expansion, Land Grants, Graded Land Rights and
2. Peasantry.
3. Varna, Proliferation of Jatis: changing norms of marriage and property.
4. Post- Gupta Politics - Pallavas, Chalukyas, and Vardhanas

Suggested Textbooks:

- ✓ Upinder Singh, *A History of Ancient and Early Medieval India: From the Stone Age, Delhi, Pearson, 2008. to the 12th Century. Delhi: Pearson Longman. (More relevant parts are Chapters 6, 7 and 8) (Also available in Hindi)*
- ✓ D. D. Kosambi, *An Introduction to the Study of Indian History*, 1975. }
- ✓ Romila Thapar, (2012). *Asoka and the Decline of the Mauryas*. Delhi: Oxford } University Press. PP. 119-227 Romila Thapar, *The Mauryas Revisited*, Calcutta, 1986. }
- ✓ Allchin, F. R. (et al.)(1995). *The Archaeology of Early Historic South Asia: The } Emergence of Cities and States*. Cambridge: Cambridge University Press. Chapter 6 (pp.73-98) & Chapter 10 (pp. 185- 221).
- ✓ A. L. Basham, *Wonder That Was India*, Rupa. }
- ✓ Aswini. Agarwal: *The Guptas*, Delhi }
- ✓ H.P.Ray, *The Winds of Change*, Delhi, OUP. 1994 }
- ✓ R.S. Sharma, *Indian Feudalism*, Delhi, Macmillan, various edition } ,
- ✓ B. D. Chattopadhyaya (1994). *The Making of Early Medieval India*, Delhi: Oxford } University Press. (Introduction, pp. 1-37.)
- ✓ *Age of Imperial Unity*, Bharatiya Vidya Bhawan Series, Vol 2. } Suvira Jaiswal, (1998). *Caste: Origin, Function and Dimensions of Change*, Delhi: } Manohar. (pp.1-131.)
- ✓ R. S Sharma, (1990). *Sudras in Ancient India: A Social History of the Lower Order } Down to circa. A. D. 600*. Delhi: Motilal Banarsidas. (pp. 90-254)
- ✓ A.S Altekar, *Education in Ancient India*, Delhi }

1.6 Social Formations and Cultural Pattern of Ancient World II

Course Objectives

- The Course seeks to develop a historical understanding of the major developments in some parts of the Ancient and Medieval world.
- The Course provides a scope for understanding the subject of slavery in its varied dimensions in the Ancient world. One of the objectives of the course is to highlight the interconnectedness of Greek and Roman religion, culture and society. We discuss the medieval world in the Course by analysing the nature of European 'feudal' society and economy of the 8th to the 14th centuries.
- Explores the process of emergence of Christendom and Papacy and the 2nd Order
- The objective of paper is to the making of the three orders in Medieval Europe. By studying how the European social world shaped into an intricate structure comprising powerful institutions like monarchy and the Church.
- The Course provides a scope to understand the medieval economy of Western Europe, particularly through its agrarian dimensions and relatively newer labour systems like serfdom.
- And finally, the Course allows an undergraduate student to reflect on questions related to the emergence and spread of Islam. An enquiry into the role that it played in the transformation of a tribal identity to a Caliphal State in West Asia from the 7th to the 9th centuries widens the quest for 'training' students to understand the long-term historical processes.

Course Outcomes

- Upon completion of this course the student shall be able to: Identify the main historical developments in Ancient Greece and Rome.
- Gain an understanding of the restructuring of state and society from tribe based polities to those based on territorial identity and citizenship.
- Trace the emergence and institutionalization of social hierarchies and marginalization of dissent.
- Explain the trends in the medieval economy.
- Analyse the rise of Islam and the move towards state formation in West Asia.
- Understand the role of religion and other cultural practices in community organisation.

Unit-I: Polity and Economy in Ancient Rome

1. Polity, Society and economy in Ancient Rome
2. Expansion and Crisis, -Rise and fall of Julius Caesar, Augustus Caesar, Political Expansion, Crisis of Roman Empire
3. Cultural Developments: literature: Vigil, Ovid, Seneca, Histories: Livy, Tacitus; Art and Architecture

Unit-II: Economic Developments in Europe from 7th to 14th Centuries:

1. Feudalism- Major Debates, Origin, Forms, Structure, Two Phases of Feudalism & its Decline
2. Agricultural Production in Two Phases of Feudalism
3. Towns and Trade

Unit-III: Religion and Culture in Medieval Europe:

1. Medieval Church: Expansion of Christianity, Early Bishopries, Papacy at Rome, Schism in Church- Ecumenical Councils and Great Schism between Eastern and Western Church of 1054
2. Monastic Communities: Benedictine, Dominicans, Franciscan order, Anchoress; Monasteries and Education & Health
3. Papacy: Growth of Papacy from St. Peter to Avignon Papacy

Unit-IV: Societies in Central Islamic Lands:

1. The Tribal background, Rise of Islam; Major pillars of Islam, expansion of Islam
2. Religious Developments: the Origins of Shariah, Ummah, Islamic Jurisprudence, Sufism,
3. Cultural Developments in Islamic World: Tarik Tardition of Historiography,

Suggested Textbooks:

- ✓ *Perry Anderson, Passages from Antiquity to Feudalism.* }
- ✓ *Marc Bloch, Feudal Society, 2 Vols, Londo, various editions }*
- ✓ *Gorges Duby, Rise of Three Orders, Chicago, University of Chicago Press, 1982 }*
- ✓ *Roger Collins, Keepers of the Keys of Heaven: A History of Papacy, New York, 2009. }*
- ✓ *Marshall G.S Hodgson, Ventures of Islam (Three Vols), Chicago, 1977 }*

Reference Reading:

- ✓ *J. Barrawclough, the Medieval Papacy.* }
- ✓ *Cambridge History of Islam, 2 Vol. }*
- ✓ *Will Durant, The Story of Civilization (vols. I } & II).*
- ✓ *T.W. Wallbank } & N.M. Bailey, Civilization –Past and Present.*
- ✓ *R. Coulborne, Feudalism in History, }*

1.7 Basic Course in Front Office -II

Course Objective

The objective of this course is to enable students to master the comprehensive guest service cycle and execute complex reservation procedures using modern industry systems and legal frameworks.

Course Outcome (CO)

- **CO 1:** To explain the sequential stages of the guest cycle and their impact on hotel-guest relationships.
- **CO 2:** To differentiate between various reservation sources (FIT, Group, Corporate) and guaranteed versus non-guaranteed booking types.
- **CO 3:** To utilise diverse reservation systems, including GDS and CRS, to manage electronic and manual booking processes.
- **CO 4:** To formulate professional responses to operational challenges such as amendments, cancellations, overbookings, and no-shows.

Unit I: The Guest Service Cycle

- Introduction to the Guest Cycle.
- Detailed stages: Pre-Arrival, Arrival, Occupancy, Departure, and Post-Departure.

Unit II: Reservation Fundamentals and Sources

- Functions and channels of reservation.
- Sources of Reservation: FIT, FFIT, Groups, Travel Agents, Airlines, and Corporate.
- Types: Guaranteed vs. Non-Guaranteed Reservations.

Unit III: Technology in Reservation Systems

- Evolution of systems: Central Reservation Systems (CRS) and Global Distribution Systems (GDS).
- Property Direct, Inter-sell Agencies, and Internet-based bookings.
- Computerized Reservation Systems and Future Blocks.

Unit IV: Operational Procedures and Policies

- The Reservation Process: In-person, Telephone, and Email (FIT/Group).
- Confirmation, Amendment, and Cancellation policies.
- Managing Overbooking, No-Shows, Waiting Lists, and Legal Implications.

Suggested Reading List

- **Bardi, J. A.** (2011). *Hotel front office management*. John Wiley & Sons.
- **Kasavana, M. L., & Brooks, R. M.** (2009). *Managing front office operations*. American Hotel & Lodging Educational Institute.
- **Tewari, J. R.** (2016). *Hotel front office: Operations and management*. Oxford University Press.

Basic Course in Front Office Operations- Lab I

S. No	Modules	Outcomes
1	PRACTICAL	Demonstrate: • Procedure of Taking Reservations – in Person and on Telephones • Handling Guest Enquiries at Reservation • How to Convert inquiries into Valid Reservations • Practice on Room Management System, Reservation, Check in, Practical Situations & Guest Problems. • Amendments in Reservations, Cancellation, Room Availability Charts • Filling Up of Reservation Forms, Making Amendments & Cancellations. • Updating Reservations on the Computer-Actual Computer Lab Work on PMS. • Situations on Basis of Charging. • Practice on Cases Related to Front office & Other Departmental Communications • How to prepare a Tour Itinerary • Telephonic Conversations - Standard Phrases, Manners, Do's & Don'ts • Mock Situations – Role – Plays

1.8 Basic Course in Accommodation Operations- II

Course Objective

To provide students with advanced practical knowledge of guest room management, specialized cleaning techniques, and the professional maintenance of diverse interior surfaces.

Course Outcome (CO)

- **CO 1: To execute** professional guest floor etiquettes and standardized cleaning procedures for specialized room statuses (VIP, Long-stay, DND).
- **CO 2: To demonstrate** proficiency in specialized housekeeping tasks, including turndown services, guestroom inspections, and public area maintenance.
- **CO 3: To analyse** surface types and chemical properties to perform effective stain removal and polishing using manual and mechanical equipment.
- **CO 4: To apply** specific care and preservation protocols for varied materials such as metals, wood, carpets, and upholstery.

Unit I: Daily Routine and Guest Room Management

- Guest floor etiquettes and standardized room cleaning processes.
- Handling special room statuses: VIP, Long-staying guests, and DND protocols.
- Specialized services: Turndown service, second service, and guest requests.
- Quality control: The guestroom inspection process.

Unit II: Public Area and Surface Maintenance

- Public area cleaning procedures.
- Safety standards: Use of warning signs and protective measures.
- Step-by-step cleaning procedures for soft and stubborn stains.

Unit III: Stain Removal and Polishing Science

- Chemical science: Mixing cleaning solutions and chemical ratios.
- Polishing equipment and agent selection for various surfaces.
- Manual and mechanical polishing procedures; use of sealants and post-polishing care.

Unit IV: Specialized Care of Interior Materials

- Care and cleaning of Metals, Glass, and Ceramics.
- Maintenance of synthetic materials: Plastic and Rexene.
- Preservation of Wood, Upholstery, Carpets, and Wall/Floor finishes.

Suggested Reading List

- ✓ *Andrews, S. (2013). Hotel housekeeping: A training manual. Tata McGraw-Hill Education.*
- ✓ *Raghubalan, G., & Raghubalan, S. (2015). Hotel housekeeping: Operations and management. Oxford University Press.*
- ✓ *Schneider, M., & Tucker, G. (1998). The professional housekeeper. John Wiley & Sons.*

Basic Course in Accommodation Operations - Lab II

S. No	Modules	Outcomes
1	PRACTICAL	• Demonstrate the Procedure of Taking Reservations – in Person and on Telephones • Demonstrate Handling Guest Enquiries at Reservation • Role Play on Standard Phrases, Manners, Do's & Don'ts • Role Plays on Mock Situations • Demonstrate Guest Room Cleaning: Bed Making, Bedroom Cleaning, Bathroom Cleaning, Turndown Service • Demonstrate Public Area Cleaning- Cleaning of Front Areas and Cleaning of Back of The House • Demonstrate the process of Guest Room Inspection.

2.2 Travel and Tourism Industry

Course Objective

To enable students to analyze the historical evolution of travel and understand the socio-economic, planning, and organizational frameworks of the modern travel and tourism industry.

Course Outcome (CO)

- **CO 1:** To explain the historical progression of travel from ancient times to the modern era, highlighting major catalysts like the Industrial Revolution and transport innovations.
- **CO 2:** To analyze the socio-economic significance of tourism, including travel motivations, the multiplier effect, and the role of tourism in promoting international understanding.
- **CO 3:** To apply planning and development principles to assess tourist demand, resource allocation, and regional environmental considerations.
- **CO 4:** To evaluate the functions and operational structures of travel agencies and tour operators, from pioneers like Thomas Cook to modern digital distribution systems.

Unit I: Historical Evolution and Fundamentals of Travel

- Ancient travel, pleasure, and religion as motivators; the Grand Tour.
- Impact of the Industrial Revolution and World Wars on transport.
- Evolution of jets and high-speed trains; post-WWII growth.
- Meaning, nature, and basic components of tourism.

Unit II: Motivations and Socio-Economic Impact

- Sociology of tourism and basic travel motivations.
- Economic benefits, multiplier effect, and employment generation.
- Social tourism and the Manila Declaration.
- Cultural tourism in India and infrastructure development.

Unit III: Tourism Planning and Management

- Assessment of tourist demand and supply; establishing objectives.
- Financial, territorial, and human resource planning.
- Administrative structures and marketing strategies.
- Environmental and regional planning considerations.

Unit IV: Travel Intermediaries and Operations

- Historical role of Thomas Cook and American Express.
- Profiles and organizational setup of modern travel agencies.
- Need for legislation and the role of the Tour Operator (GITs).

- Travel Agencies in India and the role of TAAI.

Suggested Reading List

- ✓ Bhatia, A. K. (2006). *Tourism development: Principles and practices*. Sterling Publishers.
- ✓ Cooper, C., Fletcher, J., Fyall, A., Gilbert, D., & Wanhill, S. (2008). *Tourism: Principles and practice*. Pearson Education.
- ✓ Goeldner, C. R., & Ritchie, J. R. B. (2012). *Tourism: Principles, practices, philosophies*. John Wiley & Sons.
- ✓ Negi, J. (2005). *Travel agency and tour operation: Concepts and principles*. Kanishka Publishers.
- ✓ Burkart and Medlik, *Tourism: Past, Present and Future*
- ✓ Christopher.J. Hollway: Longman; *The Business of Tourism*
- ✓ Cooper, Fletcher et al. : *Tourism Principles and Practices*
- ✓ Mill, R.C., *Tourism: The International Business*
- ✓ Roberts, K: *Leisure in Contemporary Society*, Wallingford
- ✓ Rojek, C: *Leisure and Culture*, Basingstoke, Hants, Mc Millan
- ✓ Seth, P.N.: *Successful Tourism Management (Vol 1 &2)*
- ✓ *Tourism Policy of India*, Govt. Of India.
- ✓ Charles R. Goeldner & J. R. Brent Ritchie: *TOURISM: Principles, Practices, Philosophies*
- ✓ Kamra & Mohinder Chand: *Basics of Tourism*

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester III

1.9 History of India-III

Course Objectives

- They can acquire knowledge about the society, economy and culture in early medieval India and can gather knowledge towards the Arabs Conquest of Northern part of India from this paper.
- Knowledge about the religious and Cultural changing scenarios especially impact Bhakti cult and Tantricism.
- With its focus on multiple historiographical approaches to various issues of historical significance during this period, the course will also apprise students of the divergent ways in which historians approach, read and interpret their sources.
- The paper debates about urban decay and emergence of new kind of cities in early medieval

Course Outcomes

- Understand the new periodisation and its basis
- critical analysis of the relation between political realm and religious realm
- interrelation between economy, society, polity and culture in the making of vernacular region
- Debates the emergence of medieval social order, including condition of peasantry
- Discusses the nature of brahmanical social order and relations with law books which reinforced an andro-centric brahmanical social order
- Explain, in an interconnected manner, the processes of state formation, agrarian expansion, proliferation of caste and urban as well as commercial processes.
- Discuss the major currents of development in the cultural sphere, namely bhakti movement, Puranic Hinduism, Tantricism, architecture and art as well as the emergence of a number 'regional' languages.

Unit –I: Studying Early Medieval India: Political Structures

1. Sources of early medieval and Debates on early Medieval
2. Evolution of Political structures: Rajputs, Tripartite Struggle and Cholas
3. Legitimization of Kingship; Brahmanas and Temples, Tirthas and Courtly culture
4. Issues of Islam Rule: Arab conquest of Sindh

Unit-II: Social and Economic Processes:

1. Agricultural Expansion: forest-dwellers, peasants and landlords
2. Proliferation of Castes: Varna Jatis, Peasantisation of tribes.
3. Trade and Commerce: Urban Centres, Inter-regional Trade, Maritime Trade and Forms of Exchange, Ayyavole, Manigramam Guilds

Unit-III: Religious & Cultural Developments:

1. Puranic Traditions & Vajrayana Buddhism
2. Islamic Intellectual Traditions: Al-Biruni
3. Regional Languages and Literature

Unit IV: Cultural Strands: Art, Architecture and religion

1. Evolution of Regional styles: Kalingan and Dravidian style of Temple Architecture
2. Tantric Saiva and Sakta Tradition: Kashmir Saivism
3. Bhaktism and Issue of Monism and Dualism: Alvars & Nayanars of South India; Sankara, Ramanuja, Madha

1.10 Rise of Modern West

Course Objectives:

- The focus of the course is on transition from feudalism to capitalism in Europe.
- The paper familiarises the student with important transitions and transformations in the economy, polity, and socio-cultural life from late medieval period to 1600 in various parts of Europe.
- The course shall critically examine the dynamics of economic and political power within Europe, and contact with the New World. The processes by which Europe's economy benefited from colonial expansion and exploitation of indigenous and slave labour will be explained.
- Students shall also engage with continuities and changes in intellectual and
- Artistic realms; the social and economic milieu which influenced developments in religion;
- Will understand the emergence of nation state in the aftermath of 100 year
- Religious War

Course Outcomes

- Upon completion of this course the student shall be able to: Outline important changes that took place in Europe from the medieval period.
- Acquire an integrated approach to the study of economic, social, political and cultural developments in Europe.
- Explain the processes by which major transitions occurred in Europe's economy, state forms, social structure and cultural life. Examine elements of early modernity in these spheres.
- Critically analyse linkages between Europe's state system and trade and empire.
- Understand the historically contingent nature of nation state in history and its locus in the Western Europe

Unit-I: Transition from Feudalism to Capitalism:

1. The problems of Transition: Economic Expansion, Industrial production
2. Trade and Commerce
3. Urban Development, Town Life

Unit-II: Early Colonial Expansion:

1. Motives, Voyages and Explorations.
2. The Conquests of America
3. Mining and Plantation, the African Slaves.

Unit-III: Renaissance and Reformation:

1. Its Social Roots Spread of Humanism in Europe.
2. The Renaissance: Art, Architecture, Sculpture, Painting and Literature
3. Origins and Spread of Reformation Movements.
4. Emergence of European State system: Spain, France, England, Russia

Unit-IV: Economic Developments of the Sixteenth Century:

1. Shift of economic balance from the Mediterranean to the Atlantic.
2. Commercial Revolution- Causes and Nature
3. Growth of Industries and its Impact

Suggested Textbooks:

- ✓ *John Merriman, A History of Modern Europe: From Renaissance to the Present Day, New York, 2010*
- ✓ *Meenakshi Phukan, Rise of the Modern West: Social and Economic History of Early Modern Europe, Trinity Press*
- ✓ *Arvind Sinha, Europe in transition: From Feudalism to Industrialisation, Delhi Manohar, 2016.*
- ✓ *Charles A. Nauert, Humanism and the Culture of the Renaissance (1996).*
- ✓ *Harry Miskimin, The Economy of Later Renaissance Europe: 1460 -1600.*
- ✓ *Fernand Braudel, The Wheels of Commerce, London, 1983 (Civilisation and Capitalism 1500-1800)*

1.11 Historical Theories & Methods

Course Objectives

- It explains the major interpretive frameworks that guide modern historical writings and identify the key elements of major contemporary theories of History.
- Students will learn to evaluate the similarities and differences between historical theories and identify the central issues and problems that a particular historical theory addresses.
- Students will also learn the use of appropriate analytical language in discussing historical interpretations and can formulate interpretation in historical narratives.

Course Outcomes

- Cognitive competence by understanding the theoretical underpinning of historical construction
- Analyse the changing discourse of history
- Critical aptitude about the nature and authenticity of sources
- Understand how historical theories shaped historical narrative in different periods
- Appreciate the evolution of the discipline of history as Humanities Subject to that of a Social science discipline to integration of archaeo-metric and other natural sciences in the construction of past

Unit-I: Meaning and Scope of History

1. Definition, Nature and Scope of History.
2. Object and Value of History.
3. History, Science and Morality.

Unit-II: Traditions of Historical Writing

1. Ancient Greek Traditions – Herodotus, Thucydides
2. Ancient Roman Traditions - Polybius, Livy and Tacitus
3. Medieval Understanding: Western – St. Augustine, Arabic – Ibn Khaldun.

Unit-III: History as Interdisciplinary Practice

1. History and Archaeology, History and Anthropology.
2. History and Psychology, History and Literature.
3. History and Political Science, History and Sociology

Unit-IV: Historical Methods

1. Sources of History: Written, Oral. Visual & Archaeological.
2. Historical facts.
3. Historical Causation.
4. Historical Objectivity

Suggested Textbooks:

- ✓ *B. Sheik Ali, History: Its Theory and Method, Macmillan, Reprinted, 1996.*
- ✓ *E. H. Carr, What is History? , Penguin Books, Reprinted, 1983.*
- ✓ *R.G. Collingwood, The Idea of History, OUP, Delhi,*
- ✓ *E. Sreedharan, A Text Book of Historiography, Orient Longman, Reprinted, 2004.*
- ✓ *Goldstein: historical Knowing*

1.12 History of Odisha- I

Course Objectives:

- This paper aims at making students familiar with the major currents of political and socio-economic history of pre-colonial Odisha.
- The students will understand the significance of different ruling dynasties of ancient Odisha and the process of making of a region and state formation in ancient and early medieval Odisha
- This course paper will also make the students familiar with the political and administrative history of the Afghans, Mughals and the Marathas in Odisha.

Course Outcomes:

- The students will be able to appreciate the process of state formation in precolonial Odisha
- They will develop critical understanding of process of making of regional traditions.
- They will be able to trace the evolution of Odia script and language.

Unit-I: Locating Odisha as a Region

1. Historical Geography: Kalinga, Utkal, Kosala, Odra
2. Early Developments: Mauryan intervention and Kharavela(significance of Kalinga War and Understanding Hatigumpha Inscription).
3. Rise of Local States: Matharas, Eastern Gangas, Sailodbhavas

Unit-II: Towards Regional States

1. Bhaumakaras and Somavamsis: Land grants, Political Developments, Social formations: Occupational Groups under Bhaumakaras and Somavamsis
2. Imperial Gangas: Career and Achievements of Chodagangadeva and Narasimhadeva,
3. Emergence and Evolution of Kalinga Temple Architecture: Major Specimens of (Satrugneswara, Parsurameswara, Muketsvara, Lingaraja, Vaital, Hypetheral Temples of 64 Yoginis of Ranipur-Jharial and Hirapur)

Unit-III: Imperial Gajapatis: Apogee and Decline

1. Kapilendradeva's achievements, Setbacks to Kapilendra's Odisharajya from Bengal and South during the period of Purushottama and Prataparudra,
2. Administration and Culture under the Gajapatis
3. Historical events leading to the Decline of Hindu Kingdom of Odisha

Unit IV: Religion, Art and Architecture

1. Buddhism and Jainism in Odisha, Their art and architecture
2. Saiva-Sakta Religion: Origin and Growth, Iconographic forms of Durga and Siva, Saptmatrkas
3. Vaisnava Religion: Origin and Growth, Forms of Visnu, Dasavatara sets and Cult of Jagannath

Suggested Reading List:

- ✓ K.C. Panigrahi, *History of Odisha, Kitab Mahal.* }
- ✓ N.K Sahu, Mishra } &Sahu, *History of Odisha.*
- ✓ S.K. Panda, *Political and Cultural History of Odisha.* }
- ✓ A. C Pradhan, *A Study of History of Orissa* }
- ✓ Tripathy, KB (1962) *Evolution of Oriya Language and Script, Bhubaneswar: Sahitya } Academy*
- ✓ R. D Banarjee, *History of Orissa, 2 vols.* }
- ✓ Acharya, Paramanand () *Essays in History, Culture, Archaeology of Orissa,* }
- ✓ Kishor Basa,, Mohanty, Pradeep (ed)(2000) *Archaeology of Orissa, Delhi:Pratibha }*
- ✓ Kulke, H. (1982) 'Fragmentation and Segmentation versus Integration: reflections on } the Concept of Indian Feudalism and the Segmentary State in Indian History'. *Studies in History, Vol. IV, No. 2, 1982, pp.257-63.*
- ✓ Upinder Singh, King, *Brahamana and temples, Delhi, 1994.* }
- ✓ Bhairabi Prasad Sahu, *Changing Gaze, Delhi, OUP, 2013 Sahu }*
- ✓ Bhairabi, P. Sahu 'Authority and Patronage in Early Orissa', in K. K Basa and P. } Mohanty (eds) *Archaeology of Orissa, vol. 1: 431-440, Delhi, Pratibha Prakashan 2000.*
- ✓ Satyanarayan Rajaguru, *Odishara Sansrutika Itihasa, Cuttack, Grantha Mandira }*
- ✓ Sahu, N.K *Buddhism in Orissa, Bhubaneswar: Utkal University, 1958 }*
- ✓ T. E Donaldson,, *Hindu Temple Art of Orissa. 3 Vols, Leiden: Brill, 1987.* }
- ✓ T. E Donaldson,, *The Iconography of Vaisnava Images in Orissa. New Delhi: India } D.K. Printworld (P) Ltd., 2001.*
- ✓ T. E Donaldson,, *Iconography of the Buddhist Sculpture of Orissa. 2 Vols. (Volume } I: Text; Volume II: Plates), New Delhi: India Indira Gandhi National Centre for the Arts in } Association with Abhinav Publications, 2001.*
- ✓ T. E Donaldson,, *. Tantra and Sakta Art of Orissa. New Delhi: India D.K. } Printworld (P) Ltd., 2002.*
- ✓ T. E Donaldson,, *Siva-Parvati and Allied Images: Their Iconography and Body } Language. 2 Vols, New Delhi: India D.K. Printworld (P) Ltd, 2007. }*
- ✓ K.C. Panigrahi, *Arcaheologcial Remains of Bhubaneswar, Calcutta, Longman, 1961.* }
- ✓ Ramesh Prashad Mohapatra, *Jaina Monuments of Orissa, Delhi, 1984.* }
- ✓ Subrata Kumar Acharya, *palaeography of Inscriptions of Orissa,* }

2.3 Emerging Trends in Tourism

Course Objective

To enable students to critically analyze contemporary shifts in the tourism industry, focusing on sustainability, community-based models, and the growing sector of Special Interest Tourism (SIT).

Course Outcome (CO)

- **CO 1:** Examine the evolution and principles of sustainable tourism as a strategic development and management approach.
- **CO 2:** Evaluate the role of local community involvement and visitor responsibility in the success of regional ecotourism projects.
- **CO 3:** Discuss the scope of Rural and Ethnic tourism in India by analyzing government policies and regional case studies like Ladakh and Jharkhand.
- **CO 4:** Explain the concepts of Health and Wellness tourism, emphasizing the therapeutic roles of Ayurveda, Yoga, and medical travel in India.

Unit I: Sustainable Tourism:

- Evolution, Concepts, Principles, Sustainability as a development and management Approach, Planning, Issues and Challenges, Techniques for sustainable development, Environmental Issues and models of ecotourism development, Case studies of Ecotourism, Coastal Tourism and Mountain Tourism

Unit II: Ecotourism:

- Definition, concept, principles, environmental issues and tourism, responsibility of visitors, involvement of local community in tourism, case study of a project in North Eastern states/Kerala/Sikkim

Unit III: Rural Tourism and Ethnic Tourism

- Concepts, difference with other rural based tourism, village tourism, Govt of India Policy on Rural Tourism, identified villages, Scope of developing ethnic tourism in India, Case Studies of Ladakh, Jharkhand.

Unit IV: Health Tourism

- Concepts, introduction to natural living, Physical and mental well-being, Medical tourism and Wellness Tourism, Ayurveda, Siddha, Unani, Homeopathy, Aromatherapy, Yoga, Spa (Water Therapy) Role of Ayurveda in Health Tourism - Basic Principle of Ayurveda – four Aspects of Life, Scope of Health Tourism In India.

Suggested Reading

- ✓ Ashworth, G.J.: *The tourist Historic city: Retrospect and Prospect of Managing the Heritage City*
- ✓ Dr. S. P. Bansal., Sushma, Sonia & Chander Mohan: *Tourism in the New Millenium.*
- ✓ Erlet Cater & Gwen Lowman: *Ecotourism*
- ✓ Foster, D. S.: *The Business of Travel Agency Operation and Administration*
- ✓ Local Agenda 21, U.N-World Tourism Organisation
- ✓ Malik, S.S.: *Adventure Tourism* • Negi, J. : *Adventure Tourism and Sports – Part- I & II*

- ✓ *Inskip, Edward: Tourism Planning, An Integrated and Sustainable Development Approach (1991)*
- ✓ *New Som, D., Moore, S.A., Dowling, R.K.: Natural Area Tourism*
- ✓ *P. K. Rao: Sustainable Development*
- ✓ *Pond K. L.: The Professional Guide: Dynamics of tour guiding*
- ✓ *Robert Svoboda and Arnie Lade: Chinese Medicine and Ayurveda*
- ✓ *Robinet Jacob: Ayurvedic Tourism in Kerala*
- ✓ *Salah Vahab & John J. Pigram: Tourism Development and Growth*
- ✓ *Sunil.V. Joshii : Ayurveda and Panchakarma*
- ✓ *Theobald and Theobald: Global Tourism*
- ✓ *Victor T. C. Middleton & Rebecca Hawkins: Sustainable Tourism*

2.4 Art Heritage of India

Course Objective

To provide a comprehensive understanding of India's cultural evolution, architectural diversity, and the significance of performing arts and museums in heritage tourism.

Course Outcome (CO)

- **CO 1: To summarize** the chronological stages of Indian culture from the Harappan period to the modern era.
- **CO 2: To differentiate** between major architectural styles, including Hindu-Buddhist, Mughal, and colonial designs.
- **CO 3: To evaluate** the role of museums and classical paintings in the preservation and marketing of artistic heritage.
- **CO 4: To analyze** the impact of performing arts, cinema, and traditional handicrafts on contemporary tourism development.

Unit I: Introduction to Indian Culture and Heritage:

Concept- History-Stages of evolution-The Mohenjodaro and Harappan period- Vedic Age, Buddhist epoch, Gupta Period, Early and Late Medieval period, Modern Period Features of Indian Cultural Heritage-Conservation of Culture

Unit II: Study of Indian Architecture

1. The prominent Architectural style in different period-Harappan Architecture, Ancient Indian Architecture viz Hindu_Buddhist style, Mughal Architecture, The Rock-Cut monuments-colonial Architecture.
2. Study of Important Architectural sites of India Study of Indian Temple Architecture and popular Religious Centres-Hindu, Buddhist, Jain, Sikh, Muslims, Parsis and Christian

Unit III: Study of Indian Paintings and Museums and their roles

1. Indian Paintings- Characteristic features-
2. Medieval and Modern Paintings.
3. Museums and their role Role of Museums in preservation of art Heritage
 - a. Types of Museums
 - b. Acquisition of Museum Articles
 - c. Role of Museum in Special Interest Tourism.

Unit IV: Study about Performing Arts of India

1. Dances of India, Historical Evolution- archeological and literary evidence
2. Indian Classical Dances-Folk Dances
3. Music of India- classification-Marg & Desi, Karnatic style, North Indian Music- Musical instruments
4. Role of Performing Art in Tourism Development
5. Indian Theatre- Different Theatrical forms Indian Cinema- Evolution

6. Role in Tourism Development Handicrafts Indian Handicrafts-textiles, clayworks, stone works, woodworks etc.- craft melas
7. Marketing of Handicrafts

Suggested Readings:

- ✓ S.P. Gupta: Cultural Tourism in India, Indraprastha Museum of Art and Archaeology, New Delhi.
- ✓ Hussain.A.K: The National Culture of India, National Book Trust, New Delhi.
- ✓ Robinet Jacob: Indian Tourism Products, Abhijeet publications.
- ✓ Surendra Sahai: Indian Architecture: Hindu Buddhist and Jain, Prakash Books.
- ✓ The Gazette of India: History and Culture, Vol.2, publication division, Ministry of Information and Broadcasting
- ✓ Basham.A.L: The Wonder that was India, Rupa and Com, Delhi
- ✓ Dallen J Timothy and Stephan W Boyd: Heritage Tourism, Prentice Hall

Basic Principles of Management

Course Objective

To equip students with a comprehensive understanding of human resource management and development within the hospitality sector, focusing on strategic planning, job evaluation, and operational integration.

Course Outcome (CO)

- **CO 1: To analyze** the macro and micro scenarios of Human Resource Planning (HRP) specifically within the tourism industry.
- **CO 2: To evaluate** the functions of personnel offices and the role of HRD systems in fostering a professional hotel culture.
- **CO 3: To execute** job evaluation methods and ranking techniques to determine organizational scope and limitations.
- **CO 4: To design** professional job descriptions and person specifications using various job analysis information-gathering methods.

Unit I: Human Resource Planning in Tourism: Macro/micro level scenarios and HRP processes.

Unit II: Personnel Management and HRD: HRD relevance in hotels; personnel office operations; the Personnel Manager's role.

Unit III: Systems and Culture: HRD in the service industry; importance of HRD systems; and Intellectual Property Rights (IPR).

Unit IV: Job Analysis and Evaluation: Methods and recent developments in evaluation; designing job descriptions versus requirements.

Suggested Reading List

- ✓ *Boella, M. J., & Goss-Turner, S. (2019). Human resource management in the hospitality industry: A guide to best practice. Routledge.*
- ✓ *Dessler, G., & Varrkey, B. (2020). Human resource management (16th ed.). Pearson Education India.*
- ✓ *Go, F. M., Monachello, M. L., & Baum, T. (1996). Human resource management in the hospitality and tourism industry. Wiley.*
- ✓ *Jatashankar, R. T. (2016). Hotel front office: Operations and management. Oxford University Press. (Useful for Unit II regarding Personnel Office operations).*
- ✓ *Woods, R. H. (2006). Managing hospitality human resources. American Hotel & Lodging Educational Institute.*

Computer Skills for Hotel Professionals

Course Objective

To provide students with a fundamental understanding of computer systems and the practical proficiency required to utilize productivity software and internet-based services in a professional hotel environment.

Course Outcome (CO)

- **CO 1:** To identify the core functions and classifications of computer systems used in modern hospitality operations.
- **CO 2:** To describe hardware components, generations of computing, and storage types to ensure basic troubleshooting and hardware literacy.
- **CO 3:** To execute complex document formatting, spreadsheet calculations, and professional presentations using the Microsoft Office suite.
- **CO 4:** To demonstrate proficiency in digital communication, web navigation, and secure online banking protocols essential for guest service and administration.

Unit I: Fundamentals of Computer Systems: Definitions, classification, and core functions.

Unit II: Hardware Architecture and Storage: Physical components, generations of computers, storage types, and I/O devices.

Unit III: Microsoft Office Suite for Hospitality: Advanced Word processing, Excel spreadsheets (formulas/charts), and PowerPoint presentations.

Unit IV: Internet, Communication, and Digital Services: Web searching, email management, and online banking security.

Suggested Readings

- ✓ *Goel, A. (2010). Computer fundamentals. Pearson Education India.*
- ✓ *Kasavana, M. L. (2011). Managing technology in the hospitality industry. American Hotel & Lodging Educational Institute.*
- ✓ *Lambert, J., & Frye, C. (2016). Microsoft Office 2016 step by step. Microsoft Press.*
- ✓ *Rajaraman, V., & Adabala, N. (2014). Fundamentals of computers. PHI Learning Pvt. Ltd.*

Semester IV

1.13 History of Orissa-I: The Making of a Region**Course Objectives:**

- This will also help students to understand and assess the nature, causes and impact of the several resistance movements in the 19th century Odisha with a special reference to the Paik rebellion of 1817.
- The paper will critically evaluate the process through which Odia nationalism emerged in late 19th century leading to the formation of a separate state on linguistic basis.
- It also focuses on the forms and agencies of colonial capitalism in changing the pre-colonial social order in Odisha as well as political arithmetic during colonial period.

Unit I: Afghan to Maratha Occupation of Odisha (1568-1803)

1. Afghan, Mughal and Maratha Occupation of Odisha: Events, Administration and Impact
2. Emergence of Garjat States: Case of Sambalpur and Mayurbhanj
3. Evolution of Odia literature (Panchasakhas and Riti Yuga)

Unit II:

1. British Occupation and Early Colonial Administration: Land Revenue, Salt Policy, Currency Policy, Jail and Police Administration.
2. Nature, form, Limitations and causes of Resistance Movements: Ghumsar Rebellion, Paik rebellion, Keonjhar Uprisings. Revolt of 1857 and Surendra Sai
3. Famine of 1866 – Causes, Consequences and significance

Unit III:

1. Growth of Press, Education, Language Movement and Odia Nationalism
2. Nationalist Politics in Odisha (Non-cooperation, Civil Disobedience and Quit India movements in Odisha) Developments leading to Formation of a separate Province of Orissa
3. Prajamandal Movement and Merger of Princely States

Unit IV: Odisha after Independence

1. Political Developments from 1952 to 1977
2. Economic and Industrial Development in Post Independent Odisha
3. Social Development in Post Independent Odisha: Education, women empowerment: policies and Programme.

Suggested Reading List:

- ✓ P.K. Mishra & J.K. Samal, *A Comprehensive History and Culture of Orissa- Vol. I & II* K.M. Patra, *Freedom Struggle in Odisha.*
- ✓ J.K.Samal, *Orissa under the British Crown.*
- ✓ K.M.Patra, *Orissa State Legislature & Freedom Struggle.*
- ✓ A.C. Pradhan, *A Study of the History of Odisha, Panchasheel.*
- ✓ B.K. Mallik, *Paradigm of Dissent and Protest :- Social Movements in Eastern India*
- ✓ Chaudhury, Pradipta (1991) "Peasants and British Rule in Orissa", *Social Scientist*, Vol. 19, No. 8/9 (Aug. - Sep., 1991), pp.28-56. Mohanty, Nivedita (1982.) *Oriya nationalism: quest for a united Orissa, 1866- 1936*, New Delhi: Manohar,
- ✓ Mohanty, Sachidananda () *Social Reform Movements in Orissa, Study of* Sailabala Das, Delhi:
- ✓ Mohapatra, Bishnu N (2001) "Social Connectedness and Fragility of Social Capital: View from an Orissa Village", *Economic and Political Weekly*, Vol. 36, No. 8 (Feb. 24 - Mar. 2, 2001), pp.665-672
- ✓ Mubayi, Yaaminey. 2004. *Altar of Power: The Temple and the State in the Land* of Jagannatha, Delhi: Manohar.
- ✓ Nanda, CP (2008) *Vocalising Silence: Political protest in Orissa-1930-42,* Delhi: Sage.
- ✓ Pati Biswamoy (1992) "Of Movements, Compromises and Retreats: Orissa, 1936- 1939", *Social Scientist*, Vol. 20, No. 5/6 (May - Jun., 1992), pp.64-88
- ✓ Pati Biswamoy (1999) "Oriya Intellectuals Then and Now" *Economic and Political Weekly*, Vol. 34, No. 19 (May 8-14, 1999), p.1093
- ✓ Pati, Biswamoy (1998) *Siting the Body: Perspectives on Health and Medicine in Colonial Orissa* Author(s): *Social Scientist*, Vol. 26, No. 11/12 (Nov. - Dec., 1998), pp.3-26.
- ✓ Pati, Biswamoy (1999) "The Dialectics of Retreat: Orissa, 1943-1950," *Social Scientist*, Vol. 27, No. 7/8 (Jul. - Aug., 1999), pp.75-112.
- ✓ Pati, Biswamoy () "High'-Low' Dialectic: Peasant in Oriya Literature" *Economic and Political Weekly*, Vol. 24, No. 14 (Apr. 8, 1989), pp.747-75
- ✓ Pati, Biswamoy (1992) "Dialectics of Transition: Orissa, 1943-50", *Economic and Political Weekly*, Vol. 27, No. 7 (Feb. 15, 1992), pp.353-364
- ✓ Pati, Biswamoy (Jul. 1983), "Peasants, Tribals and the National Movement in Orissa (1921-1936)" *Social Scientist*, Vol. 11, No. 7, pp.25-49.
- ✓ Pati, Biswamoy "Autonomous Enclaving", *Economic and Political Weekly*, Vol.25, No. 42/43 (Oct. 20-27, 1990), p. 2388.
- ✓ Pati, Biswamoy "Koraput: Perceptions in a Changing Society" *Economic and Political Weekly*, Vol. 25, No. 18/19 (May 5-12, 1990), pp.986-988 Patra, K. M: *Freedom Movement in Orissa,* Pattnaik, J () *Feudatory States in Orissa,*
- ✓ Pattnaik, NR (ed.) *Comprehensive History of Orissa*
- ✓ Pradhan, Prasant Kumar; (1998) *Gandhians' rise to power : national movement, power politics & independence, 1920-47 AD*, New Delhi : Commonwealth Publishers,
- ✓ Samal, J () *Orissa under the British Crown*, Calcutta Sinha, Surjit (1977) *Kshatrisation . In MN Das (ed.), Sidelights on the History and Culture of Orissa*

1.14 Accommodation Operations

Course Objective

To enable students to manage complex housekeeping logistics, material planning, laundry operations, and safety protocols within a professional lodging environment.

Course Outcome (CO)

- **CO 1: To construct** professional duty rosters and staff allocation schedules to optimize housekeeping manning and night shift operations.
- **CO 2: To develop** material planning strategies and inventory controls for linen, bedding, and specialized soft furnishings.
- **CO 3: To evaluate** emerging trends, such as eco-friendly cleaning and green amenities, to enhance sustainable accommodation practices.
- **CO 4: To implement** safety and security protocols, including emergency response (fire/disaster) and OSHA-compliant hazard control standards.

Unit I: Operational Management and Staffing

- Manning, scheduling, and staff allocation in housekeeping.
- Preparation of duty rosters and shift management.
- Specialized night shift duties and responsibilities.

Unit II: Material Planning and Sustainable Trends

- Material planning for beds, bedding, mattresses, and soft furnishings.
- Eco-friendly cleaning practices: Staff and guest involvement.
- Green amenities and latest technological trends in accommodations.

Unit III: Linen and Laundry Management

- Linen room: Functions, layout, par stock, and discarding processes.
- Laundry operations: Commercial, On-site, and Laundromats.
- Laundry machinery, chemicals, valet services, and care label interpretation.

Unit IV: Safeguarding Assets and Emergency Handling

- Security concepts and guestroom safety; Loss prevention strategies.
- Emergency management: Fire, bomb threats, natural disasters, and civil disturbances.
- OSHA regulations and hazard control standards.

Suggested Readings

- ✓ *Andrews, S. (2013). Hotel housekeeping: A training manual. Tata McGraw-Hill Education.*
- ✓ *Kappa, M. M., & Nitschke, A. (2005). Managing housekeeping operations. American Hotel & Lodging Educational Institute.*
- ✓ *Raghubalan, G., & Raghubalan, S. (2015). Hotel housekeeping: Operations and management. Oxford University Press.*

Accommodation Operations- Lab

S. No.	Module Name	Outcomes
1	Accommodation Operations Practical	Demonstrate: • Guest Room Inspection • Public Area Inspection • Handling Checklist • Mini-Bar Management: Issue, Stock Taking, Checking Expiry Date (FIFO) • Cleaning Different Surfaces- Glass, Wood, Brass, Silver, Leather • Handling Guest Complaints • Role Play and Situation Handling Case Study • Model Guest Room Designing • Draw a Layout of Linen and Laundry room • Preparation of First aid Kit and Dealing with Different Emergency Situations

1.15 Front Office Operations

Course Objective

To master the technical integration of Property Management Systems (PMS), financial accounting cycles, and auditing procedures essential for managing modern hotel front office operations.

Course Outcome (CO)

- **CO 1:** Demonstrate proficiency in navigating Property Management Systems (PMS), including reservation, room, and guest accounting software modules.
- **CO 2:** Execute standardized registration and departure procedures for diverse guest profiles (FIT, Group, VIP) while adhering to legal and payment protocols.
- **CO 3:** Analyze the front office accounting cycle, including the management of folios, vouchers, and credit control measures to ensure financial accuracy.
- **CO 4:** Evaluate night auditing reports and emerging technological trends like mobile check-in and self-service kiosks to improve operational efficiency.

Unit I: Property Management Systems (PMS) and Guest Arrival

- PMS Modules: Reservations, Rooms, Guest Accounting, and General Management software.
- System Interfaces and Back Office integration.
- Registration types and legal implications (Foreigners, FITs, and Groups).
- Automated registration procedures and payment methods.

Unit II: Guest Departure and Post-Departure Management

- Departure protocols: FIT, Group, Airline Crew, and VIP (Bell Desk to Cashier).
- Account settlement and handling late charges.
- Maintaining guest history and feedback management systems.

Unit III: Front Office Accounting and Credit Control

- Accounting Cycle: Account creation, maintenance, and settlement.
- Management of Folios (Guest, Master, Split) and Vouchers (Correction, Paid-out, Allowance).
- Ledger systems: City Ledger and Visitor Tabular Ledger.
- Internal Credit Control: Cash sheets, cash banks, and petty cash.

Unit IV: Night Auditing and Emerging Digital Trends

- Responsibilities and procedures of the Night Auditor (Manual to Fully Automated).
- Analysis of Night Audit reports and Flash reports.
- Innovations: Web/Mobile check-in, Express check-out, and Self-registration kiosks.

Suggested Readings

- ✓ *Bardi, J. A. (2011). Hotel front office management. John Wiley & Sons.*
- ✓ *Kasavana, M. L., & Brooks, R. M. (2009). Managing front office operations. AHLEI.*
- ✓ *Tewari, J. R. (2016). Hotel front office: Operations and management. Oxford University Press.*

Front Office Operations- Lab

S. No	Module Name	Outcomes
1	PRACTICAL	• Preparing & Filling Up of Registration Card. • Role Play for Check-In of Different Types of Guests-FIT, Walk-In, VIP, Groups • Role Plays of Check-In of foreigners Using C-Form • Handling Room Keys (Issuing, Receiving, Missing Keys, Computerized Key Cards) • Operating PMS for Registration • Rooming a Guest, Dealing with Change of Room Request. • Handling Guest Enquiries at Reception & Guest Relations • Handling of Keys-Situations Related to Loss of Keys. • Role Play on Situation Handling Like Emergencies, Walking a Guest, Dealing With Overbooking Situations, Complaints • Identification of Vouchers • Use of F.O. Stationary during Arrival & Departure Process. • Reception and Concierge and Cash Counter Activities. • Departure Control Procedure • Express Check Out, Late Check Out • Role Plays of Check-Out Procedure • Mock Situations – Role – Plays • Preparation of Guest History Cards

2.5 Tourism Marketing

Course Objective

To equip students with fundamental marketing principles and the strategic skills required to develop, implement, and evaluate integrated marketing plans specifically for the global tourism and hospitality sectors.

Course Outcome (CO)

- **CO 1: To define** core marketing concepts and evaluate various marketing philosophies in the context of the service-oriented tourism industry.
- **CO 2: To analyze** market segments and consumer buying behaviour to implement effective STP (Segmentation, Targeting, Positioning) and pricing strategies.
- **CO 3: To construct** a comprehensive promotional mix utilizing the 5 M's of advertising, public relations, and diverse distribution channels.
- **CO 4: To formulate** specialized marketing programs for airlines, hotels, and tour operators while leveraging destination branding and digital tools.

Unit I: Introduction

1. Core concepts in marketing- Needs, Wants, Demands, Markets, Products, value, satisfaction, quality, exchange, transaction and relationship;
2. Marketing Philosophies- production, product, sales, marketing, societal marketing; economic importance of marketing;
3. 8 P's of Marketing- Marketing Mix; marketing Services and its special features, Tourism Marketing and its uniqueness

Unit II: Marketing Strategies, Product and Pricing

1. Marketing Research- Need, Methods;
2. SWOT analysis- setting objectives, measuring and forecasting tourism demands, forecasting methods, managing demand and capacity;
3. market segmentation, targeting and positioning (STP);
4. niche marketing; developing marketing environment-consumer buying behavior
5. Product concept, approaches and strategies,
6. 5 Aspect Meal Model, Product Life Cycle, Product mix, product line and depth,
7. New Product development; Pricing Considerations, Approaches and Strategies

Unit III: Promotion and Distribution Channel

1. Major Promotional Tools/ Promotional Mix, Branding, Packaging,
2. 5 M's of Advertising - Setting objectives, budgeting, Message Decision, Media Selection, Campaign evaluation,
3. Sales Promotion – objectives and tools, Direct Marketing, Publicity, Public Relations, Sponsorship.
4. Distribution Channel and Strategies, GSA, Tourism Journals and periodicals, Marketing Skills needed in Tourism – creativity, communication, self-motivation, team building and personality development, CRM, CEM

Unit IV: Tourism Marketing

1. Marketing strategies for Airlines, Tour Operators, Hotels;
2. Effectiveness, role of travel brochure and videos, travel shows, Sales Promotion – techniques and Planning; direct marketing and its Characteristics.
3. Destination Marketing, New Product Development...

Suggested Reading:

- ✓ Assael H.: Consumer Behaviour and Marketing Action
- ✓ Subroto Sengupta: Brand Positioning
- ✓ Crough: Marketing Research for Managers.
- ✓ Kotler, Philip : Marketing Management & Hospitality and Tourism Marketing
- ✓ Kotler, Philip and Armstrong Philip: Principles of Marketing, 1999 • J.C. Gandhi: Marketing
- ✓ Kotler, Jon Bower, James Maken: Marketing for Hospitality and Tourism
- ✓ Christopher Holloway & Chris Robinson: Marketing for Tourism
- ✓ Victor T.C. Middleton: Marketing in Travel and Tourism
- ✓ V.S. Ramaswamy , S. Namakumari: Marketing Management
- ✓ Patel, S.G.: Modern Market Research, Himalaya Publishing.
- ✓ Singh Raghubir: Marketing and Consumer Behaviour.
- ✓ Sinha, P.C : Tourism Marketing
- ✓ Stephen F. Wilt and Luiz Mountinho: Tourism Marketing & Management Handbook
- ✓ Les Lumsdon: Tourism Marketing:
- ✓ Vearne, Morrisson Alison: Hospitality marketing
- ✓ Stephen Pike : Tourism Marketing

2.6 Temples and Biodiversity of Odisha **(to be taught for promotion of tourism)**

Course Objectives:

- Enable the learner to develop tourism in Odisha.
- To understand basic of temples, Buddhist and Hindu art and architecture from tourism point of view
- Promote awareness of Odisha's rich biodiversity, protected areas, wildlife, and ecological heritage.
- Foster appreciation for the conservation of cultural monuments and biodiversity as essential components of sustainable tourism.

Course outcomes (COs)

After successful completion of the course, students will be able to:

- Explain the evolution of rock art, rock-cut architecture, and early artistic traditions of Odisha.
- Describe the historical development of Buddhism and Jainism in Odisha and evaluate the significance of major Buddhist heritage sites.
- Analyze the architectural features, historical importance, and tourism potential of the major temples and forts of Odisha.
- Identify the major biodiversity hotspots, national parks, wildlife sanctuaries, and biosphere reserves of Odisha and explain their ecological significance.

Unit - 1:**Early Art and Architecture of Odisha.**

1. Rock Art of Odisha – Pictographs & Petroglyphs – an outline.
2. Rock -Cut Sculpture at Dhauli, Rock -Cut Architecture at Khandagiri & Udayagiri – an outline.
3. Sitabinji – Cave Painting.

Unit-II:**Buddhist Art and Architecture of Odisha.**

1. Lalitagiri, Udayagiri and Ratnagiri – An outline. (A Historical Background)
2. Jainism in Odisha. An outline. (A Historical Background)

Unit-III:**Temple Architecture of Odisha**

1. Mature Phase – Lingaraj Temple and Jagannath Temple.
2. Sun Temple at Konark.
3. Barabati Fort

Unit- IV:**Biodiversity places in Odisha**

1. Similipal: National Park and Biosphere reserve
2. Gandhamardan : Biodiversity Heritage
3. Deomali: Koraput mountain peak
4. Wildlife sanctuaries of Odisha: Bhitarkanika, Satkosia Tiger Reserve, Debrigarh

Suggested Readings / References Books

- ✓ The Heritage of Odisha – Odisha State Museum.
- ✓ Konark – Archaeological Survey of India.
- ✓ The Temples of Odisha – K. C. Panigrahi.
- ✓ Literature of temples of Odisha by archeological survey of India and Odisha archeological survey report
- ✓ Students are advised to used open survey

Organisational Behaviour

Course Objectives:

- To learn the basic concepts of Organizational Behaviour and its applications in contemporary organizations
- To understand how individual, groups and structure have impacts on the organizational effectiveness and efficiency.
- To appreciate the theories and models of organizations in the workplace
- To creatively and innovatively engage in solving organizational challenges

Course outcomes (COs)

- To understand the conceptual framework of the discipline of OB and its practical applications in the organizational set up
- To deeply understand the role of individual, groups and structure in achieving organizational goals effectively and efficiently
- To critically evaluate and analyze various theories and models that contributes in the overall understanding of the discipline
- To develop creative and innovative ideas that could positively shape the organizations

Unit I Organizational Behavior:

Learning objectives, Definition & Meaning, Why to study OB, An OB model, New challenges for OB Manager LEARNING: Nature of learning, How learning occurs, Learning, Theories of learning- Classical conditioning, Operant conditioning, social learning, cognitive learning & OB Case Study Analysis

Unit II PERSONALITY:

Meaning & Definition, Determinants of Personality, Personality Traits, Personality & OB PERCEPTION: Meaning & Definition, Perceptual process, Importance of Perception in OB MOTIVATION: Nature & Importance, Herzberg's Two Factor theory, Maslow's Need Hierarchy theory, Alderfer's ERG theory Case Study Analysis.

Unit III

- COMMUNICATION: Importance, Types, Barriers to communication, Communication as a tool for improving Interpersonal Effectiveness GROUPS IN ORGANISATION: Nature, Types, Why do people join groups, Group Cohesiveness & Group Decision Making- managerial Implications, Effective Team
- Building LEADERSHIP: Leadership & management, Theories of leadership- Trait theory, Behavioural Theory, Contingency Theory, Leadership & Followership, How to be an Effective
- Leader CONFLICT: Nature of Conflict & Conflict Resolution TRANSACTIONAL ANALYSIS: An Introduction to Transactional Analysis Case Study Analysis

Unit IV Organizational Culture:

- Meaning & Definition, Culture & Organisational Effectiveness HUMAN RESOURCE MANAGEMENT: Introduction to HRM, Selection, Orientation, Training & Development, Performance Appraisal, Incentives ORGANISATIONAL CHANGE: Importance of Change, Planned Change & OB Techniques .
- ORGANISATIONAL DEVELOPMENT: Pre-requisites for OD,OD interventions. Text Books Organisation Behaviour- K. Aswathappa- Himalaya Publisher } Essential of Organisation Behaviour –Robins –PHP References } Organisation Theory and behavior - S KGupta& R.Joshi- Kalyani Publisher

Organization of Event, Meetings and Conferences

Course Objective

To equip students with the strategic and operational skills needed to plan, design, and manage professional events, meetings, and conferences within the global tourism sector.

Course Outcome (CO)

- **CO 1: To analyze** tourism sub-sectors and identify specialized career pathways for professional event and meeting planners.
- **CO 2: To design** comprehensive event proposals based on systematic client requirement analysis and scope definition.
- **CO 3: To evaluate** venues based on regulatory compliance, accessibility, and facility inspection standards.
- **CO 4: To execute** logistical management plans including vendor selection and venue layout optimization.

Unit I: The Event Planning Landscape: Sub-sectors, career roles, and core packaging terminology.

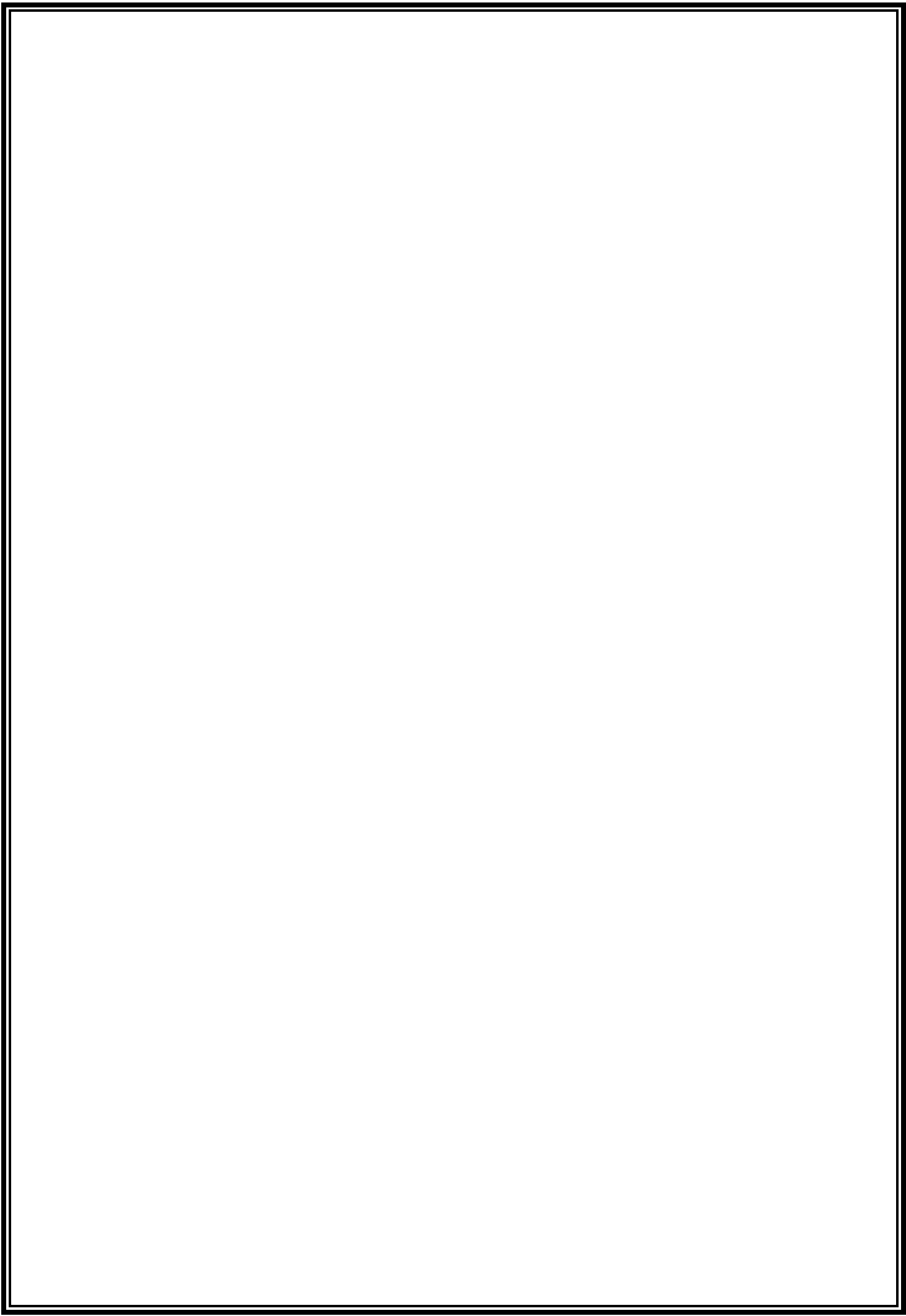
Unit II: Concept, Design, and Proposal: Event types (themed/traditional), client analysis, and proposal drafting.

Unit III: Venue Selection and Regulatory Compliance: Venue categories, selection procedures, and safety standards.

Unit IV: Vendor Logistics and Layout Management: Vendor management procedures and venue layout design.

Suggested Readings

- **Fenich, G. G.** (2015). *Meetings, expositions, events, and conventions: An introduction to MICE*. Pearson.
- **Raj, R., Walters, P., & Rashid, T.** (2013). *Events management: Principles and practice*. Sage.
- **Wagen, L. V. D.** (2010). *Event management*. Pearson Education.



**Draft Model Curriculum for 3yr./4yr. Degree Course with
Apprenticeship Embedded Degree program**

**B.A/B.Sc in Mathematics with Double Major in
Computing**



**Higher Education
Department**
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Calculus & Analytic Geometry	4
	MJ -1.2	Introduction to Algebra & Number Theory	4
	MJ -1.3	Real Analysis-I	4
	MJ- 1.4	Algebra-I	4
	MJ -2.1	Programming and Data structures with Lab	4
	AEC (Ability Enhancement Courses)	English: Business communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	Probability	4
	MJ 1.6	Differential Equations-I	4
	MJ 1.7	Linear Algebra	4
	MJ- 1.8	Real Analysis-II	4
	MJ 2.2	Computer organization and operating system	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / or any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	Complex Analysis-I	4
	MJ 1.10	Algebra-II	4
	MJ 1.11	Statistical Methods -Add	4
	MJ- 1.12	Differential Equations-II	4
	MJ 2.3	Designing and Analysis of Algorithm with Lab	4
	MJ -2.4	Data management system with Lab	4
	MDC (Multidisciplinary Course)	Discrete Mathematics/ or any other discipline	3
	SEC (Skill Enhancement Course)	Analytical thinking and logical reasoning / or any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	Numerical Analysis & Scientific Computing	4
	MJ- 1.14	Multivariable Calculus	4
	MJ- 1.15	Real Analysis-III	4
	MJ -2.5	Computer network and software engineering	4
	MJ -2.6	AI & Machine Learning with Lab	4

	MDC (Multidisciplinary Course)	Optimization techniques/ or any other discipline	3
	SEC (Skill Enhancement Course)	IOT with lab or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20
TOTAL			150

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Programme Outcome

- To prepare the students for a career in Mathematics.
- To prepare the students for Higher Education and Research in Mathematics.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To generally promote wider reading on the subject and allied inter disciplinary subject.

Course Objective:

The main emphasis of this course is to equip the student with necessary analytic and technical skills to handle problems of mathematical nature as well as practical problems. More precisely, main target of this course is to explore the different tools for higher order derivatives to plot the various curves and to solve the problems associated with differentiation and integration of vector functions.

Learning Outcomes:

After completing the course the student will be able to

- Trace a curve and find asymptotes.
- Calculate integrals of typical type using reduction formulae, etc.
- Calculate arc length, surface of revolution and know about conics
- Calculate triple products, gradient divergence, curl, etc.

Unit I

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of the type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax + b)^n\sin x$, $(ax + b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital rule, application in business, economics and life sciences.

Unit II

Riemann integration as a limit of sum, integration by parts, reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \tan^n x dx$, $\int \sec^n x dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^n x dx$, definite integral, integration by substitution.

Unit III

Volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution, techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

Unit IV

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation, partial differentiation, div, curl and integration of vector functions, tangent and normal components of acceleration.

Books Recommended:

- ✓ *H. Anton, I. Bivens and S. Davis: Calculus, 10th Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.*
- ✓ *Shanti Narayan, P. K. Mittal: Differential Calculus, S. Chand, 2014.*
- ✓ *R. J. T Bell: An elementary Treatise on coordinate geometry, MacMillan and Company Limited, 2005.*

Books for Reference:

- ✓ *James Stewart: Single Variable Calculus, Early Transcendental, 8th edition, Cengage Learning, 2016.*
- ✓ *G.B. Thomas and R. L. Finney: Calculus, 9th Ed., Pearson Education, Delhi, 2005.*
- ✓ *M. J. Strauss, G. L. Bradley and K. J. Smith: Calculus, 3rd edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*

Course Objectives:

- To present a systematic introduction to number theory and a basic course on algebra.

Learning Outcomes:

After completing the course the student will be able to

- Understand the equivalence relations and concept of group with different examples.
- Understand the properties of cyclic groups, rings, and integral domain.
- Know divisibility and division algorithm and find gcd using Euclidean Algorithm.
- Solve linear Diophantine equations, find least common multiples, solve linear congruence applying the Chinese remainder theorem.

Unit I

Integers and equivalence relations, properties of integers, modular arithmetic, mathematical inductions, equivalence relations, Introduction to groups, symmetries of a square, the dihedral groups, definitions and examples of groups, elementary properties of groups, subgroups, examples of subgroups.

Unit II

Cyclic groups, properties of cyclic groups, classification of subgroups of cyclic groups, definitions and examples of normal subgroups, Introduction to rings, definition and examples of rings, properties of rings, subrings, definition and examples of integral domain and fields.

Unit III

Divisibility, division algorithms, prime and composite numbers, Fibonacci and Lucas numbers, Fermat numbers, greatest common divisor, Euclidean algorithm.

Unit IV

Fundamental theorem of arithmetic, least common multiple, linear Diophantine equations, congruence, linear congruence, Chinese remainder theorem, Wilson's theorem, Fermat little theorem, Euler's theorem.

Books Recommended:

- ✓ *Joseph A. Gallian, Contemporary Abstract Algebra (4th Edition), Narosa Publishing*

House, New Delhi, 1999.(IX Edition 2010).

- ✓ *Thomas Koshy, Elementary Number Theory with Applications (2nd Edition), Academic Press, 2007.*

Books for Reference:

- ✓ *I. N. Herstein: Topics in Algebra, Wiley Eastern Limited, India, 1975.*
- ✓ *David M. Burton: Elementary Number Theory (6th Edition), Tata McGraw-Hill Edition, Indian Reprint, 2007.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>.*

1.3 Real Analysis-I

Course Objective:

The objective of the course is to introduce the basics of real number system and the properties of sequence and series of real numbers. The ideas of completeness, least upper bound property, denseness, limit, continuity and uniform continuity will also be introduced. This is one of the core courses essential to start doing mathematics.

Learning Outcomes:

On successful completion of this course, students will be able to

- Learn basics of real number system and test countability of a set.
- Know on sequence of real numbers and their basic properties.
- Test convergence of an infinite series.
- Find limit and continuity of functions and test uniform continuity of functions.

Unit I

Finite and infinite sets, countable and uncountable sets, examples, algebraic and order Properties of $\mathbb{R}$, uncountability of $\mathbb{R}$, completeness property of $\mathbb{R}$, applications of the supremum property, Intervals, nested interval property, denseness of rationals in $\mathbb{R}$.

Unit II

Sequence and their limits, limit theorems, monotone sequences, monotone Convergence theorem, subsequences, divergence criteria, monotone subsequence theorem, Bolzano Weierstrass theorem for sequences, Cauchy sequence, Cauchy's convergence criterion.

Unit III

Infinite series, convergence and divergence of infinite series, Cauchy criterion, Tests for convergence: comparison test, limit comparison test, ratio test, Cauchy's nth root test, Raabe's test, integral test, alternating series, Leibniz test, absolute and conditional convergence.

Unit IV

Limits of functions, limit theorems, some extensions of limit concept, continuous functions and their combinations, continuous functions on intervals, boundedness theorem, maximum minimum theorem, intermediate value theorem, uniform continuity, examples, uniform continuity theorem.

Books Recommended:

- ✓ *R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Edn., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.*
- ✓ *G. Das and S. Pattanayak, Fundamentals of Mathematical Analysis, TMH Publishing Co., 30th reprints, 2021.*

Books for Reference:

- ✓ *S. C. Mallik and S. Arora, Mathematical Analysis, New Age International Publications.*
- ✓ *A. Kumar, S. Kumaresan, A basic course in Real Analysis, CRC Press, 2014.*
- ✓ *Brian S. Thomson, Andrew M. Bruckner, and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.*
- ✓ *Gerald G. Bilodeau, Paul R. Thie, G. E. Keough, An Introduction to Analysis, Jones & Bartlett, Second Edition, 2010.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

1.4 Algebra-I

Course Objectives:

To present a systematic and rigorous study on algebraic structures like groups, rings and some important results with their applications. After pursuing this course, one can opt for advanced topics in groups, rings and their applications to

problems in physics, computer science and engineering.

Learning Outcomes:

After completing this course, students will be able to

- Understand permutation groups with some results and application in Rubik's cube.
- Understand the concept of homomorphisms, isomorphisms, normal subgroups and factor groups.
- Explore more properties of rings and ideals rigorously.
- Get introduced to the concept of reducibility and irreducibility of polynomials and concept of unique factorization domain.

Unit I

Permutation groups, definition and notations, cyclic notation, properties of permutations, isomorphisms, definition and examples, Cayley's theorem, properties of isomorphisms, automorphisms, cosets, properties of cosets, Lagrange's theorem and consequences, an application of cosets to permutation groups, an application of cosets to Rubik's cube.

Unit II

External direct products, definition and examples, properties of external direct products, the group of units modulo n as an external direct product, applications, normal subgroups, factor groups, application of factor groups, internal direct products, group homomorphisms, definition and examples, properties of homomorphisms, the first isomorphism theorem.

Unit III

Characteristic of a ring, ideals, factor rings, prime ideals and maximal ideals, ring homomorphisms, definition and examples, the field of quotients, polynomial rings, notations and terminology, division algorithm and consequences.

Unit IV

Factorization of polynomials, reducibility test, irreducibility test, unique factorization in $\mathbb{Z}[x]$, divisibility in integral domains, irreducible, primes, unique factorization domain, Euclidean domain.

Books Recommended:

- ✓ *Joseph A. Gallian, Contemporary Abstract Algebra (9th Edition), Narosa Publishing House, New Delhi, 2010.*
- ✓ *I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.*

Books for Reference:

- ✓ *John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.*
- ✓ *D. S. Dummit, R. M. Foote, Abstract Algebra, Wiley-India edition, 2013.*
- ✓ *Joseph I. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.*
- ✓ *M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*

2.1 Programming and Data Structures with Lab

Objective: The objective of the course is to learn the basics about C and C++ programming languages such as variables, data types, arrays, pointers, functions and classes etc. It also covers the concept of linear data structures like linked list, stack and queue.

Expected Outcome:

On successful completion of the course, students should have a good understanding about the concept of C, object-oriented programming using C++ and be able to write basic C and C++ code. Students can also implement the linked list, stack and queue using both C and C++.

Unit I: Programming in C: Programming methodology, overview of C, Lexical elements, syntax rules, basic data types, operators, expressions, flow of control, function definitions, conditional execution, loops.

Unit II: One-dimensional array, two-dimensional arrays, sparse matrix, recursion, pointers, strings, preprocessor, file input/ output.

Unit III: Introduction to C++, variables and constant declarations, expressions, input using the extraction operator >> and cin, output using the insertion operator << and cout, Preprocessor directives, increment (++) and decrement(--) operators, operators, if-else statement, switch and break statements, loops, Continue statement, nested control statement. Functions, arrays.

Unit-IV: Data Structures: ADTs, linear data structures, linked list, stacks and queues, applications. Lab Work: Execution of simple programmes using C and C++.

Recommended Texts:

1. Brian W. Kernighan and Dennis M. Ritchie: The C Programming Language.
2. Bruce Eckel: Thinking in C++.
3. Byron S. Gottfried: Theory and Problems of Programming with C.
4. A. Kelly, I. Pohl, A book on C, Pearson Education, 2000.
5. D. S. Malik: C++ Programming Language, Course Technology, Cengage Learning, India Edition, 2009.

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	• Communication, its Importance and Factors • Types of Communication • Verbal and Non-verbal Communication • Styles of Communication
2	English Language and Communication: Listening and Speaking	• Types of Listening • Speaking to communicate effectively • Style of speaking in Various Situations • English Pronunciation
3	English Language and Communication: Reading and Writing	• Reading methods and techniques. • Reading texts to Understand meaning • Writing Process • Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	• Grammar • Sentence structure • Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)
2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lightning)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

- A. a) Environmental Ethics: Issues and possible solutions.
- b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
- c) Environment Protection Act
- d) Air (Preservation Control of Pollution) Act
- e) Water (Preservation Control of Pollution) Act
- f) Wildlife Protection Act
- g) Forest Conservation Act
- h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
- B. Human Population and the Environment
- Population Ecology: Individuals, species, population, community
- Human population growth, population control method
- Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester-II

1.5 Probability

Course Objective:

The objective of the course is to make the student understand basics of probability which is of use in everyday life.

Learning Outcomes:

After completing the course the student will be able to

- Learn the basics of probability and random variables with axioms of probability.
- Know the discrete and continuous distributions and learn how to calculate mean, variance and moments of them.
- Learn on limit theorems with their applications and know about the conditional expectations.
- Learn on Markov chains and their applications.

Unit I

Sample space and events, probability axioms, probability defined on events, conditional probabilities, Independent events, Bayes formula, real random variables, discrete and continuous random variables, probability distribution function, probability mass/density functions, mathematical expectation, and properties, variance and standard deviation.

Unit II

Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential, their expectations and variance, moments, moment generating function, characteristic function and computation of these for the distributions, joint distribution function and its properties, joint probability density functions, marginal and conditional distributions, independent random variables.

Unit III

Limit theorems: Markov inequality, Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, application to problems, conditional probability and conditional expectation, discrete case, continuous case, applications, expectation of function of two random variables, conditional expectations, bivariate normal distribution, correlation coefficient, joint moment generating function and calculation of covariance, linear regression for two variables.

Unit IV

Central limit theorem for independent and identically distributed random variables with finite variance, Markov chains, Chapman-Kolmogorov equations, classification of states, Gambler Ruin problem.

Book Recommended

1. *Sheldon Ross, Introduction To Probability Models (9th Edition), Academic Press, Indian Reprint, 2007.*
2. *Robert V. Hogg, Joseph W. McKean And Allen T. Craig, Introduction To Mathematical Statistics, Pearson Education, Asia, 2007.*
3. *Kai Lai Chung, Elementary Probability Theory With Stochastics Process, Springer International Students Edition, (Narosa Publ.)*

Book for Reference

- ✓ *Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, (3rd Edition), Tata McGraw- Hill, Reprint 2007.*
- ✓ *Chow Y S, Teicher H Probability theory Springer International edition*
- ✓ *Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications (7th Edition), Pearson Education, Asia, 2006.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

1.6 Differential Equations-I

Course Objective:

Differential Equations introduced by Leibnitz in 1676 models almost all Physical, Biological, Chemical systems in nature. The objective of this course is to familiarize the students to various methods of solving differential equations, partial differential equations and to have a qualitative applications through models. The students have to solve problems to understand the methods.

Learning Outcomes:

After completing the course the student will be able to

- Get the idea to solve first order linear ordinary differential equations of different types those are arising in physical problems.
- Get the idea to solve second order linear ordinary differential equations of different types those are arising in physical problems.
- Get basic ideas of first order partial differential equations, its formulation in two, three variables and variable separable method for identify the solutions.
- Get idea to solve various mathematical models of ODEs and PDEs which may be helpful for simulation process.

Unit I

Differential equations and mathematical models, general, particular, explicit, implicit and singular solutions of a differential equation, exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equations and Bernoulli's equation, compartmental model, population model for single species.

Unit II

General solution of homogeneous equation of second order, principle of superposition, Wronskian, its properties and applications, method of undetermined coefficients, method of variation of parameters, linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equations.

Unit III

Partial Differential Equations - Basic concepts and definitions, origin of first order PDEs, Classification of first order PDEs, Pfaffian differential forms and equations, solution of Pfaffian differential equations in three variables, Cauchy's problem for first order PDEs, linear equations of first order, integral surfaces passing through a given curve, Cauchy's method of characteristics, compatible systems, method of separation of variables for solving first order and second order partial differential equations.

Unit IV (Practical)

The students will implement the following problems in the computer Lab using *Matlab* / *Mathematica* / *Maple* etc.

1. Plotting of second order solution family of differential equations.
2. Plotting of third order solution family of differential equations.
3. Population growth model (exponential case only).
4. Population decay model (exponential case only).
5. Solution of Cauchy problem for first order PDEs.
6. Finding the characteristics for the first order PDEs.
7. Plot the integral surfaces of a given first order PDE with initial data.

Books Recommended:

- ✓ *J. Sinha Roy and S. Padhy: A course of Ordinary and Partial differential equations, Kalyani Publishers, New Delhi, 2018.*
- ✓ *Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approaching Maple and Matlab, 2nd Edn. Taylor and Francis group, London and New York, 2009.*
- ✓ *Sneddon; Elements of Partial Differential Equations, McGraw-Hill, International Students Edition, 1957.*

Books for Reference:

- ✓ *G. F. Simmons, Differential equation, Tata McGraw Hill, 1991.*
 - ✓ *J. N. Sharma and Kehar Singh, PDE for Engineers and Scientists, Narosa, New Delhi, 2009.*
 - ✓ *Martin Braun, Differential Equations and their Applications, Springer International Student Ed. 1978.*
 - ✓ *S. L. Ross, Differential Equations, 3rd Edition, John Wiley and Sons, India, 2014.*
 - ✓ *C.Y. Lin, Theory and Examples of Ordinary Differential Equations, World Scientific, 2011.*
 - ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
1. e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>

1.7 Linear Algebra

Course Objective:

The objective of this course is to acquaint students with matrix operations, solution of system of equations, vector spaces and linear transformations. In addition, the student will learn about eigenvalues, diagonalization, canonical forms, etc., which has many applications in almost all areas of science and engineering.

Learning Outcomes: After completing the course the student will be able to

- Determine basis and the dimension of a finite-dimensional vector space, know the relation between rank and nullity of a linear transformation.
- The relation between matrix and linear transformation.
- To find solution of system of linear equations, compute eigenvalues, eigenvectors of a matrix and linear transformation.
- About orthogonality of vectors and application of it to different form of matrix, introduced to different operators.

Unit I

Vector spaces, subspaces, span of a set, more about subspaces, linear dependence, independence, product and quotient space, dimension and basis, linear transformations, range and kernel of a linear map, rank and nullity of linear map.

Unit II

Inverse of linear transformation, consequences of rank – nullity theorem, the space $L(U, V)$, composition of linear maps, matrix associated with linear map, linear map associated with matrix, rank and nullity of a matrix, determinant minors and rank of a matrix, transpose of a matrix and special type of matrices, elementary row operations

Unit III

System of linear equations, matrix inversion, application of determinant to linear equations, eigenvalues and eigenvectors, similarity of matrices, invariant subspaces, minimal polynomial (eigenvalues and the minimal polynomial), upper triangular matrices, diagonalizable operators (diagonal matrices, conditions for diagonalizability).

Unit IV

Inner product space: inner products and norms, orthonormal bases, orthogonal complements, self-adjoint and normal operators, spectral theorems, isometries, unitary operators, characteristic polynomial, Cayley – Hamilton theorem, Jordan form, trace, quadratic form, application to reduction of quadrics.

Books Recommended:

- ✓ *V. Krishnamurthy, V.P. Mainra, J. L. Arora, An introduction to linear algebra, Affiliated East – West press Pvt. Ltd., New Delhi, 1976.*
- ✓ *Sheldon Axler, Linear algebra done right (Fourth edition), Springer, 2024.*

Books for References:

- ✓ *Seymour Lipschutz and Marc Lars Lipson, Linear Algebra (Schaum's outlines, Fourth Edition), McGraw Hill, New York, 2009.*
- ✓ *A. Ramachandra Rao and P. Bhimsankaram, Linear Algebra (Second Edition), Hindustan Book Agency, 2000.*
- ✓ *Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (Fourth Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.*
- ✓ *Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.*
- ✓ *S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org> ; <https://linear.axler.net>; and <https://library.oapen.org/handle/20.500.12657/85067>*

1.8 REAL ANALYSIS-II**Course Objective:**

As a second course in real analysis, the objective is to learn on the concept of differentiation, Riemann Integration and their applications. The series of functions and the improper integrals have also been introduced.

Learning Outcomes: After completing the course the student will be able to

- Learn working out problems on derivatives of function and their applications.
- Learn about Riemann Integration and their properties including Improper Integrals.
- Learn on pointwise and uniform convergence of power series.
- Learn to calculate value of improper integrals.

Unit I

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions, relative extrema, interior extremum theorem. Rolle's theorem, Mean value theorems, Cauchy's mean value theorem, Lagrange mean value theorem, intermediate value property of derivatives, Darboux's theorem, applications of mean value theorem, Taylor's theorem and applications.

Unit II

Riemann integration: partitions, conditions of integrability, definition of Riemann integral properties of the Riemann integral, Riemann integral as limit of a sum, mean value theorem for integrals, integration by parts, Fundamental theorems of calculus, Taylor theorem with remainder.

Unit III

Pointwise and uniform convergence of sequence of functions, Cauchy criterion for uniform convergence and Weierstrass M-test, uniform convergence and continuity, term by term integration and differentiation of a series, power series, Abel's theorem, Weierstrass approximation theorem, Taylor series

Unit IV

Improper integrals, integration of unbounded functions with finite limits of integration, comparison tests of convergence, infinite range of integration, integrand as product of functions convergent at infinity, absolutely convergent integral, tests of convergence, convergence of Beta and Gamma functions, applications.

Books Recommended:

- ✓ *R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) Pvt. Ltd., Singapore*
- ✓ *G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, TMH Publishing Co.*
- ✓ *S. C. Mallik and S. Arora, Mathematical Analysis, New Age International Ltd., New Delhi.*

Book for Reference:

- ✓ *K. A. Ross, Elementary Analysis: The theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.*
- ✓ *Charles G. Denlinger, Elements of Real Analysis, Jones and Bartlett (Student Edition), 2011.*
- ✓ *A. Kumar, S. Kumaresan, A basic course in Real Analysis, CRC Press, 2014*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

2.2 Computer Organization & Operating System

Course Objectives:

This course will discuss the basic concepts of computer architecture and organization that can help the students to have a clear view as to how a computer system works. Starting from the basics, the students will be introduced to the state-of-the-art in this field. Operating System is a computer software that manages the hardware components. It acts as an intermediary between the users and the hardware. It is responsible for managing the system resources and providing a smooth working environment for the users.

Expected Outcomes:

This course will address all the fundamental points, starting from the foundations to the architectural issues to correlation with existing commercial operating systems. Students shall learn process management, processor management, memory management, storage management, user management, protection and security. As a subject, it is an amalgamation of the fields like computer architecture, and operating system. A course on operating systems is essential to equip the students for taking up the challenges in understanding and designing of computer systems.

Computer Organization

Unit-I:

Introduction to computer architecture, Instruction set, Instruction set principles and trade offs, Computer arithmetic, ALU design, Assessing computer system performance, Amdahl's Law.

Unit-II:

Pipelining, Pipeline control, pipeline hazards, Basics of caching, Cache mapping, virtual memory, Main memory, Disks and buses, Interfacing Input/ output devices to the memory, processor and operating system.

Operating System

Unit-III:

Process Management (Processes, CPU Scheduling, critical section problem, semaphore, Dead lock-prevention and avoidance & detection & recovery)

Unit-IV:

Storage Management (Memory management- paging & segmentation, virtual memory, file system interface), I/ O system, secondary - storage structure, protection and security. Case study of UNIX/ LINUX system.

Recommended Texts:

- ✓ J. L. Hennessy, and D. A .Patterson, *Computer Organization: The Hardware/Software Interface*, Morgan Kaufman Publishers 1994.
- ✓ J. L. Hennessy, and D. A .Patterson, *Computer Architecture: A Quantitative Approach*, Morgan Kaufman Publishers 1990.
- ✓ Silberschatz & P. B. Galvin, *Operating System concepts*, John Wiley.
- ✓ P. C. Bhatt, *An Introduction to operating systems*, PHI.

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester-III

Major I

Credit 04

1.9 Complex Analysis-I

Course Objectives:

The objective of the course is to introduce the theories for functions of a complex variable. The concepts of analyticity and complex integration and its applications, are discussed in detail. This course is prerequisite to many other advanced analysis courses such as advanced complex analysis, geometric functions, theory, potential theory, theory of entire and meromorphic functions, etc.

Learning Outcomes:

After completing the course the student will be able to

- Understand the geometric aspects of complex numbers system, convergence of series of complex numbers.
- Understand the significance of complex differentiability, analyticity and construction of analytic functions from given harmonic functions.
- Relate the notion of line integral, Cauchy fundamental theorems on integrals and its applications.
- Classify the nature of singularities, properties of zeros and poles and be able to know the applications of residue theorem.

Unit I

Basic properties of complex number and, Stereographic projection, power series, absolute convergence, uniform convergence, Cauchy-Hadamard formula for the radius of convergence, circle of convergence, exponential, logarithmic, sine and cosine functions for complex numbers.

Unit II

Continuity and differentiability of a complex valued function, analytic function, necessary and sufficient conditions for analytic functions, Cauchy-Riemann equations (Cartesian and polar form), harmonic and conjugate harmonic functions, construction of analytic function (Milne-Thomson's method).

Unit III

Line integral, path independence, complex integration, Green's theorem, anti-derivative

theorem, Cauchy-Goursat theorem, Cauchy integral formula, Cauchy's inequality, derivative of analytic function and its generalizations, Liouville's theorem, Morera's theorem, Taylor's and Laurent's theorem, expansion of analytical function in Taylor and Laurent series.

Unit IV

Zeroes of an analytic function, singularities of complex functions and its classifications, residues, Cauchy's residue theorem, residue at infinity, residues at poles and its examples, maximum modulus theorem.

Books Recommended:

- ✓ *Elias M. Stein & Rami Shakarchi: Complex Analysis, Princeton University press, Princeton and Oxford, 2003.*
- ✓ *Joseph Bak and Donald J. Newman: Complex analysis (3rd Edition), Undergraduate Texts in Mathematics, Springer-Verlag, NewYork, 1997.*

Books for Reference:

- ✓ *S. Ponnusamy and Herb Silverman: Complex variables with Applications: Birkhauser, (2006) (Indian Edition 2012).*
- ✓ *H. A. Priestly: Introduction to Complex Analysis, Oxford University Press, 2008.*
- ✓ *Donald Sarason: Complex Function Theory: AMS, Second Edition, 2007.*
- ✓ *James Ward Brown and Ruel V.Churchill: Complex Variables and Applications (Eighth Edition), McGraw-Hill International Edition, 2009.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*

1.10 Algebra-II

Course Objectives:

To present a systematic study on finite abelian groups, Sylow's theorems and Modules.

Learning Outcomes:

After completing the course the student will be able to

- Know on finite abelian groups, the class equation and Sylow's theorems.
- Know on applications of Sylow's theorems and test the simplicity of groups.
- Learn on group action, composition series, nilpotent groups and solvable groups.
- Solve problems in modules and related results.

Unit I

Fundamental theorem of finite abelian groups, isomorphism classes of abelian groups, proof of the fundamental theorem, Sylow's theorems, conjugacy classes, the class equation, Sylow's first theorem, Cauchy theorem, Sylow's second and third theorems.

Unit II

Application of Sylow's theorem, finite simple groups, non-simplicity tests, the simplicity of alternating group A_5 , free groups, classification of groups of order up to 15, characterization of dihedral groups.

Unit III

Group actions and permutation representations, composition series and holder programs, nilpotent groups, solvable groups.

Unit IV

Introduction to modules, definition and examples, direct sum, free modules, quotient modules, homomorphisms, simple modules, modules over PIDs.

Books Recommended:

- ✓ *Joseph A. Gallian, Contemporary Abstract Algebra (4th Edition), Narosa Publishing House, New Delhi, 1999.(IX Edition 2010).*
- ✓ *D. S. Dummit, R. M. Foote, Abstract Algebra, Wiley-India edition, 2013.*
- ✓ *C. Musili, Introduction to Rings and Modules, Narosa Publishing House.*

Books for Reference:

- ✓ *John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.*
- ✓ *N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.*
- ✓ *M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.*
- ✓ *S. Nanda, Topics in Algebra, Allied Publishers, New Delhi.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in>; <http://ocw.mit.edu>; <http://mathforum.org>*

1.12 Differential Equations-II

Course Objective:

The objective of this course is to understand basic methods for solving nonlinear first order ordinary differential equations and existence of solutions along with some special type of second order ordinary differential equations of mathematical physics. Also, students will be exposed to second order partial differential equations arising in thermal physics and thermodynamics.

Learning Outcomes:

After completing the course the student will be able to

- Understand first order nonlinear ordinary differential equations and existence of solutions
- Learn the methods to find solutions of second order linear ordinary differential equations with constant coefficients and variable coefficients.
- The different methods for solving first and second order partial differential equations and can take more courses on wave equation, heat equation, diffusion equation, gas dynamics, nonlinear evolution equations etc. All these courses are important in engineering and industrial applications for solving boundary value problems.
- Get idea to solve various mathematical models of ODE and PDE which may be helpful for simulation process.

Unit I

Existence and Uniqueness of Solutions: Lipschitz condition, Gronwall type inequality, successive approximations, Picard's theorem, non-uniqueness of solutions, continuation and dependence on initial conditions, existence of solutions in the large.

Unit II

Solution of second order ODE with constant coefficients, power series solutions of ordinary and singular points, and special functions of Legendre's differential equations, Bessel's differential equations and their properties.

Unit III

Charpit's method, special types of first order PDE, Jacobi's method, Linear second order PDE, canonical forms of second order PDE and characteristics curves, one dimensional wave equation, its origin and elementary solutions, vibration of an infinite string, vibration of a semi finite string, vibration of a string of finite length, existence of unique solution.

Unit IV (Practical)

Laboratory work for the following problems using *MATLAB / Mathematica / Maple* etc.

- 1) Plot the Fourier series of the following functions:
 - i. $f(x) = x^2, x \in [-1, 1]$
 - ii. $f(x) = \begin{cases} 1, & 0 < x < \pi \\ -1, & -\pi < x < 0 \end{cases}$
 - iii. $f(x) = \sin x, 0 < x < \frac{\pi}{2}$
- 2) Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:
 - (i) $u(x, 0) = \varphi(x), u_t(x, 0) = \sigma(x), x \in \mathbb{R}, t > 0$
 - (ii) $u(x, 0) = \varphi(x), u_t(x, 0) = \sigma(x), u(0, t) = 0, x \in (0, \infty), t > 0$
 - (iii) $u(x, 0) = \varphi(x), u_t(x, 0) = \sigma(x), u_x(0, t) = 0, x \in (0, \infty), t > 0$
 - (iv) $u(x, 0) = \varphi(x), u_t(x, 0) = \sigma(x), u(0, t) = 0, u(l, t) = 0, 0 < x < l, t > 0$
- 3) Solution of one dimensional heat equation $\frac{\partial u}{\partial t} - k \frac{\partial^2 u}{\partial x^2} = 0$ for the following conditions
 - (i) $u(x, 0) = \varphi(x), u(0, t) = a, u(l, t) = b, 0 < x < l, t > 0$
 - (ii) $u(x, 0) = \varphi(x), x \in \mathbb{R}, 0 < t < T$
 - (iii) $u(x, 0) = \varphi(x), u(0, t) = a, x \in (0, \infty), t \geq 0.$

Books Recommended:

- ✓ Deo and Raghavendra, *Text Book of Ordinary Differential Equations*, Tata McGraw-Hill Pub. Company Ltd, New Delhi, 2017.
- ✓ Simmons G F, *Differential equation*, Tata McGrawHill, 1991. (Ch-5. 28-30, Ch-8. 44-47, Ch-6, 33-36)
- ✓ I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Students Edition. (Ch-2. 10, 11, 13; Ch-3. 4-7; Ch-5. 1, 2), 2006.
- ✓ Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers*, 4th edition, Birkhauser, Indian reprint, 2014.

Books for Reference:

- ✓ J. N. Sharma and Kehar Singh, *PDE for Engineers and Scientists*, Narosa, New Delhi, 2009.
- ✓ T Amarnath, *An Elementary Course in Partial Differential Equations*, Narosa Publications, 2003.
- ✓ Martin Braun, *Differential Equations and their Applications*, Springer International Student Ed. 1978.
- ✓ S. L. Ross, *Differential Equations*, 3rd Edition, John Wiley and Sons, India, 2014.
- ✓ C.Y. Lin, *Theory and Examples of Ordinary Differential Equations*, World Scientific, 2011.
- ✓ e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>
- Suggested digital platform: NPTEL/SWAYAM/MOOCs

2.3 Design and Analysis of Algorithms with Lab

Objectives:

To understand the importance of algorithm and its complexity. To analyze the complexity of an algorithm in terms of time and space complexities. To design and implement various programming paradigms and its complexity.

Course Outcome:

Ability to analyze the time and space complexity, given an algorithm. Apply the techniques of algorithm in solving real world problems. Systematic development of an algorithm for solving a problems.

Unit I:

Data structures: Binary trees, binary search trees, heaps, sets and disjoint sets union, graphs (representation, BFS, DFS).

Unit-II:

Algorithms: The role of algorithms in computing, Introduction to design and analysis of algorithms, functions. Asymptotic notations, recurrences. Divide and conquer: (Heap sort, Quick sort, Lower bounds for sorting, counting sort, FFT, Strassen's matrix multiplications).

Unit-III:

Dynamic programming: (Matrix Chain Multiplication, Floyd Warshall algorithm, Longest common subsequence), Greedy method: Fractional knapsack problem, (Huffman codes, Kruskal and Prim's algorithm for finding minimum spanning tree, Dijkstra's algorithm).

Unit-IV:

Backtracking (8-queens problem, sum of subsets), Max flow, min cuts, Ford Fulkerson method, string matching (Rabin-Karp algorithm), NP-Completeness and approximation algorithms. Lab Work: Implementation of the algorithms using C or C++.

Recommended Texts:

- ✓ *Dexter Kozen, Algorithms, Springer Verlag, 1992.*
- ✓ *Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Introduction to Algorithms, MIT press, 2000.*
- ✓ *Jon Kleinberg and Eva Tardos, Algorithm Design, Pearson/ Addison-wesley, 2006.*
- ✓ *E. Horowitz, S. Sahni, and S. Rajasekharan, Fundamental of Computer Algorithms, Galgotia Publications, 2002.*
- ✓ *Aho, J. Hopcroft and J. Ullman: Data Structures and Algorithms.*
- ✓ *T. A. Standish: Data Structure Techniques, Addison Wesley*

2.4 Database Management System with Lab

Course Objectives:

At the end of the course, the students will be able to: Understand the basic concepts and the applications of database systems. Master the basics of SQL and construct queries using SQL. Understand the relational database design principles. Familiar with the basic issues of transaction processing and concurrency control. Familiar with database storage structures and access techniques.

Expected Outcomes:

After completing this course the student must demonstrate the knowledge and ability to: Demonstrate the basic elements of a relational database management system. Identify the data models for relevant problems. Design entity relationship and convert entity relationship diagrams into RDBMS and formulate SQL queries on the respect data into RDBMS and formulate SQL queries on the data. Demonstrate their understanding of key notions of query evaluation and optimization techniques. Extend normalization for the development of application software's.

Unit-I:

Overview of database systems, Introduction to database design, The relational model, Relational algebra and calculus, SQL (queries, constraints, Triggers).

Unit-II:

Overview of storage and indexing, storing data - disks & files, Tree - structured indexing, overview of query evaluation, Evaluating relational operators, A typical relational query optimizer, schema refinement,

Unit-III:

Functional dependencies, Normal forms, Physical database design and tuning, security and authorization.

Unit-IV:

Laboratory work SQL 30

Recommended Texts:

- ✓ R. Ramakrishnan and J. Gehrke - Database Management Systems - MC Grawhill - 3rd Edition 2003.
- ✓ Elmars, Navathe: Fundamentals of Database System, Addison Wesley.
- ✓ Silberschata, H. Korth, S. Sudarshan, Database System Concepts, Mc Grawhill.

Semester IV

1.13 Numerical Analysis & Scientific Computing

Course Objectives:

The objective of this course is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc. Develop adequate skills to apply those methods in real world problems.

Learning Outcomes:

After completing the course the student will be able to

- Understand the errors in computation, find the roots of algebraic and transcendental equations, familiarize with convergence, advantages and limitations of those numerical techniques, learn to apply Gauss–Jacobi, Gauss–Seidel methods to solve system of linear equations.
- Get aware of using interpolation techniques to solve polynomials.
- Learn numerical differentiation and integrations by using different techniques.
- Understand the techniques to find approximate solutions of ODE and PDE.

Unit I

Errors in approximation, absolute, relative and percentage errors, round-off error, solution of algebraic and transcendental equations: bisection method, Regula-Falsi method, secant method, method of iteration, Newton Raphson method, order of convergence, systems of simultaneous equations: Gauss elimination method, Gauss Jordan method, LU decomposition method, Iterative methods: Jacobi method and Gauss-Seidel method.

Unit II

Finite differences, interpolation techniques for equal intervals-Newton forward and backward, Gauss forward, Gauss backward, interpolation, interpolation with unequal intervals-Newton's divided difference method, Lagrange method, Hermite interpolation,

Numerical differentiation using Newton forward and backward formulae, numerical integration using Newton-Cotes formulas, trapezoidal rule, Simpson rules, Gauss-Legendre, Gauss-Chebyshev formulas.

Unit III

Solution of ordinary differential equations: Taylor series method, Picard's method, Euler method, Euler modified method, Runge–Kutta methods.

Unit IV (Practical)

Practical / Lab work to be perform in Computer Lab:

Use of computer algebra system (CAS) software: Python/ Sage Math / Mathematica/ MATLAB/ Maple/ Maxima/ Scilab/ R or any other (open source) software etc., for developing at least the following numerical programs:

1. Bisection method, Newton-Raphson method and Secant method.
2. LU decomposition method.
3. Gauss–Jacobi method and Gauss–Seidel method.
4. Lagrange interpolation and Newton interpolation.
5. Trapezoidal rule and Simpson's rules.
6. Taylor series method, Picard's method, Euler method, Euler modified method and Runge–Kutta Methods.

Note: Non-programmable scientific calculator is allowed in the examination.

Books Recommended:

- ✓ *M. K. Jain, S. R. K. Iyengar & R. K. Jain: Numerical Methods for Scientific and Engineering Computation, New Age International Publisher, India, 2016.*
- ✓ *R. K. Gupta: Numerical Methods: Fundamentals and Applications, Cambridge University Press, 2019.*

Books for Reference:

- ✓ *Brian Bradie: A Friendly Introduction to Numerical Analysis. Pearson Education India. Dorling Kindersley (India) Pvt. Ltd. Third impression, 2011.*
- ✓ *Curtis F. Gerald & Patrick O. Wheatley: Applied Numerical Analysis, Pearson Education. India, 2007.*
- ✓ *S. D. Conte & S. de Boor: Elementary Numerical Analysis: An Algorithmic Approach, 1980.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*

1.14 Multivariable Calculus

Course Objectives:

The primary objective of this course is to introduce students, the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables with the geometry and visualization of curves and surfaces. To aware the students about the techniques multiple integrations and higher order derivatives.

Learning Outcomes:

After completing the course the student will be able to

- Learn the concept of limit, continuity and differentiations of functions of more than one.
- Understand the maximization and minimization of multivariable functions with the given constraints on variables.
- Learn about inter-relationships amongst the line integral, double, and triple integral formulations.
- Familiarize with the Green's, Stokes' and Gauss divergence theorems and their applications.

Unit I

Functions of several variables, limit and continuity of functions of two variables: partial differentiation, total differentiability, sufficient condition for differentiability, chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes.

Unit II

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, double integration over rectangular region, double integration over non rectangular region, double integrals in polar co-ordinates.

Unit III

Triple integrals, triple integral over a parallelepiped and solid regions, volume by triple integrals, cylindrical and spherical co-ordinates, change of variables in double integrals and triple integrals.

Unit IV

Definition of vector field, divergence and curl, line integrals, applications of line integrals: mass and work, fundamental theorem for line integrals, conservative vector fields, independence of path, Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes' theorem, the divergence theorem.

Books Recommended:

- ✓ *M. J. Strauss, G. L. Bradley and K. J. Smith: Calculus, 3rd Edition, Dorling Kindersley (India) Pvt. Ltd. Pearson Education, Delhi, 2007.*
- ✓ *E. Marsden, A. J. Tromba and A. Weinstein: Basic Multivariable Calculus, Springer Student International Edition, Indian reprint, 2005.*

Book for References:

- ✓ *S. C. Mallik and S. Arora: Mathematical Analysis, New Age International Publications, New Delhi, 2005.*
- ✓ *Tom Apostol: Mathematical Analysis, Narosa Publishing House, 2002.*
- ✓ *G. B. Thomas and R. L. Finney: Calculus, 9th Ed., Pearson Education, Delhi, 2005.*
- ✓ *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*
- ✓ *e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>*

1.15 Real Analysis-III**Course Objective:**

After a first course in real analysis in undergraduate program, the ideas of uniform continuity, uniform convergence and approximation by polynomials are crucial in analysis. In addition to the functions of bounded variation and their integrators, the student has to learn differentiating functions from $\mathbb{R}^n$ to $\mathbb{R}^m$. The techniques of integration of a function with respect to another function and the basic ideas of finding a Fourier series are also included.

Learning Outcomes:

After completing the course the student will be able to

- Find the Fourier series of a function.
- Calculate Riemann Stieltjes integrals and know whether a function is of bounded variation or not.
- Learn how to define derivatives on $\mathbb{R}^n$ including the existence of partial derivatives, inverse function theorem and implicit function theorem.
- Learn about metric spaces and their topological properties.

Unit I

Basic concepts of Fourier series, Fourier series of even and odd functions, half range series, Fourier series on other intervals, orthogonal systems of functions, theorem on best approximation, properties of Fourier coefficients, Riesz-Fisher theorem, Riemann-Lebesgue lemma, Dirichlet integral, Integral representation for the partial sum of a Fourier series, convergence of Fourier series.

Unit II

Function of bounded variation, examples, total variation, function of bounded variation expressed as difference of increasing functions, rectifiable paths, Riemann-Stieltjes integrals, properties and techniques, necessary and sufficient condition for existence of the integral, mean value theorem for Riemann-Stieltjes integrals, reduction to Riemann integrals.

Unit III

Differentiation in $\mathbb{R}^n$, partial derivatives, directional derivatives, sufficient condition for differentiability, chain rule, , mean value theorem, Jacobians, contraction mapping principle, inverse function theorem, implicit function theorem, rank theorem, differentiation of integrals, Taylor theorem in many variables.

Unit IV

Metric spaces, definitions and examples, open and closed sets, interior and exterior points, convergence and completeness, continuity and uniform continuity, compactness, connectedness.

Books Recommended:

- ✓ W. Rudin, *Principles of Mathematical Analysis*, McGraw Hill, 3rd edition.
- ✓ T. Apostol, *Mathematical Analysis*, Pearson, 2nd edition.
- ✓ S C Malik and Savita Arora, *Mathematical Analysis- New Age International*, 5th edition

Books for Reference:

- ✓ Terrence Tao, *Analysis-I*, Hindustan book agency.
- ✓ Terrence Tao, *Analysis-II*, Hindustan book agency
- ✓ K. A. Ross, *Elementary Analysis: The theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
- ✓ Charles G. Denlinger, *Elements of Real Analysis*, Jones and Bartlett, Student Edition, 2011.
- ✓ Suggested digital platform: NPTEL/SWAYAM/MOOCs
- ✓ e-Learning Source <http://ndl.iitkgp.ac.in> ; <http://ocw.mit.edu> ; <http://mathforum.org>

2.5 Computer Network and Software Engineering

Objectives:

To introduce the concept, terminologies, and technologies used in modern data communication and computer networking. To identify importance of OSI and TCP/IP models. To make students to get familiarized with different protocols and network components. Able to analyze the concept of local area networks, their topologies, protocols and applications. Be able to evaluate the performance of competing network technologies and protocols. Develop an ability to use the techniques, skills, and modern engineering tools and processes necessary for software engineering.

Course Outcomes: Illustrate the working principle of different protocols at different layers. The student installs and configures workstations, servers and networked printers, inter networking devices such as switches and routers. Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and technologies. Practice and building the skills of subnetting and routing mechanisms. To be familiar with contemporary issues in networking technologies, network tools and network programming. Allow the student to gain expertise in some specific areas of networking such as the design and maintenance of individual networks. Analyze, specify and design the topological and routing strategies for an IP based networking infrastructure. Specify and identify deficiencies in existing protocols, and then go onto formulate new and better protocols. Develop an ability to apply software engineering perspective through software design and construction, requirements analysis, verification, and validation, to develop solutions to modern problems such as security, data science, and systems engineering.

Computer Networks

Unit I: Introduction, Network models, Physical layer (Signals, digital and analogue transmission, Multiplexing, circuit switching), Data Link Layer (Error detection and correction, Data link control and Protocols, PPP, Local area networks, connecting LANS, Cellular telephone and satellite network), Network Layer (Host-to-host delivery - inter networking, addressing, and routing), Network layer protocols),

Unit-II: Transport Layer (Process to process Delivery : VDP and TCP, Congestions control and quality of service), Application Layer (Client server models, Domain name system, SMTP, FTP, HTTP and WWW), Security (Cryptography, Manage security, user authentication and key management).

Software Engineering

Unit III: Introduction, Software life cycle modules, Requirements Analysis and specification, software design, Function oriented software design. Coding and Testing, Software reliability and quality management, Computer Aided Software Engineering, Software maintenance. Introduction to object oriented Analysis and Design, Iterative Development and the unified process, case study-The next-Gen POS, Inception, Understanding Requirements, Use case Model, Identifying other requirements, Elaboration, Use case Model.

Unit-IV: Drawing system sequence diagrams, Visualizing concepts, Adding Associations, Adding attributes, Adding details with operation contracts, Interaction diagram notation. PATTERNS, GRASP, Creating design class diagrams, GOF Design pattern Planning and project queues comments on iterative development and the UP, Rational Unified Process.

Textbook:

- ✓ Crag Larman: Applying UML and Patterns-An introduction OOAP & D and the Unified process, Pearson Education Asia.
- ✓ Rajib Mail: Fundamentals of software Engineering, PHI.

Recommended Texts:

- ✓ *B. A. Forouzan- Data Communications and Networking, TMH, 3rd Edition, 2004.*
- ✓ *S. Tanenbaum, Computer Networks, Prentice Hall 3. W. Stallings, Computer Networking with Internet Protocols and Technology Prentice Hall*

2.6 AI and Machine Learning with Lab**Objectives:**

1. Differentiate between supervised, unsupervised machine learning approaches
2. Ability to choose appropriate machine learning algorithm for solving a problem
3. Design and adapt existing machine learning algorithms to suit applications
4. Understand the underlying mathematical relationships across various machine learning algorithms
5. Design and implement machine learning algorithms to real world applications

Expected Outcomes:

Upon successful completion of this course students will be able to understand the concepts and can implement simple and multiple linear regression, Logistic regression, Linear discriminant analysis, Ridge regression, Cross-validation and boot strap, Fitting classification and regression trees, K-nearest neighbours, Principal component analysis and K-means clustering algorithm.

Unit-I: Linear Methods for Regression and Classification: Overview of supervised learning, Linear regression models and least squares, Multiple regression, Multiple outputs, Subset selection, Ridge regression, Lasso regression, Linear Discriminant Analysis, Logistic regression, Principal Component Analysis.

Unit-II: Model Assessment and Selection: Bias, Variance, and model complexity, Bias-variance trade off, Estimate of In-sample prediction error, Effective number of parameters, Bayesian approach and BIC, Cross-validation, Boot strap methods, conditional or expected test error.

Unit-III: Additive Models, Trees, and Boosting: Generalized additive models, Regression and classification trees, Boosting methods-exponential loss and AdaBoost, Random forests and analysis.

Unit-IV: Neural Networks(NN), Support Vector Machines(SVM), and K-nearest Neighbor: Fitting neural networks, Back propagation, Issues in training NN, SVM for classification, Reproducing Kernels, SVM for regression, K-nearest –Neighbour classifiers, clustering and K-means.

Lab work

Implementation of following methods using Python or R:

Simple and multiple linear regression, Logistic regression, Linear discriminant analysis, Ridge regression, Cross-validation and boot strap, Fitting classification and regression trees, K-nearest neighbours, Principal component analysis, K-means clustering.

Recommended Texts:

- ✓ *Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning-Data Mining, Inference, and Prediction, Second Edition , Springer Verlag, 2009.*
- ✓ *G. James, D. Witten, T. Hastie, R. Tibshirani-An introduction to statistical learning with applications in R, Springer, 2013.*
- ✓ *E. Alpaydin, Introduction to Machine Learning, Prentice Hall Of India, 2010*

**Draft Model Curriculum for 3yr./4yr. Degree Course with
Apprenticeship Embedded Degree program**

**B.Sc. in Zoology with Double Major in Integrative Bio
Sciences**



**Higher Education
Department**
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Cell Biology	4
	MJ -1.2	Microbiology & Microbial Technologies	4
	MJ -1.3	Zoological Museum Technologies	4
	MJ- 1.4	Entomology & Integrated Pest management	4
	MJ -2.1	Animal diversity	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	27
Semester II	MJ 1.5	Fundamentals in Biochemistry	4
	MJ 1.6	Molecular Biology	4
	MJ 1.7	Principles of Genetics	4
	MJ- 1.8	Immunology	4
	MJ 2.2	Physiology: Life Sustaining Systems	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / or any other discipline	3
		TOTAL	27
Semester III	MJ 1.9	Biochemistry of metabolic Processes	4
	MJ 1.10	Biostatistics & Bioinformatics	4
	MJ 1.11	Instrumentation & Techniques in Biology	4
	MJ- 1.12	Animal Biotechnology	4
	MJ 2.3	Physiology: Controlling & Coordinating Systems	4
	MJ -2.4	Developmental Biology	4
	MDC (Multidisciplinary Course)	Vector Borne Diseases & Epidemiology / or any other discipline	3
	SEC (Skill Enhancement Course)	Molecular Diagnostics or/ any other discipline	3
		TOTAL	30
Semester IV	MJ -1.13	Wildlife & Conservation Biology	4
	MJ- 1.14	Aquaculture and Sustainable Fish Farming	4
	MJ- 1.15	Environment Impact Assessment & Toxicology	4
	MJ -2.5	Taxonomy & Evolutionary Biology	4
	MJ -2.6	Comparative Anatomy of Vertebrates	4
	MDC (Multidisciplinary Course)	Bio-resource Technologies & Bio-products / or any other discipline	3
	SEC (Skill Enhancement Course)	Marine Biotechnology / or any other discipline	3
		TOTAL	26
Semester V	Internship/Apprenticeship/Industry Training		20
Semester VI	Internship/Apprenticeship/Industry Training		20

** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020*

Program Outcomes (POs)

PO1. Fundamental Biological Knowledge

Demonstrate comprehensive understanding of core concepts in integrative biosciences, zoology, microbiology, genetics, immunology, biotechnology, ecology, and animal sciences.

PO2. Laboratory and Technical Competency

Apply standard laboratory techniques, instrumentation, molecular tools, museum techniques, and biological analytical methods for scientific investigation and experimentation.

PO3. Computational and Quantitative Skills

Use biostatistics, bioinformatics, data analytics, and logical reasoning tools for interpretation of biological data and scientific problem-solving.

PO4. Research and Analytical Ability

Design, conduct, analyse, and interpret biological experiments using scientific methodologies, critical thinking, and evidence-based approaches.

PO5. Biodiversity, Conservation, and Environmental Awareness

Understand biodiversity conservation, wildlife management, environmental toxicology, ecosystem sustainability, and environmental impact assessment for ecological stewardship.

PO6. Health and Disease Understanding

Develop foundational understanding of epidemiology, vector-borne diseases, immunology, molecular diagnostics, and public health-related biological systems.

PO7. Industry and Employability Readiness

Acquire practical skills relevant to biotechnology industries, aquaculture, diagnostics, environmental consultancy, pest management, and applied biosciences through internships and apprenticeship training.

PO8. Entrepreneurship and Innovation

Demonstrate entrepreneurial aptitude in areas such as vermitechology, aquaculture, integrated pest management, biological products, and startup-oriented bioscience applications.

PO9. Communication and Professional Ethics

Communicate scientific concepts effectively through technical writing, presentations, and interdisciplinary collaboration while adhering to ethical and biosafety principles.

PO10. Lifelong Learning and Multidisciplinary Integration

Adapt to emerging developments in biosciences, biotechnology, environmental sciences, and interdisciplinary research through continuous learning and professional development.

Program Specific Outcomes (PSOs)

PSO1: Develop practical expertise in molecular biology, microbiology, genetics, immunology, biotechnology, and animal sciences for higher studies and industrial applications.

PSO2: Apply biological instrumentation, museum technology, analytical techniques, and computational tools in research laboratories, healthcare, and industrial settings.

PSO3: Demonstrate competency in biodiversity assessment, wildlife conservation, environmental monitoring, toxicological analysis, and ecological management.

PSO4: Acquire hands-on professional experience through internships/apprenticeships in biotechnology industries, aquaculture units, diagnostic laboratories, environmental agencies, and research organizations.

PSO5: Develop innovation and entrepreneurship capabilities in bioscience-based sectors including pest management, sustainable agriculture, aquaculture, waste management, and biological product development.

Industry Linkage Framework

1. Objectives of Industry Linkage

The Industry Linkage Framework aims to:

- bridge academia and industry,
- enhance employability and skill development,
- provide practical exposure,
- facilitate internships/apprenticeships,
- promote entrepreneurship,
- encourage collaborative research and innovation.

2. Major Industry Sectors Linked to the Program

Domain	Relevant Industry Sector
Biotechnology	Biotech companies, genomics labs
Diagnostics	Molecular diagnostic laboratories
Healthcare	Public health agencies, hospitals
Environmental Science	Environmental consultancies, pollution control
Agriculture	Pest management industries, agri-biotech
Wildlife & Conservation	Forest departments, NGOs
Aquaculture	Fisheries and aquaculture industries
Bioinformatics	Computational biology and data analytics
Museum Technology	Natural history museums and archives
Research & Innovation	Universities, CSIR/ICMR/DBT laboratories

3. Potential Institutional and Industry Partners (India)

Biotechnology and Molecular Biology

- Department of Biotechnology
- Biocon
- Serum Institute of India
- Bharat Biotech

Public Health and Diagnostics

- Indian Council of Medical Research
- National Centre for Disease Control
- Regional Medical Research Centre, Bhubaneswar

Environmental and Wildlife Sector

- Odisha State Pollution Control Board
- Zoological Survey of India
- Wildlife Institute of India

Aquaculture and Fisheries

- Central Institute of Freshwater Aquaculture
- ICAR-Central Institute of Brackishwater Aquaculture

4. Internship and Apprenticeship Framework

Semester V

Short-Term Industrial Internship (4–6 Weeks)

Students may be placed in:

- Biotechnology industries
- Diagnostic laboratories
- Environmental monitoring laboratories
- Aquaculture facilities
- Wildlife conservation agencies
- Pest management industries

Expected Outputs

- Internship report
- Skill logbook

- Industry mentor evaluation
- Presentation/viva

Semester VI

Advanced Apprenticeship/Research Project (8–12 Weeks)

Students may undertake:

- Industry-based project
- Field-based ecological survey
- Diagnostic laboratory training
- Bioinformatics mini-project
- Entrepreneurship incubation project

Deliverables

- Dissertation/project report
- Research poster/seminar
- Prototype/model/startup idea
- Employability assessment

5. Skill Development and Certification Integration

Proposed Add-On Certifications

Skill Area	Certification
Bioinformatics	Python/R for Biology
Diagnostics	Molecular Diagnostic Techniques
GIS & Ecology	GIS and Remote Sensing
Entrepreneurship	Startup and Innovation Management
Instrumentation	Laboratory Instrument Handling
Data Science	Biostatistics and Data Analytics

6. Entrepreneurship and Startup Support

Students may be encouraged to develop startups in:

- Vermicomposting
- Biofertilizers
- Aquaculture
- Pest management products
- Diagnostic kits
- Environmental monitoring services
- Biodiversity consultancy

Suggested Support Mechanisms

- Innovation clubs
- Incubation centres
- Industry mentoring
- Seed funding competitions
- DBT/Startup India/ National Skill Development Corporation (NSDC) linkage

7. Research and Innovation Ecosystem

Collaborative Activities

- Industry lectures

- Hands-on workshops
- Joint projects
- Field training camps
- Hackathons in biosciences
- Research internships

Student Research Areas

- Vector-borne diseases
- Toxicology
- Molecular diagnostics
- Wildlife conservation
- Microbial biotechnology
- Aquaculture innovation
- Animal behaviour studies

8. Graduate Employability Pathways

Graduates may pursue careers as:

- Research assistants
- Laboratory technicians
- Diagnostic technologists
- Wildlife and biodiversity analysts
- Environmental consultants
- Aquaculture professionals
- Pest management executives
- Bioinformatics trainees
- Public health field investigators
- Museum and biodiversity curators

9. Higher Education Pathways

Eligible for:

- M.Sc. Biosciences
- M.Sc. Zoology
- Biotechnology
- Microbiology
- Bioinformatics
- Wildlife Science
- Environmental Science
- Public Health
- Molecular Biology
- Integrated Ph.D. programs

10. Distinctive Features of the Program

- Strong interdisciplinary bioscience integration
- Industry-oriented curriculum
- Skill-intensive practical framework
- Dedicated internship semesters
- Emerging areas like bioinformatics and molecular diagnostics
- Employability-focused training
- Entrepreneurship orientation
- Conservation and sustainability emphasis
- NEP-aligned multidisciplinary design

Potential Institutional and Industry Partners (India)**Biotechnology and Molecular Biology**

- Department of Biotechnology
- Biocon
- Serum Institute of India
- Bharat Biotech

Public Health and Diagnostics

- Indian Council of Medical Research
- National Centre for Disease Control
- Regional Medical Research Centre, Bhubaneswar

Environmental and Wildlife Sector

- Odisha State Pollution Control Board
- Zoological Survey of India
- Wildlife Institute of India

Aquaculture and Fisheries

- Central Institute of Freshwater Aquaculture
- ICAR-Central Institute of Brackishwater Aquaculture

Semester -I

Major 1.1

Credit-04

1.1 Cell Biology

Course Objectives

The course is designed to:

- Introduce students to the fundamental principles of cell biology and the organization of living systems.
- Develop understanding of prokaryotic and eukaryotic cell structure, membrane organization, and cellular transport mechanisms.
- Familiarize students with cytoskeletal systems and endomembrane organelles and their roles in cellular organization and metabolism.
- Explain the structure, function, and bioenergetics of mitochondria and related cellular organelles.
- Develop understanding of nuclear organization, chromatin packaging, cell cycle regulation, and cell division.
- Introduce basic mechanisms of cellular communication and signal transduction pathways.
- Provide hands-on laboratory skills in microscopy, cytological techniques, staining methods, and histochemical demonstrations relevant to modern biological sciences.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the structural and functional organization of prokaryotic and eukaryotic cells and describe acellular entities including viruses, viroids, prions, and mycoplasma.

CO2: Interpret plasma membrane organization and evaluate mechanisms of membrane transport and cell–cell communication.

CO3: Describe the organization and functions of cytoskeletal components and endomembrane systems in maintaining cellular architecture and intracellular transport.

CO4: Explain mitochondrial structure and function, cellular bioenergetics, respiratory mechanisms, and organelle evolution.

CO5: Demonstrate understanding of nuclear organization, chromatin structure, nucleosome packaging, and regulation of cell division and cell cycle progression.

CO6: Interpret fundamental cell signalling pathways and their significance in cellular regulation and physiological responses.

CO7: Perform basic laboratory techniques including microscopy, staining, mitotic and meiotic preparations, histochemical reactions, and osmosis demonstrations.

Course Structure (4 Credits= 4 Hours per week)

UNIT I

Cell Organization and Plasma Membrane (10 Hours)

Overview of Cells: Cell theory and diversity of life, Prokaryotic and eukaryotic cells

Comparative organization and cellular complexity, **Acellular Biological Systems:** Viruses, Viroids, Mycoplasma, Prions, Biological significance and disease associations, **Plasma Membrane Organization:** Structure and composition of plasma membrane, Historical and modern membrane models, Fluid mosaic model and membrane dynamics, **Transport Across Membranes:** Passive transport, Active transport, Facilitated transport, Membrane permeability and transport proteins, **Cell Junctions:** Tight junctions, Desmosomes, Gap junctions, Functional significance in multicellular systems.

UNIT II

Cytoskeleton and Endomembrane System (10 Hours)

Cytoskeleton: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments, Cytoskeletal organization and cellular motility

Endomembrane System: Structure and Functions of Endoplasmic reticulum, Golgi apparatus and Lysosomes

Intracellular Transport and Organelle Interactions: Vesicular transport, Protein sorting and trafficking, Cellular secretion pathways

UNIT III

Mitochondria, Peroxisomes and Cellular Bioenergetics (8 Hours)

Mitochondria: Ultrastructure and organization, Semi-autonomous nature, Mitochondrial genome and replication, Endosymbiotic hypothesis

Cellular Respiration and Bioenergetics: Mitochondrial respiratory chain, ATP synthesis, Chemiosmotic hypothesis, Bioenergetic significance

Peroxisomes: Structure and biogenesis, Functions in cellular metabolism, Detoxification and oxidative metabolism

UNIT IV

Nucleus, Cell Division and Cell Signalling (12 Hours)

Nuclear Organization: Structure of nucleus, Nuclear envelope, Nuclear pore complex, Nucleolus and nuclear functions

Chromatin Organization and Packaging: Euchromatin and heterochromatin, Chromatin organization, Nucleosome and DNA packaging

Cell Division and Cell Cycle: Mitosis, Meiosis, Cell cycle phases, Cell cycle regulation and checkpoints

Cell Signalling: Principles of cell signalling, G-protein coupled receptors (GPCR), Second messenger systems, Role of cyclic AMP (cAMP)

PRACTICAL

1. Understanding and operation of simple and compound microscopes
2. Study of different cell types: Buccal epithelial cells, Striated muscle cells (using suitable stains/virtual slides/prepared slides)
3. Preparation of temporary squash of onion root tip for mitosis
4. Study of meiotic stages in grasshopper testis/prepared slides/virtual material
5. Preparation of permanent slide showing Barr body in human female cheek/blood cells
6. Demonstration of: DNA by Feulgen reaction, DNA and RNA by Methyl Green–Pyronin (MGP), Mucopolysaccharides by PAS reaction, Proteins by Mercuric Bromophenol Blue/Fast Green
7. Demonstration of osmosis using RBC/egg/other suitable models

Suggested Teaching–Learning Methods

- ✓ *Interactive lectures*
- ✓ *Demonstration-based laboratory classes*
- ✓ *Microscopy and slide-based learning*
- ✓ *Virtual microscopy and digital histology resources*
- ✓ *Group discussion and problem-solving exercises*
- ✓ *Animation-assisted learning for cellular processes*
- ✓ *Case-based learning and mini-project assignments*

Suggested Field / Industrial Exposure

Students may undergo exposure visits/training at:

- ✓ *University central instrumentation facilities*
- ✓ *Indian Council of Medical Research laboratories*
- ✓ *Department of Biotechnology supported centres*
- ✓ *Council of Scientific and Industrial Research laboratories*
- ✓ *Regional biomedical and life science research institutes*
- ✓ *Diagnostic laboratories (Government/Corporate)*

Suggested Readings

- ✓ *Alberts, B. et al. (2008). Molecular Biology of the Cell, V Edition, Garland Publishing.*
- ✓ *Becker, W.M. et al. (2009). The World of the Cell, VII Edition, Pearson Benjamin Cummings.*
- ✓ *Suvarna, S., Layton, C. and Bancroft, J.D. (2013). Theory and Practice of Histological Techniques, Churchill Livingstone, Elsevier.*
- ✓ *Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.*
- ✓ *Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments, VI Edition, John Wiley & Sons.*
- ✓ *De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology, VIII Edition, Lippincott Williams & Wilkins.*

1.2 Microbiology & Microbial Technologies

Course Objectives

The course is designed to:

- Introduce students to the historical development, scope, and significance of microbiology in modern biological sciences.
- Develop understanding microbial diversity, classification systems, and evolutionary relationships among microorganisms.
- Familiarize students with the structure, physiology, growth, reproduction, and genetics of microorganisms.
- Provide knowledge of microbial culture techniques, isolation methods, sterilization procedures, and microbial quantification.
- Explain the role of microorganisms in agriculture, healthcare, biotechnology, and industrial applications.
- Introduce viruses, bacteriophages, microbial toxins, antibiotics, antivirals, and vaccines with relevance to human health and disease management.
- Develop practical laboratory competencies in microbiological techniques, staining procedures, microbial culture maintenance, and growth analysis.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the historical milestones in microbiology and explain the contributions of pioneering microbiologists to the development of microbial sciences.

CO2: Classify microorganisms using modern taxonomic systems and explain the evolutionary significance of microbial diversity.

CO3: Demonstrate understanding of microbial structure, nutrition, growth, reproduction, and genetic recombination mechanisms.

CO4: Apply microbiological techniques for sterilization, isolation, culture, maintenance, staining, and quantification of microorganisms.

CO5: Explain the beneficial and pathogenic roles of microorganisms in agriculture, healthcare, environmental systems, and biotechnology.

CO6: Describe viral structure, replication, transmission, microbial toxins, and the principles of antibiotics, antivirals, and vaccine action.

CO7: Perform fundamental microbiological laboratory procedures following biosafety and aseptic practices relevant to research and industrial microbiology.

Course Structure

UNIT-I

History and development of microbiology: Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming's experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

UNIT-II

Microbial systems of classification: General features of Bergey's manual for classification of microbes, Whittaker's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition and Reproduction. General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

UNIT-III

Isolation, culture and maintenance of microorganisms: Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

UNIT-IV

Virion and viroids: General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

PRACTICAL

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

Suggested Teaching–Learning Methods

- ✓ *Interactive lectures and demonstrations*
- ✓ *Laboratory-based experiential learning*
- ✓ *Problem-solving and case studies*
- ✓ *Virtual microbiology simulations*
- ✓ *ICT-enabled microbial identification tools*
- ✓ *Industry and laboratory exposure visits*
- ✓ *Student seminars and mini-projects*

Suggested Field / Industrial Exposure

Students may undergo training/exposure visits at:

- ✓ *Clinical and Diagnostic Laboratories*
- ✓ *Industrial and Applied Microbiology Facilities (Fermentation and food industries, pharmaceutical industries, Biotechnology companies, Water quality testing laboratories)*
- ✓ *Research Institutions (Council of Scientific and Industrial Research institutes (IMMT), Department of Biotechnology supported centres (ILS), Regional Medical Research Centre, Bhubaneswar)*
- ✓ *Environmental and Agricultural Microbiology Units (CRRI, CIFA, OUAT)*

Suggested Reading

- ✓ Tortora GJ, Funke BR and Case CL(2008). Microbiology: An Introduction .9th edition. Pearson Education
- ✓ Madigan M T, Martinko J M, Dunlap P V and Clark D P. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
- ✓ Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
- ✓ Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
- ✓ Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM. T. Brown Publishers.
- ✓ Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology. 5th edition. McGraw Hill Book Company.
- ✓ Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

1.3 Zoological Museum Technology

Course Objectives

The course is designed to provide practical and technical knowledge in zoological museum technology, including specimen collection, preservation, taxidermy, skeletal preparation, documentation, curation, and museum display management. The course aims to develop professional competencies required for natural history museums, biodiversity repositories, wildlife institutions, and academic collections.

Course Outcomes (COs)

Upon completion of the course, students will be able to:

CO1: Understand ethical and scientific methods of specimen collection and preservation.

CO2: Perform basic taxidermy and wet preservation techniques.

CO3: Prepare and mount skeletal specimens for museum display.

CO4: Maintain museum records and digital databases.

CO5: Design museum displays and dioramas.

CO6: Apply modern documentation and inventory management techniques including QR-code-based cataloging.

Course Structure

UNIT I

Specimen Collection, Preservation and Wet Specimen Techniques (10 Hours)

Specimen Collection and Ethical Practices: Principles and objectives of zoological museums, Ethical and legal considerations in specimen collection, Wildlife protection laws and permissions, Field collection methods for vertebrates and invertebrates, Safety precautions during specimen handling

Anesthetization and Fixation: Principles of anesthetization, Common anesthetic agents, Fixatives and fixation methods, Preparation and use of formalin solutions, Factors affecting fixation quality

Wet Specimen Preservation: Principles of wet preservation, Use of alcohol, formalin, and glycerin, Preservation techniques for: fishes, amphibians, reptiles, invertebrates, Jar preparation and sealing techniques, Prevention of fungal and bacterial contamination

UNIT II

Taxidermy and Mounting Techniques (10 Hours)

Principles of Taxidermy: History and importance of taxidermy, Tools and materials used in taxidermy, Skinning techniques

Tanning and Preservation: Preservation of skins, Tanning agents and procedures, Pest prevention and maintenance,

Mounting Techniques: Stuffing materials and armature preparation, Mounting of: birds, small mammals, reptiles, Posture and anatomical accuracy, Finishing and display preparation

UNIT III

Skeletal Preparation and Osteological Techniques (10 Hours)

Introduction to Osteology: Importance of skeletal collections, Types of skeletal preparations

Skeletal Preparation Methods: Cleaning techniques, Maceration methods, Dermestid beetle cleaning, Degreasing procedures, Whitening and bleaching methods

Skeletal Assembly and Mounting: Bone identification and arrangement, Wiring and mounting techniques, Preparation of articulated skeletons, Conservation and storage of skeletal materials

UNIT IV

Museum Documentation, Curation and Display Management (10 Hours)

Documentation and Cataloguing: Museum accession procedures, Catalog preparation and specimen numbering, Labeling standards and metadata recording, Digital database management

Modern Inventory Systems: QR code and barcode systems, Digitization of museum collections, Image archiving and cloud-based documentation

Museum Display and Archive Management: Principles of exhibition design, Diorama preparation, Habitat simulation: foliage, rocks, backgrounds, Lighting and environmental control, Museum storage and archive maintenance, Pest management in museums

PRACTICAL

- Preparation of formalin and alcohol solutions
- Fixation and preservation of fish and amphibian specimens
- Preparation of wet museum jars,
- Labeling and sealing of preserved specimens
- Safety handling of chemicals
- Skinning demonstration of small vertebrates
- Preparation of study skins
- Basic stuffing and mounting techniques
- Preparation of bird and small mammal models
- Cleaning and maintenance of mounted specimens
- Cleaning and degreasing bones
- Identification of skeletal elements
- Assembly of small vertebrate skeletons
- Preparation of articulated skeletal displays
- Labeling and storage of osteological specimens
- Preparation of specimen catalog sheets
- Digital database entry
- QR code generation and tagging
- Diorama preparation using artificial habitat materials
- Designing a small museum display unit

Teaching/Learning Methods

- Lectures
- Demonstrations
- Hands-on practical training
- Museum visits
- Field exposure
- Digital documentation exercises

Suggested Field/Industrial Exposure

Students may visit:

- Natural history museums
- Zoological Survey collections
- Wildlife interpretation centers
- University museums

Possible institutions in Odisha include:

- Zoological Survey of India
- Regional Museum of Natural History
- Nandankanan Zoological Park

Suggested Readings

- ✓ *Hall, E.R. — Collecting and Preparing Study Specimens of Vertebrates*
- ✓ *Simmons, J.E. — Fluid Preservation: A Comprehensive Reference, Bloomsbury Academic, 2025*
- ✓ *Kiersten F. Latham and John E. Simmons - Foundations of Museum Studies: Evolving Systems of Knowledge*
- ✓ *W.J. Holland — Taxidermy and Zoological Collecting*
- ✓ *Knudsen — Museum Registration Methods*
- ✓ *Carter & Walker — Care and Conservation of Natural History Collections*

1.4 Entomology & Integrated Pest Management

Course Objectives

The course is designed to:

- Introduce students to the diversity, biology, ecology, and economic importance of insects.
- Develop understanding of major agricultural, medical, veterinary, and forensic insect groups.
- Provide theoretical and practical knowledge of Integrated Pest Management (IPM) approaches for sustainable pest control.
- Train students in pest surveillance, monitoring, identification, and eco-friendly management practices.
- Familiarize students with apiculture, bee management, pollination biology, and commercial bee products.
- Develop hands-on skills in field scouting, biological control methods, trap installation, pesticide safety, and insect preservation techniques.
- Enhance employability and entrepreneurship opportunities in agriculture, pest management industries, apiculture, public health, and environmental management sectors.

Course Outcomes (COs)

After completion of the course, students will be able to:

CO1: Explain the classification, biology, ecological significance, and economic importance of insects including beneficial and harmful species.

CO2: Identify major agricultural insect pests, recognize symptoms of infestation, and apply appropriate pest monitoring and surveillance techniques.

CO3: Demonstrate understanding of Integrated Pest Management principles and evaluate sustainable pest control strategies including biological, botanical, mechanical, and chemical methods.

CO4: Apply practical knowledge of apiculture including hive management, honey extraction, bee health management, and value-added bee products.

CO5: Recognize insects of medical, veterinary, and forensic importance and explain their role in disease transmission and criminal investigations.

CO6: Perform basic entomological field and laboratory techniques such as insect collection, identification, preservation, trap installation, pesticide handling, and vector surveillance.

CO7: Develop technical and entrepreneurial skills relevant to agriculture, pest management services, beekeeping enterprises, public health programs, and environmental consultancy sectors.

Course Structure

UNIT I

Fundamentals of Entomology and Economic Insects (10 Hours)

Introduction to Entomology: Scope and importance of entomology, Insect diversity and classification, General morphology and distinguishing characteristics of insects. **Beneficial& Harmful insects:** pollinators, predators, parasitoids, silk and lac insects, Harmful insects and economic losses, **Major Agricultural Insect Pests:** Major pests of cereals, pulses, oilseeds, fibre crops, fruits and vegetables, Nature of damage and pest symptoms, Economic threshold level and crop loss assessment, **Pest Surveillance and Monitoring:** Principles of pest surveillance, Pest forecasting and monitoring, Introduction to integrated crop protection approaches

UNIT II

Integrated Pest Management (IPM) and Sustainable Pest Control (12 Hours)

Principles and Components of IPM: Concept, history and importance of IPM, Components and strategies of IPM, Sustainable agriculture and ecological pest management, **Insect Biology Relevant to Pest Management:** Reproductive systems and reproductive behaviour, Mating behaviour and insect communication, Life cycles and metamorphosis, **Pest Monitoring Techniques:** Field scouting and sampling methods, Pheromone traps, Light traps, Sticky traps and bait traps, **Sustainable Pest Management Approaches,** Chemical Control (Classification of insecticides, Mode of action, Safe handling, storage and pesticide regulations), Biological and Botanical Control (Biological control agents, Bio-pesticides and microbial pesticides, Botanical pesticides and plant-derived compounds), Mechanical and Cultural Control (Mechanical methods, Cultural practices for pest suppression).

UNIT III

Apiculture and Commercial Beekeeping (8 Hours)

Introduction to Apiculture: Importance of bees in ecosystems and agriculture, Bee species and races, Pollination biology and ecological significance, **Bee Colony Organization and Behaviour:** Social organization of bee colonies, Bee communication and behaviour, **Bee Management Practices:** Hive construction and maintenance, Seasonal management practices, Swarming and migration management, **Bee Products and Entrepreneurship:** Honey flow seasons, Honey extraction and processing, Storage, marketing and quality control, Value-added bee products (wax, propolis, royal jelly, bee pollen), **Bee Health Management:** Bee diseases and pathogens, Bee enemies and predators, Colony protection and management practices

UNIT IV

Medical, Veterinary and Forensic Entomology (10 Hours)

Medical and Veterinary Entomology: Insects of medical and veterinary importance, Mosquitoes, flies, lice, fleas and ticks, Vector-borne diseases and their epidemiology, Insect Vectors and Disease Transmission, Mechanical and biological transmission, Vector surveillance and control measures, Public Health importance of insect vectors, **Introduction to Forensic Entomology:** Scope and applications of forensic entomology, Insect succession on decomposing bodies, Role of insects in criminal investigations, Collection and preservation of forensic entomological evidence

PRACTICAL

1. Entomological Identification and Collection: Identification of major crop pests, Identification of beneficial insects, Identification of termites, borers and disease vectors, Observation of insect developmental stages, Collection and preservation techniques
2. Pest Surveillance and Management: Observation of pest symptoms, Field scouting and sampling techniques, Survey of agricultural and forest insect pests, Installation and demonstration of pheromone and light traps, Preparation of botanical pesticides, Biological control demonstrations, Sprayer calibration and safe pesticide handling
3. Apiculture Training: Identification of bee species, Hive inspection and colony management, Honey extraction and processing methods, Bee disease diagnosis and colony protection practices
4. Medical and Forensic Entomology: Mosquito larval survey, Vector surveillance techniques, Preservation of forensic specimens, Case study analysis in forensic entomology

Suggested Teaching-Learning Methods

- Interactive lectures
- Demonstration-based practical classes
- Field visits and exposure training
- Case studies and problem-solving exercises
- ICT-enabled learning and digital pest identification tools
- Industry interaction and expert lectures
- Suggested Field / Industrial Exposure

Suggested Field/Industrial Exposure

Students may undergo exposure visits/training at:

- State Department of Agriculture
- Integrated Pest Management Centres
- Krishi Vigyan Kendras (KVKs)
- Agrochemical and bio-pesticide industries
- Beekeeping farms and honey processing units
- Apiculture training centres
- Khadi and Village Industries Commission (KVIC) honey units
- Public health departments
- Indian Council for Medical Research (ICMR) Vector-borne disease control programs
- Municipal mosquito surveillance units
- Zoological Survey of India
- Indian Council of Agricultural Research (ICAR)
- National Centre for Integrated Pest Management
- Forest departments and biodiversity parks

Suggested Reading

- ✓ *An Outline of Entomology* (P.J. Gullan & P.S. Cranston), 2014, 5th Edition, Wiley Blackwell
- ✓ *Borror and DeLong's Introduction to the Study of Insects* (C.A. Triplehorn & N.F. Johnson), 2020, Brooks/Cole.
- ✓ *Entomology and Pest Management* (Larry P. Pedigo & Marlin Rice), 2021, Waveland Press.
- ✓ *A Text of Entomology* (N. Arumugam), 2025, Saras Publication, Nagercoil, Tamilnadu, India.

2.1 Animal diversity

Course Objectives

1. The course is designed to:
2. Introduce students to the diversity and classification of major invertebrate and vertebrate animal groups.
3. Develop understanding of evolutionary trends and phylogenetic relationships among animal phyla.
4. Explain structural, functional, ecological, and adaptive features of representative animal groups.
5. Familiarize students with parasitic adaptations, life cycles, and pathogenicity of medically important helminths.
6. Provide knowledge of biological phenomena such as locomotion, metamorphosis, parental care, migration, social organization, and osmoregulation.
7. Develop understanding of evolutionary transitions from lower invertebrates to higher vertebrates.
8. Enhance observational, analytical, taxonomic, and biodiversity-related competencies relevant to zoological sciences and conservation biology.

Course Outcomes (COs)

CO1: Classify major animal groups from Protista to Mammalia based on distinguishing morphological and evolutionary characteristics.

CO2: Explain structural organization, life processes, adaptations, and ecological significance of representative invertebrate and vertebrate taxa.

CO3: Describe important biological phenomena including locomotion, canal systems, polymorphism, metamorphosis, social organization, osmoregulation, migration, and parental care.

CO4: Interpret evolutionary relationships and phylogenetic significance of major animal groups including protochordates, onychophorans, echinoderms, amphibians, reptiles, birds, and mammals.

CO5: Explain life cycles, pathogenicity, and parasitic adaptations of important helminth parasites affecting human and animal health.

CO6: Analyze adaptive and evolutionary transitions involved in the origin of tetrapods, birds, and mammals.

CO7: Develop skills in zoological identification, comparative analysis, specimen observation, and biodiversity documentation.

Course Structure

UNIT I

Protista to Pseudocoelomates (10 Hours)

Protista: General characteristics and classification up to classes, Locomotion in Protista

Reproduction in Protista, **Porifera:** General characteristics and classification up to classes

Canal system in sponges and its significance, **Cnidaria and Ctenophora:** General characteristics and classification up to classes, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora, **Platyhelminthes and Nematoda:** General characteristics and classification up to classes, Parasitic adaptations in helminths and helminth parasites of man

UNIT II

Coelomates (10 Hours)

Annelida: General characteristics and classification up to classes, Evolution of coelom and metamerism, **Arthropoda:** General characteristics and classification up to classes, Vision in In insects, Metamorphosis in insects, Parasitic Arthropods, **Onychophora:** General characteristics and Evolutionary significance of Onychophora, Mollusca, **Mollusca:** General characteristics and classification up to classes, Torsion in gastropods, **Echinodermata:** General characteristics and classification up to classes, Water vascular system in echinoderms, Affinities of echinoderms with chordates

UNIT III

Protochordates to Amphibia (10 Hours)

Protochordates: General characteristics and classification up to classes, Phylogeny of protochordates, Retrogressive metamorphosis in urochordates, **Pisces:** General characteristics and classification up to classes, Osmoregulation in fishes, Parental care in fishes; **Amphibia:** General characteristics and classification up to classes, Parental care in amphibians, Origin of tetrapoda.

UNIT IV

Reptiles, Aves and Mammals (10 Hours)

Reptilia: General characteristics and classification up to classes, Poisonous and non-poisonous snakes, Biting mechanism in snakes, **Aves:** General characteristics and classification up to classes, Archaeopteryx as a connecting link, Migration in birds Flight adaptations in birds, **Mammalia:** General characteristics and classification up to classes Evolutionary origin of mammals, Adaptive radiation in mammals

PRACTICAL

1. Identification of representative invertebrate and vertebrate specimens
2. Preparation and use of taxonomic keys
3. Observation of museum specimens and preserved materials
4. Study of coral structures
5. Study of insect metamorphosis
6. Identification of poisonous and non-poisonous snakes
7. Observation of parasitic helminths and life cycle stages
8. Biodiversity documentation and faunal survey techniques
9. Scientific drawing and zoological record maintenance
10. Suggested Field / Industrial Exposure

Suggested Teaching–Learning Methods

- Interactive lectures with multimedia support
- Taxonomic key-based learning
- Museum specimen demonstrations
- Virtual zoology and digital biodiversity resources
- Comparative anatomy and morphology discussions
- Field-based biodiversity observation
- Group discussion and seminar presentations
- Problem-solving and evolutionary case studies
- ICT-enabled taxonomy learning tools
- Student assignments and mini projects

Students may undergo field visits/training at:

- Biodiversity and Wildlife Centers
- Zoological parks and biodiversity parks
- Wildlife sanctuaries and national parks
- Wetland and mangrove ecosystems
- Research and Conservation Institutions
- Zoological Survey of India
- Wildlife Institute of India
- Forest and wildlife departments
- Aquaculture and Fisheries Exposure
- Fisheries, farms and hatcheries
- Aquaculture research centers
- Museum and Taxonomy Exposure
- Natural History Museums
- University museum facilities
- Taxonomic collections and repositories
- Public Health and Parasitology Laboratories
- Vector-borne disease laboratories

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	English Language and Communication: Introduction	● Communication, its Importance and Factors ● Types of Communication ● Verbal and Non-verbal Communication ● Styles of Communication
2	English Language and Communication: Listening and Speaking	● Types of Listening ● Speaking to communicate effectively ● Style of speaking in Various Situations ● English Pronunciation
3	English Language and Communication: Reading and Writing	● Reading methods and techniques. ● Reading texts to Understand meaning ● Writing Process ● Writing short and Long texts
4	English Language and Communication: Grammar and Vocabulary	● Grammar ● Sentence structure ● Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)
2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lightning)
3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)
4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)
5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightning), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

- A. a) Environmental Ethics: Issues and possible solutions.
- b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies
- c) Environment Protection Act
- d) Air (Preservation Control of Pollution) Act
- e) Water (Preservation Control of Pollution) Act
- f) Wildlife Protection Act
- g) Forest Conservation Act
- h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)
- B. Human Population and the Environment
- Population Ecology: Individuals, species, population, community

Human population growth, population control method

Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester -II

Major 1.5

1.5 Fundamentals in Biochemistry

Credit 04

Course Objectives

The course is designed to:

- Introduce students to the structure, classification, properties, and biological significance of major biomolecules including carbohydrates, lipids, proteins, nucleic acids, and enzymes.
- Develop understanding of molecular organization and biochemical functions of cellular constituents.
- Explain the structural hierarchy and functional significance of proteins and immunoglobulins.
- Familiarize students with nucleic acid chemistry, DNA organization, denaturation-renaturation dynamics, and molecular complementarity.
- Provide knowledge of enzyme classification, kinetics, inhibition, regulation, and catalytic mechanisms.
- Develop analytical understanding of biochemical reactions and molecular interactions relevant to modern biosciences and biotechnology.
- Prepare students for advanced studies and applications in molecular biology, biotechnology, diagnostics, biomedical sciences, and pharmaceutical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the structure, classification, properties, and biological importance of carbohydrates, lipids, proteins, nucleic acids, and enzymes.

CO2: Explain the molecular organization and physiological significance of amino acids, proteins, immunoglobulins, and lipid biomolecules.

CO3: Interpret structural and functional relationships in biomolecules including glycoconjugates, phospholipids, nucleic acids, and enzyme systems.

CO4: Analyze DNA structure, complementarity, denaturation-renaturation processes, and different forms of nucleic acids.

CO5: Explain enzyme classification, catalytic mechanisms, enzyme kinetics, inhibition, and regulation of enzyme activity.

CO6: Apply biochemical concepts to understand physiological functions, metabolic regulation, molecular diagnostics, and biomedical processes.

CO7: Develop problem-solving and analytical skills relevant to biochemical experimentation, molecular sciences, biotechnology, and healthcare applications.

Course structure

UNIT I

Carbohydrates & Lipids: Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

UNIT II

Amino Acids & Proteins: Amino acids: Structure, Classification and General properties of α -amino acids; Physiological importance of essential and non-essential α -amino acids.

Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Renaturation, Denaturation; Introduction to simple and conjugate proteins

Immunoglobulins: Basic Structure, Classes and Function, Antigenic Determinants.

UNIT III

Nucleic Acids: Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids. Cot Curves, Base pairing, Denaturation and Renaturation of DNA, Types of DNA and RNA, Complementarity of DNA, Hypo and Hyperchromaticity of DNA.

UNIT IV

Enzymes: Nomenclature and classification, Cofactors, Specificity of enzyme action, Isozymes, Mechanism of enzyme action, Enzyme kinetics, Factors affecting rate of enzyme-catalyzed reactions, Derivation of Michaelis-Menten equation, Concept of K_m and V_{max} , Lineweaver- Burk plot, Multi-substrate reactions, Enzyme inhibition, Allosteric enzymes and their kinetics, Regulation of enzyme action.

PRACTICAL

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Estimation of protein by Biuret/ Lowry et al method.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase/Urease/acid oralkaline phosphatase
5. Demonstration of proteins separation by SDS-PAGE and determination of molecular weight of proteins (gel pictures may be used for plotting semi log graph)

Suggested Teaching–Learning Methods

- Interactive lectures with molecular illustrations
- Concept-based teaching using biochemical pathways
- Problem-solving sessions and numerical exercises
- ICT-enabled teaching using animations and molecular visualization tools
- Group discussion and peer learning
- Seminar presentations and case-based learning
- Laboratory and Practical Approaches Assignment-based learning
- Mini-projects on biomolecules and enzymes
- Scientific literature-based discussions
- Flipped classroom activities
- Biochemical case study analysis

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

Biotechnology and Biochemistry Industries

- Biotechnology companies
- Enzyme production industries
- Fermentation industries
- Nutraceutical and food processing industries

Healthcare and Diagnostic Laboratories

- Clinical biochemistry laboratories
- Molecular diagnostic centres
- Pathology and immunology laboratories

Pharmaceutical and Biomedical Industries

- Pharmaceutical manufacturing units
- Vaccine and therapeutic production centres
- Drug discovery and analytical laboratories

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported research centres
- University central instrumentation facilities

Industrial Exposure Components

- Enzyme assay and quality control laboratories
- Protein purification facilities
- Molecular biology and genomics laboratories
- Biochemical instrumentation units

Suggested Readings:

- ✓ Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- ✓ Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto, *Biochemistry*, 8th edition, 2015.
- ✓ Victor W., Rodwell, David A., Bender, Kathleen M., Botham, Peter J., Kennelly, P. Anthony, *Harper's Illustrated Biochemistry*, 31st edition.
- ✓ Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). *Molecular Biology of the Gene*, VI Edition, Cold Spring Harbor Lab. Press, Pearson Publication.
- ✓ Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.
- ✓ Devasena T. (2010). *Enzymology* Oxford University Press; 1 edition
- ✓ Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.

Major 1.6

Credit 04

1.6 Molecular Biology

Course Objectives

The course is designed to:

- Introduce students to the molecular organization and functional significance of nucleic acids.
- Develop understanding of DNA replication, repair mechanisms, transcription, translation, and post-transcriptional modifications in prokaryotic and eukaryotic systems.
- Explain the molecular basis of gene expression and regulation including operon systems and regulatory RNAs.
- Familiarize students with mechanisms of RNA processing, alternative splicing, and RNA editing.
- Provide knowledge of molecular control systems such as RNA interference, miRNA, siRNA, and transcriptional regulation.
- Develop laboratory skills in microbial culture techniques, nucleic acid estimation, growth kinetics analysis, and cytogenetic observations.
- Prepare students for advanced studies and applications in molecular genetics, biotechnology, genomics, diagnostics, and biomedical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the structure and functional organization of DNA and RNA and explain nucleic acid properties including denaturation, renaturation, Cot curves, and C-value paradox.

CO2: Explain the molecular mechanisms of DNA replication and DNA repair in prokaryotic and eukaryotic organisms.

CO3: Interpret the processes of transcription and translation and compare gene expression mechanisms in prokaryotes and eukaryotes.

CO4: Describe post-transcriptional modifications including RNA splicing, RNA editing, and processing of mRNA, rRNA, and tRNA.

CO5: Explain mechanisms of gene regulation including operon models, enhancers, silencers, RNA interference, miRNA, and siRNA pathways.

CO6: Perform basic molecular biology laboratory techniques including microbial culturing, nucleic acid estimation, and growth kinetics analysis.

CO7: Develop analytical and problem-solving abilities related to molecular processes, gene regulation, and modern molecular biology applications.

Course Structure

UNIT I

Nucleic Acids, DNA Replication & Repair: Salient features of DNA: Watson and Crick model of DNA, DNA denaturation and renaturation kinetics, Cot curves, C-value paradox, Salient features of RNA

DNA Replication in prokaryotes and eukaryotes: Semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear ds-DNA and RNA priming, replication of telomeres.

DNA repair mechanism: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.

UNIT II

Transcription & Translation: Transcription: RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors and regulation of transcription.

Translation: Genetic code, Degeneracy of the genetic code and Wobble Hypothesis, Process of protein synthesis in prokaryotes: Ribosome structure and assembly in prokaryotes, Fidelity of protein synthesis, Aminoacyl tRNA synthetase and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation.

UNIT III

Post Transcriptional Modifications and Processing of Eukaryotic RNA : Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of rRNA and tRNA.

UNIT IV

Gene Regulation &Regulatory RNAs: Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from Lac-operon and Trp-operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, RNA interference, miRNA, si-RNA.

PRACTICAL

1. Study of Polytene chromosomes from Chironomous / *Drosophila* larvae.
2. Preparation of liquid culture medium (LB) and raise culture of *E. coli*.
3. Estimation of the growth kinetics of *E. coli* by turbidity method.
4. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
5. Quantitative estimation of calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A 260 nm measurement).
6. Quantitative estimation of RNA using Orcinol reaction.
7. Study and interpretation of electron micrographs/photograph showing (a) DNA replication, (b) Transcription and (c) Split genes.

Suggested Teaching–Learning Methods

- Interactive lectures with molecular illustrations and animations
- Concept-oriented teaching of central dogma and gene regulation
- Comparative analysis of prokaryotic and eukaryotic systems
- Problem-solving sessions and molecular case studies
- ICT-enabled teaching using digital molecular models
- Group discussions and student seminars

Suggested Field / Industrial Exposure

- Students may undergo educational visits/training at:
- Molecular Biology and Biotechnology Laboratories
- Biotechnology and Pharmaceutical Industries
- Biotechnology industries
- Vaccine production facilities
- Pharmaceutical research laboratories
- Fermentation and microbial biotechnology industries
- Clinical and Diagnostic Centres
- Clinical Microbiology Laboratories

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- University central instrumentation facilities
- Industrial Exposure Components
- DNA/RNA extraction and quantification units
- Molecular imaging and sequencing facilities
- Bioprocessing and fermentation units
- Quality control and molecular testing laboratories

Suggested Readings

- ✓ Karp G, Iwasa J, Marshall W. Karp's Cell and Molecular Biology, 9th Edition. John Wiley and Sons. Inc. ISBN: 978-1-119-59816-9
- ✓ Krebs JE, Goldstein ES, Kilpatrick ST. (2018) Lewin's Gene XII, Jones and Bartlett Publishers, Inc. ISBN: 9781284104493.
- ✓ DeRobertis E. D. P. (2017) Cell and Molecular Biology 8th Edition. ISBN: 10-8184734506, 13-978-8184734508
- ✓ Lodish H, Berk A, Kaiser CA, Kreiger M, Bretscher A, Ploegh H, Amon A, Martin KC. (2016) Molecular Cell Biology. 8th Edition. WH Freeman. ISBN: 10-1464183392, 13-978-1464183393
- ✓ Becker W. M., Kleinsmith L.J., Hardin J, Bertoni G.P. (2009). *The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.*
- ✓ Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (2002) *Molecular Biology of the Cell, 4th Edition. ISBN: 10-0815332181, 13-978-0815332183*
- ✓ Cooper G.M. and Robert E. Hausman R.E. *The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.*
- ✓ McLennan A., Bates A., Turner, P. and White M. (2015). *Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.*
- ✓ *Lewin's Genes XII- by Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick*

Major 1.7

Credit 04

1.7 Principles of Genetics

Course Objectives

The course is designed to:

1. Introduce students to classical and modern principles of genetics and patterns of inheritance.
2. Develop understanding of Mendelian genetics, linkage, crossing over, chromosomal mapping, and polygenic inheritance.
3. Explain mechanisms of mutation, chromosomal aberrations, and mutagenesis.
4. Familiarize students with sex determination systems and extra-chromosomal inheritance mechanisms.
5. Provide knowledge of recombination in bacteria and viruses and the biological significance of transposable genetic elements.
6. Develop analytical and problem-solving skills in genetic interpretation and chromosomal analysis.
7. Prepare students for advanced studies and applications in molecular genetics, genomics, biotechnology, agriculture, medicine, and biomedical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain principles of Mendelian and non-Mendelian inheritance including dominance relationships, epistasis, pleiotropy, and polygenic inheritance.

CO2: Analyze linkage, crossing over, recombination frequency, and chromosomal mapping using genetic crosses and numerical approaches.

CO3: Describe different types of gene mutations and chromosomal aberrations and explain their molecular basis and biological consequences.

CO4: Interpret mechanisms of sex determination and extra-chromosomal inheritance in various organisms.

CO5: Explain genetic recombination mechanisms in bacteria and bacteriophages including conjugation, transformation, transduction, and complementation tests.

CO6: Describe the structure, function, and significance of transposable genetic elements in prokaryotes and eukaryotes.

CO7: Develop analytical, quantitative, and critical thinking skills related to genetic problem-solving, hereditary patterns, and mutation analysis.

Course Structure

UNIT I

Mendelian Genetics, Linkage, Crossing Over and Chromosomal Mapping: Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance. Polygenic inheritance with suitable examples; simple numerical based on it.

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

UNIT II

Mutations: Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in

relation to UV light and chemical mutagens; Detection of mutations: CLB and sex- linked visible attached X method.

UNIT III

Sex Determination & Extra-chromosomal Inheritance

Chromosomal mechanisms of sex determination in Drosophila and Man; Criteria for extra-chromosomal inheritance, Antibiotic resistance in Chlamydomonas, Mitochondrial mutations in Saccharomyces, Cytoplasmic inheritance in Paramecium.

UNIT IV

Recombination in Bacteria and Viruses & Transposable Genetic Elements: Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposons in bacteria, Ac-Ds elements in maize and P elements in Drosophila, Transposons in human.

PRACTICAL

1. Study of Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from Drosophila crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Experiments on epistatic interactions including test cross and back cross.
7. Experiments on probability and Chi-square test.
8. Study on sex linked inheritance in Drosophila.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures using genetic diagrams and inheritance models
- Problem-solving sessions involving genetic crosses and pedigree analysis
- Concept-based teaching of chromosomal behavior and recombination
- ICT-enabled teaching using animations and genomic visualization tools
- Comparative discussion of classical and molecular genetics
- Student seminars and group discussions
- Assignment-based learning
- Case studies on genetic disorders and mutations
- Mini-projects on inheritance patterns and transposable elements
- Flipped classroom and peer-learning activities
- Scientific literature-based discussions
- Bioinformatics and genome database demonstrations
- Simulation of genetic crosses and recombination mapping
- Molecular visualization of chromosomal rearrangements
- Online tools for pedigree and linkage analysis
- Computational interpretation of genetic data

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

Genetics and Molecular Biology Laboratories

Biotechnology and Biomedical Industries

Agricultural and Plant Breeding Institutes

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- National Institute of Biomedical Genomics

Industrial Exposure Components

- Molecular diagnostics and genetic testing laboratories (e.g., InDNA)
- Cytogenetics and karyotyping units (e.g. Needan, GENEX, Lal's Patholab etc)
- Microbial genetics and recombinant DNA facilities (Heredity Life Science)
- Bioinformatics and genomics analysis units (ILS)

Suggested Readings:

- ✓ *Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition.*
- ✓ *Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.*
- ✓ *Fletcher H. and Hickey I. (2015). Genetics. IV Edition. GS, Taylor and Francis Group, New York and London.*
- ✓ *Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freeman publication*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition.*

1.8 Immunology

Course Objectives

The course is designed to:

1. Introduce students to the fundamental principles and components of the immune system.
2. Develop understanding of innate and adaptive immune mechanisms and their roles in host defense.
3. Explain antigenicity, immunogenicity, immunoglobulin structure, and antigen-antibody interactions.
4. Familiarize students with immunological techniques including ELISA and radioimmunoassay.
5. Provide knowledge of major histocompatibility complex (MHC), antigen processing, cytokines, and complement pathways.
6. Explain mechanisms of hypersensitivity reactions and advances in vaccine development.
7. Prepare students for advanced studies and applications in immunology, diagnostics, biotechnology, vaccine science, and biomedical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the structure, organization, and functions of cells and organs involved in the immune system.

CO2: Differentiate innate and adaptive immunity and explain mechanisms of humoral and cell-mediated immune responses.

CO3: Explain antigenicity, immunogenicity, epitopes, immunoglobulin classes, and antigen-antibody interactions.

CO4: Interpret principles and applications of immunological techniques including ELISA and radioimmunoassay.

CO5: Describe the structure and functions of MHC molecules, cytokines, and complement pathways in immune regulation.

CO6: Explain mechanisms of hypersensitivity reactions and evaluate different types of vaccines and recent advances in vaccine technology.

CO7: Develop analytical and applied understanding of immunological concepts relevant to diagnostics, therapeutics, public health, and biomedical sciences.

Course Structure

UNIT I

Innate and Adaptive Immunity: Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), passive: Artificial and natural Immunity, Active: Artificial and natural Immunity.

UNIT II

Antigens and Immunoglobulins: Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA- Direct, Indirect, Competitive, Sandwich and RIA).

UNIT III

Major Histocompatibility Complex, Cytokines and Complement system: Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation; Cytokines – Types, properties and functions, Complement System -Components and pathways of complement activation.

UNIT IV

Hypersensitivity and Vaccines: Gell and Coombs' causes of hypersensitive reactions, classification and brief description of various types of hypersensitivities.

Vaccines -various types of vaccines, Advances in vaccine production.

PRACTICAL

1. Study of lymphoid organs.
2. Histological study of spleen, thymus, skin and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of White blood cells.
4. ABO blood group determination.
5. Total WBC counting.
6. Differential count.
7. WIDAL Test.
8. Demonstration of ELISA.
9. Demonstration of Bone marrow smears to study Immune cells.
10. ICT Tests

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures using immunological diagrams and flowcharts
- Concept-based teaching of immune mechanisms and pathways
- ICT-enabled teaching using animations and immunology simulations
- Comparative discussions on innate and adaptive immunity
- Case-based learning on immunological disorders and vaccines
- Student seminars and group discussions
- Assignment-based learning
- Mini-projects on vaccines and immunological disorders
- Scientific literature discussions
- Peer teaching and flipped classroom activities
- Clinical and epidemiological case analysis

Digital and Computational Learning

- Molecular visualization of antibodies and MHC molecules
- Online immunology databases and vaccine resources
- Simulation of immune pathways and complement activation
- Bioinformatics tools for immunological analysis
- Data interpretation of immunological assays

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

- Immunology and Diagnostic Laboratories
- Clinical immunology laboratories
- Molecular diagnostic centres

- Serology and pathology laboratories
- Vaccine testing and quality control laboratories
- Biotechnology and Pharmaceutical Industries
- Vaccine production industries
- Biotechnology companies
- Immunodiagnostic manufacturing units
- Pharmaceutical and biomedical industries
- Healthcare and Public Health Institutions
- Hospitals and healthcare diagnostic facilities
- Epidemiology and public health laboratories
- Blood banks and transfusion centres

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Department of Biotechnology supported centres
- Council of Scientific and Industrial Research institutes
- National Institute of Immunology
- Industrial Exposure Components
- Immunodiagnostic kit production units
- Vaccine manufacturing and formulation facilities
- ELISA and molecular testing laboratories
- Biomedical instrumentation and quality assurance units

Suggested Readings:

- ✓ *Abbas K. Abul and Lechtman H. Andrew (2017). Cellular and Molecular Immunology. V Edition. Saunders Publication.*
- ✓ *Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2017). Immunology, VI Edition. W.H. Freeman and Company.*
- ✓ *Fahim Halim Khan (2009). The Elements of Immunology. Pearson Education.*
- ✓ *Peter J. Delves and Seamus J. Martin (2017) Roitt's Essential Immunology, Wiley-Blackwell; 13th edition.*
- ✓ *Immunology- Weir*
- ✓ *Lab manual in Biochemistry, Immunology and Biotechnology- Arti Nigam and Archana Ayyagari (McGraw-Hill Education (India)).*

2.2 Physiology: Life Sustaining Systems**Course Objectives**

The course is designed to:

1. Introduce students to the physiological organization and functioning of major life-sustaining systems in animals and humans.
2. Develop understanding of digestive, respiratory, renal, circulatory, and cardiovascular physiology.
3. Explain the mechanisms underlying nutrient digestion, absorption, gas exchange, excretion, and maintenance of homeostasis.
4. Familiarize students with physiological regulation of blood composition, cardiac activity, respiration, and fluid-electrolyte balance.
5. Provide knowledge of blood physiology, haemopoiesis, blood groups, haemoglobin function, and clotting mechanisms.
6. Explain the physiological basis of health, disease, and adaptation in relation to life-supporting systems.
7. Prepare students for advanced studies and careers in physiology, biomedical sciences, healthcare, biotechnology, and clinical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the structural organization and physiological functions of the gastrointestinal tract and associated digestive glands.

CO2: Explain the mechanisms of digestion, absorption, and hormonal regulation of gastrointestinal functions.

CO3: Interpret respiratory processes including pulmonary ventilation, gaseous exchange, transport of respiratory gases, and regulation of respiration.

CO4: Explain renal physiology including urine formation, osmoregulation, acid-base balance, and homeostatic regulation of kidney functions.

CO5: Describe the composition and functions of blood, haemopoiesis, haemoglobin, blood coagulation mechanisms, and blood group systems.

CO6: Explain the structure and physiology of the heart, cardiac cycle, electrocardiography, blood pressure regulation, and cardiovascular homeostasis.

CO7: Analyze physiological data and relate organ system functions to maintenance of health, homeostasis, and disease conditions.

Course Structure**UNIT I****Physiology of Digestion**

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

UNIT II

Physiology of Respiration

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

UNIT III

Renal Physiology

Structure of kidney and its functional unit, Mechanism of urine formation, Regulation of water balance, Regulation of acid-base balance, Homeostatic regulation of tubular reabsorption and secretion.

UNIT IV

Blood and Physiology of Heart

Haemopoiesis, Components of blood and their functions; Structure and functions of haemoglobin, Blood clotting system, Blood groups: Rh factor, ABO and MN.

Structure of mammalian heart, Coronary circulation, Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure.

PRACTICAL

1. Determination of Blood group and Rh factor
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Preparation of blood smear for differential count.
4. Estimation of haemoglobin using Sahli's haemoglobinometer.
5. Preparation of haemin and haemochromogen crystals.
6. Recording of blood pressure using a sphygmomanometer.
7. Examination of sections of mammalian slides: oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by physiological diagrams and flowcharts
- ICT-enabled teaching using animations and virtual physiology simulations
- Case-based learning on physiological disorders
- Concept mapping of organ systems and regulatory pathways
- Student seminars and group discussions
- Problem-solving exercises involving physiological data interpretation

Digital and Computational Learning

- Virtual physiology laboratory simulations
- ECG and spirometry software demonstrations
- Digital anatomy and physiology atlases
- Online physiological databases and educational platforms
- Computer-assisted analysis of physiological parameters

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

Healthcare and Diagnostic Facilities

- Clinical diagnostic laboratories
- Hospital physiology departments
- Cardiology and pulmonary function laboratories
- Blood banks and transfusion centres

Biotechnology and Pharmaceutical Industries

- Biomedical device manufacturing units
- Pharmaceutical research and development laboratories
- Clinical trial and pharmacology centres
- Healthcare technology companies

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- All India Institute of Medical Sciences
- Council of Scientific and Industrial Research institutes
- National Institute of Nutrition
- University physiology and biomedical science laboratories

Suggested Readings:

- ✓ Guyton & Hall, (2016) *Textbook of Medical Physiology*. Elsevier, 12th edition.
- ✓ Tortora, G.J. & Grabowski, S. (2006). *Principles of Anatomy & Physiology*. XI Edition John Wiley & sons.
- ✓ Marieb E.N. and Hoehn K.N. (2009) *Human Physiology*. Pearson Education Publication, 9th edition
- ✓ Victor P. Eroschenko. (2008). *diFiore's Atlas of Histology with Functional correlations*. XII Edition. Lippincott W. & Wilkins.
- ✓ Vander A Sherman J. and Luciano D. (2014). *Vander's Human Physiology: The Mechanism of Body Function*. XIII Edition, McGraw Hills.
- ✓ Moyes C.D., Schulte PM (2016), *Principles of physiology*, 2nd edition, Pearson education, 3rd.
- ✓ Guyton, A.C. & Hall, J.E. (2006). *Textbook of Medical Physiology*. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	Basic Communication	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	Communication	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	Hotel English	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. Indian Constitution (1 Credit= 15 hours)

Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. Patriotism (1 Credit= 15 hours)

Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. Work Ethics (1 Credit= 15 hours)

Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester -III

1.9 Biochemistry of Metabolic Processes**Course Objectives**

The course is designed to:

1. Introduce students to the fundamental concepts of intermediary metabolism and cellular bioenergetics.
2. Develop understanding of catabolic and anabolic pathways involved in carbohydrate, lipid, and protein metabolism.
3. Explain the biochemical mechanisms of ATP generation, oxidative phosphorylation, and mitochondrial electron transport systems.
4. Familiarize students with metabolic regulation, compartmentalization, reducing equivalents, and metabolic integration.
5. Provide knowledge of glycolysis, citric acid cycle, pentose phosphate pathway, gluconeogenesis, glycogen metabolism, fatty acid metabolism, ketogenesis, and amino acid catabolism.
6. Develop analytical understanding of metabolic disorders and biochemical regulation of cellular energy pathways.
7. Prepare students for advanced studies and applications in biochemistry, biotechnology, molecular medicine, nutrition, and biomedical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the organization of metabolic pathways and distinguish between catabolic and anabolic processes in living systems.

CO2: Describe the biochemical pathways and regulatory mechanisms involved in carbohydrate metabolism including glycolysis, TCA cycle, gluconeogenesis, glycogenolysis, and glycogenesis.

CO3: Interpret lipid metabolic pathways including β -oxidation, omega oxidation, fatty acid biosynthesis, and ketogenesis.

CO4: Explain amino acid metabolism including transamination, deamination, urea cycle, and metabolic fate of glucogenic and ketogenic amino acids.

CO5: Describe mitochondrial electron transport systems, oxidative phosphorylation, redox reactions, and mechanisms of ATP generation.

CO6: Analyze metabolic regulation, energy transfer, enzyme-mediated reactions, and the effects of inhibitors and uncouplers on cellular respiration.

CO7: Develop analytical and problem-solving skills related to biochemical metabolism, energy homeostasis, and metabolic disorders

Course Structure**UNIT I**

Overview of Metabolism: Catabolism vs Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

UNIT II

Carbohydrate Metabolism: Sequence of reactions and regulation of glycolysis, Citric acid cycle, Pentose Phosphate Pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

UNIT III

Lipid and protein Metabolism: B-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis.

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

UNIT IV

Oxidative Phosphorylation: Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers of Electron Transport System.

PRACTICAL

1. Estimation of total protein in given solutions
2. Measurement of SGOT and SGPT activity.
3. Determination of GSH level in serum/tissue.
4. Measurement of GST activity.
5. To study the enzymatic activity of Trypsin/ Lipase.
6. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
7. Dry Lab (Virtual): To trace the labelled C atoms of Acetyl-CoA till they evolve as CO₂ in the TCA cycle.

Suggested Teaching–Learning Methods

- Interactive lectures with biochemical pathway illustrations
- Concept-based teaching using metabolic maps
- ICT-enabled teaching using animations and molecular visualizations
- Problem-solving sessions on metabolic regulation and energetics
- Group discussions and seminar presentations
- Case-based learning on metabolic disorders
- Assignment-based learning
- Mini-projects on metabolic disorders and energy metabolism
- Scientific literature discussions
- Peer teaching and flipped classroom activities
- Clinical and nutritional case studies

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

Biochemistry and Biotechnology Laboratories

- Clinical biochemistry laboratories
- Molecular metabolism research laboratories
- Enzyme and fermentation industries

Healthcare and Diagnostic Centres

- Clinical diagnostic laboratories
- Metabolic disorder screening centres
- Nutritional biochemistry laboratories

Pharmaceutical and Biomedical Industries

- Pharmaceutical manufacturing units
- Drug metabolism and toxicology laboratories
- Nutraceutical and biomedical industries

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- University central instrumentation facilities

Industrial Exposure Components

- Metabolic assay and quality control laboratories
- Enzyme production and industrial fermentation units
- Biomedical instrumentation facilities
- Molecular diagnostics and analytical laboratories

Suggested Readings:

- ✓ Cox, M.M and Nelson, D.L. (2008). *Lehninger Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- ✓ Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
- ✓ Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
- ✓ Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.
- ✓ Satyanarayan and Chakrapani, (2017) *Biochemistry*, Elsevier; Fifth edition.

1.10 Biostatistics & Bioinformatics**Course Objectives**

The course is designed to:

- Introduce students to the principles and applications of biostatistics in biological sciences and research.
- Develop understanding of statistical methods including descriptive statistics, probability distributions, hypothesis testing, correlation, and regression analysis.
- Familiarize students with biological databases, sequence analysis, phylogenetics, and genome organization.
- Provide knowledge of computational tools used in bioinformatics, genomics, proteomics, and protein structure prediction.
- Develop analytical and quantitative skills for interpretation of biological and molecular datasets.
- Explain applications of bioinformatics and statistical analysis in modern biotechnology, healthcare, genomics, and drug discovery.
- Prepare students for advanced studies and careers in bioinformatics, computational biology, biotechnology, biomedical data science, and research analytics.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain principles of biostatistics including data collection, descriptive statistics, probability distributions, and inferential statistical methods.

CO2: Apply statistical tools such as t-test, chi-square test, ANOVA, correlation, and regression for analysis and interpretation of biological data.

CO3: Describe biological databases, sequence data formats, and methods for biological data storage, retrieval, and analysis.

CO4: Perform sequence alignment and interpret phylogenetic relationships using computational approaches and scoring matrices.

CO5: Explain genome organization, transcriptomics, proteomics, and comparative genomic features of model organisms.

CO6: Describe protein structural hierarchy, structure prediction methods, Ramachandran plots, and applications in rational drug design.

CO7: Develop computational, analytical, and problem-solving skills relevant to biostatistics, bioinformatics, genomics, and biomedical research.

Course Structure**UNIT I**

Introduction: definition and scope of biostatistics. Concepts of population and methods of sampling. Simple random sampling, stratified sampling, systematic and clustered sampling. Types of biological data: Qualitative and quantitative, cross sectional and time series, discrete and continuous. Data Measurement scales: Nominal, ordinal, interval and ratio. Data presentation: Tabular and graphical. Histogram and Frequency distribution, cumulative frequency distributions and its graphical representation

UNIT II

Basic concept of measures of Central tendency and Dispersion. Mean, Median and Mode. Arithmetic, Geometric and Harmonic means. Measure of Range, Variance (sample and population), Quartile deviation, Mean deviation, Standard deviation and their relative measures.

UNIT III

Probability distributions: Normal (Dispersion percentage & Z-score) and binomial distribution. Inferential statistics: Hypothesis testing (Null hypothesis), p-value, χ^2 test, t-test (one sample t-test and paired sample t-test). Principal component analysis

UNIT IV

Introduction to bioinformatics and its web resources: NCBI, EMBL-EBI, ExPASy, etc. Biological data resources, access and management. Various genome across the tree of life and major sequencing projects. Data base to store and analyze DNA, RNA, protein sequences and 3-D structures (motifs and domains). Local and Global Sequence alignment programs. Genome and protein BLAST. Scoring matrices, E-value and Bit-score. OTUs and molecular phylogenetics.

PRACTICAL

- Manual and spreadsheet/software tools for descriptive statistics (mean, median, mode, standard deviation, standard error of mean)
- Graphical presentation of Data
- Hypothesis testing: Students' t-Test (paired, unpaired), Chi-square test and ANOVA
- Introduction to different operating systems - UNIX, LINUX and Windows
- Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
- Sequence retrieval using BLAST
- Sequence alignment & phylogenetic analysis using clustalW & phylip
- Picking out a given gene from genomes using Genscan or other softwares (promoter
- Region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
- Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
- Prediction of different features of a functional gene

Suggested Teaching–Learning Methods

- Interactive lectures with statistical and computational demonstrations
- Problem-solving sessions and numerical exercises
- ICT-enabled teaching using bioinformatics software and databases
- Concept-based discussions on genomics and computational biology
- Student seminars and group presentations
- Case studies on biological data analysis and drug discovery
- Assignment-based learning
- Mini-projects on biological datasets and genome analysis
- Scientific literature discussions
- Flipped classroom and peer-learning activities
- Data interpretation and case-based exercises

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:
Bioinformatics and Computational Biology Centres

- Genomics and proteomics laboratories
- Computational biology research centres
- Biomedical data analytics laboratories

Biotechnology and Pharmaceutical Industries

- Drug discovery and molecular modelling industries
- Biotechnology companies
- Genomics and sequencing facilities
- Bioinformatics service industries

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- National Institute of Biomedical Genomics

Industrial Exposure Components

- Biological database management systems
- Genomic sequencing and analysis facilities
- Protein modelling and computational drug design units
- Biostatistics and biomedical analytics laboratories

Suggested Reading

- ✓ Chainy GBN, Mishra G., Mohanty P.K. *Biostatistics-Theory and Applications*. Kalyani Publishers (2019).
- ✓ W. Danial: *Biostatistics: A foundation for Analysis in Health Sciences*, John Wiley and Sons Inc; 2004.
- ✓ Banerjee P.K. *Introduction to Biostatistics (A Textbook of Biometry)*, S Chand and Company Ltd., New Delhi. 2004.
- ✓ Saxena Sanjay (2003) *A First Course in Computers*, Vikas Publishing House
- ✓ Pradeep and Sinha Preeti (2007) *Foundations of Computing*, 4th ed., BPB Publications
- ✓ Lesk M.A. (2008) *Introduction to Bioinformatics*. Oxford Publication, 3rd International Student Edition
- ✓ Rastogi S.C., Mendiratta N. and Rastogi P. (2007) *Bioinformatics: methods and applications, genomics, proteomics and drug discovery*, 2nd ed. Prentice Hall India Publication
- ✓ Primrose and Twyman (2003) *Principles of Genome Analysis & Genomics*. Blackwell.

1.11 Instrumentation & Techniques in Biology**Course Objectives**

The course is designed to:

- Introduce students to the principles, instrumentation, operation, and applications of major analytical and molecular biology techniques used in biological sciences.
- Develop understanding of microscopy, spectroscopy, electrochemical techniques, radioisotope methods, centrifugation, chromatography, electrophoresis, blotting techniques, and flow cytometry.
- Familiarize students with modern laboratory instrumentation used in biological research, diagnostics, biotechnology, and pharmaceutical industries.
- Provide knowledge of molecular separation, identification, quantification, and characterization techniques for proteins, nucleic acids, and cellular components.
- Develop analytical skills for interpretation of biological data generated from advanced instrumentation.
- Enhance practical competencies required for research laboratories, biotechnology industries, and diagnostic facilities.
- Prepare students for advanced studies and careers in biotechnology, molecular biology, biomedical sciences, diagnostics, pharmaceutical sciences, and research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the principles, instrumentation, operation, and applications of light, fluorescence, and electron microscopes used in biological sciences.

CO2: Describe the principles and applications of UV-Visible spectroscopy, electrochemical techniques, pH measurements, and radioisotope-based analytical methods.

CO3: Apply principles of centrifugation and chromatography for separation, purification, and analysis of biological molecules.

CO4: Explain the methodology and applications of protein and nucleic acid electrophoresis techniques used in research and diagnostics.

CO5: Describe the principles, instrumentation, and applications of Southern, Northern, and Western blotting techniques.

CO6: Interpret the basic principles and applications of flow cytometry in cellular and molecular analyses.

CO7: Develop technical and analytical skills for handling biological instrumentation, interpreting experimental data, and applying modern techniques in research, diagnostics, and industrial settings.

Course Structure**UNIT I**

Microscopic: Instrumentation and operation of Principle of Light, Fluorescence and Electron Microscopes and their applications.

UV-Visible absorption Spectroscopy: Principle, instrumentation and application.

Principles of electrochemical techniques: Electrochemical cells and reactions, potentiometry and voltammetry, pH electrode.

Radioisotope techniques: Measurement of radioactivity in biological materials (carbon dating, Geiger-Muller counting and liquid scintillation counting).

UNIT II

Centrifugation techniques: Basic principles of sedimentation, Rotor types, Types of centrifugation.

Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

UNIT III

Electrophoretic techniques: Principle and applications of electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels) and Nucleic acids (Agarose gel electrophoresis).

UNIT IV

Blotting techniques: Principle, Instrumentation and applications (Southern, Northern and Western blotting). **Flow cytometry:** Basic principle, Instrumentation and application.

PRACTICAL

1. Calibration of pH meter using standards and determine the pH of water samples.
2. Isolation of genomic DNA from animal tissue/blood.
3. Quantification and purity check of isolated DNA.
4. Agarose gel electrophoresis of DNA.
5. SDS PAGE (Demonstration).
6. Isolation of Mitochondria.
7. Study of Microscopic methods.
8. Study of Microtomy and Histological techniques.
9. Blotting Techniques (Demonstration).

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures with instrument schematics and animations
- Concept-based teaching using analytical workflows
- ICT-enabled teaching using virtual laboratory platforms
- Demonstration videos of sophisticated instrumentation
- Case studies on biomedical and industrial applications
- Group discussions and student seminars
- Problem-based learning
- Instrumentation-focused assignments
- Mini-projects involving biological data acquisition and analysis
- Peer learning and collaborative laboratory exercises
- Literature review of emerging analytical technologies

Suggested Field / Industrial Exposure

- Students may undergo educational visits and training at:
- Central Instrumentation Facilities of Universities, Advanced Research Instrumentation Centres, Analytical Testing Facilities

- Biotechnology and Molecular Biology Laboratories such as Molecular diagnostics laboratories, Genomics and proteomics centres, Biotechnology research laboratories, Cell culture and molecular biology facilities
- Healthcare and Diagnostic Institutions
- Pharmaceutical and Industrial Laboratories
- Research Organizations; DBT, CSIR, ICAR, ICMR, NISER and IISERs instrumentation facilities.

Suggested Reading

- ✓ *Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.*
- ✓ *Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)*
- ✓ *An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).*
- ✓ *Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.*
- ✓ *Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)*
- ✓ *An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).*
- ✓ *Mark F. Vitha. 2018. Spectroscopy: Principles and Instrumentation. Wiley, ISBN: 978-1-11943660-7.*
- ✓ *Kay Ohlendieck and Stephen E. Harding. 2017. Centrifugation and ultracentrifugation. Basic principles of sedimentation.*
- ✓ *Baraem Ismail and Suzanne Nielsen. 2010. Basic Principles of Chromatography. Food Science Texts Series, DOI 10.1007/978-1-4419-1478-1-27.*
- ✓ *Biophysical Chemistry: Principles and techniques – Upadhyay A, Upadhyay K and Nath N (Himalaya Publishing House).*
- ✓ *A Textbook of Biophysics- R N Roy (NCBA, New Central Book Agency)*

1.12 Animal Biotechnology**Course Objectives**

The course is designed to:

1. Introduce students to the principles, scope, and applications of animal biotechnology.
2. Provide knowledge of recombinant DNA technology, cloning vectors, restriction enzymes, and gene cloning methodologies.
3. Familiarize students with molecular techniques including PCR, DNA sequencing, DNA fingerprinting, blotting methods, and DNA microarrays.
4. Explain the production and applications of transgenic and cloned animals in agriculture, medicine, and research.
5. Develop understanding of animal cell culture technologies and expression of recombinant genes.
6. Introduce molecular diagnostic approaches for inherited genetic disorders and recombinant therapeutics.
7. Prepare students for advanced studies and careers in biotechnology, molecular diagnostics, pharmaceutical biotechnology, genetic engineering, and biomedical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the principles, scope, and applications of animal biotechnology and recombinant DNA technology.:

CO2: Describe the structure, characteristics, and applications of various cloning and expression vectors used in genetic engineering.

CO3: Apply knowledge of restriction enzymes, genomic and cDNA library construction, transformation techniques, and molecular cloning strategies.

CO4: Explain molecular techniques such as PCR, DNA sequencing, DNA fingerprinting, DNA microarrays, and blotting methods used in modern biotechnology.

CO5: Describe methods for producing cloned and transgenic animals and evaluate their applications in biomedical research and biopharmaceutical production.

CO6: Explain principles of animal cell culture, recombinant protein production, molecular diagnosis of genetic disorders, and gene therapy approaches.

CO7: Develop analytical, technical, and problem-solving skills relevant to biotechnology industries, molecular diagnostics, translational medicine, and biomedical research.

Course Structure**UNIT I**

Introduction to Animal Biotechnology: Concept and scope of biotechnology, **Cloning vectors:** Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC and Expression vectors (characteristics). **Restriction enzymes:** Nomenclature, detailed study of Type II restriction enzymes. **Library construction & Screening:** Construction of genomic and cDNA libraries and screening by colony and plaque hybridization.

UNIT II

Molecular Techniques: DNA Transformation techniques (Calcium chloride method and electroporation), Polymerase Chain Reaction, DNA sequencing (Sanger method), DNA Finger Printing and DNA microarray.

UNIT III

Genetically Modified Organisms: Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection, Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock-out animals.

UNIT IV

Animal Cell Culture Techniques and Applications: Animal cell culture, expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Thalassemia, Haemophilia and Sickle cell anemia), Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

PRACTICAL

Animal Biotechnology

1. Genomic DNA isolation from E. coli / Animal tissue
2. Plasmid DNA isolation (pUC 18/19) from E. coli
3. Restriction digestion of plasmid DNA / Lambda Phage DNA
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques and interpretation through photographs/simulation/wet lab
 - a. Southern Blotting
 - b. Northern Blotting
 - c. Western Blotting
 - d. DNA Sequencing (Sanger's Method)
 - e. PCR
 - f. DNA fingerprinting.
- Interactive lectures with biotechnology workflow illustrations
- ICT-enabled teaching using animations and molecular visualizations
- Case studies on recombinant therapeutics and transgenic animals
- Problem-based learning on genetic engineering applications
- Group discussions on bioethics, biosafety, and GMOs

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

- Biotechnology Industries
- Molecular Diagnostic Laboratories
- Animal Biotechnology and Research Centres
- Pharmaceutical and Biomedical Industries
- Research Organizations

Suggested Readings:

- ✓ *T.A. Brown. (2016) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell. ISBN-10-9781119072560*
- ✓ *S.B. Primrose and R.M. Twyman (2006) Principles of Gene Manipulation and Genomics. 7th Edition. Wiley-Blackwell. ISBN: 978-1-405-13544-3*
- ✓ *Richard J. Reece (2003) Analysis of Genes and Genomes. 8th Edition. ISBN: 978-0-470-84380-2*
- ✓ *Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.*
- ✓ *Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). RecombinantDNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.*
- ✓ *BD Singh, (2014) Biotechnology: Expanding Horizons, Kalyani Publishers*
- ✓ *U.Satyanarayana and U Chakrapani, (2014) Biotechnology, Books & Allied Ltd*

2.3 Physiology: Controlling and Coordinating systems**Course Objectives**

The course is designed to:

1. Introduce students to the structural organization and functions of animal tissues and tissue systems.
2. Develop understanding of muscle physiology, nervous system organization, and mechanisms of neural communication.
3. Explain the physiological basis of sensory perception including vision, hearing, taste, smell, and somatic sensations.
4. Familiarize students with mechanisms of neuronal signaling, synaptic transmission, and neuromuscular coordination.
5. Provide knowledge of homeostatic regulation and physiological adaptations to environmental challenges.
6. Explain osmoregulation, thermoregulation, and maintenance of internal physiological balance in animals.
7. Prepare students for advanced studies and careers in physiology, neuroscience, biomedical sciences, healthcare, and biological research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the structure, classification, location, and functions of epithelial, connective, muscular, and nervous tissues.

CO2; Explain bone and cartilage organization, ossification processes, bone growth, and bone remodeling mechanisms.

CO3: Interpret the ultrastructure of skeletal muscles and explain the molecular basis of muscle contraction.

CO4: Describe the organization and functions of the central, peripheral, and autonomic nervous systems, including neuronal communication and reflex mechanisms.

CO5: Explain the physiology of sensory systems involved in vision, hearing, balance, olfaction, gustation, and somatic sensations.

CO6: Analyze mechanisms of homeostasis, body fluid regulation, osmoregulation, and thermoregulation in different animal groups.

CO7: Apply physiological concepts to understand adaptive responses, neural coordination, environmental regulation, and maintenance of internal stability.

Course Structure**UNIT I**

Tissues & Tissue system: Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue. Structure and types of bones and cartilages, Ossification, bone growth and resorption.

UNIT II

Muscle & Nervous System: Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction. Introduction to CNS, PNS and ANS. Structure of neuron, Types of neurons, Action potential and its propagation, Synapse and synaptic transmission, Neuromuscular junction; Reflex action.

UNIT III

Physiology of Special senses: Sensory Neurons-types; Physiology and pathway- hearing and balance, Olfaction, Gustation and Vision. Interoception – Nociceptors, Baroreceptors, Chemoreceptors, Thermoreceptors, Osmoreceptors, Cutaneous Receptors.

UNIT IV

Homeostasis: Homeostasis and body fluids, Sources of body water and loss, Control of homeostasis, Homeostatic imbalances. Osmoregulation in fish, thermoregulation in Poikilotherms, homeotherms and heterotherms.

PRACTICAL

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as kneejerk reflex).
2. Study of permanent slides- Squamous epithelium, Striated muscle fibres, nerve cells and others relevant to the theory.
3. Microtomy: Preparation of permanent slides.
4. Models of mammalian tissues (Any five) /photographs.
5. Effect of salt concentration on cells.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by histological and physiological diagrams
- ICT-enabled teaching using animations of nerve impulse transmission and muscle contraction
- Concept-based discussions on physiological coordination
- Comparative studies of regulatory mechanisms across animal groups
- Group discussions and student seminars
- Case studies on neurological and sensory disorders
- Flipped classroom discussions
- Problem-based learning using physiological case studies

Digital and Computational Learning

- Virtual histology and anatomy platforms
- Neurophysiology simulations
- Interactive sensory pathway models
- Digital atlases of tissues and organ systems
- Computer-assisted physiological data analysis
- Online neuroscience and physiology learning modules

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

Biomedical and Healthcare Institutions

- Neurophysiology laboratories
- Clinical neurology departments
- Sensory diagnostic and rehabilitation centres
- Audiology and vision assessment laboratories

Research and Academic Institutions

- Physiology and neuroscience research laboratories
- Biomedical research centres
- Animal physiology laboratories
- Environmental physiology research facilities

Biotechnology and Biomedical Industries

- Biomedical instrumentation companies
- Neurodiagnostic equipment manufacturers
- Health monitoring technology industries
- Physiological assessment laboratories

Museums and Specialized Centres

- Zoological museums with comparative anatomy collections
- Human anatomy and physiology museums
- Natural history museums

Research Organizations

- Indian Council of Medical Research laboratories
- National Institute of Mental Health and Neurosciences
- Council of Scientific and Industrial Research institutes
- All India Institute of Medical Sciences
- University neuroscience and physiology research centres

Suggested Books:

- ✓ *Textbook of Medical Physiology, Guyton & Hall, Elsevier, 12th edition, 2016.*
- ✓ *Marieb EN and Hoehn K, Human Physiology, (2013), 9th edition, Pearson Education, USA.*
- ✓ *Endocrinology, Hadley ME and Levine JE (2009), Pearson Education India; 6 edition.*
- ✓ *Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition., Lippincott W. & Wilkins*
- ✓ *Martini F H, Nath J L and Bartholomew E F (2015) Fundamentals of Anatomy and Physiology. Pearson Education Publication,*
- ✓ *Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.*

2.4 Developmental Biology**Course Objectives**

The course is designed to:

1. Introduce students to the principles, concepts, and historical development of developmental biology.
2. Explain the cellular and molecular mechanisms governing gametogenesis, fertilization, embryogenesis, and organogenesis.
3. Develop understanding of early and late embryonic development in vertebrate model organisms.
4. Familiarize students with mechanisms of cell differentiation, embryonic induction, pattern formation, and developmental regulation.
5. Provide knowledge of post-embryonic developmental processes including metamorphosis, regeneration, and ageing.
6. Explain developmental abnormalities, teratogenic effects, stem cell biology, assisted reproductive technologies, and prenatal diagnostic methods.
7. Prepare students for advanced studies and careers in developmental biology, reproductive biology, regenerative medicine, biotechnology, and biomedical research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the fundamental concepts, historical developments, and molecular basis of developmental biology including cell differentiation and pattern formation.

CO2: Describe the processes of gametogenesis, fertilization, egg organization, and mechanisms preventing polyspermy.

CO3: Interpret cleavage patterns, blastulation, gastrulation, fate mapping, and embryonic induction during early embryonic development.

CO4: Explain the formation and developmental significance of germ layers, extra-embryonic membranes, implantation, and placentation.

CO5: Analyze post-embryonic developmental processes including metamorphosis, regeneration, and ageing in different animal groups.

CO6: Evaluate the impact of teratogenic agents and explain applications of stem cells, in vitro fertilization, and prenatal diagnostic technologies.

CO7: Develop analytical and experimental understanding of developmental processes relevant to reproductive health, regenerative medicine, developmental disorders, and biotechnology.

Course Structure**UNIT I****Introduction to Developmental Biology, Gametogenesis & Fertilization**

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division. Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy.

UNIT II

Early Embryonic Development: Cleavage: Planes and patterns of cleavage, Types of Blastula, Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

UNIT III

Late Embryonic Development: Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

UNIT IV

Post Embryonic Development & Interferences in Developmental Biology: Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories. Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis.

PRACTICAL

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
4. Study of different sections of placenta (photomicrograph/slides).
5. Project report on *Drosophila* culture/chick embryo development.
6. Study of developmental stages by raising chick embryo in the laboratory.
7. Estimation of calcium in egg shell.
8. Estimation of carbohydrates and proteins in egg.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by embryological diagrams and developmental models
- ICT-enabled teaching using developmental animations and time-lapse embryogenesis videos
- Concept-based discussions on developmental mechanisms and gene regulation
- Comparative developmental studies across animal groups
- Student seminars and scientific presentations
- Case-based learning on developmental disorders and reproductive technologies
- Demonstration of stem cell and assisted reproductive technology concepts through multimedia resources
- Digital and Computational Learning
- Virtual embryology laboratories
- Developmental biology simulation software
- 3D embryonic development models
- Stem cell and regenerative medicine educational platforms

Suggested Field / Industrial Exposure

- Students may undergo educational visits and training at:
- Reproductive and Fertility Centres
- Assisted reproductive technology (ART) clinics
- IVF laboratories
- Fertility and reproductive health centres
- Biomedical and Stem Cell Research Laboratories
- Stem cell research facilities
- Regenerative medicine laboratories
- Developmental genetics laboratories
- Healthcare and Diagnostic Centres
- Prenatal diagnostic laboratories
- Cytogenetic and molecular diagnostic centres
- Maternal and fetal medicine units
- Biotechnology and Pharmaceutical Industries
- Reproductive biotechnology companies
- Regenerative medicine industries
- Biomedical research and development facilities
- Research and Academic Institutions
- Indian Council of Medical Research laboratories
- National Institute for Research in Reproductive and Child Health
- Department of Biotechnology supported centres
- Centre for Cellular and Molecular Biology
- Institute for Stem Cell Science and Regenerative Medicine

Suggested Reading

- *Lewis Wolpert (2010). Principles of Development. II Edition, Oxford University Press.*
- *Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA*
- *Carlson, R. F. Patten's Foundations of Embryology.*
- *Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.*
- *Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).*

Vector Borne Diseases & Epidemiology

Unit I: Insects, Concept of Vectors, Insects as Vectors

General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts with reference to feeding habits, Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity, Classification of insects up to orders, detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera.

Unit II: Vectors and diseases

Important insect vectors – Mosquitoes, Sandfly, Houseflies; Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes, Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sandfly, Study of house fly as important mechanical vector, Myiasis, Control of house fly

Unit III: Epidemiology-an introduction

Definition, Objective and uses and core functions of epidemiology, Epidemiologic approach, Historical evolution of epidemiology, Concept of health and disease, Determinants of health and diseases, Difference between epidemiology and clinical/preventive medicine, Epidemiology as the cornerstone of public health/health - for example: contribution of Nurses' Health study, British Doctors' study and Framingham Heart Study to public health etc.

Unit IV: Disease types, mode of transmission and management

Difference between infectious and communicable diseases vs. non communicable diseases, Natural history of disease, Chain of infection, Mode and route of transmission of diseases, Meaning of outbreak or epidemic, endemic and pandemic, incubation period, latency period, clinical case, subclinical case, carrier, infectivity, pathogenicity and virulence, theories and principles of causation- epidemiological triad, web of causation, Bradford Hill criteria and Rothman's Causal pies, levels of prevention and modes of intervention.

Suggested Readings

- ✓ Mathews, G. (2011). *Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases*. Wiley-Blackwell
- ✓ Chapman, R.F. (1998). *The Insects: Structure and Function*. IV Edition, Cambridge University Press, UK.
- ✓ Mike Service (2012) *Medical Entomology for Students* Cambridge University Press; 5th edition.
- ✓ Pedigo L.P. (2002). *Entomology and Pest Management*. Prentice Hall Publication
- ✓ Victor Schoenback and Wayne B. Rosamond (2000) *Understanding the fundamentals of Epidemiology- An evolving text..*
- ✓ *Modern Epidemiology-* Kenneth Rothman, Sebastien Haneuse , Timothy L. Lash , Tyler J. Vander Weele (2021).

Molecular Diagnostics**Unit I**

Introduction and history of disease diagnosis, mode and type of infectious disease, philosophy and ethics for clinical samples. Various methods of collection, storage and transport/shipping procedures for clinical samples. Diagnosis of infectious disease caused by bacteria, fungi, viruses, protozoa and Helminthes.

Unit II

Biochemical parameters for detection and quantification of clinical samples (i.e. urine, blood, fecal matters, tissue biopsy) for bacterial disease. Detection and quantification of sugars, albumin, urea, protein, globulin and vitamins. Disease identification, genetic test for disorders, population screening for genetic disorder. Treatment and management in genetic diseases.

Unit III

Culture independent analysis of bacteria, PCR based microbial typing, Molecular diagnosis of fungal pathogens. DNA finger printing, Southern blotting and electrophoresis analysis, RAPD and RFLP techniques, DNA sequencing (Sanger). Multiplex-PCR analysis.

Unit IV

Principle and diagnosis techniques of immunoassays: Radio immunoassay (RIA), Enzyme linked immunosorbent assay (ELISA), chemiluminescent immunoassay (CIA), fluorescent antibody test/ immunoassay (FIA). Principle and techniques of Immunohistochemistry. Application of Biosafety cabinets and containment for clinical specimens. Good laboratory practices in handling clinical samples.

Suggested Reading

- ✓ *Lela Buckingham and Maribeth Flaws. (2007) Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, F.A. Davis Company.*
- ✓ *Nader Rifai, Andrea Rita Horvarth, Kaqrl T Wittwer, Tietz Textbook of Clinical Chemistry and Molecular Diagnostics, 6th Edition, 2017, Elsevier.*
- ✓ *David E. Bruns, Edward R. Ashwood, Carl A. Burtis, Fundamentals of Molecular Diagnostics, 1st Edition, Elsevier.*

Semester -IV

1.13 Wildlife & Conservation Biology**Course Objectives**

The course is designed to:

1. Introduce students to the principles, values, and significance of wildlife conservation and management.
2. Develop understanding of wildlife habitats, ecological requirements, and habitat assessment methodologies.
3. Familiarize students with wildlife conservation laws, biodiversity protection strategies, and national and international conservation frameworks.
4. Provide knowledge of habitat restoration, in-situ and ex-situ conservation, and wildlife management practices.
5. Develop skills in wildlife population estimation, monitoring techniques, bio-telemetry, and ecological data interpretation.
6. Introduce wildlife health management, disease surveillance, rehabilitation, and quarantine procedures.
7. Prepare students for careers in wildlife conservation, biodiversity management, ecological consultancy, forestry, protected area management, and environmental governance.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the ecological, economic, cultural, and conservation values of wildlife and the importance of biodiversity conservation.

CO2: Assess wildlife habitats using physical, biological, and technological approaches including GIS and remote sensing tools.

CO3: Evaluate habitat management strategies for restoration, conservation, genetic diversity preservation, and sustainable wildlife management.

CO4: Interpret wildlife protection laws, conservation policies, wildlife trade regulations, and legal frameworks governing biodiversity conservation.

CO5: Apply wildlife population estimation techniques, census methods, bio-telemetry, and ecological monitoring tools for wildlife assessment.

CO6: Analyze wildlife health issues, disease management, rehabilitation protocols, and conservation challenges in protected areas.

CO7: Develop wildlife management and conservation plans for protected areas, ecotourism initiatives, and species recovery programmes using scientific and ethical approaches.

Course Structure**UNIT I: Introduction to Wildlife**

Values of wild life: Positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies, Conservation and protection Laws, Wild animal of India and Odisha. Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

UNIT II: Management of Habitats

Setting back succession; Grazing logging; Mechanical treatment; Advancing the succession process; Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats, *In-situ* and *Ex-situ* conservation, Wild life Protection acts, Wildlife trade and its related laws.

UNIT III Population estimation

Attributes of population: Density, natality, mortality, sex ratio computation, Bayesian models in abundance estimation (Spatial and Non Spatial); Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Census methods; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals.

UNIT IV Management planning of wildlife in protected areas

Estimation of carrying capacity; Ecotourism/ wildlife tourism in forests; Concept of climax persistence; Ecology of perturbation, National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation: Tiger reserves in India; Management challenges in Tiger reserve.

PRACTICAL

1. Study of equipments used in sample collection (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
2. Study of museum specimens/ pictures (relevant to Wild Life).
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Determination of population density in a natural/ hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
5. Identification and Demonstration of different field techniques of fauna (Odisha and India)
6. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers, animal sounds.
7. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
8. Submission of field study report (national park/ reserve forest/ sanctuary).
9. Visit to Forest/ Wildlife Sanctuary/ Biodiversity Park/ Zoological Park to study animals and prepare a short report.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures with wildlife case studies
- ICT-enabled teaching using GIS maps, wildlife documentaries, and conservation databases
- Group discussions on conservation challenges and wildlife policies
- Problem-based learning using real conservation scenarios
- Student seminars and wildlife conservation debates
- Expert talks from forest officers and conservation practitioners
- Wildlife conservation projects
- Biodiversity documentation assignments
- Protected area management case studies
- Ecotourism planning exercises
- Community-based conservation awareness activities
- GIS and remote sensing software demonstrations
- Wildlife database exploration
- Population modelling exercises
- Camera trap image analysis
- Biodiversity informatics applications
- Wildlife conservation decision-support tools

Suggested Field / Industrial Exposure

Students should undergo extensive field exposure through visits to:

Protected Areas and Wildlife Habitats

- Similipal Tiger Reserve
- Bhitarkanika National Park
- Satkosia Tiger Reserve
- Chilika Wildlife Sanctuary
- National parks and wildlife sanctuaries across India

Wildlife and Conservation Organizations

- Wildlife Institute of India
- Zoological Survey of India
- Bombay Natural History Society
- World Wide Fund for Nature India

Government Agencies

- State Forest Departments
- Wildlife Divisions
- Biodiversity Boards
- Nandankan Zoological Park
- Eco-development Committees

Conservation and Ecotourism Projects

- Community conservation initiatives
- Habitat restoration projects
- Wildlife rescue and rehabilitation centres
- Ecotourism development programmes

Suggested Readings:

- ✓ *The diversity of life (The College Edition), E.O. Wilson. W.W. Northern & co.*
- ✓ *Gopal Rajesh (2011) Fundamentals of Wildlife Management, Natraj Publishers.*
- ✓ *Caughley G and Sinclair ARE. (1994). Wildlife Ecology and Management. Blackwell Science.*
- ✓ *Woodroffe R, Thirgood S and Rabinowitz A (2005) People and Wildlife, Conflictor Co-existence? Cambridge University.*
- ✓ *Bookhout TA (1996). Research and Management Techniques for Wildlife and Habitats, 5th Edition. The Wildlife Society, Allen Press.*
- ✓ *Sutherland WJ (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.*
- ✓ *Hunter ML, Gibbs JB and Sterling EJ (2008) Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.*

1.14 Aquaculture and Sustainable Fish Farming

Course Objectives

- Introduce students to the fundamentals of aquaculture and fish farming.
- Develop knowledge on freshwater, brackish water, and integrated aquaculture systems.
- Provide practical skills in pond preparation, hatchery management, breeding and feeding
- Build entrepreneurial understanding in aquaculture-based enterprises.
- Promote sustainable and eco-friendly aquaculture practices.

Course Outcomes (CO)

After successful completion of the course, students will be able to:

- Understand the principles and scope of aquaculture
- Identify different aquaculture systems and cultivable species
- Apply pond management and water quality techniques
- Demonstrate fish breeding, feeding, and health management skills
- Develop small-scale aquaculture business and entrepreneurship ideas
- Understand sustainable and climate-resilient aquaculture practices
- Proficient in seed production and hatchery management

Course Structure

UNIT I

Introduction to Aquaculture: Definition, history, and scope of aquaculture, Types of aquaculture: Freshwater aquaculture, Brackish water aquaculture, Marine aquaculture, Extensive, semi-intensive, and intensive culture systems, Composite fish culture, Integrated fish farming, nets and gears used for fish catching, Net mending and making by hand and by machines.

UNIT II

Aquaculture Systems and breeding: Pond construction and design, Pond preparation methods, Cage culture and tank culture, Biofloc technology – basics and applications, RAS management. Natural and induced breeding, Hatchery management, Broodstock management, Nursery and rearing pond management.

UNIT III

Fish Nutrition and Feed Management: Types of fish feed, Natural and artificial feed, Feed formulation techniques, Feed ingredients and additives, Feed preparation and feed mill management, Extrusion feed preparation, Feed for different stages of fish, Feed Conversion Ratio (FCR), Storage and handling of feed, feeding management.

UNIT IV

Fish Health Management & sustainable aquaculture: Common fish diseases: Bacterial diseases, Viral diseases, Fungal diseases, Parasitic infections, Preventive healthcare measures, Safe use of chemicals and antibiotics.

Waste management in aquaculture, Ornamental fish culture, Fish processing and value addition.

PRACTICAL

1. Identification of cultivable fish species
2. Types of nets and gears used in fisheries
3. Pond soil and water analysis
4. Liming and fertilization calculations
5. Feed preparation and feeding methods
6. Preparation of aquaculture business model
7. Net mending and making by hand and by machines.
8. Biofloc and RAS in aquaculture
9. Field visit to hatchery/fish farm/feed mill and hands-on learning

Suggested Teaching–Learning Methods

- Lectures
- Demonstrations
- Laboratory practicals
- Field visits
- Skill-based training
- Hands-on-training on the following
 - Fish pond preparation
 - Hatchery operation
 - Biofloc and RAS management
 - Water quality monitoring
 - Feed formulation
 - Disease diagnosis
 - Farm economics
 - Fish marketing

Suggested Field Exposure

1. Government hatcheries (Krishi Vigyan Kendra, Govt. of Odisha)
2. Fisheries research institutes (ICAR-CIFA, Kausalyaganga, Bhubaneswar)
3. Private aquaculture farms (AVANTI, FALCON, HIMEDIA etc.)
4. Fish feed industries (FALCON Feed, Godreg Feed, Avanti Feed, ABIS Feeds, TENSIFT Farmers fertilizer Pvt. Ltd. etc.)
5. Fish markets and processing units (FALCON, Hari Marine, Highland etc.)
6. Net and Gear making Industry: OPDC, GARWALE Industry etc.

Suggested Reading

- ✓ *Jhingran, V.G. (1985) Fish and Fisheries of India*
- ✓ *Rath, R.K. (2000) Freshwater Aquaculture*
- ✓ *Gupta, S.K and Gupta, P.C (2006) General and applied ichthyology (Fish and Fisheries)*
- ✓ *Ayyappan, S (2010) Handbook of Fisheries and Aquaculture*
- ✓ *Pillay, T.V.R (1993) Aquaculture Principles and Practices*
- ✓ *Srivastava, C.B.L (2006) A textbook of fishery science and Indian fisheries*
- ✓ *Paulraj, R (1997) Hand book on Aquafarming: Aquaculture Feed. Manual. MPEDA, Cochin.*
- ✓ *S.D. Gupta, P. Routray, D.K. Verma, B.C. Mohapatra, S.K. Sahoo, and N. Sarangi (2008). Textbook of breeding and hatchery management of carps*

1.15 Environment Impact Assessment & Toxicology**Course Objectives**

The course is designed to:

- Introduce students to the principles, objectives, scope, and methodologies of Environmental Impact Assessment (EIA).
- Develop understanding of environmental impact prediction, evaluation, and management for developmental projects.
- Familiarize students with environmental regulations, clearance procedures, Environmental Impact Statements, and international environmental agreements.
- Provide foundational knowledge of toxicology, toxicokinetics, dose-response relationships, and environmental contaminants.
- Explain mechanisms of toxicity, pollutant fate, bioaccumulation, biomagnification, and ecological risk assessment.
- Develop practical skills in environmental monitoring, toxicological evaluation, and environmental decision-making.
- Prepare students for careers in environmental management, consultancy, regulatory agencies, sustainability sectors, and ecological research.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the concepts, objectives, significance, and methodologies of Environmental Impact Assessment in developmental planning.

CO2: Apply various EIA tools and techniques to identify, predict, evaluate, and communicate environmental impacts.

CO3: Assess environmental impacts on air, water, land, noise, biodiversity, and ecological systems using scientific approaches.

CO4: Interpret environmental clearance procedures, Environmental Impact Statements (EIS), regulatory frameworks, and environmental governance mechanisms.

CO5: Describe fundamental principles of toxicology, dose-response relationships, toxicity testing, and bioassay methodologies.

CO6: Analyze the environmental fate and toxic effects of pesticides, heavy metals, persistent organic pollutants, and other environmental contaminants.

CO7: Evaluate ecological and human health risks associated with environmental pollutants and propose appropriate mitigation and management strategies.

Course Structure**Unit I: Fundamentals of Environmental Impact Assessment (10 Hours)**

Introduction to EIA: Objectives, concept and scope of Environmental Impact Assessment, Environmental Assessment Process and significance, Structure and components of EIA, Environmental attributes and indicators, Criteria for selection of EIA methodologies

Impact Assessment Process: Impact identification, Impact measurement, Impact interpretation, Impact evaluation, Impact communication

EIA Methodologies: Ad hoc methods, Checklist methods, Matrix methods, Network methods, Overlay methods

EIA Review Process: Baseline environmental conditions, Construction-stage impacts, Operational and post-project impacts, Environmental management and monitoring plans

Unit II: Environmental Impact Analysis and Regulatory Frameworks (10 Hours)

Environmental Impact Prediction and Assessment: Environmental impact analysis approaches, Comparative studies and modelling techniques, Prediction and assessment of environmental impacts

Assessment of Environmental Components: Air environment impact assessment, Water environment impact assessment, Noise environment impact assessment, Land environment impact assessment, Ecological impact assessment

Environmental Governance and Compliance: Environmental clearance procedures, Environmental Impact Statement (EIS), Public consultation and stakeholder participation, Projects requiring environmental clearance, Composition and role of Expert Appraisal Committees

Environmental Regulations and International Frameworks: Ecologically sensitive areas, National environmental regulations, International environmental agreements and conventions, Case studies of developmental projects

Unit III: Principles of Toxicology and Toxicity Assessment (10 Hours)

Introduction to Toxicology: Scope and significance of toxicology, Branches and sub-disciplines of toxicology, Environmental and ecological toxicology

Toxicity Testing and Evaluation: Dose-response relationships, Acute toxicity, Chronic toxicity, Sub-lethal toxicity, Determination of LD₅₀ and LC₅₀

Bioassay Techniques: Principles of bioassays, Vertebrate bioassays, Invertebrate bioassays, Applications in environmental monitoring

Toxicokinetics: Absorption, Distribution, Metabolism (Biotransformation), Excretion, Factors influencing toxicity

Unit IV: Environmental Toxicants, Ecological Risk Assessment and Management (10 Hours)

Environmental Toxicants: Organochlorine insecticides (OCIs), Organophosphate insecticides (OPIs), Persistent Organic Pollutants (POPs)

Heavy Metal Toxicity: Arsenic, Lead and Mercury toxicity, Sources, environmental fate and biological effects

Ecological Consequences of Pollutants: Bioaccumulation, Biomagnification, Ecotoxicological impacts on food chains, Wildlife and ecosystem effects

Risk Assessment and Hazard Evaluation: Hazard identification, Toxicity assessment, Exposure assessment, Risk characterization, Environmental risk management and mitigation strategies.

PRACTICAL

1. Environmental sampling demonstrations
2. Water and soil quality assessment exercises
3. Toxicological data interpretation
4. Environmental monitoring techniques
5. Exposure and risk assessment exercises
6. Case study-based environmental audits
7. Environmental impact analysis projects
8. Group assignments on industrial pollution issues
9. Environmental policy review exercises
10. Literature surveys on emerging contaminants

11. Community-based environmental awareness activities
12. Digital and Computational Learning
13. GIS-based environmental mapping

Suggested Teaching–Learning Methods

- Interactive lectures supported by real-world environmental case studies
- Problem-based learning on environmental impact scenarios
- Group discussions on environmental regulations and sustainability
- ICT-enabled teaching using GIS maps, EIA reports, and environmental models
- Student seminars on pollution and toxicology issues
- Expert lectures from environmental professionals

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

Environmental Regulatory Agencies

- Odisha State Pollution Control Board
- Central Pollution Control Board
- Environmental monitoring stations

Environmental Consultancy Firms

- EIA consultancy organizations
- Environmental auditing agencies
- Sustainability assessment companies

Industries and Infrastructure Projects

- Mining industries
- Thermal power plants
- Steel and metallurgical industries
- Waste treatment and recycling facilities
- Industrial effluent treatment plants

Conservation and Environmental Organizations

- Wildlife conservation centres
- Wetland management projects
- Biodiversity conservation programmes
- Environmental NGOs

Research Institutions

- National Environmental Engineering Research Institute
- Indian Institute of Toxicology Research
- Council of Scientific and Industrial Research laboratories
- Environmental research centres and universities

Suggested Reading

- ✓ *Anjaneyulu. Y and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007*
- ✓ *Barthwal, R. R., Environmental Impact Assessment, New Age International Publishers, 2002.*
- ✓ *Jain, R.K., Urban, L.V., Stracy, G.S., Environmental Impact Analysis, Van Nostrand Reinhold Co., New York, 1991.*
- ✓ *Rau, J.G. and Wooten, D.C., Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996.*
- ✓ *Reference Books: 1. Environmental Impact Analysis Handbook – by Rau Whooten; McGraw Hill publications*
- ✓ *Environmental Impact Assessment – by Larry Canter; McGraw Hill publications*
- ✓ *Environmental Impact Analysis – A Decision Making Tool by R K Jain 4. Handbook of Environment Impact Assessment by Judith Petts; McGraw Hill publications*

- ✓ John H Duffs.; Howard G J Worth.; (Editors). (2015). "Fundamental Toxicology". 2nd Edition
Publisher: Royal Society of Chemistry; UK
- ✓ Environmental toxicology; John H. Duffs, 1980, Edward Arnold Publishers, New Delhi.
- ✓ Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.

2.5 Taxonomy & Evolutionary Biology**Course Objectives**

The course is designed to:

- Introduce students to the principles, methods, and significance of taxonomy, systematics, and biological classification.
- Develop understanding of taxonomic procedures, nomenclature, biodiversity documentation, and modern taxonomic approaches.
- Explain the origin of life, major evolutionary theories, evidence supporting evolution, and extinction events.
- Familiarize students with population genetics and evolutionary mechanisms including natural selection, mutation, migration, and genetic drift.
- Develop understanding of speciation, adaptive radiation, phylogenetics, and macroevolutionary processes.
- Introduce students to the origin and evolution of humans using fossil and molecular evidence.
- Prepare students for careers in taxonomy, biodiversity conservation, evolutionary research, environmental management, museum sciences, and molecular systematics.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Explain the principles, procedures, and applications of taxonomy, systematics, and biological classification.

CO2: Apply taxonomic tools, nomenclatural rules, identification keys, and modern approaches such as DNA barcoding and molecular taxonomy for species identification.

CO3: Interpret major theories of evolution, origin of life hypotheses, fossil evidence, and extinction events that have shaped biodiversity.

CO4: Analyze evolutionary mechanisms including natural selection, mutation, migration, genetic drift, and population genetics using quantitative approaches.

CO5: Evaluate processes of speciation, adaptive radiation, and macroevolution responsible for biological diversity.

CO6: Construct and interpret phylogenetic relationships using morphological and molecular data.

CO7: Explain the evolutionary history of humans and critically assess evidence from paleontology, genetics, and molecular phylogenetics.

Course Structure**UNIT I: Concepts of Taxonomy**

Importance & Applications of biosystematics; taxonomic characters, Hierarchy categories; biological classification; Taxonomic procedures: collections, preservation, curation, identification, Keys; International Code of Zoological Nomenclature (ICZN): operative principles, important rules; Zoological nomenclature; Chemo and sero taxonomy, Cytotaxonomy, Numerical taxonomy, and DNA barcoding. Taxonomic publications: Kinds, Major features of manuscript for publication.

UNIT II: Theories, Evidences of Evolution and Extinction

Life's Beginnings: Chemogeny, RNA world, Biogeny, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse), Sources of

variations: Heritable variations and their role in evolution. Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction.

UNIT III: Process of Evolutionary changes

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection). Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies.

UNIT IV: Products of evolution, Species concept, Origin and Evolution of man

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric, Parapatric. Adaptive radiation/macroevolution (exemplified by Galapagos finches). Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin. Phylogenetic trees, multiple sequence alignment, construction and interpretation of phylogenetic trees.

PRACTICAL

1. Study of equipment used in sample collection.
2. Use of taxonomic keys in identification.
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Study of fossils from models/pictures
5. Study of homology and analogy from suitable specimens
6. Study and verification of Hardy-Weinberg Law by chi-square analysis
7. Demonstration of the role of natural selection and genetic drift in changing allele frequencies using simulation studies
8. Graphical representation and interpretation of data of height/weight of a sample of 100 humans in relation to their age and sex.
9. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by evolutionary case studies
- ICT-enabled teaching using phylogenetic software, fossil databases, and biodiversity portals
- Concept mapping and evolutionary tree construction exercises
- Group discussions on evolutionary controversies and species concepts
- Student seminars on biodiversity and evolutionary research
- Problem-solving sessions on population genetics
- Taxonomic survey assignments
- Evolutionary case study analyses
- Species inventory preparation
- Literature review and journal discussions
- Mini research projects on local biodiversity
- Studies on DNA barcoding repositories

- Molecular phylogenetic software demonstrations
- Bioinformatics-based sequence alignment exercises
- Online taxonomic catalogues and digital museums
- Evolutionary simulation tools

Suggested Field / Industrial Exposure

Students should be exposed to:

Biodiversity and Taxonomy Centres

- Zoological Survey of India
- Botanical Survey of India
- Natural history museums
- Biodiversity repositories

Wildlife and Conservation Organizations

- Wildlife Institute of India
- State Biodiversity Boards
- Forest Departments
- Wildlife conservation projects

Research Institutions

- Centre for Cellular and Molecular Biology
- Evolutionary biology laboratories
- Molecular taxonomy laboratories
- DNA barcoding centres

Field-Based Exposure

- Biodiversity surveys
- Faunal inventory projects
- Protected area biodiversity monitoring
- Ecological assessment programmes

Suggested Readings:

- ✓ *Principle of Animal Taxonomy*; G.G. Simpson. Oxford IBH Publishing Company.
- ✓ *Elements of Taxonomy*. E. Mayer.
- ✓ *The diversity of life (The College Edition)*, E.O. Wilson. W.W. Northern & co.
- ✓ *Theory and Practice of Animal Taxonomy*. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.
- ✓ *Advancement in Invertebrate Taxonomy and Biodiversity*. Rajeev Gupta. Agrobios International. Campbell, N.A. and Reece J.B (2011). *Biology*. IX Edition. Pearson, Benjamin, Cummings.
- ✓ Rastogi B.B., (2018). *Organic Evolution*, MedTech; 3rd edition
- ✓ B.K. and Hallgrimson, B. (2008). *Evolution IV Edition*. Jones and Barlett Publishers.
- ✓ Douglas, J. Futuyma (1997). *Evolutionary Biology*. Sinauer Associates.
- ✓ Ridley, M (2004) *Evolution III Edition* Blackwell publishing Hall.
- ✓ *Principles of Taxonomy* by Ashok Verma.
- ✓ *Evolutionary Biology with Practical* by Tripurari Mishra.

2.6 Comparative Anatomy of Vertebrates**Course Objectives**

The course is designed to:

- Introduce students to the comparative anatomy and functional organization of vertebrate organ systems.
- Develop understanding of structural adaptations and evolutionary modifications in integumentary, skeletal, digestive, respiratory, circulatory, urinogenital, and nervous systems.
- Explain evolutionary trends in vertebrate morphology and organ system specialization.
- Familiarize students with comparative features of vertebrate sensory organs and receptor systems.
- Provide knowledge of vertebrate adaptations related to feeding, respiration, circulation, excretion, reproduction, and sensory perception.
- Develop analytical and observational skills in comparative anatomy and vertebrate evolution.
- Prepare students for advanced studies and applications in zoology, physiology, biomedical sciences, wildlife biology, and veterinary sciences.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Describe the structure, functions, and evolutionary modifications of vertebrate integumentary and skeletal systems.

CO2: Explain comparative organization and adaptations of digestive and respiratory systems in vertebrates.

CO3: Interpret evolutionary trends in circulatory systems, heart organization, aortic arches, kidneys, and urinogenital ducts.

CO4: Describe comparative anatomy of vertebrate nervous systems, brain organization, spinal cord, and cranial nerves.

CO5: Explain the structure and functions of vertebrate sensory receptors including visual, auditory, chemo-, and mechanoreceptors.

CO6: Analyze adaptive and evolutionary significance of vertebrate organ systems in relation to habitat and functional specialization.

CO7: Develop observational, analytical, and diagrammatic skills relevant to vertebrate anatomy, physiology, and comparative zoology.

Course Structure

UNIT I

Integumentary & Skeletal System: Structure, functions and derivatives of integument (Scale, claw, nail, hair, feather and dentition). Axial and appendicular skeleton, Jaw suspensorium, Visceral arches.

UNIT II

Digestive & Respiratory System

Alimentary canal and associated glands; Respiration through Skin, gills, lungs and air sacs; Accessory respiratory organs.

UNIT III

Circulatory and Urinogenital system

General plan of circulation, evolution of heart and aortic arches; Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

UNIT IV

Nervous System & Sense Organs

Comparative account of brain; Nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors: Brief account of visual and auditory receptors in man. Chemo and mechano-receptors

PRACTICAL

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, Varanus, Fowl, Rabbit.
3. Carapace and plastron of turtle /tortoise (Photographs, charts etc).
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) through ICT tools.
6. Project report submission on Integumentary derivatives.

Classroom Teaching Methods

- Interactive lectures using comparative anatomical illustrations
- Comparative morphology-based discussions
- Evolutionary trend analysis using diagrams and flowcharts
- ICT-enabled teaching with 3D anatomical models and animations
- Case-based discussion on vertebrate adaptations
- Student seminars and group presentations
- Dissection demonstrations and virtual dissection tools
- Assignment-based learning
- Comparative anatomy chart preparation
- Mini-projects on vertebrate evolution and adaptation
- Flipped classroom and peer-learning activities
- Zoological museum-based learning
- Digital vertebrate anatomy resources and virtual simulations
- Comparative phylogenetic analysis tools
- Online anatomical atlases and databases

- Multimedia learning modules on vertebrate systems
- Evolutionary modelling and organ system comparison

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

- University zoological museums
- Regional Museum of Natural History
- Biodiversity conservation centres
- Zoological Survey of India Museum, Gopalpur
- Chilika Development Authority Museum, Barkul
- Wildlife Institute of India
- Indian Veterinary Research Institute
- Veterinary anatomy laboratories
- Biomedical and physiology laboratories

Industrial Exposure Components

- Museum preservation and specimen preparation units
- Histology and anatomical preparation laboratories
- Biomedical instrumentation facilities
- Wildlife rehabilitation and conservation centres

Suggested Readings:

- ✓ *Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education*
- ✓ *Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies*
- ✓ *R. K. Saxena and Sumitra Saxena (2016). Comparative Anatomy of Vertebrates 2nd edition.*
- ✓ *Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate tructure, John Wiley and Sons*
- ✓ *Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House*

Bio-resource Technologies & Bio-products**UNIT-I**

Bio resources- natural and anthropogenic; importance of bio-resources and their utilization. Natural bioresources: agricultural, forestry and aquatic biomass. Biomass availability, production and food security, nonedible biomass characteristics. Anthropogenic bio-resources: Organic wastes-domestic and industrial; characteristics of municipal sewage / sludge and industrial sludges.

UNIT-II

Conversion processes: biochemical, thermo-chemical and physico-chemical conversion processes Biochemical processes: Microbial anaerobic and aerobic processes, enzymatic processes; fermentation for alcohols and acids; penicillin and other therapeutic products. Production of single cell protein (SCP); bio-pulping, bio gasification.

UNIT-III

Thermo-chemical processes: pyrolysis (coke and pyro-oils), oxidation-combustion, gasification (downdraft, updraft and fixed bed gasification, fluidized bed and entrained bed gasification). Various methods of manufacture of activated carbons

UNIT-IV

Biofuels, biomaterials, specialty chemicals (glycol, acetic acid and downstream chemicals), anhydrous alcohol, ethanol and butanol; biodiesel, bio-aviation turbine fuel (BATF). Physico-chemical processes: Pretreatment, steam/acid/alkali hydrolysis, effect of temperature on hydrolysis

Suggested Reading:

- ✓ Tripathi, G., "Bioresource Technology", CBS Publications (2002).
- ✓ Pandey, A., "Concise Encyclopaedia of Bioresource Technology", CRC Press (2004).
- ✓ Shuler, M., Kargi, F., "Bioprocess Engineering, Basic Concept", Prentice Hall of India Pvt. Ltd. (2004)

Marine Biotechnology

Unit I

Marine Biotechnology - An Introduction, Marine Ecosystem and its Functions, Chemical Oceanography, Sedimentation, Marine microbiology, Values of Marine Biodiversity, Importance of costal aquaculture, Mariculture, Induced Breeding in Fish, Culture of Shrimps and Marine Macroalgae – Seaweeds, Culture of Live Feed Organisms, Bio-floc technology, aquaponics

Unit II

Classification of marine environment. Diseases of Fish and Shrimp, Diagnosis of Diseases of Fish and Shrimp, Chromosomal Manipulation in Fish, Transgenic Fish, Aquatic Vaccines, Probiotics in Aquaculture, Fish feed technology.

Unit III

Bio-communication in oceans, Microbe-microbe interaction, Quorum sensing, Marine biomass and productivity, Biogeochemical processes- Nutrient Cycling, Carbon, Sulphur, Phosphorus and Iron nitrogen cycle, marine pollution

Unit IV

Cryopreservation in Fishery Sciences, Biofouling, Marine Bioremediation, Marine By-products, Marine Pharmaceuticals, Marine Natural Products and their Applications, Marine Protein, Food preservation and processing, Packing.

Suggested Reading

- ✓ *Aquaculture –Principles and Practices, 1990 – TVR Pillay, Fishing Nets Books.*
- ✓ *Aquaculture Biotechnology, First edition, 2012, Eds. Garth L. Fletcher and Mathew L Rise, Wiley-Blackwell publication*
- ✓ *Aquaculture Biotechnology, V. Ramachandran, 2013, Black Prints 4. Marine Biology – An ecological approach, 1988 – James W. Nybken, Harper Collins publication*