NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all Uttarakhand State Universities and Colleges for First Three Years of Higher Education

PROPOSED STRUCTURE OF
UG - BOTANY
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

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Semester-wise Titles of the Papers in B. Sc (Botany)					
Year	**Semester**	**Course Code**	**Paper title**	**Theory/ Practical**	**Credits**
Certificate Course in Basic Botany					
First Year	I	BOT101T	Microbes, Algae, Fungi and Bryophytes	Theory	4
		BOT102P	Practical/Lab course	Practical	2
	II	BOT201T	Pteridophytes, Gymnosperms and Angiosperms	Theory	4
		BOT202P	Practical/Lab course	Practical	2
Diploma Course in Developmental Botany					
Second Year	III	BOT301T	Morphology and Anatomy	Theory	4
		BOT302P	Practical/Lab course	Practical	2
	IV	BOT401T	Embryology and Cytogenetics	Theory	4
		BOT402P	Practical/Lab course	Practical	2
Bachelor of Science					
Third Year	V	BOT501T	Molecular Biology and Plant Biotechnology	Theory	4
		BOT502T	Economic Botany and Plant Breeding	Theory	4
		BOT503 P	Practical/Lab course	Practical	2
		BOT504R	Project I-Local Plant Diversity	Practical	4
	VI	BOT 601T	Physiology and Biochemistry	Theory	4
		BOT602T	Ecology and Biostatistics	Theory	4
		BOT603P	Practical/Lab course	Practical	2
			Project II-Local Ecosystem studies	Practical	4

Year wise Structure of B.Sc. in Botany (Core/elective courses and Projects)											
Subject: Botany											
Course/ Entry-Exit level	**Year**	**Semester**	**Paper-1**	**Credits/hrs**	**Paper-2**	**Credits/ hrs**	**Paper-3**	**Credits/hrs**	**Research project**	**Credits /hrs**	**Total Credits/hrs**
Certificate Course in Basic Botany	I	I	Microbes, Algae, Fungi and Bryophytes	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
		II	Pteridophytes, Gymnosperms and Angiosperms	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
Diploma Course in Developmental Botany	II	III	Morphology and Anatomy	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
		IV	Embryology and Cytogenetics	4/60	Practical/ Lab course	2/60	-	-	-	-	6/120
Bachelor of Science	III	V	Molecular Biology and Plant Biotechnology	4/60	Economic Botany and Plant Breeding	4/60	Practical /Lab course	2/60	Project-I	4/60	14/240
		VI	Physiology and Biochemistry	4/60	Ecology and Biostatistics	4/60	Practical /Lab course	2/60	Project-II	4/60	14/240

COURSE INTRODUCTION

The new curriculum of B.Sc. in Science (Botany) offers essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core, elective and vocational papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently being used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

B.Sc. Botany Programme covers academic activities within the classroom sessions along with practical concepts at laboratory sessions. Infield, outstation activities and projects would also be organized for real-life experience and learning. Candidates who have curiosity in plants kingdom, ecosystem, love exploring exotic places and wish to work as researchers or professions like Botanist, Conservationist, Ecologist, etc. can choose B.Sc. Botany course.

Programme outcomes (POs):

Transformed curriculum shall develop educated outcome-oriented candidature, fostered with discovery- learning, equipped with practice & skills to deal practical problems and versed with recent pedagogical trends in education including e-learning, flipped class and hybrid learning to develop into responsible citizen for nation-building and transforming the country towards the future with their knowledge gained in the field of plant science.

PO1	CBCS syllabus with a combination of general and specialized education shall introduce the concepts of breadth and depth in learning.
PO2	Shall produce competent plant biologists who can employ and implement their gained knowledge in basic and applied aspects that will profoundly influence the prevailing paradigm of agriculture, industry, healthcare and environment to provide sustainable development.
PO3	Will increase the ability of critical thinking, development of scientific attitude, handling of problems and generating solutions, improve practical skills, enhance communication skill, social interaction, and increase awareness in judicious use of plant resources by recognizing the ethical value system.
PO4	The training provided to the students will make them competent enough for doing jobs in Govt. and private sectors of academia, research and industry along with graduate preparation for national as well as international competitive examinations, especially UGC-CSIR NET, UPSC Civil Services Examination, IFS, NSC, FCI, BSI, FRI etc.

PO5	Certificate and diploma courses are framed to generate self- entrepreneurship and self- employability, if multi exit option is opted.
PO6	Lifelong learning is achieved by drawing attention to the vast world of knowledge of plants and their domestication.

Programme specific objectives (PSOs): B.Sc. I Year Certificate Course in Basic Botany

- This certificate course will provide knowledge on various fields of basic Botany.
- The syllabus is prepared to enable students for competitive exams in frontier areas of plant sciences.
- Students will be able to know about habit, habitat, morphology, anatomy and reproduction of various plant groups.

Programme specific outcomes (PSOs): B.Sc. II Year/ Diploma Course in Developmental Botany

- This programme will provide knowledge on plant anatomy, embryology and cytogenetics.
- Laboratory sessions following theory will provide easy understanding of internal structure of various plant parts, structural organization, reproductive biology and genetics.
- This course will help students to become a plant morphologist.

Programme specific outcomes (PSOs): B.Sc. III Year/ Bachelor of Science

- The three year learning outcome of graduation will provide understanding of plant systematic, developmental biology, ecology, statistics, physiology, biochemistry, anatomy, and plant genetics.
- It will provide expertise in conservation biology and reproduction biology.
- After completing this course successfully students will be able to contribute in the field of plant sciences. The research project will help to develop research aptitude for higher education and scientific research.

DETAILED SYLLABUS OF B.Sc. I YEAR FOR CERTIFICATE COURSE IN BASIC BOTANY

Course	Year	Semester
Certificate Course in Basic Botany	*B.Sc. I*	*I*

Paper 1: Microbes, Algae, Fungi and Bryophytes (Course code: BOT101T) Credit: 4

Course Outcome

After the completion of the course the students will be able to:
1. Develop understanding about the classification and diversity of different microbes including viruses, Algae, Fungi & Lichens & their economic importance.
2. Develop conceptual skill about identifying microbes, pathogens, biofertilizers & lichens.
3. Gain knowledge about developing commercial enterprise of microbial products.
4. Learn host –pathogen relationship and disease management.
5. Gain Knowledge about uses of microbes in various fields.
6. Understand the structure and reproduction of certain selected bacteria algae, fungi and lichens
7. Develop critical understanding on morphology, anatomy and reproduction of Bryophytes.

Unit	Topic	No. of lectures/ hrs (60)
1	**Microbes :** Viruses-discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); economic importance; bacteria–discovery, general characteristics and cell structure; reproduction–vegetative, asexual and recombination (conjugation, transformation and transduction); economic importance.	15
2	**Algae:** General characteristics; Range of thallus organization and reproduction; classification of algae; morphology and life-cycles of: *Nostoc*, *Chlamydomonas, Oedogonium*, *Vaucheria, Fucus, Sargassum*; economic importance of algae.	15
3	**Fungi :** Introduction-general characteristics, ecology and significance, range of somatic thallus organization, cell wall composition, nutrition, reproduction and classification (G.C. Ainsworth); life cycle of *Stemonitis* (Myxomycota)	15

	Rhizopus (Zygomycota) *Penicillium* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); *Alternaria* (Deutromycota), Symbiotic associations: Lichens- General account, reproduction and significance; Mycorrhiza: ectomycorrhiza, endomycorrhiza and their significance.	
4	**Bryophytes:** General characteristics, adaptations to land habit, classification (up to family), morphology, anatomy and reproduction of *Riccia*, *Marchantia* and *Funaria*; ecology and economic importance of bryophytes.	**15**

Suggested reading

- Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
- Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
- Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
- Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi, India.
- Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol.I Vikas publishing House Pvt/ Ltd, New Delhi.
- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Bryophyta, S. Chand. Delhi, India.
- Parihar, N.S. (1991). An Introduction to Embryophyta Vol. I Bryophyta. Central Book Depot, Allahabad.

Paper 2: Practical/ Lab course (Course code: BOT102P) Credit: 2

Course Outcome

After the completion of the course the students will be able:
1. Understand the instruments, techniques, lab etiquettes and good lab practices for working in a microbiology laboratory.
2. Develop skills for identifying microbes and using them for Industrial, Agriculture and Environment purposes.
3. Practical skills in the field and laboratory experiments in Microbiology and Pathology.
4. Learn to identify algae, lichens and plant pathogens along with their symbiotic and parasitic associations.
5. Students would learn to create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to Bryophytes.

6. Understand morphology, anatomy, reproduction and developmental changes therein through typological study and create a knowledge base in understanding diversity, economic values & taxonomy of bryophytes.

Unit	Topic	No. of Lectures/ hrs (60)
1	EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle. Types of Bacteria from temporary/permanent slides/photographs; EM of bacterium; Binary Fission; Conjugation; Structure of root nodule; Gram staining technique	**15**
2	Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs)*, Oedogonium, Vaucheria, Fucus* and *Sargassum* through temporary preparations and permanent slides/specimens	**15**
3	*Rhizopus and Penicillium*: Asexual stages from temporary mounts. *Alternaria:* Specimens/photographs and tease mounts. *Puccinia*: Herbarium specimens of Black Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on wheat and permanent slides of both the hosts. *Agaricus*: Specimens of button stage and full grown mushroom. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose). Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs).	**15**
4	*Marchantia* and *Riccia*: Morphology of thallus, rhizoids and scales, V.S. thallus through gemma cup, gemmae whole mount (all temporary slides), V.S antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides). *Funaria*- Morphology, whole mount leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S capsule and protonema.	**15**

Suggested reading

- Pandey, B.P. (2014). Modern Practical Botany Vol. I. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Purohit, S.D., Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part I). Apex Publishing House Durga Nursery Road Udaipur, Rajasthan.
- Sambamurty, A.V.S.S. (2006). A text book of algae. I.K International Publishing House, Pvt. Ltd.

Course	Year	Semester
Certificate Course in Basic Botany	*B.Sc. I*	*II*

Paper 1: Pteridophytes, Gymnosperms and Angiosperms (BOT201T) Credit: 4

Course Outcome

After the completion of the course the students will be able to:
1. Develop critical understanding on morphology, anatomy and reproduction of Pteridophytes, Gymnosperms and Angiosperms.
2. Understanding of plant evolution and their transition to land habitat.
3. To learn the major patterns of diversity among plants, and the characters and types of data used to classify plants.
4. To compare the different approaches to classification with regard to the analysis of data.
5. To become familiar with major taxa and their identifying characteristics, and to develop in depth knowledge of the current taxonomy of a major plant family.
6. To discover and use diverse taxonomic resources, reference materials, herbarium collections, publications.

Unit	Topic	No. of Lectures/ hrs (60)
1	**Pteridophytes** General characteristics, classification, early land plants (*Rhynia*); classification (up to family), morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*; heterospory and seed habit, stelar evolution; ecological and economic importance of Pteridophytes.	15
2	**Gymnosperms** General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas, Pinus and Ephedra*; ecological and economic importance.	15
3	**Introduction to plant taxonomy** Identification, classification, nomenclature, functions of herbarium, important herbaria and botanical gardens of the world and India Important flora, botanical nomenclature (principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations). Classification: Types of classification-artificial, natural and phylogenetic Bentham and Hooker (upto series) and Hutchinson classification.	10
4	**Taxonomy of plant families**	20

	Ranunculaceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Solanaceae, Lamiaceae, Euphorbiaceae, Asteraceae, Poaceae and Orchidaceae **(Families can be chosen as per availability of local flora)**	

Suggested readings

- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). Pteridophyta, S Chand and Company Ltd., Ramnagar, New Delhi, India.
- Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). Gymnosperms, S Chand and Company Ltd., Ramnagar, New Delhi, India.
- Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
- Parihar, N.S. (1991). An Introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
- Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
- Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford and IBH Pvt. Ltd., New Delhi. 3rd edition.
- Gangulee H.C., Kar, A.K. and Santra S.C. (2011). College Botany Vol II. 4th Edition New Central Book Agency.
- Parihar, N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.
- Sharma, O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Delhi.
- Pandey, B.P. (2010). College Botany Vol II. S. Chand and Company Ltd., New Delhi, India.

Paper 2: Practical/ Lab course (BOT202P) Credit: 2

Course outcomes:

1. The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants growing in nature and become familiar with the biodiversity.
2. Develop an understanding by observation and table study of representative members of phylogenetically important groups to learn the process of evolution in a broad sense.
3. Understand morphology, reproduction and developmental changes therein through typological study and create a knowledge base in understanding the basis of plant diversity, economic values & taxonomy of plants.

Unit	Topic	No. of Lectures/ hrs (60)
1	*Selaginella*: Morphology, whole mount leaf with ligule, strobilus, microsporophyll and megasporophyll (temporary slides), T.S. stem, L.S. strobilus (permanent slide). *Equisetum*: Morphology, T.S. internode, L.S. strobilus, T.S and L.S.	15

	strobilus, whole mount sporangiophore,. spores (wet and dry) (temporary slides); T.S. rhizome (permanent slide). *Pteris*: Morphology, T.S rachis, V.S. sporophyll, whole mount sporangium and spores (temporary slides), T.S. rhizome, whole mount prothallus with sex organs and young sporophyte (permanent slide).	
2	*Cycas*: Morphology (coralloid roots, bulbil, leaf), T.S. coralloid root and rachis, V.S. leaflet and microsporophyll, whole mount spores (temporary slides), L.S. ovule, T.S. root (permanent slide). *Pinus*: Morphology (long and dwarf shoots, male and female cones), T.S. needle and stem, L.S./T.S. male cone, whole mount microsporophyll and microspores (temporary slides), L.S. female cone, TLS and RLS stem (permanent slide).	**15**
3	**Taxonomic Identification**: Description of an angiospermic plant, study of vegetative and floral characters (description, V.S. flower, section of ovary, floral diagram/s, floral formula/e) and systematic position of the following families according to Bentham and Hooker's system of classification: Brassicaceae, Asteraceae, Solanaceae, Lamiaceae, and Liliaceae. **(Plants can be chosen as per availability of local flora)**	**20**
4	**Herbarium techniques**: Plant collection, preservation and mounting of two properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book), digital/virtual herbarium.	**10**

Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd., New Delhi.
- Bendre, A.M. and Kumar A. (2003). Manual of Practical Botany Vol. II. Rastogi Publications, Meerut.
- Santra S.C. and Chatterjee (2005). College Botany Practical Vol. II New Central Book Agency Pvt. Ltd.

DETAILED SYLLABUS OF B.Sc. II YEAR OR DIPLOMA COURSE IN DEVELOPMENTAL BOTANY

Course	Year	Semester
Diploma Course in Developmental Botany	*B.Sc. II*	*III*

Paper 1: Morphology and Anatomy (Course code: BOT301T) Credit: 4

Course outcomes:

1. Understand morphology and anatomy.
2. Understand role of tissues in plant functions.
3. Understand the composition, modifications, internal structure & architecture of plants.

Unit	Topic	No. of Lectures/ hrs (60)
1	**Meristematic and permanent tissues**: Types of tissues, Root and shoot apical meristems, Theories related to apical meristem, simple, complex and secretary tissues	15
2	**Organs**: Structure of dicot and monocot root, stem and leaf, root stem transition	15
3	**Adaptive and protective systems**: Epidermis, cuticle and stomata	15
4	**Secondary growth:** Structure and function of Vascular cambium, secondary growth in stem and roots, abnormal secondary growth	15

Suggested readings

- Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
- Pandey, B.P. (2001) Plant Anatomy. S. Chand and Company Ltd., New Delhi.
- Sharma, P.C. (2017). Text Book of Plant Anatomy. Arjun Publishing House.
- Menan, A.B. (2008). Introduction to Plant Anatomy. Neha Publishers and Distributors.
- Sharma, M.K. (2013) Plant Structures (An Introduction to Plant Anatomy). Vayu Education of India.

Paper 2: Practical/Lab Course (Course code: BOT302P) Credits: 02

Course outcomes:

1. Understand cell structure in monocot and dicot plants.
2. Understand cell structure, secondary growth and adaptive anatomy in plants.

Unit	Topic	No. of Lectures (60 hrs)
1	Study of meristems through permanent slides and photographs. Tissues (parenchyma, collenchyma and sclerenchyma), complex and secretary tissues	**15**
2	Anatomy of monocot and dicot Stem; monocot and dicot leaf; monocot and dicot root **(Plants can be chosen as per availability of local flora)**	**15**
3	Adaptive anatomy: Xerophytes, Hydrophytes, Epiphytes **(Plants can be chosen as per availability of local flora)**	**15**
4	Normal and abnormal secondary growth in different plants **(Plants can be chosen as per availability of local flora)**	**15**

Suggested readings

- Pandey, B.P. (2014). Modern Practical Botany Vol. II. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Pandey, B.P. (2001). Plant Anatomy. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Sundara, R.S. (2002). Practical Manual Anatomy and Embryology. Anmol Publisher, New Delhi.

Course	Year	Semester
Diploma Course in Developmental Botany	*B.Sc. II*	*IV*

Paper 1: Embryology and Cytogenetics (course code: BOT401) Credit: 4

Course outcomes:

1. Understand reproduction and developmental changes in plants.

2. Understand the structure and chemical composition of chromatin and concept of cell division.

3. Interpret the Mendel's principles; acquire knowledge on cytoplasmic inheritance and sex-linked inheritance.

Unit	Topic	No. of Lectures (60 hrs)
1	**Pollination and fertilization**: Pollination mechanisms and adaptation, structure of anther and pollen, development of male and female gametophytes, double fertilization.	**15**
2	**Embryo and endosperm:** Types of ovules and embryo sacs; embryo and endosperm; types of endosperm; dicot and monocot embryo; apomixis and polyembryony.	**15**
3	**Heredity:** (Pre-mandelian genetics, brief life history of Mendel, laws of Inheritance, modified mandelian ratios, lethal genes, co-dominance, incomplete dominance, chi square, pedigree analysis, multiple allelism, chromosome theory of inheritance, sex-determination and sex-linked inheritance, cytoplasmic inheritance **Linkage and crossing over:** Linkage: concept and history, complete and incomplete linkage, bridges experiment, coupling and repulsion, recombination frequency, linkage maps based on two and three factor crosses.	**15**
4	**Crossing over:** Concept and significance, cytological proof of crossing over; mutations and chromosomal aberrations (types of mutations, effects of physical and chemical mutagens, numerical chromosomal changes: euploidy, polyploidy and aneuploidy; structural chromosomal changes: deletions, duplications, inversions and translocations).	**15**

Suggested readings

- Bhojwani, S.S. and Bhatnagar, S.P. (2010). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
- Johri, B.M. (1984). Embryology of Angiosperms. Springer-Verlag, Berlin
- Maheshwari, P. (1971). An Introduction to Embryology of Angiosperms. McGraw Hill Book Co. London.
- Rastogi, V.B. (2019). Genetics. 4th Edition. MEDTECH: A Division of Scientific International.

Paper 2: Practical/Lab Course (Course code: BOT402) Credits: 4

Course outcomes

1. Understand the pollination and seed dispersal mechanism.
2. Study the structure of ovules and female gametophytes.
3. Interpret the Mendel's principles; and understand the monohybrid and dihybrid crosses and their ratio and chromosomal changes.

Unit	Topic	No. of Lectures (60 hrs)
1	Pollination types and seed dispersal mechanisms (photographs and specimens)	**15**
2	Structure of anther (young and mature). Types of ovules: anatropous, orthotropous, circinotropous, amphitropous, campylotropous. Female gametophyte: *Polygonum* (monosporic) type of embryo sac development (permanent slides/photographs) Ultrastructure of mature egg apparatus cells through electron micrographs (permanent slides/photographs)	**15**
3	Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square. Monohybrid cross (dominance and incomplete dominance) Dihybrid cross and gene interactions Pedigree analysis for dominant and recessive autosomal and sex linked traits. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).	**15**
4	Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes through photographs. Photographs/permanent slides showing translocation ring, laggards and inversion bridge	**15**

Suggested reading

- Sundara, R.S. (2002). Practical Manual Anatomy and Embryology. Anmol Publisher, New Delhi.
- Singh, R.J. (2021). Practical Manual on Plant Cytogenetics. CRC Press, Taylor and Francis Group, Routledge.

DETAILED SYLLABUS OF B. Sc III YEAR OR BACHELOR OF SCIENCE

Course	Year	Semester
Bachelor of Science	*B.Sc. III*	*V*

Paper 1: Cell and Molecular Biology, and Biotechnology (Course code: BOT501T)Credit: 4

Course outcomes:

1. Understand cell structure, nucleic acids, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
2. Know about processing and modification of RNA and translation process, function and regulation of expression.
3. Understand the basic tools and techniques used in Plant tissue culture.

Unit	Topic	No. of Lectures (60 hrs)
1	**Cell Biology:** The cell theories, prokaryotic and eukaryotic cells, cell organelles (Mitochondria, Chloroplast, ER, golgi body, lysosomes, peroxisomes, glyoxisomes, nucleus, chromatin; DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure), cell membrane and cell wall; models of membrane structure, cell cycle **(**overview of cell cycle, mitosis and meiosis, molecular controls).	**18**
2	**Molecular Biology:** Genetic material **(**DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material); DNA replication (Prokaryotes); Transcription (Prokaryotes) Types of structures of RNA (mRNA, tRNA, rRNA); Translation (Prokaryotes), Regulation of gene expression **(**Prokaryotes: Lac operon and Tryptophan operon).	**18**
3	**Plant tissue culture:** Culture types on the basis of explants and media composition, General lab setup and instrumentation, micropropagation, brief account of protoplast culture, somatic embryogenesis with their applications.	**12**
4	**Recombinant DNA techniques:** Blotting techniques: Northern, Southern and Western Blotting, Molecular DNA markers i.e. RAPD, RFLP, SNPs, PCR, hybridoma and monoclonal antibodies, ELISA and Immunodetection.	**12**

Suggested readings

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley and Sons. Inc.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
- Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

- 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.

Paper 2: Economic Botany and Plant Breeding (Course code: BOT502T) Credit:4

Course outcomes
1. Know about the importance of medicinal plants and its useful parts, economically important plants in our daily life and also about the traditional medicines and herbs, and its relevance in modern times.
2. Understand the plant breeding systems and heterosis and mutation in plant breeding.

Unit	Topic	No. of Lectures (60 hrs)
1	Origin of cultivated plants (concept of centres of origin, their importance with reference to vavilov's work)	**18**
2	A brief knowledge of botany and commercial utilization and uses of the following plants: 1. Cereals and millets- Wheat, Rice and Maize, Ragi, Pearl millet 2. Sugar yielding plants- Sugarcane and Sugar beet 3. Fruits- Mango, Apple, Banana, Citrus and Litchi. 4. Fibers- Cotton, Jute, Hemp, Coir, Agave and Semal. 5. Vegetables- Root vegetables, stem vegetables and fruit vegetables. 6. Timbers- Teak, Shisham, Sal, Chir and Deodar. 7. Medicinal plants- *Aconitum*, *Atropa*, *Cinchona*, *Rauwolfia*, *Ephedra*, *Withania*, and *Alovera.* 8. Oils, Beverages, Fumitories, masticatories, Spices and Condiments yielding plants.	**12**
3	Plant breeding (introduction and objectives; breeding systems, important achievements and undesirable consequences of plant breeding); methods of crop improvement; centres of origin and domestication of crop plants, plant genetic resources; acclimatization; selection methods.	**18**
4	Hybridization: for self, cross and vegetatively propagated plants – procedure, advantages and limitations; inbreeding depression and heterosis (history, genetic basis of inbreeding depression and heterosis; applications); crop improvement and breeding (role of mutations; polyploidy; distant hybridization and role of biotechnology in crop improvement).	**12**

Suggested readings

- Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.

- Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
- Acquaah, G. (2007). Principles of Plant Genetics and Breeding. Blackwell Publishing.

Paper 3: Lab Course (Course code: BOT503P) Credit: 2

Course outcomes
1. Learn the basic structure and function of cells and instruments used in molecular biology,
2. Know about the commercial products produced from plants.
3. Understand about the ethnobotanical details of plants.
4. Learn about the chemistry of plants and herbal preparations.

Unit	Topic	No. of Lectures (60 hrs)
1	Structure of prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs. Study of the photomicrographs of cell organelles, structure of plant cell through temporary mounts. Study of mitosis and meiosis (temporary mounts and permanent slides). Demonstration of the effect of temperature, organic solvent on semi permeable membrane. Study of plasmolysis, deplasmolysis, Endo- and Exo-osmosis.	15
2	Instruments and equipments used in molecular biology The cell size measurements (either length or breadth/diameter) by micrometry. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene and lampbrush) either by slides or photographs. Study DNA packaging by micrographs. Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome.	15
3	Study of economically important plants: Cereals: Wheat, Rice, Maize Millets: Fingermillet, Foxtail, Ragi Pulses: Gram, Green gram, Pea, Pigeon pea, Soyabean, Chick pea Timbers: Shisam, Sal, Teak, Deodar, Pine Medicinal plants: Dhatura, Berginia, Hedychium, Poppy, Basil, Barberry Beverages: Tea, Coffee Oils: Mustard, Seseame, Coconut, Linseed, Groundnut, Castor, Laung, Sandal wood, Mentha Spices: Coriander, Cardmum, Curcuma, Cinamom, Laung, Cumin, Thyme, Nigella, Cinamom leaf	15

	Fibers: Jute, Coconut, Hemp, Urtica, Cotton Sugars and starch yielding plants: Sugarcane, Potato, Beet root Fruits and vegetables cultivated in the area. Gums and Resins.	
4	Hybridization techniques - Emasculation, Bagging (For demonstration only). Induction of polyploidy in plants (For demonstration only).	**15**

Suggested readings

- 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.
- Pandey, B.P. (1999). Economic Botany. S. Chand, New Delhi.

Paper 4: Project in Botany for Pre-graduation (Course code: BOT504R) Credit: 4

(Based on Local Plant Diversity)

Course	**Year**	**Semester**
Bachelor of Science	*B.Sc. III*	*VI*

Paper 1: Plant Physiology and Biochemistry (BOT601T) Credit: 4

Course outcome

1. Understand the role of physiological and metabolic processes for plant growth and development.
2. Learn the symptoms of mineral deficiency in crops and their management.
3. Assimilate knowledge about Biochemical constitution of plant diversity.
4. Know the role of plants in development of natural products, nutraceuticals, dietary supplements, antioxidants.

Unit	**Topic**	**No. of Lectures (60 hrs)**
1	**Plant-water relations**: Importance of water, water potential and its components; transpiration and its significance; factors affecting transpiration; root pressure and guttation. **Mineral nutrition:** Essential elements, macro and micronutrients; criteria of essentiality of elements; role of essential elements; transport of ions across cell membrane, active and passive transport, carriers, channels and pumps	**18**
2	**Photosynthesis:** (photosynthetic Pigments (Chl a, b, xanthophylls,	**18**

	carotene); photosystem I and II, electron transport and mechanism of ATP synthesis; C_3, C_4 and CAM pathways of carbon fixation; photorespiration). **Respiration** (glycolysis, anaerobic respiration, TCA cycle; oxidative phosphorylation, glyoxylate cycle).	
3	**Nitrogen metabolism:** Biological nitrogen fixation; nitrate and ammonia assimilation. **Plant growth regulators**: Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.	**12**
4	**Biochemistry:** General introduction to carbohydrates, lipids and proteins. Enzymes (structure and properties; mechanism of enzyme catalysis and enzyme inhibition, factors affecting enzyme action).	**12**

Suggested readings

- Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
- Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley and Sons, U.S.A. 4th Edition.
- Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

Paper 2: Ecology and Biostatistics (Course code: BOT602T) Credit: 4

Course outcome

1. Acquaint the students with complex interrelationship between organisms and environment;
2. Make them understand methods for studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.
3. Understanding the strategies for sustainable natural resource management and biodiversity conservation.
4. Practical knowledge of the different statistics tools and techniques.

Unit	Topic	No. of Lectures (60 hrs)
1	**Ecological factors**: **Soil** (Origin, formation, composition, soil profile) **Plant adaptation** in relation to water **(**Hydrophytes and xerophytes), light (Sciophytes and heliophytes) and temperature Pollution: Water, Soil and Radioactive.	**12**

2	**Ecosystem**: Types, structure, energy flow, trophic organization, food chains and food webs, ecological pyramids. **Biogeochemical cycles:** Cycling of carbon, nitrogen and phosphorous. **Population:** Characteristics, Growth curves, Ecotypes and Ecads **Plant communities:** Characteristics, plant succession, Biological spectrum **Biodiversity conservation**	**18**
3	**Biostatistics:** Definition and scope of statistics, sampling techniques, representation of data: tabular, graphical etc **Measures of central tendency:** Arithmetic mean, mode, median.	**18**
4	**Measures of dispersion:** range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit Regression analysis	**12**

Suggested reading

- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
- Shukla, R.S. and Chandel P.S. (2005). A text book of Plant Ecology. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Rastogi, V.B. (2015). Biostatistics. Medtech, 3rd Edition.
- Banerjee, P.K. (2006). Introduction to Biostatistics. S. Chand and Company Ltd., Ram Nagar, New Delhi.
- Singh, J.S. Singh S.P. and Gupta, S.R. (2014). Ecology, Environment and Resource Conservation. S. Chand and Compony Pvt. Ltd., New Delhi.

Paper 3: Practical/lab Course (Course code: BOT603P) Credit: 2

Course outcome

1. Understand the role of different physiological and metabolic processes of plants.
2. Gaining practical knowledge implemented in the biodiversity assessment and conservation.
3. Practical knowledge of the different statistics tools and techniques.

Unit	Topic	No. of Lectures (60 hrs)
1	Demonstration of process of diffusion, osmosis and plasmolysis Demonstration of transpiration in dorsivental leaf by four leaf and cobalt chloride method. Determination of rate of transpiration by Ganong's/Farm potometer.	**18**

	Demonstration of the effect of light intensity and bicarbonate concentration on O_2 evolution in photosynthesis by Wilmott' s bublar Determination of R.Q of different respiratory substrates by Ganong's respirometer Demonstration of anaerobic respiration in germinating seeds.	
2	Test of carbohydrates, proteins and fats.	**12**
3	Observation and study of different ecosystems mentioned in the syllabus. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, rain gauge and lux meter. Determination of pH, and analysis of soil samples for soil moisture, organic carbon, nitrogen and phosphorus. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats. Study of ecological adaptations in hydrophytes and xerophytes. Study of biotic interactions of: stem parasite (*Cuscuta)*, root parasite (orobanche), epiphytes, predation (insectivorous plants) through specimen or diagrams. Determination of minimum quadrat size for the study of herbaceous vegetation by species area curve method (species to be listed). Quantitative analysis of herbaceous vegetation in the college campus for frequency, density, abundance and A/F ratio. Population structure study of dominant tree species of the locality.	**18**
4	Analysis of statistical data: mean, median and mode by analyzing the given data of individual, discrete and continuous series, standard error and deviation Numerical based on correlation coefficient Numerical based on chi square value Representation of data by making graphs and diagrams etc. Comment upon given graphs, diagrams etc.	**12**

Suggested readings

- Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
- Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

Paper 4: Project in Botany for Pre-graduation (Course code: BOT604R) Credits: 04

(Based on Local Ecosystem studies)

Vocational/Skill Enhancement Courses in Botany

(i) Bio-fertilizers **Credit: 3**

Course outcome

1. Develop conceptual skill about identifying microbes, and bio-fertilizers.
2. Gain knowledge about developing commercial enterprise of bio-fertilizers.

Unit	Topic	No. of lecturers/ hrs (45)
1	General account about the microbes used as biofertilizer – *Rhizobium* – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	10
2	*Azospirillum:* isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation	15
3	Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants	10
4	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. National and state institutes related to the activity.	10

Suggested readings

- Dubey, R.C. (2005). A Text Book of Biotechnology. S.Chand and Co, New Delhi.
- Kumaresan, V. (2005). Biotechnology, Saras Publications, New Delhi.

- John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
- Sathe, T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.
- Subha Rao, N.S. (2000). Soil Microbiology, Oxford and IBH Publishers, New Delhi.
- Vayas, S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming. Akta Prakashan, Nadiad.

(ii) Herbal Technology **Credit: 3**

Course outcome

1. Develop conceptual skill about traditional Indian medicinal system, herbal medicines, their processing, storage and marketing.

2. Gain knowledge about developing commercial enterprise of herbal medicines.

3. Learn the basic tools and techniques for phytochemical analysis and propagation of the medicinal plants.

Unit	Topic	No. of lecturers/ hrs (45)
1	Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.	10
2	Pharmacognosy - systematic position medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka. Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).	15
3	Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds).	10
4	Medicinal plant banks micro propagation of important species (*Withania somnifera*, neem and tulsi- Herbal foods-future of pharmacognosy). National and state institutes related to the activity.	10

Suggested readings

- Chopra, R.N., Nayar S.L. and Chopra, I.C. (1956). Glossary of Indian Medicinal Plants, C.S.I.R, New Delhi.
- Arber, A. (1999). Herbal plants and Drugs. Mangal Deep Publications.
- Sivarajan V.V. and Balachandran I. (1994). Ayurvedic drugs and their plant source. Oxford IBH publishing Co.
- Miller, L. and Miller, B. (1998). Ayurveda and Aromatherapy. Banarsidass, Delhi.
- Green, A. (2000). Principles of Ayurveda, Thomsons, London.
- Kokate, C.K. (1999). Pharmacognosy, Nirali Prakashan.

(iii) Nursery and Gardening **Credit: 3**

1. Develop conceptual of nursery and gardening.
2. Gain knowledge about developing commercial enterprise of nursery.

Unit	Topic	No. of lecturers/ hrs (45)
1	Nursery: definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants. Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy-Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology - seed testing and certification	15
2	Vegetative propagation: air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – green house - mist chamber, shed root, shade house and glass house	10
3	Gardening: definition, objectives and scope - different types of gardening-landscape and home gardening - parks and its components - plant materials and design-computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting.	10
4	Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures. National and state institutes related to the activity.	10

Suggested readings

- Bose T.K. and Mukherjee, D. (1972). Gardening in India, Oxford and IBH Publishing Co., New Delhi.

- Sandhu, M.K. (1989). Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
- Kumar, N. (1997). Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.
- Agrawal, P.K. (1993). Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
- Jules J. (1979). Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.

(iv) Floriculture **Credit: 3**

Course outcome

1. Develop conceptual skill about floriculture.
2. Gain knowledge about developing commercial enterprise of commercial floriculture.

Unit	Topic	No. of lecturers/ hrs (45)
1	Introduction: History of gardening; Importance and scope of floriculture. Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Role of plant growth regulators.	15
2	Ornamental Plants: Flowering annuals; Herbaceous perennials; Shade and ornamental trees; Cacti and succulents; Palms and Cycads; Ferns; Cultivation of plants in pots; Indoor gardening; Bonsai.	10
3	Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.	10
4	Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold, Rose, Lilium, Orchids). Diseases and Pests of Ornamental Plants. National and state institutes related to the activity.	10

Suggested readings

- Randhawa, G.S. and Mukhopadhyay, A. (1986). Floriculture in India. Allied Publishers.

(v) Medicinal Botany **Credit: 3**

Course outcome

1. Understand the traditional Indian medicinal systems and their importance.

2. To learn the strategies for the conservation of medicinal plants.

3. Gain knowledge about developing commercial enterprise of herbal medicines.

Unit	Topic	No. of lecturers/ hrs (45)
1	History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definition and Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments, Siddha:	**10**
2	Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.	**10**
3	Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanical Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding	**15**
4	Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases. National and state institutes related to the activity.	**10**

Suggested readings

- Trivedi, P.C. (2006). Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
- Purohit, S.S. and Vyas, S.P. (2008). Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. Agrobios, India.

(vi) Conservation and Management of biodiversity **Credit: 3**

Course outcome

1. Understand the importance, benefits and services of biodiversity.
2. To learn the strategies for the conservation of biodiversity.

Unit	Topic	No. of lecturers/ hrs (45)
1	Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes	10
2	**Loss of Biodiversity;** Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, **Management of Plant Biodiversity:** Organizations associated with biodiversity management-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.	15
3	**Conservation of Biodiversity:** Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development	10
4	**Role of plants in relation to Human Welfare**; a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses. National and state institutes related to the activity.	10

Suggested readings

- Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity – Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi

(vii) Ethnobotany **Credit: 3**

Course outcomes

1. To learn the proper documentation and presentation of traditional knowledge about plants.
2. To use important plants by the tribal communities for various purposes.
3. To learn the conservation of wild growing plants and their socioeconomic impacts.

Unit	Topic	No. of lecturers/ hrs (45)
1	**Ethnobotany:** Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses	10
2	**Methodology of Ethnobotanical studies** a) Field work b) Herbarium c) Ancient Literature d) Temples and sacred places e) Indigenous knowledge system	10
3	**Role of ethnobotany in modern Medicine** Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum sanctum* c) *Vitex negundo*. d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia auriculata* h) *Indigofera tinctoria*. Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia, Withania*. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	15
4	**Ethnobotany and legal aspects** Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge. National and state institutes related to the activity.	10

Suggested readings

- Jain S.K. (1995). Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
- Jain S.K. (1981). Glimpses of Indian. Ethnobotany, Oxford and I B H, New Delhi.
- Jain S.K. (1989). Methods and approaches in ethnobotany. Society of Ethnobotanists, Lucknow, India.
- Jain S.K. (1990). Contributions of Indian ethnobotany. Scientific publishers, Jodhpur.
- Colton C.M. (1997). Ethnobotany-Principles and applications. John Wiley and sons Chichester.
- Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India. Botanical Survey of India. Howrah.
- Rajiv K. Sinha (1996). Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur).

(viii) Mushroom Cultivation Credit: 3

Course outcome

1. Understand the economic importance of mushroom cultivation.
2. To learn the basic tools and techniques used in mushroom cultivation.
3. To learn the skills for developing commercial enterprise of mushroom cultivation.

Unit	Topic	No. of lecturers/ hrs (45)
1	Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India- *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*.	**10**
2	Cultivation methods: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, Composting technology in mushroom production	**15**
3	Storage and nutrition: Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition- Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.	**10**
4	Food preparation: Delicacies of mushroom and its value addition, Research Centres - National level and Regional level. Cost benefit	**10**

	ratio - Marketing in India and abroad, Export Value. National and state institutes related to the activity.	

Suggested readings

- Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R. (1991). Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
- Swaminathan, M. (1990). Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
- Tewari, P. and Kapoor, S.C. (1988). Mushroom cultivation, Mittal Publications, Delhi.
- Bahl, N. (2000). Hand book of Mushrooms. Oxford & Ibh Publishing Co. Pvt Ltd

(ix) Intellectual Property Rights **Credit: 3**

1. Understand the basic concepts of intellectual property rights.
2. To learn the procedure for obtaining the intellectual property rights.

Unit	Topic	No. of lecturers/ hrs (45)
1	**Introduction to intellectual property right (IPR)** Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR, WTO TRIPS and WIPO.	10
2	**Patents** Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents, Infringement. **Copyrights** Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement. **Trademarks** Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name. **Geographical Indications** Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position.	10
3	**Protection of Traditional Knowledge** Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level,	10

	Traditional Knowledge Digital Library. **Industrial Designs** Objectives, Rights, Assignments, Infringements, Defences of Design Infringement	
4	**Protection of Plant Varieties** Plant Varieties Protection-Objectives, Justification, International Position, Plant varieties protection in India. Rights of farmers, Breeders and Researchers. National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001. **Information Technology Related Intellectual Property Rights** Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection. **Biotechnology and Intellectual Property Rights.** Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues in Patenting Biotechnological inventions.	15

Suggested readings

- N.K. Acharya (2001). Textbook on intellectual property rights, Asia Law House.
- Manjula Guru and M.B. Rao (2003). Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications.
- P. Ganguli (2001). Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill.
- Miller, A.R. and Davis M.H. (2000). Intellectual Property: Patents, Trademarks and Copyright in Nutshell, West Group Publishers.
- Watal, J. (2003) Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford.

NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all Uttarakhand State Universities and Colleges for First Three Years of Higher Education

PROPOSED STRUCTURE OF
UG - CHEMISTRY
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

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Dr. Mahesh. C. Arya	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Manoj Dhuni	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. Penny Joshi	Assistant Professor	D. S. B. Campus, Kumaun University, Nainital
Dr. A. Dandapat	Inspire Faculty	D. S. B. Campus, Kumaun University, Nainital

EXPERT COMMITTEE

Name	Designation	Affiliation
Dr. A. B. Melkani	Dean, Faculty of Science	Kumaun University, Nainital
Dr. G. C. Shah	Professor & Head	SSJ University, Almora
Dr. S. P. Sati	Professor	Sri Suman Dev University, Srinagar

Semester-wise Titles of the Papers in B.Sc. Chemistry

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Introductory Chemistry					
1	I		Fundamentals of Chemistry-I	Theory	4
			Chemical Analysis-I	Practical-1	2
	II		Fundamentals of Chemistry-II	Theory	4
			Chemical Analysis-II	Practical-1	2
Diploma in Chemical Science					
2	III		General Chemistry-I	Theory	4
			Analytical Procedures-I	Practical-2	2
	IV		General Chemistry-II	Theory	4
			Analytical Procedures-II	Practical-2	2
Degree in Bachelor of Science					
3	V		Inorganic Chemistry	Theory	4
			Organic Chemistry	Theory	4
			Analytical Procedures -III	Practical-3	2
			Research Project	Project	Qualifying
	VI		Physical Chemistry	Theory	4
			Analytical Chemistry	Theory	4
			Analytical Procedures -IV	Practical-3	2
			Research Project	Project	Qualifying

Purpose of the Program

The Importance of chemistry arises because so many other disciplines draw on certain chemical principles and concepts. The purpose of the undergraduate chemistry program at the university and college level is to prepare our students for all those fields where basic knowledge of chemistry is required including academia for careers as professionals in various industries and research institutions.

Program Outcomes

PO 1. Students will have a firm foundation in the fundamentals and applications of chemical and scientific theories including those in analytical, inorganic, organic and physical chemistry.

PO 2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the data of such experiments.

PO 3. Students will develop skill in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO 4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

PO 5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.

PO 6. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

PO 7. Students will be able to function as a member of an interdisciplinary problem-solving team.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
CERTIFICATE IN INTRODUCTORY CHEMISTRY	
First Year	Certificate in Introductory Chemistry will give the student a basic knowledge of all the fundamental principles of chemistry like atomic structure, molecular polarity, bonding theories of different molecules, resonance concept, hyperconjugation, field effects, periodic properties of more than 111 elements, mechanism of organic reactions, stereochemistry, detailed study of states of matter including kinetic theories of gases, solid and liquid states, chemistry of aliphatic and aromatic compounds, chemical kinetics, its scope and first law of thermodynamics. Student will be able to understand the qualitative and quantitative chemical analysis of the compounds in the laboratory. This certificate course is definitely going to prepare the students for various fields of chemistry and will give an insight into all the branches of chemistry. It will enable students to join the diploma course (semester III and IV) in any University or College of Higher education in Uttarakhand
Second Year	**DIPLOMA IN CHEMICAL SCIENCE**
	Diploma in Chemical Science will provide the theoretical as well as practical knowledge of handling chemicals, apparatus, equipment and instruments. The knowledge about second law of thermodynamics, chemical equilibrium, phase equilibrium, electrochemistry, coordination chemistry, acid-base theories, chemistry of transition elements, halides, alcohols, phenols, aldehydes, ketones and carboxylic acids will enable the students to work as chemists in various industries. The experimental work during the diploma course will enhance the skill of the students regarding chemical and physical tests of inorganic as well as organic compounds along with some physical experiments which will be beneficial to achieve their goals in industrial sectors. It will enable students to join the Bachelor of Science course (semester V and VI) in any University or College of Higher education in Uttarakhand
Third Year	**DEGREE IN BACHELOR OF SCIENCE**
	Degree in Bachelor of Science programme aims to introduce very important aspects of modern-day course curriculum, namely, chemistry of nitrogen containing compounds, organometallic, lipids, fats, dyes, paints, reagents in organic synthesis, carbohydrates, proteins, biomolecules, data analysis, nano-chemistry, green chemistry, stability of coordination compounds, cement, paint, ceramics, glass, inorganic fertilizers, radioactivity, corrosion, magnetic behaviour of transition metal complexes, surface chemistry, quantum mechanics, solutions, third law of thermodynamics, photochemistry, and spectroscopic techniques. This knowledge will make the students skilled to work in various chemical industries like cement industries, agro product, paint industries, rubber industries, petrochemical industries, food processing industries, fertilizer industries, pollution monitoring and control agencies etc. It will also enable the students to understand the importance of the biomolecules in biological science and related fields. Upon completion of a degree, chemistry students will able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments. It will help a candidate to succeed at an entry-level position in chemical industry or a chemistry postgraduate program.

Subject: Chemistry							
Year	**Semester**	**Theory Paper**	**Units**	**Practical Paper**	**Units**	**Research Project**	**Total Credits of the Year subject**
1	I	Fundamentals of Chemistry-I	1. Atomic Structure and Periodic Properties 2. Chemical Bonding-I 3. Mechanism of Organic Reactions 4. Stereochemistry of Organic Compounds 5. States of Matter-I 6. States of Matter-II	Chemical Analysis-I	1. Laboratory hazards and safety precautions 2. Inorganic exercise (Acidic radicals including combinations and interfering radicals) 3. Organic exercise 4. Physical exercise	NIL	4+2=6
	II	Fundamentals of Chemistry-II	1. Chemical Bonding-II 2. Salient Features of *s*- and *p*-Block Elements 3. Aliphatic Compounds 4. Aromatic Compounds 5. Chemical Kinetics and Catalysis 6. Thermodynamics I	Chemical Analysis-II	1. Laboratory hazards and safety precautions 2. Inorganic exercise (acid-base titrations) 3. Organic exercise 4. Physical exercise	NIL	4+2=6
2	III	General Chemistry-I	1. Chemistry of Transition Elements (First, second and third Transition Series) 2. Coordination Chemistry-I 3. Halides 4. Alcohols and Phenols	Analytical Procedures-I	1. Laboratory hazards and safety precautions 2. Inorganic mixture analysis (including basic radicals) 3. Organic exercise 4. Physical exercise	NIL	4+2=6

			5. Thermodynamics II 6. Chemical Equilibrium, Phase Equilibrium				
	IV	General Chemistry-II	1. Acids and Bases 2. Chemistry of Inner Transition Elements 3. Aldehydes and Ketones 4. Carboxylic Acids 5. Electrochemistry I 6. Electrochemistry II	Analytical Procedures-II	1. Laboratory hazards and safety precautions 2. Inorganic exercise (Redox titration) 3. Organic exercise 4. Physical exercise	NIL	4+2=6
3	V	Inorganic Chemistry	1. Metal-Ligand Bonding in Transition Metal Complexes 2. Thermodynamic and Kinetic Aspects of Coordination Compounds 3. Electronic Spectra of Transition Metal Complexes 4. Magnetic Properties of Transition Metal Complexes 5. Organometallic Chemistry 6. Some Industrially Important Inorganic Materials	Analytical Procedures -III	1. Laboratory hazards and safety precautions 2. Inorganic exercise (Synthesis) 3. Organic exercise 4. Physical exercise	Research Project (Qualifying)	4+4+2=10
		Organic Chemistry	1. Lipids and Fats 2. Reagents in Organic Synthesis				

			3. Nitrogen containing organic Compounds 4. Organometallic Compounds 5. Dyes and Paints 6. Carbohydrates and Proteins				
	VI	Physical Chemistry	1. Surface Chemistry 2. Elementary Quantum Mechanics 3. Photochemistry 4. Solutions and Colligative Properties 5. Thermodynamics III 6. Radiochemistry	Analytical Procedures -IV	1. Laboratory hazards and safety precautions 2. Physical exercise 3. Spectroscopic exercise/ Chromatographic technique 4. Inorganic exercise (Gravimetric)	Research Project (Qualifying)	4+4+2=10
		Analytical Chemistry	1. General Biochemistry 2. Data Analysis 3. Fundamentals of Nanochemistry 4. Basics of Green Chemistry 5. Analytical Techniques 6. Spectroscopy				

Subject: Chemistry							
Course	**Semester**	**Paper Title**		**Prerequisite for Paper**	**Elective for Major Subject**	**Hours per Semester**	**Total Credits of the Year subject**
Certificate in Introductory Chemistry	I	Theory-1	Fundamentals of Chemistry-I	Chemistry of 12th standard	Yes open for all	60	4
		Practical-1	Chemical Analysis-I	Chemistry of 12th standard	Yes open for all	60	2
	II	Theory-1	Fundamentals of Chemistry-II	Passed Sem-I Theory paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-1	Chemical Analysis-II	Opted Sem-II Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
Diploma in Chemical Science	III	Theory-1	General Chemistry-I	Passed Certificate Course in Introductory Chemistry	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-2	Analytical Procedures-I	Opted Sem-III Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
	IV	Theory-1	General Chemistry-II	Passed Sem-III Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-2	Analytical Procedures-II	Opted Sem-IV Theory Paper-1	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
Degree in Bachelor of Science	V	Theory-1	Inorganic Chemistry	Passed Sem-III and Sem-IV Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Theory-2	Organic Chemistry	Passed Sem-III and Sem-IV Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-3	Analytical Procedures-III	Opted Sem-V Theory Paper-1 &2.	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Research Project				60	Qualifying
	VI	Theory-1	Physical Chemistry	Passed Sem-V Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Theory-2	Analytical Chemistry	Passed Sem-V Theory papers Theory papers	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	4
		Practical-3	Analytical Procedures-IV	Opted Sem-VI Theory Paper-1 &2	Yes for the students with major Zoo/Bot./Physics/Math/Comp Sci/Forestry/Geo	60	2
		Research Project				60	Qualifying

Pattern of examination theory papers

A. Theory

*Each theory paper shall consist two sections **A** and **B**.*
***Section A**: (Short answers type with reasoning); 45 marks, eight questions of seven marks each, any five have to be attempted).*
***Section B**: (Long answers type);30 marks, two questions of fifteen marks each. Both the questions are compulsory with internal choice.*

B. Internal assessment

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/ the Principal of the College for uploading onto the University examination portal.

C. Practical

The laboratory work of the students has to be evaluated periodically. The internal assessment (in the form of lab test, lab record, internal evaluation, assignment/home assignment and attendance) of total 12 marks for each semester shall be conducted during the semester. A minimum of 12 experiments covering all kinds of exercises have to be conducted during a semester. Maximum 5 marks of attendance can be given to the students. In each semester practical examination of 38 marks has to be conducted by two examiners (External and internal) having duration of 4 hours for I to IV Semester and 5 hours for V and VI Semester. The total number of students to be examined per batch should not be more than sixty. Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital.

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Certificate in Introductory Chemistry					
1	**I**		Fundamentals of Chemistry-I	Theory	4
			Chemical Analysis-I	Practical	2
1	**II**		Fundamentals of Chemistry-II	Theory	4
			Chemical Analysis-II	Practical	2

Semester-I
Paper-I (Theory)
Course Title: Fundamentals of Chemistry-I

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** First
Paper-I Theory Subject: Chemistry		
Course Code:	**Course Title:** Fundamentals of Chemistry-I	

Course outcomes: There is nothing more fundamental to chemistry than the chemical bond. Chemical bonding is the language of logic for chemists. Chemical bonding enables scientists to take the 100-plus elements of the periodic table and combine them in myriad ways to form chemical compounds and materials. Periodic trends, arising from the arrangement of the periodic table, provide chemists with an invaluable tool to quickly predict an element's properties. These trends exist because of the similar atomic structure of the elements within their respective group families or periods, and because of the periodic nature of the elements. Reaction mechanism gives the fundamental knowledge of carrying out an organic reaction in a step-by-step manner. This course will provide a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. Students will gain an understanding of;

- ✓ Molecular geometries, physical and chemical properties of the molecules.
- ✓ Current bonding models for simple inorganic and organic molecules in order to predict structures and important bonding parameters.
- ✓ This course gives a broader theoretical picture in multiple stages in an overall chemical reaction.
- ✓ It describes reactive intermediates, transition states and states of all the bonds broken and formed.
- ✓ It enables to understand the reactants, catalyst, stereochemistry and major and minor products of any organic reaction. It describes the types of reactions and the kinetic and thermodynamic aspects one should know for carrying out any reaction and the ways how the reaction mechanism can be determined. ·
- ✓ The chapter stereochemistry gives the clear picture of two-dimensional and three-dimensional structure of the molecules, and their role in reaction mechanism. The course will also strengthen the knowledge of students regarding complete picture of states of matter that includes gaseous, liquid, solid and colloidal states.

Credits:4	Compulsory
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Content	Number of Hours
1	**Atomic Structure and Periodic Properties:** Dual nature of matter; de Broglie concept. Heisenberg uncertainty principle; its significance. Atomic orbitals, Schrödinger wave equation (no derivation); significance of ψ and ψ^2. Quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p and d orbitals. Aufbau energy diagram, Pauli's exclusion principle. Hund's rule of maximum multiplicity. Electronic configuration of elements (s block, p block and first series of d-block elements). Effective nuclear charge, Slater's rule. The general idea of Modern periodic table, atomic and ionic radii, ionization potential, electron affinity, electronegativity-definition, trends of variation in periodic table and their application in prediction and explaining the chemical behaviour of elements and compounds thereof.	**12**
2	**Chemical Bonding-I**: Ionic bond, covalent bond-Valence Bond Theory and its limitations; various types of hybridization and shapes of different inorganic and organic molecules. Valence Shell Electron Pair Repulsion Theory (VSEPR) and shapes of NH_3, H_2O, H_3O^+, SF_4, ClF_3, ICl_2^-, TeF_5^- NH_4^+ and other simple molecules/ions (CO_2, SO_2, SO_3, Cl_2O_7, SO_4^{2-}, CO_3^{2-}, NO_3^-, PO_4^{3-}) including compounds of xenon. Resonance, hyperconjugation, field effects- inductive, mesomeric, electromeric effect	**8**
3	**Mechanism of Organic Reactions:** Types of reagents-electrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates- carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples).	**8**
4	**Stereochemistry of Organic Compounds:** Types of isomerism-optical isomerism- elements of symmetry, molecular chirality, enantiomers, stereogenic centers, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centre, diastereomers, threo and erythro diastereomers, meso compounds, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: determination of configuration of geometrical isomers, E & Z system of	**12**

	nomenclature.	
5	**States of Matter-I: Gaseous State-**Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waal's equation of states, Critical phenomena – PV isotherms of real gases, relationship between critical constants and van der Waals constants. Molecular velocities: Root mean square, average and most probable velocities, qualitative discussion of the Maxwell's distribution of molecular velocities, Numerical problems. **Liquid State-**Intermolecular forces, Structural differences between solids, liquids and gases. Physical properties of liquids including their methods of determination: surface tension, viscosity, Numerical problems.	**12**
6	**States of Matter-II:** **Solid State:** Introduction to crystalline materials, Definition of space lattice, unit cell, crystal planes, Miller indices, Laws of crystallography – (i) law of constancy of interfacial angles (ii) law of rationality of indices (iii) law of symmetry. Symmetry elements in crystals, X-ray diffraction by crystals. Bragg's equation, Numerical problems. **Colloidal State:** Definition of colloids, classification of colloids. Solids in liquids (sols): properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.	**8**

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.

vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.

vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.

ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.

x. Mukerji, S.M., “Reaction mechanism in Organic Chemistry”, Laxmi Publications, 2007, 3rd edition.
xi. Singh, Jagdamba and Yadav, L.D.S., “Undergraduate Organic Chemistry” Pragati Prakashan, India, 2011, Vol 1.
xii. Loudon, G. Marc, “Organic Chemistry”, Oxford University Press, 2008, 4th edition.
xiii. Atkins P.W., “Atkin’s Physical Chemistry: International”, Oxford University Press, 2018, 11th edition.
xiv. Ball D.W., “Physical Chemistry”, Cengage India Private Limited, 2017, 2nd edition.
xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., “Principles of Physical Chemistry”, Vishal Publishing, India, 2020, 47th edition.
xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., “Essential of Physical Chemistry”, S. Chand Publishing, India, 2010.
xvii. Bariyar, A., Singh, R.P. and Dwivedi, A., “Text Book for B. Sc. Chemistry I”, Anu Books, 2019.

Suggested online links:

1. https://www.youtube.com/watch?v=ZeV3V0DjupQ&list=PLmxSS9XYst219YI3DjJUP52APmR9bea1Y
2. https://www.youtube.com/watch?v=q-P79gnqNR8&list=PLmUlqVgZsTVVRvO3R8g-x12EMc5vmcq_c
3. https://www.youtube.com/watch?v=gahQYHs0c8s
4. https://www.youtube.com/watch?v=w2He_Q0Mf0c
5. https://www.youtube.com/watch?v=q1qMFcZVlPk
6. https://www.youtube.com/watch?v=nWTgMr6idf0
7. https://www.youtube.com/watch?v=JNLJyhqXaTc&t=10s
8. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
9. https://onlinecourses.nptel.ac.in/noc22_cy36/preview
10. https://onlinecourses.swayam2.ac.in/cec20_lb01/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) & Attendance	10 marks

Course prerequisites: To study this course, a student must have studied the chemistry of class 12th standard.

Suggested equivalent online courses:
Further Suggestions: ……………………………

Semester-I, Paper-II (Practical)

Course Title: Chemical Analysis -I

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** First
		Paper-2 Practical Subject: Chemistry
Course Code:		**Course Title:** Chemical Analysis-I

Course outcomes:

Upon completion of this course, the students will have the knowledge and skills to: understand the laboratory methods and tests related to inorganic mixture analysis and estimation of surface tension of commercial products. Also, they can understand the absolute configuration of organic molecules with the help of models. The students will able to

- ✓ Qualitatively estimate anions and cations in samples.
- ✓ Determine the relative surface tension of a given liquid.
- ✓ Find out the absolute configuration of organic molecules.

Credits:2	**Compulsory**
Max. Marks: 12+38	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	**Salt mixture analysis:** Identification of acid radicals (three to four) including anions in combination and basic radicals upto II Group in the given salt mixture.	18
3	**Organic exercise:** Determination of absolute configuration of organic molecules using ball and stick models. Students are supposed sketch the structure of simple organic compounds showing their stereochemistry using Fischer Projection.	18
4	**Physical exercise:** Determination of relative surface tension of the given liquid using Stalagmometer.	18

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks

Attendance	06 marks
Viva voce/Record and overall performance	06 marks

Course prerequisites: To study this course, a student must have studied the chemistry of class 12th standard.

Suggested equivalent online courses:

Further Suggestions: ……………………………

One exercise each from salt mixture analysis (acidic radicals), organic exercise (absolute configuration) and physical exercise (relative surface tension) shall be given in the examination.

Distribution of marks shall be as given below:

1.	Inorganic salt analysis (Acidic and Basic radicals)	10
2.	Organic exercise	12
3.	Physical	11
4.	Viva	05
5.	Home assignment/internal assessment, lab record and attendance	12

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester lab record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 04 (four) hours.***
- ***Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital***

Suggested Readings:

i. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
ii. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
iii. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
iv. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
v. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.

Suggestive digital platforms web links:

1. http://chemcollective.org/vlabs
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. https://wp.labster.com/chemistry-virtual-labs/

Semester-II
Paper-I (Theory)
Course Title: Fundamentals of Chemistry-II

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** Second
Paper-I Theory Subject: Chemistry		
Course Code:	**Course Title:** Fundamentals of Chemistry-II	

Course outcomes: Upon successful completion of this course, the students will be able to describe the reactions shown by aliphatic and aromatic compounds. They will also able to understand the bonding in inorganic molecules, salient features of s- and p- block elements, different aspects of chemical kinetics, catalysis and first law of thermodynamics.

Credits: 4	**Compulsory**	
Max. Marks: 25+75	Min. Passing Marks:…………	
Total Number of Hours = 60		
Units	**Content**	**Number of Hours**
1	**Chemical Bonding-II:** Molecular Orbital Theory (MOT) as applied to diatomic homonuclear/heteronuclear inorganic molecules. MO diagrams and bond order of H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2, CO, NO, HF difference between VB and MO theories. Multicentre bonding in electron deficient molecules. Polarization of covalent molecules, Percentage ionic character from dipole and electronegativity difference. Polarizing power and polarizability; Fajan's rule. Metallic bond- Electron Pool, valence bond and MO theories. Weak interactions-hydrogen bonding in inorganic and organic molecules and van der Waals interactions.	**10**
2	**Salient Features of s- and p-Block Elements:** General discussion with respect to all periodic (Occurrence, electronic configuration, atomic & ionic radii, density, ionization potential, metallic behaviour, electropositive nature, electronegativity, electron affinity, hydration energy, flame colouration, photoelectric effect, polarization power, boiling and melting point) and chemical properties (reactivity towards water, oxygen, air and moisture, hydrogen, halogens, ammonia). Diagonal relationship, catenation, inert pair effect, pπ- pπ, dπ-pπ bond, chemistry of hydrides, halides, oxides and oxyacids of p-block elements. Silicates, Boron nitrogen compounds (borazene and boron nitrides), interhalogen compounds, basic property of iodine.	**10**

3	**Aliphatic Compounds:** Chemical reactions of alkanes. Mechanism of free radical halogenation of alkanes. Cycloalkanes- Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings. The case of cyclopropane ring-bent or banana bonds. Chemical reactions of alkenes- mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's Rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$, Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal- ammonia reduction, oxidation and polymerization.	**10**
4	**Aromatic Compounds:** Aromaticity- the Hückel rule, aromatic ions. Aromatic electrophilic substitution- general pattern of the mechanism, role of σ and π complexes. Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel- Crafts reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio. Side chain reactions of benzene derivatives.	**10**
5	**Chemical Kinetics and Catalysis:** Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction– concentration, temperature, pressure, solvent, light, catalyst; hetero and homocatalysis, significance. Inhibitors, poisons and promoters. Concentration dependence of rates of simple reaction, Molecularity, Order of reaction- zero order, first order, second order, pseudo-order, Radioactive decay a first order phenomenon, half-life period, Methods of determination of the order of reaction- differential method, method of integration, method of half-life period and isolation methods, Numerical problems.	**10**
6	**Thermodynamics I:** Definition of thermodynamic terms, system, surroundings etc. Types of thermodynamic systems and thermodynamic processes. Intensive and extensive properties. Concept of heat and work, first law of thermodynamics, definition of internal energy and enthalpy. Heat capacity – heat capacities at constant volume and at constant pressure and their relationship, calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and reversible conditions. Thermochemistry; standard state, Standard enthalpy of formation – Hess's law of heat summation and its application. Temperature dependence of enthalpy, Kirchoff's equation, Numerical problems.	**10**

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. First Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**
v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.
ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.
x. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
xi. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
xii. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
xiii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
xiv. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.
xvii. Bariyar, A., Singh, R.P. and Dwivedi, A., "Text Book for B. Sc. Chemistry I", Anu Books, 2019.

Suggested online links:

1. https://www.youtube.com/watch?v=Gg4-go6tTiA&list=PLmxSS9XYst208kJs0npO_v_L-AGkHZJlS
2. https://www.youtube.com/watch?v=sz17_NnMPak&t=51s
3. https://www.youtube.com/channel/UCUxhnr9H2IYKsuRypG0MAfw/videos
4. https://onlinecourses.swayam2.ac.in/nce19_sc15/preview
5. https://www.openlearning.com/courses/introduction-to-physical-chemistry/?cl=1
6. https://www.careers360.com/university/indian-institute-of-technology-bombay/chemistry-of-main-group-elements-certification-course
7. https://onlinecourses.swayam2.ac.in/cec20_lb01/preview
8. https://nptel.ac.in/courses/104/103/104103071/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-I, Theory paper-1

Suggested equivalent online courses:
Further Suggestions: ……………………………

Semester-II, Paper-II (Practical)
Course Title: Chemical Analysis -II

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** Second
		Paper-2 Practical Subject: Chemistry
Course Code:		Course Title: Chemical Analysis –II

Course outcomes:
After completing this course, the students will be able to quantitatively find out the amount of acid or base in the samples, to qualitatively differentiate among different classes of organic compounds and to measure the relative viscosity of a given liquid.

Credits:2	**Compulsory**
Max. Marks: 12+38	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Laboratory hazards and safety precautions	**6**
2	**Inorganic exercise:** Acid-base titrations; preparation of a solution in normal/molar terms, its standardization using a primary standard solution, determination of the strength of unknown solution. For example: preparation of NaOH solution (secondary standard say N/10), preparation of $(COOH)_2$ solution (primary standard say N/10), standardization of NaOH solution titrating it against $(COOH)_2$ solution using phenolphthalein (indicator) and then determination of the strength of given HCl solution.	**18**

3	**Organic exercise:** Differentiation between alkanes, alkenes and alkynes. Differentiation between aliphatic and aromatic compounds using chemical and physical tests.	**18**
4	**Physical exercise:** Determination of relative viscosity of the given liquid using Ostwald viscometer.	**18**

Suggested Readings:

i. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
ii. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
iii. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
iv. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
v. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
vi. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
vii. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
viii. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	06 marks
Viva voce/Record and overall performance	06 marks

Course prerequisites: To study this course, a student must have opted Semester-II Theory Paper-I

Suggested equivalent online courses:
Further Suggestions: ……………………………
One exercise each from volumetric analysis (acid-base titration), organic exercise (tests for alkanes, alkenes, alkynes, aliphatic and aromatic compounds) and physical exercise (relative viscosity) shall be given in the examination.

Distribution of marks shall be as given below:

1.	Inorganic exercise	12
2.	Organic exercise	11
3.	Physical	10
4.	Viva	05

5. Home assignment/internal assessment, lab record and attendance 12

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 04 (four) hours.***
- ***Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital***

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Diploma in Chemical Science					
2	**III**		General Chemistry-I	Theory	4
			Analytical Procedures-I	Practical	2
2	**IV**		General Chemistry-II	Theory	4
			Analytical Procedures-II	Practical	2

Semester-III
Paper-I (Theory)
Course Title: General Chemistry-I

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Third
Paper-I Theory Subject: Chemistry		
Course Code:	**Course Title:** General Chemistry-II	

Course outcomes: This paper provides detailed knowledge of synthesis of various classes of organic compounds and functional groups inter conversion. Organic synthesis is the most important branch of organic chemistry which provides jobs in production & QC departments related to chemicals, drugs, medicines, FMCG etc. industries.

- ✓ It relates and gives an analytical aptitude for synthesizing various industrially important compounds.
- ✓ This paper also provides a detailed knowledge on the elements present in our surroundings, their occurrence in nature. Their position in periodic table, their physical and chemical properties. This paper also gives detailed understanding of the d-block elements and their characteristics.

- ✓ After successful completion of this course, the students will be able to gather the information regarding Werner's theory and VBT of transition metal complexes.
- ✓ Students will be able to learn the basic concepts of spontaneity, chemical and phase equilibrium and able to apply these concepts in predicting the spontaneous reactions and will be able to solve the numerical problems based on these concepts.

Credit: 4	**Compulsory**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Hours- = 60	

Unit	Contents	Number of Hours
1	**Chemistry of Transition Elements (First, second and third Transition Series):** Characteristic properties of the elements; electronic configuration, atomic & ionic radii, oxidation states and stability of uncommon oxidation states, ionization energy, boiling & melting points, complex compound formation, colour, catalytic properties and magnetic properties. coordination number and geometry. Comparative treatment of 3d, 4d and 5d elements and their analogues in respect of occurrence, atomic & ionic radii, oxidation state, ionization energy, complex formation tendency, magnetic behaviour, geometry and colour.	10
2	**Coordination Chemistry-I:** Definition, terminology (ligand, coordination number, coordination sphere, complex ion etc.), Nomenclature of coordination compounds (IUPAC system), Werner's theory for coordination compounds; its experimental verification, effective atomic number (EAN) concept, 18-electron rule, stability of complexes and factors contributing to the stability. Chelates- Introduction, factors affecting the stability of chelates, thermodynamic origin of stability, applications. Valence Bond Theory (VBT) for coordination compounds, geometry of complexes (tetrahedral, octahedral, square planar), magnetic properties of complex compounds.	10
3	**Halides:** Chemical reactions. Alkyl, aryl and vinyl halides. Mechanism of nucleophilic substitution reactions, S_N2 and S_N1 reactions with energy profile diagrams.	8
4	**Alcohols and Phenols:** Alcohols: Reactions of alcohols. Dihydric alcohols-methods of preparation, chemical reactions of vicinal glycols, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacol-pinacolone rearrangement. Trihydric alcohols-methods of formation, chemical reactions of glycerol.	12

	Phenols: Physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols-electrophilic aromatic substitution, acylation and carboxylation. Mechanism of Fries rearrangement, Claisen condensation, Gatterman synthesis, Houben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.	
5	**Thermodynamics II:** Second law of thermodynamics, need of the law, different statements of the law. Carnot cycle and its efficiency, Carnot theorem. Thermodynamic scale of temperature. Concept of entropy: entropy as a state function, entropy as a function of V and T, entropy as a function of P and T, entropy change in physical and chemical processes, entropy change for reversible, irreversible and equilibrium condition. Clausius inequality, entropy as criteria of spontaneity and equilibrium. Entropy change in ideal gases. Gibbs free energy and Helmholtz work functions. Criteria for thermodynamic equilibrium and spontaneity, advantage Gibbs free energy and Helmholtz work functions over entropy change for spontaneity. Variation of G and A with P, V and T, Gibbs-Helmholtz equation, Numerical problems.	12
6	**Chemical Equilibrium:** The law of mass action, free energy and equilibrium constant, factors influencing equilibrium constant, relationship between Kp and Kc. Le-Chatelier's principle, Numerical problems. **Phase Equilibrium:** Statement and meaning of the terms: phase, component and degree of freedom, Gibbs phase rule, phase equilibria of one component systems- water, carbon dioxide and sulphur. Raoult's and Henry's law.	8

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.

vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.

vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

viii. Eliel, E.L. and Wilen, S.H., “Stereochemistry of Organic Compounds”, Willey, 1994,1st edition.
ix. Boyd, Morrison and Bhattacharjee, “Organic Chemistry”, Pearson Education India, 2010, 7th edition.
x. Mukerji, S.M., “Reaction mechanism in Organic Chemistry”, Laxmi Publications, 2007, 3rd edition.
xi. Singh, Jagdamba and Yadav, L.D.S., “Undergraduate Organic Chemistry” Pragati Prakashan, India, 2011, Vol 1.
xii. Loudon, G. Marc, “Organic Chemistry”, Oxford University Press, 2008, 4th edition.
xiii. Atkins P.W., “Atkin’s Physical Chemistry: International”, Oxford University Press, 2018, 11th edition.
xiv. Ball D.W., “Physical Chemistry”, Cengage India Private Limited, 2017, 2nd edition.
xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., “Principles of Physical Chemistry”, Vishal Publishing, India, 2020, 47th edition.
xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., “Essential of Physical Chemistry”, S. Chand Publishing, India, 2010.

Suggested online links:

1. https://www.youtube.com/watch?v=Fmclk9oUkEE&list=PLmxSS9XYst20Pz1SpRl4jdcrv-zh1AoYy
2. https://www.youtube.com/watch?v=y67STFWoQ3A&list=PLmUlqVgZsTVV9zQAF-umZzs65MzOU8Ty9
3. https://www.youtube.com/watch?v=xo2sRayaVyc&list=PLmUlqVgZsTVUAEThwJsJw_WPE87_yfhCO
4. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
5. https://nptel.ac.in/courses/104/103/104103071/#
6. https://swayam.gov.in/
7. https://nptel.ac.in/courses/104/103/104103071/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Certificate Course in Introductory Chemistry.

Suggested equivalent online courses:
Further Suggestions: ……………………………

Semester-III Paper-II (Practical)
Course Title: Analytical Procedures-I

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Third
Paper-II Practical Subject: Chemistry		
Course Code:	**Course Title:** Analytical Procedures-I	

Course outcomes:
After completing this course, the students will be able to test the inorganic mixtures of acidic and basic radicals in given samples, to qualitatively differentiate between alcohols and phenols and determine the critical solution temperature of partially miscible liquids.

Credits:2	**Compulsory**
Max. Marks: 12+38	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	**6**
2	**Inorganic exercise:** Complete analysis of inorganic mixture including both acid and basic radicals with a special emphasis on the role of common ion effect and solubility product.	**30**
3	**Organic exercise:** Functional group tests for alcohols and phenols. Differentiation between alcohols and phenols using chemical and physical tests.	**12**
4	**Physical exercise:** Determination of critical solution temperature (CST)	**12**

Suggested Readings:

i. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
ii. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wordsworth Publishing Company, Belmont, California, USA, 1988.
iii. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
iv. Harris, D. C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
v. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
vi. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
vii. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
viii. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

Suggestive digital platforms web links
1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	06 marks
Viva voce/Record and overall performance	06 marks

Course prerequisites: To study this course, a student must have opted Sem-III Theory Paper-1

Suggested equivalent online courses:
Further Suggestions: ……………………………

One exercise each from Inorganic mixture (qualitative), organic exercise (tests for alcohols and phenols) and physical exercise (critical solution temperature) shall be given in the examination.

Distribution of marks shall be as given below:

1.	Inorganic exercise	10
2.	Organic exercise	12
3.	Physical exercise	11
4.	Viva	05
5.	Home assignment/internal assessment, lab record and attendance	12

Note:
- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 04 (four) hours.***
- ***Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital***

Semester-IV
Paper-I (Theory)
Course Title: General Chemistry-II

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Fourth

Paper-I Theory Subject: Chemistry	
Course Code:	**Course Title:** General Chemistry-II

Course outcomes: This paper provides detailed knowledge of synthesis of aldehydes, ketones, carboxylic acids and functional groups inter conversion. The students will be able to describe the concepts of electrochemistry in detail and its applications. Also, they will be able to solve the numerical problems based on these concepts. Students will be able to define the acids and bases on the basis of various concepts/ theories and will be able to identify the position of various elements in the periodic table and able to explain their properties on the basis of their position.

Credits: 4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Hours- = 60

Unit	**Contents**	**Number of Hours**
1	**Acids and Bases:** Arrhenius concept, Bronsted-Lowry concept, Lux-Flood and Lewis concept of acids and bases; Hard and Soft Acid-Base Theory: Classification of acids and bases as hard and soft. Pearson's hard and soft acid base concept, acid base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness; Role of the solvent and strength of acids and bases. Acid-base properties in non-aqueous media.	10
2	**Chemistry of Inner Transition Elements:** Chemistry of Lanthanides: Electronic configuration, oxidation states, atomic & ionic radii, lanthanide contraction and its consequences, complex formation, colour; Methods of separation of lanthanides- fractional crystallization, fractional precipitation, change in oxidation state, solvent extraction and ion exchange methods. **Chemistry of Actinides:** General features of actinides-electronic configuration, atomic & ionic radii, ionization potential, oxidation states and complex formation.	10
3	**Aldehydes and Ketones:** Comparative account of properties of aliphatic and aromatic aldehydes and ketones. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensation. Condensation with ammonia and its derivatives; Wittig reaction, Mannich reaction. Use of acetals as protecting group. Oxidation of aldehydes, Baeyer-Villiger oxidation of ketones, Cannizzaro reaction, MPV, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable ketones. An introduction to α-, β-unsaturated aldehydes and ketones.	10
4	**Carboxylic Acids:** Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides.	10

	Reduction of carboxylic acids, mechanism of decarboxylation. Methods of formation and chemical reactions of halo acids, hydroxy acids- malic, tartaric, and citric acids. Methods of preparation and chemical reactions of unsaturated monocarboxylic acids. Dicarboxylic acids-methods of preparation and effect of heat and dehydrating agents.	
5	**Electrochemistry I:** Electrical transport-conduction in metals and electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution. Arrhenius theory of electrolytic dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations, Numerical Problems.	8
6	**Electrochemistry II:** Oxidation state, types of redox reactions, balancing of chemical reactions by ion electron and oxidation state method. Computations of equivalent weights. Types of reversible electrodes-gas-metal ion, metal-metal ion, metal-insoluble salt anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, standard hydrogen electrode-reference electrode, standard electrode potential, sign conventions, electrochemical series and its significance. Electrolytic and Galvanic cells-reversible and irreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurements. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K), Numerical Problems.	12

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.
ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.
iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Second Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**
v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.
vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.
vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
viii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.

ix. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.
x. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
xi. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
xii. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
xiii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
xiv. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
xv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
xvi. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.

Suggested online links:

1. https://www.youtube.com/watch?v=UJgzQ5XP8wQ&list=PLmxSS9XYst20FfphDeS03pqkcuJk0vuvv
2. https://www.youtube.com/watch?v=2G79lCT5Os8&list=PLmxSS9XYst23WTFnTWuRg-Ww0k6foth7e
3. https://www.youtube.com/watch?v=SNXFYz31iFI&list=PLmUlqVgZsTVUfjMBLDQvNLUbF9CIrEsef
4. https://www.youtube.com/watch?v=1t0GDMSzZ9A&list=PLmxSS9XYst21dec_6u2yWWj295Y8pHGrA
5. https://swayam.gov.in/
6. https://www.coursera.org/learn/physical-chemistry
7. https://www.mooc-list.com/tags/physical-chemistry
8. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
9. https://nptel.ac.in/courses/104/103/104103071/

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have had Passed Sem-III Theory Paper-1

Suggested equivalent online courses:

Further Suggestions: ....

Semester-IV Paper-II (Practical)
Course Title: Analytical Procedures-II

Programme/Class: Diploma in Chemical Science	Year: Second	Semester: Fourth
Paper-II Practical Subject: Chemistry		
Course Code:	Course Title: Analytical Procedures-II	

Course outcomes:

After completing this course, the students will be able to determine the concentrations of oxidising and reducing agents through double titration, qualitatively differentiate between aldehydes, ketones and carboxylic acids and determine the solubility of salts.

Credits:2	Compulsory
Max. Marks: 12+38	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	6
2	**Inorganic exercise:** Volumetric exercises (double titration) based on redox reactions involving internal as well as external indicators.	18
3	**Organic exercise:** Preliminary and Functional group tests for aldehydes, ketones and carboxylic acids (both aliphatic and aromatic).	18
4	**Physical exercise:** Determination of solubility of salts.	18

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

1.

Evaluation method	Marks
Attendance	06 marks
Viva voce/Record and overall performance	06 marks

Course prerequisites: To study this course, a student must have Opted Sem-IV Theory Paper-1

Suggested equivalent online courses:
Further Suggestions: ……………………………
One exercise each from inorganic volumetric analysis (quantitative), organic exercise (tests for aldehydes, ketones and carboxylic acids) and physical exercise (solubility of salts) shall be given in the examination.

Distribution of marks shall be as given below:

1.	Inorganic exercise	12
2.	Organic exercise	11
3.	Physical exercise	10
4.	Viva	05
5.	Home assignment/internal assessment, lab record and attendance	12

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 04 (four) hours.***
- ***Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital***

Year	Semester	Course Code	Paper Title	Theory/Practical	Credits
Degree in Bachelor of Science					
3	**V**		Inorganic Chemistry	Theory	4
			Organic Chemistry	Theory	4
			Analytical Procedures-III	Practical	2
3	**VI**		Physical Chemistry	Theory	4
			Analytical Chemistry	Theory	4
			Analytical Procedures-IV	Practical	2

Semester-V
Paper-I (Theory)
Course Title: Inorganic Chemistry

Programme/Class: Degree	**Year:** Third	**Semester:** Fifth

in Bachelor of Science		
		Paper-1 Theory Subject: Chemistry
Course Code:		**Course Title:** Inorganic Chemistry

Course Outcomes: Upon successful completion of this course, the students will be able to describe the stability, crystal field theory, electronic spectra and magnetic properties of coordination compounds. They will also learn about organometallic compounds, some industrially important inorganic materials and their applications in various industries. It will assist them to get a suitable job in the relevant industrial and scientific field.

Credits:4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	**Metal-Ligand Bonding in Transition Metal Complexes:** Limitations of valence bond theory, an elementary idea about crystal field theory (CFT); crystal field splitting of octahedral and tetrahedral complexes, tetragonal distortion (Jahn-Teller distortion, crystal field splitting of square planar and trigonal bipyramidal complexes, factors affecting the crystal-field parameters, calculation of crystal field stabilization energy (CFSE), spectrochemical series. Applications (color and magnetic properties) and limitations CFT. Comparison between VBT and CFT.	10
2	**Thermodynamic and Kinetic Aspects of Coordination Compounds:** Stability of metal complexes- thermodynamic and kinetic stability, stable and unstable complexes, inert and labile complexes, stepwise and overall stability constants, relationship between the stepwise and overall stability constants, factors affecting the thermodynamic and kinetic stabilities of coordination compounds. Chelate effect and its thermodynamic origin. Determination of binary formation constants by pH-metry and spectrophotometry	10
3	**Electronic Spectra of Transition Metal Complexes:** Types of electronic transitions, selection rules for d-d transitions, calculations of spectroscopic ground states (Russell Saunders/L-S coupling), Orgel energy level diagram for d^1, d^4 and d^6, d^9 tetrahedral and octahedral complexes, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.	8
4	**Magnetic Properties of Transition Metal Complexes:** Origin of magnetic behavior, concept of magnetic susceptibility, diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism and antiferromagnetism, magnetic moments, quenching of orbital magnetic moment by crystal field, magnetic susceptibility-definition relationship with temperature, Curie law and Curie Weiss law. methods of determining magnetic susceptibility;	10

	Gouy's and Quincke's methods, magnetic moment, spin only formula, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d metal complexes.	
5	**Organometallic Chemistry:** Definition, nomenclature and classification based on nature of metal-carbon bond. EAN and 18-electron rule. Definition, nomenclature, classification, general methods of preparation of organometallic compounds and a brief account of metal-ethylenic complexes. Applications of organometallic compounds-Ziegler-Natta catalyst, Wilkinson catalyst (No mechanism).	8
6	**Some Industrially Important Inorganic Materials:** Silicones, siloxanes, polymethylhydrosiloxanes, their applications. Phosphazenes, nature of bonding in triphosphazenes. Aluminosilicates- Feldspars, Ultramarines, Zeolites. Clays and Pillared Clays. Cement- manufacture, composition and setting. Glass-manufacture, annealing, types and uses. Ceramics-definition, traditional and new ceramics, structure of ceramics. Inorganic fertilizers-essential nutrients for plants, nitrogenous, phosphatic and potash fertilizers.	14

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

iv. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.

v. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.

vi. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

Suggested online links:

1. https://www.youtube.com/watch?v=0BQ38GEYF7s&list=PLmxSS9XYst22OYcJbKWq66APcEq5pVsL1
2. https://www.youtube.com/watch?v=9oQcm281TT0&list=PLmxSS9XYst20MhuKSMREzLhG4ZBIdNys9

3. https://www.youtube.com/watch?v=WGd4gOncw9s&list=PLmxSS9XYst22CtJwFrXW_VA9kCp7OP0kn
4. https://www.youtube.com/watch?v=R4rPlpWT1cA&list=PLmxSS9XYst21uxf3tsohnDUmTRFrvfVv8
5. https://www.youtube.com/watch?v=3TWLAJuVN0c&list=PLmxSS9XYst23hk5m9-MsHTpbADe1Mx-p8
6. https://www.youtube.com/watch?v=0k4ryWpwhmo&list=PLmxSS9XYst22xP0d02UtcIlgt0GIofvVm
7. https://www.youtube.com/watch?v=0ZBMRjyHWfY&list=PLmxSS9XYst205pTMkWPmDa3lv0s6DFoXM
8. https://www.youtube.com/watch?v=najS_fXL38U&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=6
9. https://www.youtube.com/watch?v=3VoKRgPj7OI&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=8
10. https://www.youtube.com/watch?v=57hQHf1E3PE&list=PLmxSS9XYst23yE3f2Kqsir4lQ1dTmofFv&index=7
11. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cy19/
12. https://onlinecourses.nptel.ac.in/noc22_cy02/preview
13. https://nptel.ac.in/courses/104/105/104105033/
14. https://nptel.ac.in/courses/104/101/104101079/
15. https://onlinecourses.nptel.ac.in/noc21_cy12/preview
16. https://nptel.ac.in/courses/104/108/104108062/
17. https://onlinecourses.nptel.ac.in/noc21_cy36/preview
18. https://onlinecourses.nptel.ac.in/noc22_cy05/preview
19. https://nptel.ac.in/courses/104/105/104105033/
20. https://www.york.ac.uk/media/chemistry/research/douthwaite/Metal-Ligand%20bonding%20and%20Inorganic%20reaction%20mechanisms.pdf
21. https://nptel.ac.in/courses/104/106/104106089/
22. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000658/M014009/ET/1456899566CHE_P3_M5_etext.pdf
23. http://ddugu.ac.in/epathshala_content1.aspx
24. https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf
25. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/07.inorganic_chemistry-ii/31.magnetic_properties_of_transition_metal_ions/et/6388_et_che p7_m31_e-text.pdf
26. https://egyankosh.ac.in/bitstream/123456789/15794/1/Unit-7.pd
27. https://www.hhrc.ac.in/ePortal/Chemistry/IImscchem-18pche3-unit1-sv.pdf
28. http://www.du.edu.eg/upFilesCenter/sci/1596861612.pdf
29. https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf
30. https://nptel.ac.in/courses/104/105/104105103/
31. https://www.uou.ac.in/sites/default/files/slm/BSCCH-301.pdf
32. https://nptel.ac.in/content/storage2/courses/103107086/module1/lecture1/lecture1.pdf
33. https://nptel.ac.in/content/storage2/courses/103107086/module4/lecture1/lecture1.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-III and Sem-IV Theory papers.
Suggested equivalent online courses:

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Further Suggestions: ……………………………

Semester-V
Paper-II (Theory)
Course Title: Organic Chemistry

Programme/Class: Degree in Bachelor of Science	**Year:** Third	**Semester:** Fifth
		Paper-II Theory Subject: Chemistry
Course Code:		**Course Title:** Organic Chemistry

Course Outcomes: Upon successful completion of this course, the students should be able to describe the chemistry of nitrogen containing compounds, the basic understanding of the chemistry of industrially important materials such as lipids, fats, soaps, detergents, dyes, paints and reagents in organic synthesis. Upon completion of this course students may get job opportunities in food, soap, detergent, paint and other organic material based synthetic labs and industries. Biomolecules are important for the functioning of living organisms. These molecules perform or trigger important biochemical reactions in living organisms. When studying biomolecules, one can understand the physiological function that regulates the proper growth and development of a human body. This course aims to introduce the students with basic experimental understanding of carbohydrates and proteins.

Credits:4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	**Lipids and Fats:** Lipids-Definition, categories, biological	12

	functions, metabolism, nutrition and health, tests, examples. Fats-Definition, biological importance, metabolism, digestion and it's metabolism. Soaps, Detergents and their action mechanism**.**	
2	**Reagents in Organic Synthesis:** Reagent compounds, types of reagents, acetylene, ammonia, Bayer's reagent, NBS, n-butyl lithium, CAN, chromic acid, chromium trioxide, diborane, DMSO, dioxane, Fehling reagent, Grignard reagent, hydrazide, hydrogen peroxide, LAH, OsO_4, PCl_5, potassium dichromate, potassium permanganate, Raney Ni, silver nitrate, sodium borohydride, NaH, THF, TMS, $SOCl_2$, Tollen's reagent.	12
3	**Nitrogen Containing Organic Compounds:** Chemical reactions of nitroalkanes. Mechanism of nucleophilic substitution in nitroarenes and their reduction in acidic, neutral and alkaline medium. Picric acid. Halo nitroarenes-reactivity, structure and nomenclature of amines. Physical properties. Separation of mixture of primary, secondary and tertiary amines. Structural features affecting basicity of amines. Amine salts as phase-transfer catalysts. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Gabriel-phthalimide reaction, Hofmann bromamide reaction. Reaction of amines, electrophilic aromatic substitution in aryl amines, reaction of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.	14
4	**Organometallic Compounds:** Organ magnesium compounds; the Grignard reagent-formation, structure and chemical reactions. Organozinc compounds; formation and chemical reactions.	10
5	**Dyes and Paints:** Color and constitution, types of dyes, Alizarin, Indigo, Congo red, Malachite green, Methylene blue, Phenolphthalein, Methyl orange. Paints and Varnishes: Definition, components, chemistry, applications.	10
6	**Carbohydrates and Proteins:** Carbohydrates: Classification and nomenclature. Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Cyclic structure of D(+)-glucose. Mechanism of mutarotation. General study of disaccharides. **Proteins**: Classification, structure and stereochemistry of amino acids. Acid-base behavior, isoelectric point and electrophoresis. Classification of proteins.	12

Books Recommended:

i. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.
ii. Eliel, E.L. and Wilen, S.H., "Stereochemistry of Organic Compounds", Willey, 1994,1st edition.
iii. Boyd, Morrison and Bhattacharjee, "Organic Chemistry", Pearson Education India, 2010, 7th edition.
iv. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.
v. Singh, Jagdamba and Yadav, L.D.S., "Undergraduate Organic Chemistry" Pragati Prakashan, India, 2011, Vol 1.
vi. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.
vii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
viii. Bahl, A. and Bahl, B.S. a "Advance Organic Chemistry", S. Chand Publishing, India, 2010.

Suggested online links:

1. https://www.youtube.com/watch?v=xBNv80Dg6nI&list=PLmUlqVgZsTVUk5NkroUmYXvbterBXbk_J
2. https://www.youtube.com/watch?v=UgbaIFI_q6E
3. https://www.youtube.com/watch?v=tz0BrCqPTV0&t=15s
4. https://www.youtube.com/watch?v=2sHlLNzTpUU&t=4s
5. https://www.youtube.com/watch?v=ALaTCbetFSg&t=210s
6. https://www.youtube.com/watch?v=kruIzuor5v8
7. https://www.youtube.com/watch?v=IuERNLx-J7k&t=19s
8. https://www.youtube.com/watch?v=RW7KlYbpNxk&t=1414s
9. https://www.youtube.com/watch?v=LcUoeFe0iN8
10. https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm
11. https://nptel.ac.in/courses/104/103/104103111/
12. https://nptel.ac.in/courses/104/103/104103071/
13. https://onlinecourses.nptel.ac.in/noc19_cy24/preview
14. https://nptel.ac.in/content/storage2/courses/104103071/pdf/mod10.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-III and Sem-IV Theory papers.

Further Suggestions: ……………………………

Semester-V, Paper-III (Practical)

Course Title: Analytical Procedures-III

Programme/Class: Certificate in Introductory/General Chemistry	**Year:** Third	**Semester:** Fifth
Paper-III Practical Subject: Chemistry		
Course Code:	**Course Title:** Analytical Procedures-III	

Course outcomes:

Upon completion of this course, the students will have the knowledge and skills to understand the synthetic methods related to inorganic and organic fields. Also, they can easily analyze the nitrogen containing compounds and separate the binary organic mixture.

Credits:2	**Compulsory**
Max. Marks: 12+38	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Laboratory hazards and safety precautions	**6**
2	**Inorganic exercise:** Inorganic synthesis – cuprous chloride, potash alum, chrome alum, ferrous oxalate, ferrous ammonium sulphate, tetraamminecopper(II) sulphate and hexaamminenickel(II) chloride. Crystallization of compounds.	**14**
3	**Organic exercise:** **Organic qualitative analysis:** Analysis of Nitrogen containing organic compounds (detection of elements, amines, nitro, amides and anilides) Binary mixture of organic compounds separable by water **Organic synthesis:** through nitration, halogenation, acetylation, sulphonation and simple oxidation	**40**

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	06 marks
Viva voce/Record and overall performance	06 marks

Course prerequisites: To study this course, a student must have opted Sem-V Theory Paper-1 &2

Suggested equivalent online courses:

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Further Suggestions: ……………………………

One exercise each from inorganic synthesis, organic qualitative analysis and organic synthesis shall be given in the examination.

Distribution of marks shall be as given below:

1.	Inorganic exercise	10
2.	Organic exercise	23
3.	Viva	05
4.	Home assignment/internal assessment, lab record and attendance	12

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 05(five) hours.***
- ***Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital***

Semester-VI
Paper-I (Theory)
Course Title: Physical Chemistry

Programme/Class: Degree in Bachelor of Science	**Year:** Third	**Semester:** Sixth
		Paper-I Theory Subject: Chemistry
Course Code:		**Course Title:** Physical Chemistry

Course outcomes: The core concepts of Physical Chemistry have been included in this semester with a view that students' command over these topics will help them to understand the higher chemistry in PG classes. Their understanding of Photochemistry and Solutions will help him to explain the day today phenomenon of the relevant filed whereas. Thermodynamics will help them to understand the natural flow of energy. Learning the Quantum Mechanics will help them to praise the beauty of behavior of fundamental particles. It will assist them to get a suitable job in the relevant industrial and scientific field.

Credits:4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	**Surface Chemistry:** Definition of surface phenomenon-Adsorption. Chemical and physical adsorption, Factors affecting adsorption. Isotherm and Isobar. Free energy of adsorption. Quantitative treatment of adsorption, Freundlich's and Langmuir's adsorption model and their applications. Limitation of Langmuir adsorption model. Adsorption in catalysis, characteristics of catalyzed reactions.	10
2	**Elementary Quantum Mechanics:** Black-body radiation, Plank's radiation law, photoelectric effect, Bohr's model of hydrogen atom (no derivation) and its defects. Compton effect, de Broglie hypothesis, Heisenberg's uncertainty principle, operator concept, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, Numerical Problems.	12
3	**Photochemistry:** Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry; Grothuss-Drapper law, Lambert's law, Lambert-Beer's law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, Numerical Problems.	10

4	**Solutions and Colligative Properties:** Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solutions, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular mass determination. Osmosis, law of osmotic pressure, determination of molecular mass from osmotic pressure. Elevation of boiling point and depression in freezing point, Numerical Problems.	10
5	**Thermodynamics III:** Statement and concept of residual entropy, third law of thermodynamics, unattainability of absolute zero, Nernst heat theorem. Evaluation of absolute entropy from heat capacity data, Numerical Problems	8
6	**Radioactivity:** Definition, nature of radioactivity, emission, types of radioactively, occurrence, Energetics and kinetics radioactivity, rates of radioactive transitions, Applications of radioactivity, Numerical Problems.	10

Books Recommended:

i. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.
ii. Atkins P.W., "Atkin's Physical Chemistry: International", Oxford University Press, 2018, 11th edition.
iii. Ball D.W., "Physical Chemistry", Cengage India Private Limited, 2017, 2nd edition.
iv. Puri, B.R., Pathania, M.S. and Sharma, L.R., "Principles of Physical Chemistry", Vishal Publishing, India, 2020, 47th edition.
v. Bahl, A., Bahl, B.S. and Tuli, G.D., "Essential of Physical Chemistry", S. Chand Publishing, India, 2010.
vi. Atkins, P. and de Paula, J. (2005).Physical Chemistry: 7th edition. Oxford University Press.
vii. Moore, W.J. (1976). Physical Chemistry: 5th edition. Orient Longman Limited.
viii. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern.
viii. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
ix. Introduction to Quantum Chemistry, A. K. Chandra, Tata McGraw Hill

Suggested online links:

1. https://www.youtube.com/watch?v=CMYg3ElZwDY
2. https://www.youtube.com/watch?v=01dY_lLWdMA&t=4s
3. https://onlinecourses.nptel.ac.in/noc20_cy27/preview
4. https://onlinecourses.nptel.ac.in/noc21_cy20/preview
5. https://www.classcentral.com/course/swayam-chemistry-i-introduction-to-quantum-chemistry-and-molecular-spectroscopy-3981
6. https://www.classcentral.com/course/swayam-quantum-chemistry-of-atoms-and-molecules-19982

7. https://nptel.ac.in/courses/104/108/104108057/
8. https://nptel.ac.in/courses/115/101/115101107/
9. https://nptel.ac.in/courses/104/101/104101124/
10. https://nptel.ac.in/courses/104/105/104105128/
11. https://www.classcentral.com/course/swayam-concepts-of-thermodynamics-13015
12. https://onlinecourses.nptel.ac.in/noc20_me20/preview
13. https://www.careers360.com/university/indian-institute-of-technology-kharagpur/concepts-of-thermodynamics-certification-course
14. https://www.coursera.org/learn/thermodynamics-intro
15. https://onlinecourses.nptel.ac.in/noc22_cy14/preview
16. https://onlinecourses.nptel.ac.in/noc20_cy22/preview
17. https://onlinecourses.nptel.ac.in/noc21_cy45/preview
18. https://onlinecourses.nptel.ac.in/noc21_ch48/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have passed Sem-VTheory papers**.**

Suggested equivalent online courses:
Further Suggestions: ……………………………

Semester-VI
Paper-II (Theory)
Course Title: Analytical Chemistry

Programme/Class: Degree in Bachelor of Science	**Year:** Third	**Semester:** Sixth
		Paper-II Theory Subject: Chemistry
Course Code:		**Course Title:** Analytical Chemistry

Course outcomes: After completion of this course, the students will be able to understand the chemistry of biomolecules. They will become acquainted in the field of data analysis. The new frontiers of chemistry such as nano-chemistry and green chemistry are the part of syllabi of this course which boost the knowledge of the students in these fields. The chemistry of industrially important inorganic materials such as cement, ceramics, glass and inorganic fertilizers has been incorporated in the course to enhance the skills and capability of the students pursuing this course. The students will also able to understand the analytical techniques such as electro-gravimetric analysis, coulometric analysis, thermogravimetry, polarography and chromatography.

- ✓ Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- ✓ Students will be able to function as a member of an interdisciplinary problem solving team.
- ✓ Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- ✓ Students will gain an understanding of how to determine the structure of organic molecules using UV, IR and NMR spectroscopic techniques.

Credits:4	**Compulsory**
Max. Marks: 25+75	Min. Passing Marks…

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	**General Biochemistry:** Introduction to biomolecules, Enzymes; Definition, classification, role in physiology. General introduction to hormones. Nucleic acids; Nitrogen bases, purines, pyrimidines, nucleosides, nucleotides, structure of RNA and DNA molecule.	12
2	**Data Analysis:** Errors; Definition, types of errors, precision, accuracy, absolute, Significant Figures; significant figures in Arithmatics-addition, subtraction, multiplication and division, Mean and Standard deviation, Standard deviation and probability.	10
3	**Fundamentals of Nanochemistry:** Definition, brief history, classification, general approach of nano synthesis, general methods of characterization, general applications.	9
4	**Basics of Green Chemistry:** Introduction, role of green chemistry in sustainable development, principles of green chemistry.	8
5	**Analytical Techniques:** Basic concepts of electro-gravimetric and coulometric analysis. Thermogravimetric analysis. Voltametry; principle of polarography Chromatography: Introduction, Types, paper and column chromatography	9
6	**Spectroscopy:** Ultraviolet (UV) absorption spectroscopy-absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation, concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.	12

	Infra-Red (IR) absorption spectroscopy- molecular vibrations, Hooke's Law, selection rules, intensity and position of IR bands, measurement of IR spectrum, finger print region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds. Nuclear magnetic resonance (NMR) spectroscopy; Proton magnetic resonance (^1H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of ^1H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone, Problems pertaining to the structure elucidation of simple organic compounds using UV, IR and ^1H NMR spectroscopic techniques	

Books Recommended:

i. Clark, J. H., and Macquarrie, D.J., Handbook of Green Chemistry and Technology, Wiley-Blackwell, 2002.
ii. Anastas, P.T., and Williamson, T.C. Green Chemistry: Frontiers in Benign Chemical Syntheses and Processes, Oxford University Press, New York, 1999.
iii. Ozin, G.A., Arsenault, A.C. and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, 2008, 2nd edition.
iv. P. H. Raven, Biology, Tata MacGraw Hill.
v. P. Sheeler, Cell and Molecular Biology, John Wiley.
vi. N. A. Campbell, Biology Pearson.
vii. L. Styer, Biochemistry, Freeman & Co.
viii. Outlines of biochemistry. Fourth edition (Conn, Eric E.; Stumpf, P. K.). Wiley India Pvt. Limited

Suggested online links:

1. https://www.youtube.com/watch?v=qJMJUtqVUVw
2. https://www.youtube.com/watch?v=58pAYgrZjF0&t=26s
3. https://onlinecourses.nptel.ac.in/noc19_mm21/preview
4. https://www.classcentral.com/course/swayam-introduction-to-data-analytics-3973
5. https://onlinecourses.nptel.ac.in/noc21_cy26/preview
6. https://www.classcentral.com/course/swayam-biochemistry-5229
7. https://onlinecourses.nptel.ac.in/noc19_cy18/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks

Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	05 marks

Course prerequisites: To study this course, a student must have passed Sem-V Theory papers**.**

Suggested equivalent online courses:
Further Suggestions: ……………………………

Semester-VI, Paper-III (Practical)

Course Title: Analytical Procedures-IV

Programme/Class: Certificate in Introductory/General Chemistry	Year: Third	Semester: Sixth
		Paper-III Practical Subject: Chemistry
Course Code:		**Course Title:** Analytical Procedures-IV

Course outcomes: Upon completion of this course, the students will have the knowledge and skills to determine the heat of neutralization, solubility of organic compounds by titration method. They will be able to estimate different metal ions through gravimetric exercise. Spectroscopic and chromatographic exercise will train them to interpret the spectral data and chromatograms of organic compounds and will make them job ready for suitable industries.

Credits:2	**Compulsory**
Max. Marks: 12+38	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Laboratory hazards and safety precautions	**6**
2	**Physical exercise:** Determination of solubility of organic compound (viz. oxalic acid) in water by titration method. Determination of Heat of neutralization.	**18**
3	**Spectroscopic exercise:** Functional Group determination by UV and IR Spectroscopy; analysis of organic compounds including alcohols, phenols, carboxylic acids, carbonyl compounds, nitrogen containing compounds.	**18**
4	**Inorganic Exercise:** Gravimetric analysis of any one or two metal ions; Ba^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+} etc.	**10**
5	**Chromatographic technique:**	**8**

	Demonstrative Chromatography- paper chromatography (Analytical separation of organic compounds- Amino acids/ dyes)	

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in viva voce, record and overall performance.

Evaluation method	Marks
Attendance	06 marks
Viva voce/Record and overall performance	06 marks

Course prerequisites: To study this course, a student must have opted Sem-VI Theory Paper-1 &2

Further Suggestions: ……………………………

One exercise each from inorganic analysis (quantitative), Spectroscopy/ Chromatography and physical exercise shall be given in the examination.

Distribution of marks shall be as given below:

1.	Inorganic exercise	13
2.	Spectroscopy/ Chromatography	10
3.	Physical exercise	10
4.	Viva	05
5.	Home assignment/internal assessment, lab record and attendance	12

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 05(five) hours.***
- ***Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital***

Minor/Elective courses

Semester-I/II
Paper-I (Theory)
Course Title: Basics of Analytical Chemistry-I

Programme/Class: Certificate in Introductory	**Year:** First	**Semester:** First/Second

Chemistry		
Paper-ITheory Subject: Chemistry		
Course Code:	**Course Title:** Basics of Analytical Chemistry-I	

Course outcomes: Upon completion of this course, the students will able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	**Analytical approaches:** Types of errors, precision & accuracy, absolute and relative uncertainty. Significant figures; significant figures in Arithmatics-addition, subtraction, multiplication and division. Mean and standard deviation.	12
2	**Laboratory Apparatus:** Laboratory burner; Bunsen burner, air flow regulation, obtaining warm gentle flame with the burner, hottest flame of the burner. Cutting and bending of glass tubing/glass rod, fire polishing of glass tubing or rod.	12
3	**Steps in Chemical Analysis:** Sampling, sample preparation, analysis, interpretation and preparation of report.	8
4	**Use of Measuring Equipments:** Pipette, burette, chemical balance, least count.	8
5	**Chemical Concentration:** Normality, morality, preparation of solution of defined normality/molarity of a given compound and from a given solution of different strength, percent composition, part per million (ppm), part per billion (ppb), calculations.	12
6	**Titration:** Types of titrations, end point, equivalence point, Indicators-types and theory.	8

Recommended Texts:

i. Nivaldo, J. and Tro, Ho Yu Au-Yeung, Introductory Chemistry, Pearson India Education, 2017, 5th edition.
ii. Timberlake, K. C., and Timberlake, W., Basic Chemistry, Pearson India Education, 2017, 4th edition.
iii. Pavia, D.L., Lampman, G. M., Kriz, G. S, and Engel, R.G., Microscale and Macroscale Techniques in the Organic Laboratory, Harcourt College Publishers, 2001, 1st edition.
iv. Harris, D. C., Exploring Chemical Analysis, W. H. Freeman and Company, New York, 1993, 4th edition.
v. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman and Company, New York, 2010, 8th edition.

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/

2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have had the chemistry in class 12^{th}

Suggested equivalent online courses:

Further Suggestions: ……………………………

Semester-I/II
Paper-II (Theory)
Course Title: Basics of Analytical Chemistry-II

Programme/Class: Certificate in Introductory Chemistry	**Year:** First	**Semester:** First/Second
		Paper-II Theory Subject: Chemistry
Course Code:	**Course Title:** Basics of Analytical Chemistry-II	

Course outcomes: Upon completion of this course, the students will able to understand the analytical principles behind polarimetry, refractometry, distillation, crystallization and extraction. Further, the students will able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments, at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program.

Credits:4	**Elective**
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

S. No.	**Contents**	**Contact Hours/ Hours**

1	**Physical Constants:** Melting points, melting point theory, mixture melting point, packing of melting point tube, Determination of melting point; decomposition, discoloration, softening, shrinking and sublimation. Boiling point, determination of boiling point, use of boiling chips, calibration of thermometer.	12
2	**Polarimetry and Refractometry:** Polarimetry: Nature of polarized light, polarimeter, sample cells, operation of the polarimeter, optical purity. Refractometry: Refractometry; The refractive index, Refractometer.	12
3	**Electromagnetic Radiation:** Properties, absorption of light, transmittance, absorbance and Beer's Law. Spectrophotometer-Single beam and double beam instruments.	8
4	**Distillation:** Simple distillation, distillation theory, fractional distillation, difference between simple and fractional distillation, vapour-liquid composition diagram, Raoult's Law, types of fractionating columns, column efficiency, azeotropes.	10
5	**Crystallization and Filtration:** Filtration-Selection of suitable solvent/s, purification of compounds. Filtration-Gravity filtration, filter papers, vacuum filtration, aspirator, working of aspirator.	10
6	**Solubility and Extraction:** Solubility-Definition, predicting solubility behaviour, water as a solvent, organic solvents. Extraction-Theory, distribution coefficient, separation and drying agents.	8

Recommended Texts:

i. Nivaldo, J. and Tro, Ho Yu Au-Yeung, Introductory Chemistry, Pearson India Education, 2017, 5th edition.
ii. Timberlake, K. C., and Timberlake, W., Basic Chemistry, Pearson India Education, 2017, 4th edition.
iii. Pavia, D.L., Lampman, G. M., Kriz, G. S, and Engel, R.G., Microscale and Macroscale Techniques in the Organic Laboratory, Harcourt College Publishers, 2001, 1st edition.
iv. Harris, D. C., Exploring Chemical Analysis, W. H. Freeman and Company, New York, 1993, 4th edition.
v. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman and Company, New York, 2010, 8th edition.

Suggestive digital platforms web links

1. https://www.labster.com/chemistry-virtual-labs/
2. https://www.vlab.co.in/broad-area-chemical-sciences
3. http://chemcollective.org/vlabs
4. https://onlinecourses.swayam2.ac.in/ugc19_bt16/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities)	05 marks
Attendance	05 marks

Course prerequisites: To study this course, a student must have studied the chemistry of class 12^{th} standard

Suggested equivalent online courses:

Further Suggestions: ……………………………

Semester-III/IV
Paper-I (Theory)
Course Title: Chemistry of d-Block Elements, Quantum Chemistry and Spectroscopy

Programme/Class: Diploma in Chemical Science	Year: Second	Semester: Third/Four
		Paper-I Theory Subject: Chemistry
Course Code:	**Course Title: Chemistry of d-Block Elements, Quantum Chemistry and Spectroscopy**	

Course outcomes: After completion of this course, the students will be able to understand the chemistry of d- and f-block elements, coordination compounds, quantum mechanical aspects of spectroscopy. The students will also able to understand principles and applications of spectroscopic techniques and photochemistry.

Credits:4	**Elective**
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	**Transition Metal Elements:** Introduction to transition metals. Transition and inner transition elements. Chemistry and trends of properties (Ability to form complexes, stability, variable oxidation states) of d-block and f-block elements. Applications.	12
2	**Coordination Compounds:** Introduction, isomerism, IUPAC system of nomenclature, VBT, CFT, distortions in coordination	14

	compounds.	
3	**Quantum Mechanical Approach:** Quantum mechanical background behind molecular characterization. Quantum mechanical approach for molecular spectroscopy. Interaction between matter and electromagnetic radiation-wave-particle duality, particle in 1-D box, normalization of wave functions, Born-Oppenheimer approximation.	16
4	**Spectroscopy:** Principle and Applications. Microwave spectroscopy- Rotational and Vibrational spectra, Infrared Spectroscopy, Electronic spectroscopy,	10
5	**Photochemistry:** Introduction of photochemistry, Principle and Applications of photochemistry.	8

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.

vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.

vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

viii. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.

ix. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.

x. Clark, J. H., and Macquarrie, D.J., Handbook of Green Chemistry and Technology, Wiley-Blackwell, 2002.

xi. Anastas, P.T., and Williamson, T.C. Green Chemistry: Frontiers in Benign Chemical Syntheses and Processes, Oxford University Press, New York, 1999.

xii. Ozin, G.A., Arsenault, A.C. and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, 2008, 2nd edition.

Suggested online links:

1. https://onlinecourses.nptel.ac.in/noc22_cy23/preview

2. https://www.swayamprabha.gov.in/asset/new_team/images/course_files/ch-15/S21%20QUANTUM%20MECHANICS%20AND%20MOLECULAR%20SPECTROSCOPY.pdf
3. https://onlinecourses.nptel.ac.in/noc19_cy19/preview
4. https://www.classcentral.com/course/swayam-transition-metal-organometallic-chemistry-principles-to-applications-10047
5. https://www.swayamprabha.gov.in/index.php/program_data/flipMore/S13/15

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities)	05 marks
Attendance	05 marks

Course prerequisites: To study this course, a student must have had the chemistry in class 12th

Suggested equivalent online courses:
https://onlinecourses.swayam2.ac.in/cec21_ma16/preview

Further Suggestions: ……………………………

Semester-III/IV
Paper-III (Theory)
Course Title: Coordination Chemistry, States of Matter and Chemical Kinetics

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Third/Four
Paper-II Theory Subject: Chemistry		
Course Code:	**Course Title: Coordination Chemistry, States of Matter and Chemical Kinetics**	

Course outcomes: After completion of this course, the students will be able to understand the chemistry of d- and f-block elements, coordination compounds, quantum mechanical aspects of spectroscopy. The students will also able to understand principles and applications of spectroscopic techniques and photochemistry.

Credits:4	Elective
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	**Transition Metal Elements:** Introduction to transition metals. **3d series-**Chemistry and trends of properties (Electronic configuration, atomic and ionic radii, density, melting and boiling point, ability to form complexes, stability, variable oxidation states, colour, magnetic properties). Applications.	15
2	**Coordination Chemistry:** Introduction, Definition, terminology (ligand, coordination number, coordination sphere, complex ion etc.), VBT, CFT, crystal field splitting of octahedral, tetrahedral and square planar complexes, Jahn Teller distortion, Applications.	16
3	**States of Matter:** Gas, liquid and solid states. Kinetic theory of gases, properties of gas, liquid and solid, liquid crystals, crystal defects	13
4	**Chemical Kinetics:** Introduction, rate of a reaction, factors influencing the rate of a reaction–concentration, temperature, pressure, solvent, light, catalyst. Concentration dependence of rates of simple reaction, Molecularity, Order of reaction- zero order, first order, second order, pseudo-order.	16

Books Recommended:

i. Lee, J.D., "Concise, Inorganic Chemistry", Oxford University Press, 2008, India, 5th edition.

ii. Puri, B.R., Sharma, L.R., and Kalia, K.C., "Principles of Inorganic Chemistry", Vishal Publishing Co., India, 2020, 33rd edition.

iii. Madan, R.L., "Chemistry for Degree Students, B. Sc. Third Year", S. Chand Publishing, New Delhi, India, 2011, 3rd edition.

iv. Madan, R.D., Malik, U.M. and Tuli, G.D., "Selected topics in Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2010**.**

v. Chandra, S., "Comprehensive Inorganic Chemistry" New Age International Publishers, India, 2018, 1st edition.

vi. Prakash, S., Tuli, G.D., Basu, S.K. and Madan, R.D., "Advanced Inorganic Chemistry", S. Chand Publishing, New Delhi, India, 2000, Vol 1.

vii. Finar, I.L., "Organic Chemistry", Pearson Education India, 2002, 6th edition.

viii. Mukerji, S.M., "Reaction mechanism in Organic Chemistry", Laxmi Publications, 2007, 3rd edition.

ix. Loudon, G. Marc, "Organic Chemistry", Oxford University Press, 2008, 4th edition.

x. Clark, J. H., and Macquarrie, D.J., Handbook of Green Chemistry and Technology, Wiley-Blackwell, 2002.
xi. Anastas, P.T., and Williamson, T.C. Green Chemistry: Frontiers in Benign Chemical Syntheses and Processes, Oxford University Press, New York, 1999.
xii. Ozin, G.A., Arsenault, A.C. and L. Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, 2008, 2nd edition.

Suggested online links:

1. https://www.classcentral.com/course/swayam-transition-metal-organometallic-chemistry-principles-to-applications-10047
2. https://onlinecourses.nptel.ac.in/noc19_cy19/preview
3. https://www.swayamprabha.gov.in/index.php/program_data/flipMore/S13/15
4. https://www.classcentral.com/course/swayam-chemistry-xi-part-i-17540
5. https://onlinecourses.nptel.ac.in/noc20_cy09/preview
6. http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch12/trans.php
7. http://www.chemistry.wustl.edu/~edudev/LabTutorials/naming_coord_comp.html
8. http://chemed.chem.wisc.edu/chempaths/GenChem-Textbook/Coordination-Compounds-1052.html
9. http://wwwchem.uwimona.edu.jm/courses/CFT.html
10. http://scienceworld.wolfram.com/chemistry/CrystalFieldTheory.html
11. www.thermopedia.com/content/1232/
12. http://www.pci.tu-bs.de/aggericke/PC4e/Kap_IV/Sym-Op.html
13. www. highered.mcgraw-hill.com/sites/dl/free/0073402680/.../Chapter_13.pdf

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities) and Attendance	10 marks

Course prerequisites: To study this course, a student must have had the chemistry in class 12th

Suggested equivalent online courses:

https://onlinecourses.swayam2.ac.in/cec20_lb01/preview

Further Suggestions: ……………………………

Semester-III/IV
Paper-I (Theory)
Course Title: Industrial Inorganic Chemistry

Programme/Class: Diploma in Chemical Science	**Year:** Second	**Semester:** Third/Fourth
Paper-I Theory Subject: Chemistry		
Course Code:	**Course Title: Industrial Inorganic Chemistry**	

Course outcomes: This paper provides detailed knowledge of synthesis of various class of industrially important inorganic compounds which will help the students to work in chemical-based industries. It relates and gives an analytical aptitude for synthesizing various industrially important compounds. This paper also provides a detailed knowledge on the applications of various inorganic materials.

Credits:3	**Skill Development Course**
Max. Marks: 25+75	Min. Passing Marks:…………

Total Number of Hours = 45

Unit	Contents	Number of Hours
1	**Chemicals and Industry:** Importance of chemical industry, chemical, types of chemicals, water.	5
2	**Inorganic Compounds I:** Hydrogen, inorganic peroxide compounds, nitrogen compounds, chloramine, hydroxylamine, nitric acid, uses and importance. Phosphorus and its compounds.	8
3	**Halogen Compounds:** Nitrogen and potassium fertilizers	5
4	**Metals and their Compounds:** Lithium, sodium, potassium, magnesium, calcium, barium, chromium, manganese, silicon.	7
5	**Inorganic Solids:** Glass, zeolites, inorganic fibres, ceramics.	5
6	**Carbon modifications:** Glassy carbon, foamed carbon, carbon black, activated carbon.	5
7	**Metallic Hard Materials:** Carbides, borides, silicides.	5
	Inorganic pigments: Fillers, types of pigments (oxide, luminescent, corrosion protection, magnetic).	5

Books Recommended:

i. Buechel, K. H., Moretto, H-H., Woditsch, P., Industrial Inorganic Chemistry, Wiley-VCH, 2008, 2nd edition.
ii. Swaddle, T. W., Inorganic Chemistry: An Industrial and Environmental Perspective, *Journal of Chemical Education,* 1997, 74 (12), 1399.

Suggested online links:
https://onlinecourses.swayam2.ac.in/cec20_lb01/preview

Suggested Continuous Evaluation Methods: Students can be evaluated on the basis of score obtained in a mid-term exam, together with the performance of other activities which can include short exams, in-class or on-line tests, home assignments, group discussions or oral presentations.

Evaluation method	Marks
Mid-term exam/ in-class or on-line tests/ home assignments/ group discussions/ oral presentations	15 marks
Overall performance throughout the semester, Discipline, participation in different activities)	05 marks
Attendance	05 marks

Course prerequisites: To study this course, a student must have studied the chemistry of class 12th standard

Suggested equivalent online courses:

https://onlinecourses.swayam2.ac.in/cec20_lb01/preview
https://nptel.ac.in/courses/104/105/104105103/

Further Suggestions: ……………………………

NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all
Uttarakhand State Universities and Colleges for
First Three Years of Higher Education

PROPOSED STRUCTURE OF
<u>UG - MATHEMATICS</u>
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

Sr.No.	Name & Designation	
1.	Prof. N.K. Joshi Vice-Chancellor , Kumaun University Nainital	Chairman
2.	Prof. O.P.S. Negi Vice-Chancellor , Uttarakhand Open University	Member
3.	Prof. P. P. Dhyani Vice-Chancellor , Sri Dev Suman Uttarakhand University	Member
4.	Prof. N.S. Bhandari Vice-Chancellor, Soban Singh Jeena University Almora	Member
5.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun	Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member

SYLLABUS EXPERT COMMITTEE

S. No.	Name	Signature
1	Prof. Anita Tomar, HoD, Department of Mathematics, Sri Dev Suman Campus, Rishikesh	
2	Prof. Jaya Upreti, HoD, Department of Mathematics, S. S. J. Campus, Almora	
3	Dr. Shankar Kumar, Assistant Professor, Department of Mathematics, Govt. P. G. College, Ranikhet.	
4	Dr. Sundar Kumar Arya, Assistant Professor, Department of Mathematics, Govt. P. G. College, Pithoragarh.	

SYLLABUS PREPRATION COMMITTEE

S. No.	Name	Signature
1	Prof. Jaya Upreti, HoD, Department of Mathematics, S. S. J. Campus, Almora	
2	Prof. Anita Tomar, HoD, Department of Mathematics, Sri Dev Suman Campus, Rishikesh	
3	Dr. Shankar Kumar, Assistant Professor, Department of Mathematics, Govt. P. G. College, Ranikhet.	
4	Dr. Sundar Kumar Arya, Assistant Professor, Department of Mathematics, Govt. P. G. College, Pithoragarh.	
5	Dr. Anita Kumari, Assistant professor, Department of Mathematics, D. S. B. Campus, Almora.	

<table>
<tr><th colspan="6">SEMESTER WISE TITLES OF THE PAPER IN UG MATHEMATICS COURSE</th></tr>
<tr><th>YEAR</th><th>SEMESTER</th><th>COURSE CODE</th><th>PAPER TITLE</th><th>THEORY/ PRACTICAL</th><th>CREDIT</th></tr>
<tr><th colspan="6">CERTIFICATE COURSE IN BASIC MATHEMATICS</th></tr>
<tr><td rowspan="3">FIRST YEAR</td><td rowspan="2">I</td><td>UGMAT101T</td><td>Matrices, Trigonometry and Differential Calculus</td><td>THEORY</td><td>4</td></tr>
<tr><td>UGMAT102P</td><td>Practical</td><td>PRACTICAL</td><td>2</td></tr>
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<tr><th colspan="6">DEGREE IN MATHEMATICS</th></tr>
<tr><td rowspan="4">THIRD YEAR</td><td rowspan="2">V</td><td>UGMAT501T</td><td>Real Analysis, Functions of several variables and Partial Differential Equations</td><td>THEORY</td><td>5</td></tr>
<tr><td>UGMAT502T</td><td>Any one of the following-
(i) Mathematical Methods and Graph Theory
(ii) Number Theory and Relativity
(iii) Numerical Analysis and Operations Research</td><td>THEORY</td><td>5</td></tr>
<tr><td rowspan="2">VI</td><td>UGMAT601T</td><td>Complex Analysis and Mechanics</td><td>THEORY</td><td>5</td></tr>
<tr><td>UGMAT602T</td><td>Linear Algebra and Metric Spaces</td><td>THEORY</td><td>5</td></tr>
</table>

PROPOSED STRUCTURE OF UG MATHEMATICS SYLLABUS AS PER NEP 2020 GUIDELINES GENERAL OVERVIEW

B.A./B.Sc. I

PROGRAMME	YEAR	SEMESTER (15Weeks)	PAPER	CREDIT	PERIODS Per Week	PERIODS (HOURS) Per Semester	PAPER TITLE	UNIT (Periods Per Semester)	PREREQUISITE	ELECTIVE (For Other Faculty)
CERTIFICATE COURSE IN BASIC MATHEMATICS	FIRST YEAR	SEMESTER – I	**Paper-1**	**4**	4	4x15=60	**Matrices, Trigonometry and Differential Calculus** **Part A: Matrices** **Part B: Trigonometry** **Part C: Differential Calculus**	**Part A** Unit I (8) Unit II (7) Unit III (5) **Part B** Unit IV (6) Unit V (6) **Part C** Unit VI (7) Unit VII (6) Unit VIII (8) Unit IX (7)	Mathematics in12th	Engg. and Tech. (UG), Chemistry/ Biochemistry/ Life Sciences (UG), Economics (UG/PG), Commerce (UG), BBA/ BCA, B.Sc. (C.S.)
			Paper-2 Practical	**2**	**2 Lab Periods (2 Hours Each)**	2x2x15=60	**Practical** (Practicals to be done using Mathematica/MATLAB / Maple /Scilab /Maxima etc.)		Mathematics in 12th	Engg. and Tech. (UG), B.Sc. (C.S.)
		SEMESTER – II	**Paper-1**	**6**	**6**	15x6=90	**Integral Calculus and Vector Analysis** **Part A: Integral Calculus** **Part B: Vector Analysis**	**Part A** Unit I (12) Unit II (11) Unit III (12) Unit IV (11) **Part B** Unit V (11) Unit VI (12) Unit VII (11) Unit VIII (10)	Mathematics in 12th	Engg. and Tech. (UG), B.Sc. (C.S.)

B.A./B.Sc. II										
PROGRAMME	**YEAR**	**SEMESTER (15 Weeks)**	**PAPER**	**CREDIT**	**PERIODS Per Week**	**PERIODS (HOURS) Per Semester**	**PAPER TITLE**	**UNIT (Periods Per Semester)**	**PREREQUISITE**	**ELECTIVE (For Other Faculty)**
DIPLOMA IN MATHEMATICS	**SECOND YEAR**	**SEMESTER – III**	Paper-1	**6**	**6**	6x15=90	**Group Theory and Analytical Geometry** **Part A: Group Theory** **Part B: Analytical Geometry**	**Part A** Unit I (12) Unit II (20) Unit III (13) **Part B** Unit IV (11) Unit V (12) Unit VI (12) Unit VII (10)	Certificate Course in Basic Mathematics	Engg. and Tech. (UG), B.Sc. (C.S.)
		SEMESTER – IV	Paper-1	**6**	**6**	6x15=90	**Ordinary Differential Equations and Ring Theory** **Part A: Ordinary Differential Equations** **Part B: Ring Theory**	**Part A** Unit I (12) Unit II (11) Unit III (11) Unit IV (11) **Part B** Unit V (11) Unit VI (10) Unit VII (12) Unit VIII (12)	Certificate Course in Basic Mathematics	Economics (UG/PG), B.Sc. (C.S.) Engineering and Technology (UG), Science (Physics-UG)

B.A./B.Sc. III

PROGRAMME	YEAR	SEMESTER (15Weeks)	PAPER	CREDIT	PERIODS Per Week	PERIODS (HOURS) Per Semester	PAPER TITLE	UNIT (Periods Per Semester)	PREREQUISITE	ELECTIVE (For Other Faculty)
DEGREE IN MATHEMATICS	THIRD YEAR	SEMESTER–V	Paper-1	**5**	**5**	5x15=75	**Real Analysis & Functions of several variables and Partial Differential Equations** **Part A: Real Analysis** **Part B: Functions of several variables and Partial Differential Equations**	**Part A** Unit I (8) Unit II (8) Unit III (7) Unit IV (7) Unit V (7) **Part B** Unit VI (8) Unit VII (8) Unit VIII (7) Unit IX (8) Unit X (7)	Diploma in Mathematics	Engg. And Tech.(UG), Economics (UG/PG), B.Sc.(C.S.)
			Paper-2	**5**	**5**	5x15= 75	**(i) Mathematical Methods & Graph Theory** **Part A: Mathematical Methods** **Part B: Graph Theory**	**Part A** Unit I (8) Unit II (10) Unit III (10) Unit IV (9) **Part B** Unit V (10) Unit VI (10) Unit VII (9) Unit VIII (9)	Diploma in Mathematics	Engg. and Tech.(UG), BCA, B.Sc.(C.S.)

DEGREE IN MATHEMATICS	THIRD YEAR	SEMESTER–V	Paper-2	**5**	**5**	5x15= 75	**(ii) Number Theory** **&** **Relativity** **Part A: Number Theory** **Part B: Relativity**	**Part A** Unit I (16) Unit II (11) Unit III (12) **Part B** Unit IV (14) Unit V (12) Unit VI (10)	Diploma in Mathematics	Engg. and Tech. (UG), BCA, B.Sc. (C.S.)
			Paper-2	**5**	**5**	5x15= 75	**(iii) Numerical Analysis** **&** **Operations Research** **Part A: Numerical Analysis** **Part B: Operations Research**	**Part A** Unit I (9) Unit II (9) Unit III (10) Unit IV (10) Unit V (9) **Part B** Unit VI (16) Unit VII (12)	Diploma in Mathematics	Engg. and Tech. (UG), Economics(UG/PG), BBA/BCA, B.Sc.(C.S.)
DEGREE IN MATHEMATICS	THIRD YEAR	SEMESTER–VI	Paper-1	**5**	**5**	5x15=75	**Complex Analysis** **&** **Mechanics** **Part A: Complex Analysis** **Part B: Mechanics**	**Part A** Unit I (9) Unit II (9) Unit III (10) Unit IV (9) **Part B** Unit V (10) Unit VI (10) Unit VII (9) Unit VIII (9)	Diploma in Mathematics	Engg. and Tech. (UG), B.Sc.(C.S.)

DEGREE IN MATHEMATICS	**THIRD YEAR**	**SEMESTER–VI**	Paper-2	**5**	**5**	5x15= 75	**Linear Algebra & Metric Spaces** **Part A: Linear Algebra** **Part B: Metric Spaces**	**Part A** Unit I (10) Unit II (9) Unit III (9) Unit IV (9) Unit V (9) **Part B** Unit VI (6) Unit VII (11) Unit VIII (12)	Diploma in Mathematics	Engg. and Tech. (UG), B.Sc.(C.S.)

Programme Outcome/Programme Specific Outcome

Programme Outcome:

PO1: It is to give in-depth knowledge of geometry, algebra, calculus, differential equations and several other branches of pure and applied mathematics. This also leads to study the related areas such as computer science and other allied subjects.
PO2: The skills and knowledge gained in this program will be helpful for modeling and solving of real life problems.
PO3: Students will become employable in various government and private sector.
PO4: The completing this programme develop enhanced quantitative skills and pursuing higher mathematics and research as well.
PO5: The completion of this programme will enable the learner to use appropriate digital programmes and softwares to solve various mathematical problems.

Programme Specific Outcome:

PSO1: Student should be able to think in a critical manner and develop problem solving skills.
PSO2: Students should be able to recall basic facts about mathematics and display knowledge of conventions such as notations, terminology etc.
PSO3: Students are able to formulate and develop mathematical arguments in a logical manner.
PSO4: Students are motivate and prepare for research studies in mathematics and related fields.

PSO5: Student should be able to apply their skills and knowledge in various fields of studies including, science, engineering, commerce and management etc.

B.A./B.Sc. I (MATHEMATICS)

Detailed Syllabus For

CERTIFICATE
COURSE IN
BASIC MATHEMATICS

B.A. / B.Sc. I (SEMESTER-I) PAPER-I

Matrices, Trigonometry and Differential Calculus

Programme: Certificate **Class: B.A. / B.Sc.**	**Year: First**	**Semester: First**
Subject: Mathematics		
Course Code: UGMAT101T	**Course Title: Matrices, Trigonometry and Differential Calculus**	

Course outcomes:

CO1: The programme outcome is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for developing enhanced quantitative skills and pursuing higher mathematics and research as well.
CO2: By the time students complete the course they will have wide ranging application of the subject and have the knowledge of matrices and basics of differentiation.
CO3: The student will be able to sum the trigonometric series of real and complex numbers and separate the trigonometric function in form of A+iB.
CO4: The main objective of the course is to equip the student with necessary analytic and technical skills. By applying the principles of differentiation, he learns to solve a variety of practical problems in science and engineering.
CO5: The student is equipped with standard concepts and tools at an intermediate to advance level that will serve him well towards taking more advance level course in mathematics.

Credits: 4	**Core Compulsory / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

Total No. of Lectures-Tutorials – Practical (in hours per week): L-T-P:4-0-0

Part-A
Matrices

Unit	Topics	No. of Lectures
I	Matrix introduction, matrix operations with their properties, symmetric, skew-symmetric, Hermitian and skew- Hermitian matrices, idempotent, nilpotent, involuntary, orthogonal and unitary matrices, singular and non-singular matrices, elementary operations on matrices, adjoint and inverse of a matrix, singular and non-singular matrices, negative integral powers of a non-singular matrix, Trace of a matrix.	**8**
II	Rank of a matrix, elementary transformations of a matrix and invariance of rank through elementary transformations, normal form of a matrix, elementary matrices, rank of the sum and product of two matrices, inverse of a non-singular matrix through elementary row transformations, equivalence of matrices.	**7**
III	Solutions of a system of linear equations, condition of consistency and nature of the general solution of a system of linear non-homogeneous equations.	**5**

Part-B
Trigonometry

Unit	Topics	No. of Lectures
IV	Trigonometric or circular and hyperbolic function of complex variable together with their inverses, De Moivre's Theorem and its applications, Euler's theorem, relation between trigonometric and hyperbolic function, Exponential function of a complex variable, Logarithms of complex variable, Properties of logarithmic function, Separation into real and imaginary parts	**6**
V	Gregory's series, Value of π by different series, Summation of Trigonometric series by C+iS method based on Arithmetic Progression, Geometric Progression, Logarithms and Binomial expansions, Summation of Trigonometric series by difference method.	**6**

Part-C Differential Calculus		
Unit	**Topics**	**No. of Lectures**
VI	Functions of one variable, Limit of a function (ε-δ Definition), Continuity of a function, Properties of continuous functions, Intermediate value theorem, Classification of discontinuities, Differentiability of a function, Jacobians, maxima and minima of singe variable function, Rolle's Theorem, Mean value theorems and their geometrical interpretations, Applications of mean value theorems.	**7**
VII	Successive Differentiation, n^{th} Differential coefficient of functions, Leibnitz Theorem, Taylor's Theorem, Maclaurin's Theorem, Taylor's and Maclaurin's series expansions.	**6**
VIII	Geometrical meaning of tangent, Definition and equation of Tangent, Tangent at origin, Angle of intersection of two curves, Definition and equation of Normal, Cartesian sub tangent and subnormal, Tangents and normals of polar curves, Angle between radius vector and tangent, Perpendicular from pole to tangent, Pedal equation of curve, Polar sub tangent and polar subnormal, Derivatives of arc (Cartesian and polar formula).	**8**
IX	Curvature, Radius of curvature, Cartesian, Polar and pedal formula for radius of curvature, Tangential polar form, Centre of curvature, Asymptotes of algebraic curves, Methods of finding asymptotes, Parallel asymptotes, existence and classification of singular points, points of inflection.	**7**

Suggested Readings (PART-A Matrices):

1. Hari Kishan, A Textbook of Matrices, Atlantic Publishers, 2008
2. Fuzhen Zhang, Matrix Theory- Basic Results and Techniques, Springer, 1999
3. Shanti Narayan, P.K. Mittal, A Textbook of Matrices, S Chand & Company, 2010
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (PART-B Trigonometry):

1. Margaret L. Lial, John Hornsby, David I. Schneider, Trigonometry, Addison-Wesley, 2001
2. Robert Moyer,Frank Aryes, Schaum's Outline of trigonometry, 2012
3. I. M. Gelfand, Mark Saul, Trigonometry, Birkhäuser; 2001st edition (June 8, 2001)
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part- C Differential Calculus):

1. R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 1999
2. T.M. Apostal, Calculus Vol. I, John Wiley & Sons Inc., 1974
3. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2019
4. S. Balachandra Rao & C. K. Shantha, Differential Calculus, New Age Publication. 1992
5. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc. 2007
6. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2010
7. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Chemistry/ Biochemistry/ Life Sciences (UG), Economics (UG/PG), Commerce (UG), BBA/ BCA, B.Sc. (C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S.N.	Assessment Type	Max. Marks
1	**Class Tests**	**10**
2	**Online Quizzes/Objective Tests**	**5**
3	**Presentation**	**5**
4	**Assignment**	**5**

Course perquisites: To study this course a student must have subject Mathematics in class 12^{th}.

Suggested equivalent online courses:

Further Suggestions:

B.A./ B.Sc. I (SEMESTER-I) Paper-II

Practical

Programme: Certificate **Class: B.A./B.Sc.**	**Year: First**	**Semester: First**
Subject: Mathematics		
Course Code: UGMAT102P	**Course Title: Practical**	

Course outcomes:

CO1: The main objective of the course is too familiar the student with different computer software such as Mathematica /MATLAB /Maple /Scilab/Maxima etc.

CO2. The students will be able to compute various operations on matrices by using different computer software such as Mathematica /MATLAB /Maple /Scilab/Maxima etc.

CO2. The students will also be able to compute n^{th} derivative of various functions by using different computer software.

Credits:2	**Core Compulsory/Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

Total No. of Lectures – Tutorials – Practical (in hours per week): L-T-P: 0-0-4

Unit	Topics	No. of Lectures
	Practical / Lab work to be performed in Computer Lab. List of the practical to be done using R/Python/Mathematica/MATLAB/Maple/Scilab/Maxima etc. 1. Introduction to the software and commands related to the topic. 2. Computation of addition and subtraction of matrices, 3. Computation of multiplication of matrices. 4. Computation of Trace and Transpose of Matrix. 5. Computation of Rank of matrix. 6. Computation of Inverse of a Matrix. 7. Solving the system of homogeneous and non-homogeneous linear algebraic equations. 8. Finding the n^{th} Derivative of e^{ax}, trigonometric and hyperbolic functions. 9. Finding the n^{th} Derivative of algebraic and logarithmic functions. 10. Finding the n^{th} Derivative of $e^{ax}\sin(bx + c)$, $e^{ax}\cos(bx + c)$. 11. Finding the Taylor's and Maclaurin's expansions of the given functions.	**60**

Suggested Readings:

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc. (C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S.N.	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/ Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course a student must have subject Mathematics in class 12^{th}.

Suggested equivalent online courses:

Further Suggestions:

B.A. / B.Sc. I (SEMESTER-II) PAPER – I
Integral calculus and Vector Analysis

Programme: Certificate **Class: B.A./B.Sc.**	**Year: First**	**Semester: Second**
Subject: Mathematics		
Course Code: UGMAT201T	**Course Title: Integral calculus and Vector Analysis**	
Course outcomes: **CO1:** The Programme outcome is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for developing enhanced quantitative skills and pursuing higher mathematics and research as well. **CO2:** By the time students complete the course they will have wide ranging application of the subject and have the knowledge of surface area and volume of shapes. **CO3:** The main objective of the course is to equip the student with necessary analytic and technical skills. By applying the principles of integral he learns to solve a variety of practical problems in science and engineering. **CO4:** The student is equipped with standard concepts and tools at an intermediate to advance level that will serve him well towards taking more advance level course in mathematics.		
Credits: 6	**Core Compulsory/Elective**	
Max. Marks: 25+75	**Min. Passing Marks:**	
Total No. of Lectures – Tutorials – Practical (in hours per week): L-T-P: 6-0-0		

PART-A **Integral Calculus**		
Unit	**Topics**	**No of Lectures**
I	Integral as a limit of sum, Properties of Definite integrals, Fundamental theorem of integral calculus, Summation of series by integration, Infinite integrals, Differentiation and integration under the integral sign.	**12**
II	Beta function, Properties and various forms, Gamma function, Recurrence formula and other relations, Relation between Beta and Gamma function, Evaluation of integrals using Beta and Gamma functions.	**11**
III	Double integrals, Repeated integrals, Evaluation of Double integrals, Double integral in polar coordinates, Change of variables, Change of order of integration in Double integrals, Triple integrals, Evaluation of Triple integrals, Drichlet's theorem and its Liovelle's extension.	**12**
IV	Area bounded by curves (quadrature), Rectification (length of curves), Volumes and Surfaces of Solids of revolution.	**11**

PART- B **Vector Analysis**		
Unit	**Topics**	**No. of Lectures**
V	Triple product, Reciprocal vectors, Product of four vectors, General equation of a Plane, Normal and Intercept forms, Two sides of a plane, Length of perpendicular from a point to a plane, Angle between two planes, System of planes.	**11**
VI	Direction Cosines and Direction ratios of a line, Projection on a straight line, Equation of a line, Symmetrical and unsymmetrical forms, Angle between a line and a plane, Coplanar lines, Lines of shortest distance, Length of perpendicular from a point to a line, Intersection of three planes, Transformation of coordinates.	**12**
VII	Ordinary differentiation of vectors, Velocity and Acceleration, Differential operator-Del, Gradient, Divergence and Curl.	**11**
VIII	Line, Surface and volume integrals, Simple applications of Gauss divergence theorem, Green's theorem and Stokes theorem (without proof).	**10**

Suggested Readings (Part- A Integral Calculus):

1. T.M. Apostal, Calculus Vol. I, John Wiley & Sons Inc., 1974
2. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc. 2007
3. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2010
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part- B Vector Analysis):

1. Murray R. Spiegel: Vector Analysis, Schaum's Outline Series, McGraw Hill.
2. N. Saran and S. N. Nigam: Introduction to Vector Analysis, Pothishala Pvt. Ltd. Allahabad.
3. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc. (C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S.N.	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/ Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course a student must have subject Mathematics in class 12^{th}.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. II (MATHEMATICS)

Detailed Syllabus For

DIPLOMA
IN
MATHEMATICS

B.A./B.Sc. II (SEMESTER-III) PAPER-I Group Theory and Analytical Geometry

<table>
<tr><td>Programme: Diploma

Class: B.A./B.Sc.</td><td>Year: Second</td><td colspan="2">Semester: Third</td></tr>
<tr><td colspan="4">Subject: Mathematics</td></tr>
<tr><td>Course Code: UGMAT301T</td><td colspan="3">Course Title: Group Theory and Analytical Geometry</td></tr>
<tr><td colspan="4">Course outcomes:

CO1: Group theory is one of the building blocks of modern algebra. Objective of this course is to introduce students to basic concepts of Group and their properties.
CO2: This course will lead the student to basic course in advanced mathematics and geometry.
CO3 The subjects learn and visualize the fundamental ideas about coordinate geometry and learn to describe some of the surface by using analytical geometry.
CO4: On successful completion of the course students have gained knowledge about regular geometrical figures and their properties. They have the foundation for higher course in geometry.
CO5: On successful completion of the course students should have knowledge about higher different mathematical methods and will help him in going for higher studies and research.</td></tr>
<tr><td colspan="2">Credits: 6</td><td colspan="2">Core Compulsory / Elective</td></tr>
<tr><td colspan="2">Max. Marks: 25+75</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures - Tutorials-Practical (in hours per week): L-T-P:6-0-0</td></tr>
<tr><td colspan="4">Part-A

Group Theory</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td>I</td><td colspan="2">Cartesian product of Sets, Functions or mappings, Binary operations, Relation, Equivalence relations and partitions, Congruence Modulo n, Definition of a group with examples and simple properties, Abelian group, Finite and infinite group, Order of a finite group, General properties of groups, Composition table for finite groups</td><td>12</td></tr>
<tr><td>II</td><td colspan="2">An Alternative set of postulates of groups, Subgroups, Permutations, Cyclic Permutations, Even and odd permutations, group of Permutations alternating group, Integral power of an element of a group, Order of an element of a group, Group homomorphism, Isomorphism on groups, the relation of isomorphism in the set of all groups Complexes and subgroup of a group, theorems on subgroups, Coset decomposition, Lagrange's theorem and its consequences, Cayley's theorem, Cyclic group, generating system of group.</td><td>20</td></tr>
<tr><td>III</td><td colspan="2">Normal subgroups, Simple group, Conjugate elements, Normalizer of an element of a group, Class equation of a group, Centre of a group, Conjugate subgroups, Invariant sub groups, Quotient group, Homomorphism and Isomorphism on groups, Kernel of a Homomorphism and related theorems.</td><td>13</td></tr>
</table>

Part-B Analytical Geometry		
Unit	**Topics**	**No. of Lectures**
IV	Polar Equation of conics, Polar coordinate system, Distance between two points, Polar equation of a Straight line, Polar equation of a circle, Polar equation of a conic, Chords, Tangent and Normal to a conic	**11**
V	Curvilinear coordinates, Spherical and Cylindrical coordinates, Definition and equation of a sphere, Plane section of a sphere, Intersection of two spheres, Intersection of a sphere and a line, Power of a point, tangent plane, Plane of contact, Polar plane, Pole, Angle of Intersection of two spheres, Radical plane, Co-axial system of spheres.	**12**
VI	Definition and equation of a cone, Vertex, Guiding curve, Generators, Three mutually perpendicular generators, Intersection of a line with a cone, Tangent line and tangent plane, Reciprocal cone, Right circular cone, Definition and equation of a cylinder, Right circular cylinder, Enveloping cylinder.	**12**
VII	General equation of second degree, Tangent plane, Director sphere, Normal, Plane of contact, Polar plane, Conjugate plane and conjugate points	**10**

Suggested Readings (Part-A Group Theory):

1. J. B. Fraleigh, A first course in Abstract Algebra, Addison-wiley, 2003
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2006
3. Thomas W Hungerford, Abstract Algebra–An Introduction, Sauders College Publishing, 1990
4. Joseph A Gallian, Contemporary Abstract Algebra, Brooks/Cole Cengage Learning, 2016
5. V. K. Khanna and S. K. Bhambri, A course in Abstract Algebra, Vikas Publishing House Pvt (Ltd), 2014.
6. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Analytical Geometry):

1. Robert J.T Bell, An Elementary Treatise on Coordinate Geometry of three dimensions, Macmillan India Ltd., 1923
2. P.R. Vittal, Analytical Geometry 2d & 3D, Pearson, 2013
3. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London. 2018
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc. (C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25		
S.N.	**Assessment Type**	**Max. Marks**
1	**Class Tests**	**10**
2	**Online Quizzes/Objective Tests**	**5**
3	**Presentation**	**5**
4	**Assignment**	**5**

Course prerequisites: To study this course, a student must have Certificate Course in Basic Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. II (SEMESTER-IV) PAPER-I Ordinary Differential Equations and Ring Theory

Programme: Diploma **Class: B.A./B.Sc.**	**Year: Second**	**Semester: Fourth**
Subject: Mathematics		
Course Code: UGMAT401T	**Course Title: Ordinary Differential Equations and Ring Theory**	

Course outcomes:

CO1: The objective of this course is to familiarize the students with various methods of solving differential equations of first and second order and to have qualitative applications.
CO2: A student doing this course is able to solve differential equations and is able to model problems in nature using ordinary differential equations. After completing this course, a student will be able to take more courses on wave equation, heat equation, diffusion equation, gas dynamics, nonlinear evolution equation etc.
CO3: Ring theory is one of the building areas of modern algebra. Objective of this course is to introduce students to basic concepts of Ring, Integral domain and other structures with their properties. This course will lead the student to basic course in advanced mathematics and Algebra.

Credits: 6	**Core Compulsory/Elective**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Lectures - Tutorials-Practical (in hours per week): L-T-P:6-0-0	

Part-A

Ordinary Differential Equations

Unit	Topics	No. of Lectures
I	Introduction of Differential equations, Order and Degree of Differential Equations, Complete primitive (general solution, particular solution and singular solutions), Existence and uniqueness of the solution dy/dx= f(x,y).	12
II	Differential equations of first order and first degree, Separation of variables, Homogeneous linear Equations, Exact Equations, Integrating Factor, Linear Equation, Equation of First order but not of first degree, Various methods of solution, Clairaut's form, Singular solutions, Trajectory, Orthogonal Trajectory, Self-Orthogonal family of Curves.	11
III	Linear differential equations with constant coefficients, Complementary function, Particular integral, Working rule for finding solution of linear differential equations with constant coefficients, Homogeneous linear equations or Cauchy-Euler equations.	11
IV	Simultaneous differential equations, Differential equations of the form dx/P= dy/Q= dz/R where P, Q, R are functions of x, y, z. Exact differential equations, Total differential equations, Series solutions of differential equations, Linear differential equations of second order with variable coefficients, Initial and boundary value problems.	11

Part-B Ring Theory		
Unit	**Topics**	**No. of Lectures**
V	Rings, Various types of rings, Rings with unity, Rings without zero divisors, Properties of rings, Sub rings.	**11**
VI	Ideals, Quotient rings, Principal ideals, Maximal ideals, Prime ideals, Principal ideal domains, Characteristic of a ring.	**10**
VII	Integral domain, Field, Skew field etc., Field of quotients of an integral domain, Embedding of an integral domain in a field, Factorization in an integral domain, Divisibility, Units, Associates, Prime and irreducible elements, Unique Factorisation Domain, Euclidean rings.	**12**
VIII	Polynomials over a ring, Degree of a polynomial, Zero, Constant and monic polynomials, Equality of polynomials, Addition and multiplication of polynomials, Polynomial rings, Embedding of a ring R into R[x], Division algorithm, Euclidean algorithm, Units and associates in polynomials, Irreducible polynomials.	**12**

Suggested Readings (Part-A Differential Equations):

1. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata –McGraw Hill, 2002
2. B. Rai, D.P. Choudhary & H. J. Freedman, A Course of Ordinary Differential Equations, Narosa, 2002
3. Ian N. Snedden, Elements of Partial Differential Equations, Dover Publication, 2013
4. L.E. Elsgolts, Differential Equation and Calculus of variations, University Press of the Pacific. 1970
5. M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand, 2018.
6. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Ring Theory):

1. J.B. Fraleigh, A first course in Abstract Algebra, Addison-wiley, 2003
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2006
3. Thomas W Hungerford, Abstract Algebra – An Introduction, Sauders College Publishing, 1990
4. Joseph A Gallian, Contemporary Abstract Algebra, Brooks/Cole Cengage Learning, 2016
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Economics (UG/PG), B.Sc. (C.S.) Engineering and Technology (UG), Science (Physics-UG)

Suggested Continuous Evaluation Methods: Max. Marks:25

S.N.	Assessment Type	Max. Marks
1	**Class Tests**	**10**
2	**Online Quizzes/Objective Tests**	**5**
3	**Presentation**	**5**
4	**Assignment**	**5**

Course prerequisites: To study this course, a student must have Certificate Course in Basic Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. III (MATHEMATICS)

Detailed Syllabus For

DEGREE
IN
MATHEMATICS

B.A./B.Sc. III (SEMESTER-V) PAPER-I Real Analysis, Functions of several variables and Partial Differential Equations

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Fifth**
Subject: Mathematics		
Course Code: UGMAT501T	**Course Title: Real Analysis, Functions of several variables and Partial Differential Equations**	

Course outcomes:
CO1: Students will be able to know the basic concepts and developments of real analysis which will prepare the students to take up further applications in the relevant fields.
CO2: On successful completion of the course students should have knowledge about real analysis and will help him in going for higher studies and research.
CO3: The main objective of the course is to equip the student with necessary analytic and technical skills.
CO4: The course in partial differential equation intends to develop problem solving skills for solving various types of partial differential equation especially hyperbolic, parabolic and elliptic types of PDE.

Credits: 5	**Core Compulsory / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0

PART-A
Real Analysis

Unit	Topic	No. of Lectures
I	**Continuity and Differentiability of functions:** Continuity of functions, Uniform continuity, Differentiability, Taylor's theorem with various forms of remainders.	8
II	**Integration:** Riemann integral-definition and properties, integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus.	8
III	**Sequence and Series:** Sequences, theorems on limit of sequences, Cauchy's convergence criterion, infinite series, series of non-negative terms, Absolute convergence, tests for convergence, comparison test, Cauchy's root Test, ratio Test, Rabbe's, Logarithmic test, De Morgan's Test, Alternating series, Leibnitz's theorem.	7
IV	**Improper Integrals:** Improper integrals and their convergence, Comparison test, Dritchlet's test, Absolute and uniform convergence, Weierstrass M-Test, Infinite integral depending on a parameter.	7
V	**Uniform Convergence:** Point wise convergence, Uniform convergence, Test of uniform convergence, Weierstrass M-Test, Abel's and Dritchlet's test, Convergence and uniform convergence of sequences and series of functions.	7

PART-B
Functions of several variables and Partial Differential Equations

Unit	Topic	No. of Lectures
VI	**Functions of several variables:** Limit, continuity and differentiability of functions of several variables.	8

VII	**Partial Derivatives:** Partial derivatives and their geometrical interpretation, differentials, derivatives of composite and implicit functions, Jacobians, Chain rule, Euler's theorem on homogeneous functions, harmonic functions, Taylor's expansion of functions of several variables.	8
VIII	**Maxima and Minima:** Maxima and minima of functions of several variables – Lagrange's method of multipliers.	7
IX	**Partial differential equations:** Partial differential equations of first order, Charpit's method, Linear partial differential equations with constant coefficients. First-order linear, quasi-linear and non-linear PDE's using the method of characteristics: know how to obtain explicit solutions.	8
X	**Partial differential equations of 2nd-order:** Classification of 2nd-order linear equations in two independent variables: hyperbolic, parabolic and elliptic types (with examples).	7

Suggested Readings (Part-A Real Analysis):

1. Walter Rudin: Principle of Mathematical Analysis (3rd edition) McGraw-Hill Kogakusha, 1976, International Student Edition.
2. K. Knopp: Theory and Application of Infinite Series.
3. T. M. Apostol: Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.
4. P. R. Halmos: Naive Set Theory, Van Nostrand, 1960.
5. S. C. Malik and Savita Arora, Mathematical Analysis , New Age International Pvt. (Ltd), 2012.
6. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Functions of several variables and Partial Differential Equations):

1. W. Fleming: Functions of several variables, Springer
2. R P Agrawal: Ordinary and Partial Differential Equations, Springer
3. K Sankar Rao: Partial Differential Equations, PHI
4. M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand, 2018.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. And Tech.(UG), Economics (UG/PG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S. N.	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. III (SEMESTER-V) PAPER-II (i) Mathematical Methods and Graph Theory

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Fifth**
Subject: Mathematics		
Course Code: UGMAT502T	**Course Title: Mathematical Methods and Graph Theory**	
Course outcomes: **CO1:** The student will be able to find the integral transform, Laplace transform, inverse Laplace transform and Fourier transform. The course in mathematical methods basically develops a problem solving skill in the students. **CO2:** Upon successful completion, students will have the knowledge of various types of graphs, their terminology and applications. **CO3:** After Successful completion of this course students will be able to understand the isomorphism and homomorphism of graphs. This course covers the basic concepts of graphs used in computer science and other disciplines. The topics include path, circuits, adjacency matrix, tree, coloring. After successful completion of this course the student will have the knowledge graph coloring, color problem, vertex coloring.		
Credits: 5	**Core Compulsory / Elective**	
Max. Marks: 25+75	**Min. Passing Marks:**	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0		

PART-A
Mathematical Methods

Unit	Topic	No. of Lectures
I	**Integral Transforms:** Definition, Kernel.	8
II	**Laplace Transforms:** Definition, Existence theorem, Linearity property, Laplace transforms of elementary functions, Heaviside Step and Dirac Delta Functions, First Shifting Theorem, Second Shifting Theorem, Initial-Value Theorem, Final-Value Theorem, The Laplace Transform of derivatives, integrals and Periodic functions.	10
III	**Inverse Laplace transforms:** Inverse Laplace transforms of simple functions, Inverse Laplace transforms using partial fractions, Convolution, Solutions of differential and integro-differential equations using Laplace transforms. Dirichlet's condition,	10
IV	**Fourier Transforms:** Fourier Complex Transforms, Fourier sine and cosine transforms, Properties of Fourier Transforms, Inverse Fourier transforms.	9

PART-B

Graph Theory

Unit	Topic	No. of Lectures
V	Introduction to graphs, basic properties of graphs, Simple graph, multi graph, graph terminology, representation of graphs, Bipartite, regular, planar and connected graphs, connected components in a graph, Euler graphs, Directed, Undirected, multi-graph, mixed graph.	10
VI	Walk and unilateral components, unicursal graph, Hamiltonian path and circuits, Graph coloring, chromatics number, isomorphism and homomorphism of graphs, Incidence relation and degree of the graph.	10

VII	Operation of graph circuit, Path and circuits, Eulerian circuits, Hamiltonian path and cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, shortest path, Dijkstra's algorithm.	**9**
VIII	Tree, Binary and Spanning trees, Coloring, Color problems, Vertex coloring and important properties.	**9**

Suggested Readings (Part-A Mathematical Methods):

1. Murry R. Spiegal: Laplace Transform (SCHAUM Outline Series), McGraw-Hill.
2. J. F. James: A student's guide to Fourier transforms, Cambridge University Press.
3. Ronald N. Bracewell: The Fourier transforms and its applications, Mcgraw Hill.
4. J. H. Davis: Methods of Applied Mathematics with a MATLAB Overview, Birkhäuser, Inc.,Boston, MA, 2004.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Graph Theory):

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Dover Publications, 2017.
2. Douglas B West, Introduction to Graph Theory, Pearson, 2018.
3. Santanu Saha Ray, Graph Theory with Algorithms and Its Applications: In Applied Science and Technology, Springer India, 2012.
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech.(UG), BCA, B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S. No	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. III (SEMESTER-V) PAPER-II (ii) Number Theory and Relativity

<table>
<tr><td>Programme: Degree
Class: B.A./B.Sc.</td><td>Year: Third</td><td colspan="2">Semester: Fifth</td></tr>
<tr><td colspan="4">Subject: Mathematics</td></tr>
<tr><td>Course Code: UGMAT502T</td><td colspan="3">Course Title: Number Theory and Relativity</td></tr>
<tr><td colspan="4">Course outcomes:
CO1: The student will be able to solve problems in elementary number theory and also apply elementary number theory to cryptography.
CO2: Upon successful completion, students will be able to describe the basic concepts of the theory of relativity.
CO3: After Successful completion of this course students will be able to discuss postulates of the special theory of relativity and their consequences.</td></tr>
<tr><td colspan="2">Credits: 5</td><td colspan="2">Core Compulsory / Elective</td></tr>
<tr><td colspan="2">Max. Marks: 25+75</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0</td></tr>
</table>

PART-A

Number Theory

Unit	Topic	No. of Lectures
I	Prime Numbers, Unique Factorization theorem, Farey series, Irrational numbers, Congruences, Residues, Quadratic Reciprocity Law, Primitive roots.	16
II	Fermet's theorem, Wilson's theorem, Continued fractions, Approximation of irrational of rationals, Hurwitz theorem.	11
III	The fundamental theorem of arithmetic in K(1), K(i), K(ρ), Diophantine equation $X^2+Y^2=Z^2$, $X^4+Y^4=Z^4$, $ax^2+by^2+cz^2=0$, Quadratic fields, The arithmetic functions: d(n), σ(n), μ(n) and $\varphi(n)$ including elementary result on their order and average order.	12

PART-B

Relativity

Unit	Topic	No. of Lectures
IV	**Special Relativity:** Inertial Frames of reference, Michelson-Morley experiment, Doppler effect, Stellar aberration, Simultaneity, Postulates of special relativity, Lorentz transformation, Length contraction, Time dilation, Clock paradox, Addition of velocities and accelerations, Four- dimensional space time, Light cone, Mass variation, Velocity four vector, Momentum and force, Mass-Energy relationship.	14
V	**General Relativity:** Geodesics, Geodesic coordinates, Curvature tensor and its algebraic properties, Bianchi's identities, Contracted curvature tensor, Conditions for a flat space time, Displacement of space –time, Killing equations, Groups of motion, Space–time of constant curvature.	12
VI	Principal of covariance, Non-inertial frames of reference, Principal of equivalence, Weak field approximation of geodesic equations, Law of gravitation in empty space-time, Canonical coordinates, Schwarzschild solutions.	10

Suggested Readings (Part-A Number Theory):

1. G. H. Hardy and E. M. Wright: Introduction to the theory of numbers, Oxford University Press, 4th Edition.
2. D. M. Burton: Elementary Number Theory, 6th Edition, Tata McGraw Hill.
3. Thomas Koshy: Elementary Number Theory with Applications, Academic Press, 2nd Edition.
4. Kenneth H. Rosen: Elementary Number Theory and its Applications, Addison-Wesley Publishing Company, 1986.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Relativity):

1. D. F. Lawden: An Introduction to tensor calculus and relativity.
2. J. V. Narlikar: General relativity and cosmology.
3. R. H. Good: Basic concept of relativity, 1978.
4. A. S. Eddington: Mathematical theory of relativity, 1981.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), BCA, B.Sc. (C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S. No	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. III (SEMESTER-V) PAPER-II (iii) Numerical Analysis and Operations Research

Programme: Degree Class: B.A./B.Sc.	Year: Third	Semester: Fifth
Subject: Mathematics		
Course Code: UGMAT502T	Course Title: Numerical Analysis and Operations Research	

Course outcomes:

CO1: After Successful completion of this course the student will be able to perform error analysis for arithmetic operations.

CO2: Upon successful completion, students will be able to understand the use of interpolation and curve fitting and finite differences.

CO3: After Successful completion of this course students will be able to use some solution methods for solving the linear programming problems.

Credits: 5	Core Compulsory / Elective
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0

PART-A
Numerical Analysis

Unit	Topic	No. of Lectures
I	**Errors in numerical Calculations**: Absolute, Relative and Percentage errors, General Error, Error in series approximation.	9
II	**Solutions of Algebraic and Transcendental Equations:** Bisection method, False position method, Newton-Raphson Method, Picard's iteration method.	9
III	**Linear systems of equations:** Consistency of Linear System of equations, Solutions of Linear Systems by direct method: Guassian elimination and computation of inverse of a matrix, Method of Factorization, Solutions of linear systems by iterative methods: Jacobi method, Gauss-Siedel method.	10
IV	**Interpolation and curve fitting:** Errors in Polynomial interpolation, Finite differences, Differences of a polynomial, Newton's forward and backward interpolation, Central differences, Gauss, Stirling, Bessel's and Everett's Formulae, Lagrange's Interpolation formula.	10
V	**Numerical differentiation and integration**: Numerical differentiation, Newton-Cotes Integration formula, Numerical integration by Trapezoidal rule, Simpson'1/3, Simpson's 3/8, and Romberg Integration.	9

PART-B
Operations Research

Unit	Topic	No. of Lectures
VI	**Basics of OR and LPP**: Development of OR, Definition, characteristics, scope, objectives and limitations of OR, convex sets, Basic feasible solutions, Formulation of LPP, Graphical Method to solve LPP, General LPP, Canonical and Standard forms, Properties of Solutions and Theory of Simplex method, Big M Method and Two phase simplex method, Degeneracy in LPP, Duality in LPP, Duality and simplex method, Dual simplex method.	16

VII	**Transportation and assignment Models**: Formulation of TP, Transportation Table, Finding initial basic feasible solution, Test of optimality, Degeneracy, MODI method, Stepping Stone method, Solutions of Assignment problems, Hungarian method.	12

Suggested Readings (Part-A Numerical Analysis):

1. S. S. Sastry: Introductory Methods Numerical Analysis, Prentice- Hall of India.
2. C.F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Addison- Wesley, 1998.
3. Konte and Debour: Numerical Analysis.
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Operations Research):

1. G. Hadley, Linear Programming, Narosa Publishing House, 1995.
2. S. I. Gass, Linear Programming: Methods and Applications (4th edition) McGraw-Hill, New York, 1975.
3. Kanti Swaroop, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New
4. Hamdy A. Taha, Operations Research, Prentice-Hall of India, 1997.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), Economics(UG/PG), BBA/BCA, B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S. No	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. III (SEMESTER-VI) PAPER-I Complex Analysis and Mechanics

<table>
<tr><td>Programme: Degree
Class: B.A./B.Sc.</td><td>Year: Third</td><td colspan="2">Semester: Sixth</td></tr>
<tr><td colspan="4">Subject: Mathematics</td></tr>
<tr><td>Course Code: UGMAT601T</td><td colspan="3">Course Title: Complex Analysis and Mechanics</td></tr>
<tr><td colspan="4">Course outcomes:
CO1: The course is aimed at exposing the students to foundations of analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.
CO2: Upon successful completion, students will be able to understand the complex variables, analytic functions, complex integration and residues.
CO3: The object of the paper is to give students knowledge of basic mechanics such as simple harmonic motion, motion under other laws and forces.
CO4: The student, after completing the course can go for higher problems in mechanic such as hydrodynamics, this will be helpful in getting employment in industry.</td></tr>
<tr><td colspan="2">Credits: 5</td><td colspan="2">Core Compulsory / Elective</td></tr>
<tr><td colspan="2">Max. Marks: 25+75</td><td colspan="2">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0</td></tr>
</table>

PART-A
Complex Analysis

Unit	Topic	No. of Lectures
I	**Complex Variables:** Functions of a complex variable, Limit, continuity and differentiability.	9
II	**Analytic functions:** Analytic functions, Cauchy and Riemann equations, Harmonic functions.	9
III	**Complex Integration:** Complex integrals, Cauchy's theorem, Cauchy's integral formula, Morera’s Theorem, Liouville’s Theorem, Taylor's series, Laurent's series, Poles and singularities.	10
IV	**Residues:** Residues, the Residue theorem, the principle part of a function, Evaluation of Improper real integrals.	9

PART-B
Mechanics

Unit	Topic	No. of Lectures
V	**Rectilinear motion:** Newton’s Laws of Motion, velocity and acceleration, motion under constant acceleration, motion under inverse square law, rectilinear motion with variable acceleration, Simple Harmonic Motion.	10

VI	**Kinematics in two dimension:** Angular velocity and angular acceleration, Components of velocity and acceleration along coordinate axes, Radial and transverse components of velocity and acceleration, tangential and normal components of velocity and acceleration.	**10**
VII	**Motion in resisting medium, constrained motion and Central orbits:** Terminal Velocity, Motion in resisting medium in a straight line, Motion on vertical circle, Cycloidal motion, Central Force, Central orbit, intrinsic equation, Pedal form, apse and apsidal distance.	**9**
VIII	**Statics:** Coplanar Forces, Equilibrium of forces in three dimensions, Common catenary, Catenary of uniform strength, Virtual work.	**9**

Suggested Readings (Part-A Complex Analysis):

1. J. B. Conway: Functions of One Complex Variable, Narosa Publishing House, 1980.
2. E. T. Copson: Complex Variables, Oxford University Press.
3. L. V. Ahlfors: Complex Analysis, McGraw-Hill, 1977.
4. D. Sarason: Complex Function Theory, Hindustan Book Agency, Delhi, 1994..
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Suggested Readings (Part-B Mechanics) :

1. M. Ray: A Textbook on Dynamics, S. Chand.
2. M. Ray: A Textbook on Statics, S. Chand.
3. A. S. Ramsay: Dynamics, Cambridge University Press.
4. S. L. Loney: Dynamics of a particle and of rigid bodies, Cambridge University Press.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S. No	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics.

Suggested equivalent online courses:

Further Suggestions:

B.A./B.Sc. III (SEMESTER-VI) PAPER-II Linear Algebra and Metric Spaces

Programme: Degree **Class: B.A./B.Sc.**	**Year: Third**	**Semester: Sixth**
Subject: Mathematics		
Course Code: UGMAT602T	**Course Title: Linear Algebra and Metric Spaces**	

Course outcomes:

CO1: Liner algebra is a basic course in almost all branches of science. The objective of this course is to introduce a student to the basics of linear algebra and some of its applications.

CO2: After Successful completion of this course, students should be able to understand the concept of linear transformation.

CO3: On successful completion of the course students should have knowledge about metric spaces, connectedness and compactness.

Credits: 5	**Core Compulsory / Elective**
Max. Marks: 25+75	**Min. Passing Marks:**
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0	

PART-A

Linear Algebra

Unit	Topic	No. of Lectures
I	**Vector space:** Introduction, subspaces, Linear combinations, linear spans, Sums and direct sums, Linear dependence and independence, Bases and dimensions, Dimensions and subspaces, Coordinates and change of bases.	**10**
II	**Linear transformations:** Linear transformations, rank and nullity, Linear operators, Algebra of linear transformations, Invertible linear transformations, isomorphism.	**9**
III	**Matrix and linear transformation:** Matrix of a linear transformation, Matrix of the sum and product of linear transformations, Change of basis, similarity of matrices.	**9**
IV	**Linear functional:** Linear functional, Dual space and dual basis, Double dual space, Annihilators, Hyperspace, Transpose of a linear transformation.	**9**
V	**Eigen values and Eigen vectors:** Eigen vectors and Eigen values of a matrix, product of characteristic roots of a matrix and basic results on characteristic roots, nature of the characteristic roots of Hermitian, skew-Hermitian, unitary and orthogonal matrices, characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix.	**9**

PART-B

Metric Spaces

Unit	Topic	No. of Lectures

VI	Definition and examples of metric space, pseudo metric, discrete and usual metric space, diameter of a set	**6**
VII	Open and closed sets in a metric space, Interior point, Limit point, Adherent point, Closed set, Neighbourhood, Closure of a set, Interior of a set, Bolzano-Weirstrass theorem, Complete metric space, Cauchy sequence, Convergent sequence, Bounded Sequence	**11**
VIII	Separated sets, Connected and disconnected sets, Continuity and connectedness, Compactness, Compactness and uniform continuity, Continuity and Uniform continuity in a metric space.	**12**

Suggested Readings (Part-A Linear Algebra):

1. Hadley: Linear Algebra.
2. Hoffman and Kunze: Linear Algebra, Prentice Hall of India, New Delhi, 1972.
3. H. Helson: Linear Algebra, Hindustan Book Agency, New Delhi, 1994.
4. K. B. Dutta: Matrix and Linear Algebra, Prentice Hall of India.
5. S. Lang: Linear Algebra, Springer.
6. Suggested digital platform: NPTEL/SWAYAM/MOOCs.

Suggested Readings (Part-B Metric Spaces):

1. Dhananjay Gopal, An Introduction to Metric Spaces, Chapman and Hall/CRC; 1st edition 2020.
2. Satish Shirali & H. L. Vasudeva, Metric Spaces, Springer, First Indian Print. 2009
3. S. Kumaresan, Topology of Metric Spaces Narosa Publishing House, 2014
4. Suggested digital platform: NPTEL/SWAYAM/MOOCs.

This course can be opted as an elective by the students of following subjects: Engg. and Tech. (UG), B.Sc.(C.S.)

Suggested Continuous Evaluation Methods: Max. Marks: 25

S. No	Assessment Type	Max. Marks
1	**Class Tests**	10
2	**Online Quizzes/Objective Tests**	5
3	**Presentation**	5
4	**Assignment**	5

Course prerequisites: To study this course, a student must have Diploma in Mathematics.

Suggested equivalent online courses:

Further Suggestions:

NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all
Uttarakhand State Universities and Colleges for
Five Years of Higher Education

PROPOSED STRUCTURE OF
UG & PG PHYSICS
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

Sr.No.	Name & Designation	
1.	Prof. N.K. Joshi Vice-Chancellor , Kumaun University Nainital	Chairman
2.	Prof. O.P.S. Negi Vice-Chancellor , Uttarakhand Open University	Member
3.	Prof. P. P. Dhyani Vice-Chancellor , Sri Dev Suman Uttarakhand University	Member
4.	Prof. N.S. Bhandari Vice-Chancellor, Soban Singh Jeena University Almora	Member
5.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun	Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member

Expert Committee

S.N.	Name	Designation	Department	Affiliation
1.	Dr. Sanjay Pant	Professor	Physics Department	Kumaun University, Nainital
2.	Dr. P.S. Bisht	Professor	Physics Department	S.S.J. University, Almora
3.	Dr. Ramesh Chandra	Professor	Physics Department	Kumaun University, Nainital
4.	Dr. Bimal Pande	Associate Professor	Physics Department	Kumaun University, Nainital
5.	Dr. Y.K. Sharma	Professor	Physics Department	S.S.D. University, Rishikesh
6.	Dr. Nandan Singh	Assistant Professor	Physics Department	S.S.J. University,Almora
7.	Dr. Kamal Devlal	Assistant Professor	Physics Department	Uttarakhand Open University Haldwani

Syllabus Preparation Committee

S.N.	Name	Designation	Department	Affiliation
1.	Dr. Sanjay Pant	Professor & Head	Physics Department	Kumaun University, Nainital
2.	Dr. Shuchi Bisht	Professor	Physics Department	Kumaun University, Nainital
3.	Dr. Ramesh Chandra	Professor	Physics Department	Kumaun University,Nainital
4.	Dr. Alok Durgapal	Associate Professor	Physics Department	Kumaun University, Nainital
5.	Dr. Bimal Pande	Associate Professor	Physics Department	Kumaun University, Nainital
6.	Dr. Seema Pande	Associate Professor	Physics Department	Kumaun University, Nainital

List of Papers in Six Semesters (B.Sc. Degree) Semester-wise Titles of the Papers in Physics					
Year	**Sem.**	**Course Code**	**Paper Title**	**Theory/ Practical**	**Credits**
Certificate Course in Basic Physics					
FIRST YEAR	I		Mechanics	Theory	(04)
			Mechanical Properties of Matter	Practical	(o2)
	II		Electricity and Magnetism	Theory	(04)
			Demonstrative Aspects of Electricity & Magnetism	Practical	(o2)
Diploma in Applied Physics					
SECOND YEAR	III		Thermodynamics	Theory	(04)
			Demonstrative Aspects of Thermal Properties of Matter	Practical	(o2)
	IV		Geometrical Optics	Theory	(04)
			Demonstrative Aspects of Geometrical Optics	Practical	(o2)
Bachelor of Science					
THIRD YEAR	V		Physical Optics	Theory	(04)
			Demonstrative Aspects of Physical Optics	Practical	(o2)
			Basic Electronics	Theory	(04)
			Demonstrative Aspects of Basic Electronics	Practical	(o2)
	VI		Modern Physics	Theory	(04)
			Demonstrative Aspects of Modern Physics	Practical	(o2)
			Analog and Digital Electronics	Theory	(04)
			Demonstrative Aspects of Analog & Digital Circuits	Practical	(o2)

Subject prerequisites:

1. For Semester I: 12^{th} pass with subjects Physics, Chemistry & Mathematics
2. For Semester II: Passed Semester I with Physics
3. For Semester III: Passed Semester II with Certificate Course in Basic Physics
4. For Semester IV: Passed Semester III
5. For Semester V: Passed Semester IV with Diploma in Applied Physics
6. For Semester VI: Passed Semester V

Programme outcomes (POs):

Students having Degree in B.Sc. (with Physics) should have knowledge of different concepts and fundamentals of Physics and ability to apply this knowledge in various fields of academics and industry. They may pursue their future career in the field of academics, research and industry.

PO 1	1. Competence in the methods and techniques of calculations using Mechanics. 2. Students are expected to have hands-on experience to apply the theoretical knowledge to solve practical problems.
PO2	1. Students are expected to have deep understanding of electricity and magnetism. 2. Student should be able to make basic electrical circuits and handle electrical instruments.
PO 3	1. Competence in the concepts of Thermodynamics. 2. Students are expected to have hands on experience in Thermal Physics Experiments.
PO 4	1 Knowledge of different concepts in Geometrical Optics. 2 Students are expected to have hands on experience of Experiments of Geometrical Optics
PO 5	1. Knowledge of basic concepts of optical instruments with their applications in technology 2. Students are expected to have an insight in handling electronic instruments.
PO 6	1. Comprehensive knowledge of Analog & Digital Principles and Applications. 2. Learn the integrated approach to analog electronic circuitry and digital electronics for R&D.

Programme specific outcomes (PSOs):
UG I Year / Certificate course in Basic Physics

After completing this certificate course, the student should have

- Acquired the basic knowledge of Mechanics, Electricity and Magnetism.
- Hands-on experience to apply the theoretical knowledge to solve practical problems of basic physical phenomena. He should be able to carry out experiments to understand the laws and concepts of Physics.

.
- An insight in understanding electrical circuits and in handling electrical instruments.

Programme specific outcomes (PSOs):
UG II Year/ (Diploma in Applied Physics)

After completing this diploma course, the student should have
• Knowledge of different concepts in Thermodynamics, and Geometrical Optics.
• Knowledge of different aspects of Thermal Physics which serves as a basis for many physical systems used in industrial applications and deals with the physics and technology of Engines and Refrigerators.
• A deeper insight in Ray Optics to understand the Physics of many optical instruments which are widely used in research and Industry, Optoelectronics, IT and communication devices, and in industrial instrumentation.
• Knowledge of basic concepts of optical instruments with their applications in technology.

Programme specific outcomes (PSOs): **UG III Year / Bachelor of Science**	
After completing this degree course, the student should have:	
PSO 1	*Knowledge of Mechanics and basic properties of matter. The course will empower him to apply his theoretical knowledge in various physical phenomena that occur in day to day life and he can use this scientific knowledge for the betterment of the society.*
PSO2	*Understanding of basic concepts related to Electricity and Magnetism.He should be proficienct in designing and handling different electrical circuits*
PSO3	Expertise in different aspects of Thermal Physics which serves as a basis for many physical systems used in industrial applications and deals with the physics and technology of Engines and Refrigerators.
PSO4	*Proficient in the field of Optics which will increase his demand in research and industrial establishments engaged in activities involving optical instruments.*
PSO5	*Basic knowledge in the field of Modern physics,* which have utmost importance at both undergraduate and graduate level.
PSO6	• Comprehensive knowledge of Analog & Digital Principles and Applications. • Learn the integrated approach to analog electronic circuitry and digital electronics for R&D.

Year wise Structure of B.Sc. in Physics (CORE / ELECTIVE COURSES & PROJECTS)

Subject: Physics

Type of Programme	Year	Sem	Paper I	Credit /hrs	Paper 2	Credit/ hrs	Paper 3	Credits /hrs	Paper 4	Credits /hrs	Elective Paper	Credits /hrs	Research Project	Credit/hrs
Certificate	I	I	Mechanics (Theory)	4/60	Mechanical Properties of Matter (Practical)	2/60					EL1 (One from the list) (06)	4/60		
		II	Electricity and Magnetism (Theory)	4/60	Demonstrative Aspects of Electricity& Magnetism (Practical)	2/60								
Diploma	II	III	Thermodynamics (Theory)	4/60	Demonstrative Aspects of Thermal Properties of Matter (Practical)	2/60					EL2 (One from the list) (06)	4/60		
		IV	Geometrical Optics (Theory)	4/60	Demonstrative Aspects of Geometrical Optics (Practical)	2/60								
Bachelor of Science	III	V	Physical Optics (Theory)	4/60	Basic Electronics (Theory)	4/60	Demonstrative Aspects of Physical Optics (Practical)	2/60	Demonstrative Aspects of Basic Electronics (Practical)	2/60			Industrial Training/Research Project	Qualifying
		VI	Modern Physics (Theory)	4/60	Analog and Digital Electronics (Theory)	4/60	Demonstrative Aspects of Modern Physics (Practical)	2/60	Demonstrative Aspects of Analog & Digital Circuits (Practical)	2/60			Industrial Training/Research Project	Qualifying

CERTIFICATE COURSE IN BASIC PHYSICS

Programme: *Certificate Course in Basic Physics*	Year: I	Semester: I Paper-I

Subject: Physics

Course Code:	Course Title: Mechanics

Course Outcomes

1. Understanding of Vector Algebra and Vector Calculus.
2. Understand the physical interpretation of gradient, divergence and curl.
3. Study of gravitational field and potential and understanding of Kepler's laws of Planetary motion.
4. Understanding of different frames of references and conservation laws.
5. Understand the dynamics of rigid body and concept of moment of inertia. Study of moment of inertia of different bodies and its applications.
6. Study the properties of matter, response of the classical systems to external forces and their elastic deformation and its applications.
7. Comprehend the dynamics of Fluid and concept of viscosity and surface tension along with its applications.

Credits: 04	Core Compulsory
Max. Marks: 100 External Exam: 75 Internal Assessment : 25	Min. Passing Marks: 33

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Vectors Algebra** Vector algebra. Scalar and vector products, scalar and vector triple products, Derivative of a vector with respect to a parameter, Del operator, gradient, divergence and curl, Gauss divergence theorem, Stokes curl theorem and Green's theorem, Line, surface and volume integral of a vector function.	10
Unit II	**Gravitation field and potential** Gravitational field and potential, Gravitational potential energy, Gravitational field Intensity and potential due to a ring, a spherical shell, solid sphere and circular disc, gravitational self-energy, Inverse square law of forces, Kepler's laws of planetary motion.	10

Unit III	**Conservation Laws** Frames of reference, Concept of inertial and Non-inertial frames of references, Work energy theorem, Conservative and non-Conservative forces, Linear restoring force, Gradient of potential, Conservation of energy for the particle; Energy function, Concept of Centre of mass, Angular momentum and torque, Laws of conservation of total energy, total linear momentum and total angular momentum along with their examples.	**15**
Unit IV	**Dynamics of rigid body and Moment of Inertia** Translatory and Rotatory motion, Equation of motion for Rotating rigid body, angular momentum vector and moment of inertia, Theorem of parallel and perpendicular axes, Moment of inertia of a cylinder, rod, lamina, ring, disc, spherical shell, solid sphere, kinetic energy of rotation, rolling along a slope, Application to compound pendulum.	**10**
Unit V	**Properties of Matter** Basic concept, Elastic constants and their Interrelations, torsion of cylinder, bending of beam, bending moment, Cantilever, shape of Girders/ rail tracks. Viscosity, Stokes's law, Posieuille's formula, Equation of continuity, Bernoulli's theorem, Surface tension and its molecular interpretation.	**15**

Suggested Reading

1.R. Resnick and D. Hilliday : Physics Vol-I
2.Berkeley Physics Course : Mechanics Vol-I
3.R.P. Feynman, R.B.Lightan and M.Sand : The Feynman Lectures in Physics
4.D.S. Mathur : Mechanics
5.D.S. Mathur : Elements of Properties of Matter
6. Murray Spiegel, Seymour Lipschutz, Dennis Spellman, "Schaum's Outline Series: Vector Analysis", McGraw Hill, 2017.
7. J. C. Upadhaya: Mechanics, S. Chand

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment- (25 marks)

Course Prerequisites: Physics and Mathematics in 12^{th}

<table>
<tr><td colspan="4">CERTIFICATE COURSE IN BASIC PHYSICS</td></tr>
<tr><td colspan="2">Programme: Certificate Course in Basic Physics</td><td>Year: I</td><td>Semester: I Practical</td></tr>
<tr><td colspan="4">Subject: Physics (Practical)</td></tr>
<tr><td>Course Code</td><td colspan="3">Course Title: Mechanical Properties of Matter (Practical)</td></tr>
<tr><td colspan="4">Course Outcomes:
1. Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the mechanical properties.
2. Measurement precision and perfection is achieved through Lab Experiments.</td></tr>
<tr><td colspan="2">Credits: 02</td><td colspan="2">Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 50
Internal (Record File): 15
External Practical Exam: 20
External Viva Voce : 15</td><td colspan="2">Min. Passing Marks: 17</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td></td><td colspan="2">1. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
2. To determine the Moment of Inertia of a Flywheel.
3. To determine g and velocity for a freely falling body using Digital Timing Technique.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
5. To determine the Young's Modulus of a Wire by Optical Lever Method.
6. To determine the Young's Modulus by bending of beam.
7. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle. To determine the elastic Constants of a wire by Searle’s method.
8. To determine the value of g using Bar Pendulum.
9. To determine the value of g using Kater’s Pendulum.
10. To determine Surface Tension.</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.

2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.

3. Indu Prakash: Practical Physics

4. S.L. Gupta, V. Kumar, “Practical Physics”, Pragati Prakashan, Meerut, 2014.

Suggestive Digital Platforms / Web Links:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74

2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

Suggested Continuous Evaluation Methods:

Continuous internal evaluation shall be based on attendance of student in Lab and presentation of practical in the record file. The marks shall be as follows

Record File (15 marks)

PREREQUISITE: Opted / Passed Semester I, Theory Paper-1

Further Suggestions:

• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

CERTIFICATE COURSE IN BASIC PHYSICS		
Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: I Vocational/ Minor**
Subject: Physics		
Course Code:	**Course Title: Basic Instrumentation Skills**	
Credits: 03	**Vocational/Minor (Experiments/hands on training)**	
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**	
Total No. of Lectures-Tutorials-Practical (in hours per week): 3-0-0		

Unit	Topic	No. of Lectures
Unit I	**Basics of Measurement** Instruments accuracy, precision, sensitivity, resolution, range, least count of different instruments etc. Errors in measurements and loading effects. Principle of Galvanometer, Voltmeter and Ammeter, Conversion of galvanometer into voltmeter and ammeter.	**15**
Unit II	**Multimeter** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity.	**10**
Unit III	**Digital Multimeter** Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time-base stability, accuracy and resolution.	**10**
Unit IV	**Digital Instruments:** Comparison of analog and digital instruments. Characteristics of a digital meter. Working principle of digital voltmeter.	**10**

Suggested Reading

1. B L Theraja : A text book in Electrical Technology
2. M G Say : Performance and design of AC machines
3. Venugopal : Digital Circuits and Systems
4. P. Vingron, Shimon : Logic Circuit Design
5. Subrata Ghoshal : Digital Electronics.
6. S. Salivahanan& N. S.Kumar : Electronic Devices and Circuits, , 3rd Edn

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL),
https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel,
https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

CERTIFICATE COURSE IN BASIC PHYSICS

Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: II** **Paper-I**

Subject: Physics

Course Code:	**Course Title: Electricity and Magnetism**

Course Outcomes:

1. Understanding of Electric Field and Potential. Evaluation of Electric Field and Potential for different types of charge distributions.
2. Study of Electric and Magnetic Fields in matter. Understand the concept of polarizability, Magnetization and Electric Displacement Vector.
3. Study ofSteady and Varying electric currents.
4. Understanding of different aspects of alternating currents and its applications.
5. Understand the Magnetostatics, Lorentz Force and Energy stored in magnetic Field.
6. Comprehend the different aspects of Electromagnetic induction and its applications.

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal Assessment : 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Electric field and potential** Coulomb law, Gauss' theory, its integral and differential forms, line integral of Electric field, Electric field and potential due to an arbitrary charge distribution. Electrostatic energy, energy stored in an Electric field. Electric field and potential due to long charged wire, Spherical shell, sphere, disc, dipole.	**15**
Unit II	**Electric and Magnetic fields in Matter** Moments of charge distributions, Polar and non-polar molecule, polarization vector, electric displacement vector, three electric vectors, dielectric susceptibility and permittivity, polarizability, Clausius-Mossotti relation. Magnetization, magnetic susceptibility, diamagnetic, paramagnetic and ferromagnetic substances, Hysteresis and B-H curve, Langevin's theories of Diamagnetism and paramagnetism, Weiss theory of ferromagnetism.	**15**
Unit III	**Electric Currents (Steady and Varying)** Current density, Equation of Continuity, Ohm's law and electrical conductivity, LorentzDrude theory, Wiedmann-Frenz law, Kirchhoff's laws	**10**

	and their applications, Transient current, Growth and decay of D. C. in L - R and L - C circuits, charging and discharging of a capacitor through a resistance.	
Unit IV	**Magnetostatics** Lorentz force, Bio-Savert's law, Ampere's law, Application of Biot-Savert law, magnetic field due steady current in a long straight wire, Interaction between two wires, field due a Helmholtz coil, solenoid and current loop, magnetic vector potential, permeability, Energy stored in Magnetic field.	**10**
Unit V	**Electromagnetic Induction and Alternating Current** Faraday's laws of induction, Lenz's law, Electromotive force, Measurement of magnetic field, Eddy current, Mutual inductance, Self-inductance. Impedance, admittance and reactance, R-C, R-L and L-C circuits with alternating e.m.f. source, series and parallel L-C-R circuits, resonance and sharpness, Quality factor, Power in A. C. circuits, Choke coil.	**10**

Suggested Reading

1. Edward M. Purcell : Electricity and Magnetism

2. J.H. Fewkes&J.Yarwood : Electricity & Magnetism, Vol. I

3. D C Tayal : Electricity and Magnetism ", Himalaya Publishing House Pvt. Ltd., 2019.

4. D.J.Griffiths : Introduction to Electrodynamics .

5. Lal and Ahmed : Electricity and Magnetism

6. H. K. Malik and A.K. Singh "Engineering Physics", McGraw Hill Education (India) Private Limited, 2018.

7. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics Vol. 2", Pearson Education Limited, 2012.

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

Course Prerequisites: Passed semester I, theory paper-1

<table>
<tr><td colspan="4">CERTIFICATE COURSE IN BASIC PHYSICS</td></tr>
<tr><td colspan="2">Programme: Certificate Course in Basic Physics</td><td>Year: I</td><td>Semester: II Practical</td></tr>
<tr><td colspan="4">Subject: Physics (Practical)</td></tr>
<tr><td>Course Code:</td><td colspan="3">Course Title: Demonstrative Aspects of Electricity & Magnetism (Practical)</td></tr>
<tr><td colspan="4">Course Outcomes:
1. Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the electric and magnetic properties.
2. Measurement precision and perfection is achieved through Lab Experiments.</td></tr>
<tr><td colspan="2">Credits: 02</td><td colspan="2">Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 50
Internal (Record File): 15
External Practical Exam: 20
External Viva Voce : 15</td><td colspan="2">Min. Passing Marks: 17</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td></td><td colspan="2">1. Frequency of A.C. Mains.
2. Calibration of Voltmeter by potentiometer.
3. Calibration of ammeter by potentiometer.
4. Specific resistance determination.
5. Conversion of a Galvanometer into a Voltmeter.
6. Conversion of a Galvanometer into Ammeter.
7. Variation of magnetic field along the axis of a current carrying circular coil.
8. Comparison of capacities by Ballistic Galvanometer.
9. Determination of Ballistic Constant.
10. Electrochemical equivalent.
11. De Sauty's bridge- C1/ C2
12. R1/R2 by potentiometer.
13. Study of R-C, L-C-R circuits.
14. Determination of self inductance, mutual inductance.
15. Magnetic field determination by search coil and ballistic galvanometer.</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.
2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.
3. Indu Prakash: Practical Physics
4. S.L. Gupta, V. Kumar, “Practical Physics”, PragatiPrakashan, Meerut, 2014.

Suggestive Digital Platforms / Web Links:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

Suggested Continuous Evaluation Methods:

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File (15 marks)

PREREQUISITE: Passed Semester I

Further Suggestions:

• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

CERTIFICATE COURSE IN BASIC PHYSICS

Programme : ***Certificate Course in Basic Physics***	**Year: I**	**Semester: II** **Vocational/Minor**
Subject: Physics		
Course Code:	**Course Title: Electronics Instrumentation skills**	
Credits: 03	**Vocational/Minor**	
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**	
Total No. of Lectures-Tutorials-Practical (in hours per week): 3-0-0		

Unit	Topic	No. of Lectures
Unit I	**Electronic Voltmeter** Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter, Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac milli -voltmeter, specifications and their significance.	**10**
Unit II	**Cathode Ray Oscilloscope** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.	**15**
Unit III	**Signal and pulse Generators** Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.	**10**
Unit IV	**Impedance Bridges** Block diagram of bridge. Working principles of basic (balancing) RLC bridge. Specifications of RLC bridge. Block diagram and working principleas of a Q-meter. Digital LCR bridges.	**10**

Suggested Reading

1. B L Theraja : Basic Electronics
2. M G Say : Performance and design of AC machines
3. Venugopal : Digital Circuits and Systems
4. P. Vingron, Shimon : Logic Circuit Design
5. Subrata Ghoshal : Digital Electronics
6. S. Salivahanan & N. S.Kumar : Electronic Devices and Circuits
7. V. K. Mehta: Basic Electronics

Suggested Online Link:

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2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

Minor/Elective (04 Credit, One from the list El 1)

Students having major in Physics will have to choose the elective/minor from sl. no. 1-4 only. Other students may have choice from sl. no. 1-6.

1. Statistical Physics
2. Numerical Methods
3. Computer Programming
4. Waves and Oscillations
5. Fundamental Mechanics
6. Basic Electricity and Magnetism

CERTIFICATE COURSE IN BASIC PHYSICS		
Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: I/II**
Subject: Physics		
Course Code:	**Course Title: Statistical Physics**	

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Basic Concepts in Statistical Physics** Basic postulates of Statistical Physics, Macro and Micro States, Phase Space, Density distribution in phase space, μ space representation and its division, Statistical average values, Condition of equilibrium, Stirling's Approximation, Entropy and Thermodynamic probability, Boltzmann entropy relation.	**15**
Unit II	**Ensembles and Thermodynamic connections** Ensembles, Micro -canonical, Canonical and Grand Canonical ensembles, Statistical definition of temperature and interpretation of second law of thermodynamic, Pressure, Entropy and Chemical potential. Entropy of mixing and Gibb's paradox, Partition function and Physical significances of various statistical quantities.	**15**
Unit III	**Classical Statistics** Maxwell-Boltzmann statistics and Distribution law, Energy distribution function, Maxwell Boltzmann law of velocity distribution (most probable velocity, average velocity, RMS velocity), Limitations of M-B statistics,	**15**

	Elementary idea of quantum statistics.	
Unit IV	**Bose-Einstein and Fermi-Dirac Statistics** B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas, Bose derivation of Planck's law. Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	**15**

Suggested Reading

1. B.B.Laud : Introductions to Statistical Mechanics
2. Bhattarjee J.K. : Statistical Physics (Allied Publishers)
3. F.Reif : Statistical Physics (Mc.Graw Hill)
4. Kamal Singh : Elements of Statistical Mechanics
5. K.Hung : Statistical Physics (Chapman and Hall/CRC)
6. J.P. Srivastava : Elements of Solid State Physics
7. K.E.Atkinson : Elementary Numerical Analysis
8. R.K. Pathria, B. Heinemann : Statistical Mechanics

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL),
https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel,
https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

CERTIFICATE COURSE IN BASIC PHYSICS		
Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: I/II**
Subject: Physics		
Course Code:	**Course Title: Numerical Methods**	

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

Unit	Topic	No. of Lectures
Unit I	**Ordinary Differential Equations** Brief review of ordinary differential equations, Exact equations, Equations reducible to exact equations, Equations of the first order and higher degrees, Clairaut's equation. Applications of ODEs in concerned engineering branch. Linear differential equations with constant co-efficient, Complimentary functions and particular integral, Method of variation of parameters, Equations reducible to linear equations with constant co-efficient (Cauchy's and Legendre's linear equations), Initial and Boundary value problems, Simultaneous linear equations with constant co-efficient, Applications of differential equations in concerned engineering branch.	**15**
Unit II	**Partial Differential Equations** Formulation of Partial Differential Equations (PDE), Solution of PDE, Linear PDE of First Order (Lagrange's Linear Equation), Non-linear Equation of First Order (Standard Forms), Charpit's Method, Homogeneous Linear Equations with Constant Coefficients, Non-homogeneous Linear Equations. Applications of PDE: Method of separation of variables, Solution of one dimensional wave and heat equation and two dimensional Laplace's equation.	**15**
Unit III	**Transforms Theory** Laplace Transform: Laplace Transforms of standard functions and their properties, Inverse Laplace Transforms, General Properties of inverse Laplace transforms and Convolution Theorem, Laplace Transforms of periodic functions, Dirac-delta Function, Heaviside's Unit Function, Solution of ODE	**15**

	and linear simultaneous differential equations using Laplace transforms. Fourier Transform: Fourier integral representation, Fourier sine, cosine and complex transform, Finite Fourier Transforms and their applications. Z – Transforms: Z–Transforms & its properties, inversion of Z – transform and applications of Z – transform	
Unit IV	**Probability and Statistics** Review of probability, Conditional probability and sampling theorems, Discrete and Continuous Probability Distribution, Probability Mass & Probability Density Functions, Distribution function, Discrete and Continuous probability distributions, Binomial, Poisson and Normal distributions.	**15**

Suggested Reading

1. Advanced Engineering Mathematics by E. Kreyszig, John Wiley and Sons, NC, New York.
2. Differential Equations by S. L. Ross, John Wiley & Sons, New York.
3. An Introduction to Probability Theory & its Applications by W. Feller, Wiley.
4. Probability and Statistics for Engineers and Scientists by R.E. Walpole, S. L. Myers and K. Ye, Pearson.
5. Integral Transforms and Their Applications by Lokenath Dennath and Dambaru Bhatta, Chapman and Hall/CRC Press.

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

CERTIFICATE COURSE IN BASIC PHYSICS		
Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: I/II**
Subject: Physics		
Course Code:	**Course Title: Computer Programming**	

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Programming Fundamentals** Introduction to computer, block diagram and organization of computer, number system and binary arithmetic, processing data, hardware, software, firmware, types of programming language -Machine language, Assembly level language, higher level language, source file, object file, translator-assembler, compiler, interpreter. Evolution and classification of programming languages.	**15**
Unit II	**Programming Techniques** Steps in program development, algorithm, flowchart, pseudo code. **C Language**: 'C' character set, literals, keywords, identifiers, data types and size, variable declaration, expression, labels, statements, formatted input output statements, types of operators, data type conversion, mixed mode arithmetics, control structures.	**15**
Unit III	**Data Structures** Storage classes, scope rules and visibility, arrays, pointers, dynamic storage allocation, structures and unions, self-referential structures. Relationship between pointers and arrays, dynamic arrays: Introduction to dynamic data structures linked lists, stack, and binary trees.	**15**
Unit IV	**Functions and File Handling** 'C' functions, library functions, parameter passing, recursion, 'C' files, function for file handling, 'C' pre-processors and command line arguments, macros and conditional compiler directives.	**15**

Suggested Reading

1. C Programming Language by Briain W. Kenigham and Dennis Ritchie, Prentice Hall of India.
2. Programming with C by Byron Gottfried, Tata McGraw Hill.
3. The Complete Reference C by Herbert Schildt, Tata McGraw Hill.
4. Let us C by Yashwant Kanetkar, BPB Publication.
5. A Structured Programming Approach in C by B.A. Forouzan and R.F. Gilberg, Cengage Learning.

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

CERTIFICATE COURSE IN BASIC PHYSICS		
Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: I/II**
Subject: Physics		
Course Code:	**Course Title: Fundamental Mechanics**	

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

Unit	Topic	No. of Lectures
Unit I	**Vectors Algebra and Ordinary Differential Equations** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.	**15**
Unit II	**Translatory and Rotatary Motion and Conservation Laws** Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass, Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets, Angular velocity and angular momentum. Torque. Conservation of angular momentum.	**15**
Unit III	**Gravitation** Newton's Law of Gravitation. Motion of a particle in a central force field (motion in a plane, angular momentum conservation). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.	**15**
Unit IV	**Elasticity** Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire – Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method.	**15**

Suggested Reading

1. Sears, Zemansky and Young : University Physics
2. Berkeley Physics Course : Volume-1 Mechanics
3. Resnick, Halliday & Walker Fundamentals of Physics
4. Basudeb Bhattacharya : Engineering Mechanics 2nd Edn
5. Ronald Lane Reese : University Physics
6. B.L. Flint and H.T. Worsnop : Advanced Practical Physics for Students

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

CERTIFICATE COURSE IN BASIC PHYSICS		
Programme: ***Certificate Course in Basic Physics***	**Year: I**	**Semester: I/II**
Subject: Physics		
Course Code:	**Course Title: Waves and Oscillations**	

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

Unit	Topic	No. of Lectures
Unit I	**Analysis of wave motion** Characteristics, Differential equation of a wave motion, principle of superposition, Interference, Beats, stationary waves, Energy of stationary waves, Wave velocity and group velocity, Fourier theorem, Fourier analysis of square, triangular and saw-tooth waves. Energy density of plane acoustic waves, Acoustic intensity, Measurement of acoustic intensity – the dB scale, Characteristics and loudness of Musical sound, Acoustic impedance, Reflection and transmission of acoustic waves. Acoustics of buildings, reverberation time, Sabine's formula, Principle of sonar system.	**15**
Unit II	**Ultrasonics** Classification of Sound waves, Ultrasonics, Quartz crystal and Piezo electric effect, Magnetostriction effect, Properties of Ultrasonic, Detection of ultrasonic waves, Determination of velocity of ultrasonic waves in liquid (Acoustic grating method) . Application of Ultrasonics.	**15**
Unit III	**Simple Harmonic Oscillations** Periodic motion, SHM in mechanical systems, Energy of Simple harmonic oscillator, Superposition of SHM(s), Oscillations of two masses connected by a spring, Non-linear (An-harmonic) oscillator and its applications to simple pendulum. Applications of Simple harmonic motion in compound pendulum, Torsional pendulum and LC circuit, Composition of two SHM(s) of different frequency ratio, Lissajous' figures for equal frequencies ratio and 2:1 frequencies ratio	**15**
Unit IV	**Damped and Forced Harmonic Oscillations** Damping force, Different cases for over, critical and under damping, Mechanical damped harmonic oscillators, Logarithmic decrement, Power Dissipation, Relaxation time & Quality Factor.	**15**

	Forced oscillations, Mechanical driven harmonic oscillators, Transient and steady state behavior, Power absorption, phenomenon of resonance, amplitude resonance, velocity resonance, sharpness of resonance/Fidelity, Bandwidth and quality factor.	

Suggested Reading

1. R. Resnick and D. Hilliday : Physics Vol-I
2. D.S. Mathur : Mechanics
3. Brijlal and Subrahmanyam : Waves and Oscillations
4. B.S.Semwal and M.S.Panwar : Wave Phenomena and Material Science
5. Berkeley Physics Course : Mechanics Vol-I
6. R.K.Ghose : The mathematics of waves an Vibrations
7. D.P.Khandelwal : Oscillations and Waves
8. I.I.Pain : Physics of Vibration
9. A. P. French : Vibrations and Waves

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

CERTIFICATE COURSE IN BASIC PHYSICS			
Programme: ***Certificate Course in Basic Physics***		**Year: I**	**Semester: I/II**
Subject: Physics			
Course Code:	**Course Title: Basic Electricity and Magnetism**		

Credits: 04		**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**		**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
Unit	**Topic**	**No. of Lectures**
Unit I	**Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere.	**15**
Unit II	**Magnetism** Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferromagnetic materials.	**15**
Unit III	**Electromagnetic Induction and Alternating Current** Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. Basic concepts of alternating currents.	**15**
Unit IV	**Maxwell`s equations and Electromagnetic wave propagation** Equation of continuity, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave and its transverse nature.	**15**

Suggested Reading

1. Edward M. Purcell : Electricity and Magnetism

2. J.H. Fewkes & J.Yarwood : Electricity & Magnetism, Vol. I

3. D C Tayal : Electricity and Magnetism
4. Ronald Lane Reese : University Physics
5. D.J.Griffiths : Introduction to Electrodynamics, 3rd Edn.
6. B.L.Flint & H.T.Worsnop : Advanced Practical Physics for Students
7. M. Nelson and J. M. Ogborn : Advanced level Physics Practicals, 4th Ed
8. I.Prakash & Ramakrishna : A Text Book of Practical Physics, 11th Ed
9. S.Panigrahi & B.Mallick : Engineering Practical Physics

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS

Programme: ***Diploma in Applied Physics***	**Year: II**	**Semester: III** **Paper-I**

Subject: Physics

Course Code:	**Course Title: Thermodynamics**

Course Outcomes:

1. Recognize the difference between reversible and irreversible processes.
2. Understand First and Second Law of Thermodynamics and concept of Entropy.
3. Understand the physical significance of thermodynamical potentials.
4. Comprehend the kinetic model of gases w.r.t. various gas laws.
5. Study the implementations and limitations of fundamental radiation laws.

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Basic concepts and First law of thermodynamics** Thermodynamic Systems, Thermal equilibrium and Zeroth law of thermodynamics, Equation of state and First law of thermodynamics, Discussion of Heat and Work, Quasi-static Work; Reversible and Irreversible; Path Dependence; Heat Capacities Adiabatic Processes, Vander Wall equation, Distinction between Joule, Joule-Thompson and Adiabatic expansion of a gas.	**15**
Unit II	**Second law of Thermodynamics and Entropy** Insufficiency of first law of thermodynamics, Condition of Reversibility, Carnot‟s Engine and Carnot‟s Cycle, Second law of thermodynamics, Carnot‟s Theorem, Thermodynamic scale of temperature and its identity to perfect gas, scale of temperature. Entropy, Mathematical formulation of Second law of thermodynamics, Entropy of an ideal gas, T-S diagram and its applications, Evaluation of Entropy changes in simple cases, Third law of thermodynamics.	**10**
Unit III	**Thermodynamic Relations** Thermodynamic potentials, Maxwell‟s equation from thermodynamic potentials, Some useful manipulations with partial derivatives (cooling in adiabatic processes and Adiabatic stretching of a wire), The Clausius–Clapeyron‟s equations, Triple point, Applications of Maxwell‟sthermo dynamical relations.	**10**

Unit IV	**Transport of Heat** Modes of heat transfer via Conduction, Convection and Radiation, Fourier"s law. One dimensional steady state conduction, Heat conduction through plane. Thermal conductivity and its experimental detection, Newton"s law of cooling, Dimensional analysis applied to forced and free convection. Black body radiation, Thermodynamics of radiations inside a hollow enclosure, Kirchoff"s Laws, Derivation of Stefan Boltzmann Law, Wein"s displacement law, Black body spectrum formulaearly attempts, Raleigh Jean"s Law, Quantum theory of Radiation, Planck"s formula for black body spectrum, Wien"s law, Radiation as a photon gas.	**15**
Unit V	**Kinetic Theory of Gases** Kinetic theory of gases, Microscopic description of an Ideal gas, Degrees of freedom, Law of Equipartition of Energy, Distribution law of velocities, Most probable speed, Average speed and root mean square velocity of molecules, Pressure exerted by a perfect gas, Kinetic Interpretation of Temperature	**10**

Suggested Reading

1. S. Loknathan : Thermodynamics, Heat and Statistical Physics
2. Sharma and K.K. Sarkar : Thermodynamics, and Statistical Physics
3. Brijlal and Subrahmanyam : Heat and Thermodynamics
4. Garg, Bansal and Ghose : Thermal Physics, McGraw Hill, 2012.
5. M.W. Zemansky, R. Dittman, "Heat and Thermodynamics", McGraw Hill, 1997.
6. Enrico Fermi, "Thermodynamics", Dover Publications, 1956.
7. MeghnadSaha, B.N. Srivastava, "A Treatise on Heat", Indian Press, 1973
8. F.W. Sears, G.L. Salinger, "Thermodynamics, Kinetic theory & Statistical thermodynamics", Narosa Publishing House, 1998.
9. Singhal and Prakash: Heat and Thermodynamics, Pragati Prakashan

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

Course Prerequisites: Passed Certificate course in Basic Physics.

<table>
<tr><td colspan="4">DIPLOMA IN APPLIED PHYSICS</td></tr>
<tr><td colspan="2">Programme: Diploma in Applied Physics</td><td>Year: II</td><td>Semester: III Practical</td></tr>
<tr><td colspan="4">Subject: Physics (Practical)</td></tr>
<tr><td>Course Code:</td><td colspan="3">Course Title: Demonstrative Aspects of Thermal Physics (Practical)</td></tr>
<tr><td colspan="4">Course Outcomes:
1. Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the thermal properties.
2. Measurement precision and perfection is achieved through Lab Experiments.</td></tr>
<tr><td colspan="2">Credits: 02</td><td colspan="2">Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 50
Internal (Record File): 15
External Practical Exam: 20
External Viva Voce : 15</td><td colspan="2">Min. Passing Marks:17</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td></td><td colspan="2">1. Thermal conductivity of a bad conductor by Lee's method.
2. Mechanical equivalent of heat by Searle's method.
3. Stefan's law
4. Platinum resistance thermometer.
5. Thermal conductivity of a good conductor by Searle's method.
6. J by Callendar and Barnes method.
7. Random throw- statistical method.
8. Newton's law of cooling, sp. heat of Kerosene oil.
9. Constant volume thermometer.
10. Variation of thermo-emf across two junctions of a thermocouple with Temperature</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.
2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.
3. Indu Prakash: Practical Physics
4. S.L. Gupta, V. Kumar, “Practical Physics”, Pragati Prakashan, Meerut, 2014.

Suggestive Digital Platforms / Web Links:
1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

Suggested Continuous Evaluation Methods:
Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File (15 marks)

PREREQUISITE: Passed Certificate course in Basic Physics

Further Suggestions:
• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

DIPLOMA IN APPLIED PHYSICS		
Programme: ***Diploma in Applied Physics***	**Year: II**	**Semester: III Vocational/Minor**
Subject: Physics		
Course Code:	**Course Title: Number System and Boolean Algebra**	
Credits: 03	**Vocational/Minor**	
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**	
Total No. of Lectures-Tutorials-Practical (in hours per week): 3-0-0		

Unit	Topic	No. of Lectures
Unit I	Number systems, Decimal, Binary, Octal and Hexadecimal number systems, Binary to decimal conversion, Double-Dadd method, Decimal to Binary conversion-shifting the place point Binary operations,	**10**
Unit II	Binary addition, Binary subtraction. Complement of a number (1‟s complement and 2‟s complement), Binary division, Representation of a Binary number as electrical signals.	**10**
Unit III	Octal number system, Conversion of Binary to octal and octal to binary, Advantages of octal number system, Hexadecimal number system, Binary to hexadecimal and vice-versa (Inter-conversion), BCD, GREY, EXCESS-3 codes	**15**
Unit IV	Boolean algebra, Features of Boolean algebra, Laws of Boolean algebra, Equivalent switching circuit, Demorgan’s theorems and Duals.	**10**

Suggested Reading

Books Recommended :

1. M.K. Baagde, S.P.Singh and Kamal Singh ,Elements of Electronics ,(S. Chand and Co.)
2. B.L.Thereza, Basic Electronics, (S. Chand and Co.)
3. V.K.Mehta, Elements of Electronics, (S. Chand and Co.)
4. Brophy, Communication Electronics (McGraw-Hill Education)
5. R Boylested , Electronic Devices & Circuit theory (PHI)

Suggested Online Link: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/

2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS			
Programme: ***Diploma in Applied Physics***		**Year: II**	**Semester: IV Paper-I**
Subject: Physics			
Course Code:	**Course Title: Geometrical Optics**		

Course Outcomes:

1. Study of Fermat's Principle of Extremum Path and understand fundamental physics behind reflection and refraction of light.
2. Understand the theory of image formation by an optical system.
3. Study of different types of optical Aberrations and techniques for their reduction.
4. Study of different types of optical instruments used in industry and research

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	Fermat's Principle and refraction (Spherical Surfaces) Fermat's principle of extremum path and its application to deduce laws of reflection and refraction, Refraction at concave surface, Principal foci, Lateral and longitudinal magnifications, Aplanatic points of spherical surface.	**15**
Unit II	Image Theory for Lens Systems Gauss's general theory of image formation, Coaxial symmetrical system, Cardinal points of an optical system, General relationships, Thick and Thin lens, lens combinations, Newton's formula, Coaxial lens system, Lagrange's equation of magnification, Refraction through a thick lens. Matrix theory of image formation.	**15**
Unit III	Optical Aberrations and dispersion Aberrations in images, Spherical aberration, Chromatic aberration, Condition of achromatism, Achromatic combination of lenses in contact and separated lenses, Monochromatic aberrations and their reduction, Spherical mirrors and Schmidt corrector plates, Theory of dispersion.	**15**
Unit IV	Associated Optical Instruments Nodal Slide, Eyepiece, Ramsden's, Huygen's and Gaussian eyepieces, their comparison. Types of telescopes, Astronomical Reflecting and refracting telescope, Microscopes: principle and types, Spectrometer and its uses, Oil immersion objectives meniscus lens.	**15**

Suggested Reading

1. D.P. Khandelwaland : Optics and Atomic Physics
2. Jenkins and White : Fundamentals of Optics
3. A.K. Ghatak : Physical Optics
4. Brijlal and Subrahmanyam : Optics
5. K.D. Moltev : Optics
6. B. K. Mathur : Optics
7. B. D. Guenther : Modern Optics, Oxford Press
8. E. Hecht: Optics, Pearson.

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested equivalent online courses:

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Assignment (05 marks)

Class Test/Assignment (25 marks)

Course Prerequisites: Passed Certificate course in Basic Physics and Passed Semester III.

<table>
<tr><td colspan="4">DIPLOMA IN APPLIED PHYSICS</td></tr>
<tr><td colspan="2">Programme: Diploma in Applied Physics</td><td>Year: II</td><td>Semester: IV Practical</td></tr>
<tr><td colspan="4">Subject: Physics (Practical)</td></tr>
<tr><td>CourseCode:</td><td colspan="3">Course Title: Demonstrative Aspects of Geometrical Optics (Practical)</td></tr>
<tr><td colspan="4">Course Outcomes:
1. Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties.
2. Measurement precision and perfection is achieved through Lab Experiments.</td></tr>
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Internal (Record File): 15
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<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td></td><td colspan="2">1. Nodal slide assembly, Location of cardinal points of lens system.
2. Newton's formula.
3. Dispersive power of prism.
4. Resolving power of a telescope.
5. To determine the Resolving Power of a Prism.
6. To verify the Cauchy's dispersion formula.
7. To find the thickness of the wire using optical bench.
8. To determine the thickness of mica-sheet by using Biprism</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962.
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015.
3. Indu Prakash, Practical Physics
4. S.L. Gupta, V. Kumar, "Practical Physics", PragatiPrakashan, Meerut, 2014.

Suggestive Digital Platforms / Web Links:
1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

Suggested Continuous Evaluation Methods:
Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File (15 marks)

PREREQUISITE: Passed Certificate course in Basic Physics and Semester III.

Further Suggestions:
The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

<table>
<tr><td colspan="4" align="center">DIPLOMA IN APPLIED PHYSICS</td></tr>
<tr><td colspan="2">Programme: Diploma in Applied Physics</td><td>Year: II</td><td>Semester: IV
Vocational/Minor</td></tr>
<tr><td colspan="4" align="center">Subject: Physics</td></tr>
<tr><td>CourseCode:</td><td colspan="3" align="center">Course Title: Digital Electronics</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="2">Credits: 03</td><td colspan="2">Vocational/Minor</td></tr>
<tr><td colspan="2">Max. Marks: 100
External Exam: 75
Internal Assessment: 25</td><td colspan="2">Min. Passing Marks: 33</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 3-0-0</td></tr>
</table>

Unit	Topic	No. of Lectures
Unit I	Positive and Negative logic, Two input OR gate, Diode OR gate and transistor OR gate, Three input OR gate and its truth table, Exclusive OR gates, The AND gate, Diode AND gate and transistor AND gate, The NOT gate,	**10**
Unit II	Bubbled gates, The NOR gate, The NAND gate, NAND and NOR as universal gates, The XNOR gate. Adders and subtractors, Half Adders, Full adders	**10**
Unit III	Logic Families, Saturated and Non- saturated Logic circuits, Characteristics of Logic Families, RTL Circuits, DTL Circuits, TTL Circuits.	**10**
Unit IV	Basic idea of Flip Flop, RS Latch, D-type flip flop and T-type Flip Flop . JK Flip Flop and Master Slave Flip Flop.	**15**

Suggested Reading

Books Recommended :

1. M.K. Baagde, S.P.Singh and Kamal Singh ,Elements of Electronics ,(S. Chand and Co.)
2. 2. B.L.Thereza, Basic Electronics, (S. Chand and Co.)
3. 3. V.K.Mehta, Elements of Electronics, (S. Chand and Co.)
4. 4. Brophy, Communication Electronics (McGraw-Hill Education)
5. 5. R Boylested , Electronic Devices & Circuit theory (PHI)

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

Minor/Elective (04 Credit, One from the list El2)

Students having major in Physics will have to choose the elective/minor from sl. no. 1-5. Other students may have choice from sl. no. 1-6.

1. **Solid State Physics**
2. **Elements of Modern Physics**
3. **Electromagnetic Theory**
4. **Optoelectronic Devices**
5. **Opto-Electronics and Laser Instrumentation**
6. **Classical Dynamics**

DIPLOMA IN APPLIED PHYSICS			
Programme: ***Diploma in Applied Physics***		**Year: II**	**Semester: III/IV**
Subject: Physics			
Course Code:	**Course Title:** Solid State Physics		

Credits: 04		**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**		**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
Unit	**Topic**	**No. of Lectures**
Unit I	**Crystal Structure** Single crystals and polycrystalline forms, Lattice, Basis and crystal structure, Translational symmetry and basis vectors, Unit cell (primitive and non-primitive), Two dimensional point groups and Bravais lattices, Miller indices, SC, BCC and Sodium Chloride structures, closed packed structures (FCC and HCP). Reciprocal lattice, X-rays diffraction, Bragg's law, Laue and powder methods of X-rays diffraction.	**15**
Unit II	**Lattice Dynamics** Lattice vibrations, Monoatomic lattice, Phonons, Free electron theory of metals, limitations of Lorentz Drude theory, Somerfield theory, Specific heat and paramagnetism of free electrons, Dulong and Petit's law, Departure of the law at low temperatures, Einstein's theory of specific heat and its limitations, Debye's theory of specific heat of solids.	**15**

Unit III	**Band theory of Solids** Motion of an electron in periodic potential (one dimensional), Results of Kronig-Penny model, Distinction between conductors, Semiconductors and Insulators, Intrinsic and Extrinsic semiconductors, Effective mass of electron, Concept of holes.	**15**
Unit IV	**Magnetic and Dielectric Properties of Matter** Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Hysteresis and Energy Loss,. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.	**15**

Suggested Reading

1. Dekker : Solid State Physics
2. C.kittel : Introduction to Solid State Physics
3. S.O.Pillai : Solid State Physics
4. Saxena,Gupta and Saxena : Fundamental of Solid State Physics
5. B.B.Laud : Introductions to Statistical
8. Leonid V. Azaroff : Introduction to Solids
9. N.W. Ashcroft and N.D. Mermin : Solid State Physics
10. H. Ibach and H. Luth : Solid-state Physics
6. B.L.Flint & H.T.Worsnop : Advanced Practical Physics for Students

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS		
Programme: ***Diploma in Applied Physics***	**Year: II**	**Semester: III/IV**
Subject: Physics		
Course Code:	**Course Title: Elements of Modern Physics**	

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

Unit	Topic	No. of Lectures
Unit I	**Quantum Mechanics and Bohr Atom Model** Planck's quantum, Planck's constant and light as a collection of photons; Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Rutherford model, Bohr's model, quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.	**15**
Unit II	**Quantum Systems and Heisenberg Uncertainty Principle** Position measurement; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.	**15**
Unit III	**Matter Waves and Schrödinger Equation** Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.	**15**
Unit IV	**Motion in a Potential Well** One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical tunnelling in one dimension - across a step potential and across a rectangular potential barrier.	**15**

Suggested Reading

1. Arthur Beiser : Concepts of Modern Physics
2. J.R. Taylor, C.D. Zafiratos : Modern Physics
3. Thomas A. Moore : Six Ideas that Shaped Physics: Particle Behave like Waves
4. Berkeley Physics Course : Vol.4 (Quantum Physics)
5. Serway, Moses, and Moyer : Modern Physics
6. G. Kaur and G.R. Pickrell : Modern Physics
7. B.L. Flint and H.T. Worsnop : Advanced Practical Physics for Students
8. Michael Nelson and Jon M. Ogborn : Advanced level Physics Practicals, , 4th Edition

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS		
Programme: ***Diploma in Applied Physics***	**Year: II**	**Semester: III/IV**
Subject: Physics		
Course Code:	**Course Title: Electromagnetic Theory**	

Credits: 04		**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**		**Min. Passing Marks: 25**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
Unit	**Topic**	**No. of Lectures**
Unit I	**Maxwell's Equations** Review of electrostatic and electromagnetic equations, their differential and integral forms, Maxwell's equations. Displacement Current. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density.	**15**
Unit II	**EM Wave Propagation in Unbounded Media** Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth.	**15**
Unit III	**EM Wave in Bounded Media** Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection and Refraction, Fresnel's Formulae, Brewster's law. Total internal reflection,	**15**
Unit IV	**Polarization of Electromagnetic Waves** Description of Linear, Circular and Elliptical Polarization. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices.	**15**

Suggested Reading

1. D.J. Griffiths : Introduction to Electrodynamics

2. M.N.O. Sadiku : Elements of Electromagnetics

3. T.L. Chow : Introduction to Electromagnetic Theory

4. M.A.W. Miah : Fundamentals of Electromagnetics

5. R.S. Kshetrimayun : Electromagnetic field Theory
6. Willian H. Hayt : Engineering Electromagnetic
7. J.A. Edminster : Electromagnetics, Schaum Series, 2006
8. B.L. Flint and H.T. Worsnop : Advanced Practical Physics for Students
9. Michael Nelson and J. M. Ogborn : Advanced level Physics Practicals

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS		
Programme: *Diploma in Applied Physics*	Year: II	Semester: III/IV
Subject: Physics		
Course Code:	Course Title: Optoelectronic Devices	

Credits: 04	Minor/Elective
Max. Marks: 100 External Exam: 75 Internal Assessment: 25	Min. Passing Marks: 33
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

Unit	Topic	No. of Lectures
Unit I	**Properties of semiconductors** Electron and photon distribution: density of states, effective mass and band structure, effect of temperature and pressure on band gap, recombination processes. Basics of semiconductor optics: Dual nature of light, band structure of various semiconductors, light absorption and emission, photoluminescence. electroluminescence, radioactive and non-radiative recombination, wave trains.	15
Unit II	**Semiconductor light-emitting diodes and Semiconductor lasers** Structure and types of LEDs and their characteristics, guided waves and optical modes, optical gain, confinement factor, internal and external efficiency, semiconductor heterojunctions, double hetero structure LEDs. Semiconductor lasers: Spontaneous and stimulated emission, principles of a laser diode, threshold current, effect of temperature, design of an edge-emitting diode, emission spectrum of a laser diode, quantum wells, quantum-well laser diodes.	15
Unit III	**Semiconductor light modulators** Modulating light (direct modulation of laser diodes, electro-optic modulation, acousto-optic modulation), isolating light (magneto-optic isolators), inducing optical nonlinearity (frequency conversion, switching)	15

Unit IV	**Semiconductor light detectors** I-V characteristics of a p-n diode under illumination, photovoltaic and photoconductive modes, load line, photocells and photodiodes, pi-n photodiodes, responsivity, noise and sensitivity, photodiode materials, electric circuits with photodiodes, solar cells.	**15**

Suggested Reading

1. Semiconductor Optoelectronics: Physics and Technology, Jasprit Singh, McGraw Hill Companies, ISBN 0070576378
2. Optoelectronics, E. Rosencher and B. Vinter, Cambridge Univ. Press, ISBN 052177813.
3. Photonic Devices, J. Liu, Cambridge Univ. Press, ISBN 0521551951.
4. Semiconductor Optoelectronic Devices 2nd Edition", P. Bhattacharya, Prentice Hall, ISBN 0134956567.
5. Physics of Semiconductor Devices, by S. M. Size (2nd Edition, Wiley, New York, 1981)

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS			
Programme: ***Diploma in Applied Physics***		**Year: II**	**Semester: III/IV**
Subject: Physics			
Course Code:	**Course Title: Opto-Electronics and Laser Instrumentation**		

Credits: 04	**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

Unit	Topic	No. of Lectures
Unit I	**Introduction** Characteristics of optical radiation, luminescence, irradiance – Optical Sources – Photo Detectors – Opto-couplers and their application in analog and digital devices. Optical Fiber Fundamentals – modes, types of optical fibers – fiber coupling – Fiber optic sensors for common industrial parameters – V, I, pressure, temperature – IR sources and detectors – fiber optic gyroscope.	**15**
Unit II	**Characteristics of LASERS** Einstein's equations – population inversion two, three and four level system. Laser rate equation, properties – modes – Resonator configurations – Q switching and mode locking, cavity dumping, single frequency operation – Types of Lasers. Applications – Lasers for measurement of distance and length, velocity, acceleration, atmospheric effects, pollutants.	**15**
Unit III	**Applications** Lasers for measurement of distance and length, velocity, acceleration, atmospheric effects, pollutants. Material processing applications – Laser heating, melting, scribing, splicing, welding and trimming of materials, removal and vaporization.	**15**
Unit IV	**Holographic Interferometry and Applications** Holography for non-destructive testing – medical applications – lasers and tissue interaction -surgery – dermatology.	**15**

Suggested Reading

1. Wilson and Hawkes, "Opto Electronics-An Introduction", Third Edition, Pearson Education, 1998.
2. John Ready, "Industrial Applications of Lasers", Second Edition, Academic Press, 1997.
3. Bhattacharya P, "Semiconductor Optoelectronics", Second Edition, Pearson Education, 1998.
4. Djafar K. Mynbaev, Lowell L. Scheiner, "Fiber-Optic Communications Technology", First Edition, Prentice Hall of India Pvt. Limited, 2000.
5. R. P. Khare, "Fiber Optics and Optoelectronics", Oxford Press, 2004.

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

DIPLOMA IN APPLIED PHYSICS		
Programme: ***Diploma in Applied Physics***	**Year: II**	**Semester: III/IV**
Subject: Physics		
Course Code:	**Course Title: Classical Dynamics**	

Credits: 04		**Minor/Elective**
Max. Marks: 100 **External Exam: 75** **Internal Assessment:25**		**Min. Passing Marks: 25**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
Unit	**Topic**	**No. of Lectures**
Unit I	**Classical Mechanics of Point Particles** Review of Newtonian Mechanics; Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, particle in a central force field	**15**
Unit II	**Small Amplitude Oscillations** Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) - identical springs.	**15**
Unit III	**Special Theory of Relativity** Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.	**15**
Unit IV	**Fluid Dynamics** Density and pressure in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes	**15**

	equation, qualitative description of turbulence, Reynolds number, Basic physics of fluids: Definition of a fluid- shear stress; Fluid, properties-viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow visualization - streamlines, pathlines, Streaklines	

Suggested Reading

1. H. Goldstein : Classical Mechanics
2. N.C. Rana & P. S. Jog : Classical Mechanics
3. Landau and Lifshitz : Mechanics
4. Sommerfeld : Mechanics
5. Whittaker : Analytical Dynamics of Particles and Rigid Bodies
6. Raychaudhuri : Classical Mechanics

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL),
https://www.youtube.com/user/nptelhrd
3. Swayam Prabha - DTH Channel,
https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/Assignment (25 marks)

DEGREE IN SCIENCE			
Programme: ***Degree in Science***		**Year: III**	**Semester: V** **Paper-I**
Subject: Physics			
Course Code:	**Course Title: Physical Optics**		

Course Outcomes:

1. Study of Interference of light. Interference by division of wavefront and division of amplitude.
2. Understanding Diffraction of Light and concept of Zone Plate.
3. Understand the polarization of light..
4. Study of different types of associated optical instruments based on interference and diffraction of light which are widely used in industry and research.

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	Interference The principle of superposition, Two slit interference, coherence, Division of wave front and amplitude, Optical path retardations lateral shift of fringes, Fresnel biprism, Interference with multiple reflection, Thin films, Application for precision measurements, Haidinger fringes, Fringes of equal thickness and equal inclination.	**15**
Unit II	Diffraction Fresnel's and Fraunhofer diffraction: Diffraction of single slit, Zone plates, intensity distribution, Resolution of image, Rayleigh criterion, Resolving power of telescopes and microscopes, Diffraction due to 2-slits and N-slits, Diffraction grating, Resolving power of grating and comparison with resolving powers of prisms.	**15**
Unit III	Polarization Plane polarized, Circular polarized and elliptically polarized light, Malus law, Brewster's law, Double reflection and uniaxial crystals, Application of bi-refringence, Dichroism, Optical rotation, Rotation of plane of polarization, Optical rotation in liquids and crystals, Polarimeter.	**15**
Unit IV	Associated Optical Instruments Michelson intereferometer and its application for precise measurement of wavelength, Wavelength difference and width of spectral lines, Twyman-Green interferometer, Tolansky fringes, Fabry-Perot interferometer and Etalon.	**15**

Suggested Reading

1. D.P. Khandelwaland : Optics and Atomic Physics
2. Jenkins and White : Fundamentals of Optics
3. A.K. Ghatak : Physical Optics
4. Brijlal and Subrahmanyam : Optics
5. K.D. Moltev : Optics
6. B. K. Mathur : Optics

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test /Assignment (25 marks)

Course Prerequisites: Passed Semester IV.

<table>
<tr><td colspan="4">DEGREE IN SCINCE</td></tr>
<tr><td colspan="2">Programme: Degree in Science</td><td>Year: III</td><td>Semester: V
Practical</td></tr>
<tr><td colspan="4">Subject: Physics
(Practical)</td></tr>
<tr><td>Course Code:</td><td colspan="3">Course Title: Demonstrative Aspects of Physical Optics (Practical)</td></tr>
<tr><td colspan="4">Course Outcomes:
1. Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties.
2. Measurement precision and perfection is achieved through Lab Experiments.</td></tr>
<tr><td colspan="2">Credits: 02</td><td colspan="2">Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 50
Internal (Record File): 15
External Practical Exam: 20
External Viva Voce : 15</td><td colspan="2">Min. Passing Marks: 17</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td></td><td colspan="2">1. Biprism- determination of λ.
2. Newton’s ring experiment- Determination of λ.
3. Determination of λ by a transmission grating.
4. Zone-plate experiment study of different orders.
5. Malus Law
6. Spectrometer: Refractive index of the material of a prism using sodium light
7. Spectrometer: Dispersive power of the material of a prism using mercury light
8.Polarimeter: Specific rotation of sugar solution.</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.

2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.
3. Indu Prakash : Practical Physics
4. S.L. Gupta, V. Kumar, “Practical Physics”, PragatiPrakashan, Meerut, 2014.

Suggestive Digital Platforms / Web Links:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual
Universities

Suggested Continuous Evaluation Methods:

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File (15 marks)

PREREQUISITE: Passed Semester IV.

Further Suggestions:

• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

DEGREE IN SCIENCE		
Programme: ***Degree in Science***	**Year: III**	**Semester: V** **Paper-II**
Subject: Physics		

Course Code:	**Course Title: Basic Electronics**

Course Outcomes:

1. Study of different Network Theorems for simplifying complicated electronics circuits.
2. Study of Regulated Power Supply. Understand different types of Rectifiers, Filters and Voltage Regulator.
3. Study of different types of special diodes and their applications
4. Study of Transistors and their applications in different types of Amplifiers.

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal Exam: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Network Theorems** Superposition Theorem, Constant voltage source and constant current source, Conversion of voltage source into current source, Thevenin's Theorem and procedure for finding thevenin equivalent circuit, Norton‟s Theorem and procedure for finding Norton equivalent circuit, Maximum power transfer theorem, Applications of Network Theorems.	**10**
Unit II	**Power Supplies** Semiconductor diode: P-N Junction diode, Diode circuits with DC and AC Voltage sources, Diode as a rectifier: Half and Full wave rectifiers, Bridge rectifiers, Peak inverse voltage, Efficiency, Ripple factor, Filters: Low pass and High pass filters, Band pass and Band stop filters, L and π – filters (Series inductor, Shunt capacitor, LC, CLC filters), Zener diode, its characteristics, Voltage regulation.	**15**
Unit III	**Special Diodes** Special Diodes Tunneling effect, Tunnel diode, Varactor diode, Point contact diode, V-I characteristic of these diodes, Optoelectronic devices: Light emitting diode, Photodiode.	**10**
Unit IV	**Transistors** Bipolar junction transistor, Transistor operation and its Biasing rule, Transistor currents, Transistor circuit configuration, Transistor characteristics in different	**10**

	configuration, cut-off and saturation points, Active region, Relation between transistor current in various configuration, h Parameters, General idea of FETs.	
Unit V	**Transistor Amplifiers** Single-stage transistor amplifiers, Common base (CB), Common emitter (CE) and, Common collector (CC) amplifier, Comparison of a amplifier configurations. Amplifier classification based on biasing condition, Power amplifiers (Class A, Push-Pull amplifier, Class B and Class C), Noise and Distortion in amplifiers, Multistage amplifier, Amplifier coupling, RC- coupled two stage amplifier and its frequency response, Advantage of RC coupling	**15**

Suggested Reading

1. M.K. Baagde, S.P. Singh and Kamal Singh : Elements of Electronics
2. B.L. Theraja : Basic Electronics
3. V.K. Mehta : Elements of Electronics
4. J.D. Ryder : Networks, Lines and Fields
5. J.D. Ryder : Electronic Fundamentals and Applications.
6. Millman and Halkias : Integrated Electronics

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

Course Prerequisites: Passed Semester IV.

DEGREE IN SCINCE				
Programme: ***Degree in Science***			**Year: III**	**Semester: V Practical**
Subject: Physics (Practical)				
Course Code:	**Course Title:** Demonstrative Aspects of Basic Electronics (Practical)			
Course Outcomes: **1.** Experimental physics has the most striking impact on the industry wherever the instruments are used to study the Electronics and its application in industry and research. **2.** Measurement precision and perfection is achieved through Lab Experiments.				
Credits: 02		**Core Compulsory**		
Max. Marks: 50 **Internal (Record File): 15** **External Practical Exam: 20** **External Viva Voce : 15**		**Min. Passing Marks:17**		
Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4				
Unit	**Topic**			**No. of Lectures**
Lab Experiment List				
	1. To study characteristics of R-C coupled Amplifier with and without feedback. 2. To study the characteristics of integrating and differentiating circuit. 3. To draw the characteristics of P-N junction diode. 4. To draw the characteristics of PNP and NPN junction transistor. 5. Measurements of h-parameters of a transistor. 6. Study of different types of Rectifiers and Filters. 7. Verification of Network theorems. 8. Child Langmuir law. 9. Triode/ Tetrode/ Pentode characteristics and constants. 10.Study of power supply (Ripple factor). 11. Study of Zener diode and regulation (taking different source voltage and loads). 12. Phase measurement using a C.R.O. 13. Study characteristics of T.C. Amplifier and B.W. 14. To study the Characteristics of a Photo-diode. 15.Inverse square law using Photo-Voltaic Cell			**60**

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.
2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.
3. Indu Prakash: Practical Physics
4. S.L. Gupta, V. Kumar, “Practical Physics”, Pragat iPrakashan, Meerut, 2014.

Suggestive Digital Platforms / Web Links:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual
Universities

Suggested Continuous Evaluation Methods:

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as
follows:

Record File (15 marks)

PREREQUISITE: Passed Semester IV.

Further Suggestions:

• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

DEGREE IN SCIENCE		
Programme: ***Degree in Science***	**Year: III**	**Semester: VI Paper-I**
Subject: Physics		
Course Code:	**Course Title: Modern Physics**	

Course Outcomes:

1. Study of different atomic models.
2. Study of optical spectra and X- rays.
3. Understand the theory of LASERS which are widely used in industry and research.
4. Understanding fundamentals of molecular spectroscopy.
5. Study of structure of atomic nucleus and radioactive decay.
6. Study of Elementary Particle Physics.

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Atomic Models** Thomson model, Rutherford model, Bohr model and spectra of hydrogen atom, Fine structure, Bohr Magnetron, Larmor‟s precession, Somerfield model, Stern-Gerlach experiment, Vector atomic model, Space Quantization and Spinning of an electron.	**15**
Unit II	**Optical Spectra and X-rays** Optical spectra, Spectral notations, L-S, J-J coupling, Selection rules and intensity rules, Explanation of fine structure of Sodium D line, Zeeman effect, X-ray spectra (characteristics and continuous), Moseley‟s law.	**10**
Unit III	**Lasers and Fundamentals of Molecular Spectroscopy** Einstein A and B coefficients, Spatial and Temporal coherence, Optical pumping, Population inversion, Laser action, Basic idea of LASER and MASER, Ruby Laser and He-Ne laser, Some applications. Franck-Condon Principle, Molecular spectra, Rotational, Vibration and Electronic spectra of diatomic molecules, General features of electronic spectra, Luminescence, Basics of Raman effect.	**15**
Unit IV	**Subatomic Physics** Structure of atomic nucleus, nuclear properties (charge, mass, spin, shape), nuclear binding energy, liquid drop model and semi-empirical mass formula, Law’s of radioactive decay, Basic idea of α, β and γ-decay.	**10**

Unit V	**Elementary Particle Physics** Elementary Particles History and Classification of Elementary particles on the basis of mass, Fundamental interactions, Lepton and Baryon number, Conservation laws, Concept of Iso-spin, hypercharge and Strangeness, basic idea of quarks	**10**

Suggested Reading

1. H.S. Mani and Mehta : Introduction to Modern Physics
2. A. Beiser : Perspective of Modern Physics
3. Ahmad and Lal, : Modern Physics
4. B.V.N. Rao : Modern Physics
5. R. Murugeshan : Modern Physics
6. S.N. Ghosal : Nuclear Physics
7. C. B. Banwell : Fundamentals of Molecular Spectroscopy

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL),
https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel,
https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

Suggested Continuous Evaluation (25 Marks):

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Class Test/ Assignment (25 marks)

Course Prerequisites: Passed Semester V.

<table>
<tr><td colspan="5">DEGREE IN SCINCE</td></tr>
<tr><td colspan="3">Programme: Degree in Science</td><td>Year: III</td><td>Semester: VI Practical</td></tr>
<tr><td colspan="5">Subject: Physics (Practical)</td></tr>
<tr><td>Course Code:</td><td colspan="4">Course Title: Demonstrative Aspects of Modern Physics (Practical)</td></tr>
<tr><td colspan="5">Course Outcomes:
1. Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the modern physics concepts.
2. Measurement precision and perfection is achieved through Lab Experiments.</td></tr>
<tr><td colspan="3">Credits: 02</td><td colspan="2">Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 50
Internal (Record File): 15
External Practical Exam: 20
External Viva Voce : 15</td><td colspan="2">Min. Passing Marks:17</td></tr>
<tr><td colspan="5">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="3">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="5">Lab Experiment List</td></tr>
<tr><td></td><td colspan="3">1. Frank-Hertz Experiment.
2. Determination of ‘h’ Planck’s constant by Photoelectric effect.
3. ‘e/m’ by Thomson method.
4. ‘e/m’ Magnetron method.
5. ‘e/m’ Helical method
6. To determine the Planck’s constant using LEDs of at least 4 different colours.
7.To determine the wavelength of laser source using diffraction of single slit.
8.To determine the wavelength of laser source using diffraction of double slits.
9. Determination of Ionization Potential using thyratron valve.
10. Inverse square law.
11. Verification of Cauchy Formula</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.
2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.
3. Indu Prakash: Practical Physics
4. S.L. Gupta, V. Kumar, “Practical Physics”, PragatiPrakashan, Meerut, 2014.

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Suggested Continuous Evaluation Methods:
Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File (15 marks)

PREREQUISITE: Passed Semester IV.
Further Suggestions:
The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

DEGREE IN SCIENCE

Programme: ***Degree in Science***	**Year: III**	**Semester: VI** **Paper-II**

Subject: Physics

Course Code:	**Course Title: Analog and Digital Electronics**

Course Outcomes:

1. Study of feedback in amplifiers along with their advantages and disadvantages.
2. Study of different types of oscillators.
3. Understand the concepts of Boolean Algebra and various number systems
4. Study of logic gates and their applications.

Credits: 04	**Core Compulsory**
Max. Marks: 100 **External Exam: 75** **Internal Assessment: 25**	**Min. Passing Marks: 33**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

Unit	Topic	No. of Lectures
Unit I	**Feedback Amplifiers** Principle of feedback amplifiers, Classification of positive and negative feedback, Advantage of negative feedback, gain stability, Decreased distortion, Increased bandwidth, Forms of negative feedback, Positive feedback and its advantage.	**15**
Unit II	**Oscillators** Classification of oscillators, Frequency of oscillating current, Frequency stability of an oscillator, Essential of a feedback LC oscillator, Tuned base oscillator, Tuned collector oscillator, Hartley oscillator, Colpitt oscillator, Clapp oscillator, Tunel diode oscillator, Crystal oscillator, Phase shift oscillator, Wien Bridge oscillator, Relaxation oscillator, Astable, monostable and bistable multivibrator, Schmitt trigger, Saw-tooth generator, Blocking oscillators	**15**
Unit III	**Number System** Number systems, Decimal, Binary, Octal and Hexadecimal number systems, Binary to decimal conversion, Double-Dadd method, Binary operations, Binary addition, Binary subtravtion, Complement of a number (1‟s complement and 2‟s complement), Binary divison, Representation of a Binary number as electrical signals, Conversion of Binary to octal, Binary to hexadecimal and vice-versa (Inter-conversion), BCD, GREY, EXCESS-3 codes.	**10**

Unit IV	**Boolean Algebra** Boolean algebra, Features of Boolean algebra, Laws of Boolean algebra, Equivalent switching circuit, Demorgan‟s theorems and duals	**10**
Unit V	**Logic Gates** Positive and Negative logic, Two input OR gate, Diode OR gate and transistor OR gate, Three input OR gate and its truth table, Exclusive OR gates, The AND gate, Diode AND gate and transistor AND gate, The NOT gate, Bubbled gates, The NOR gate, The NAND gate, NAND and NOR as universal gates, The XNOR gate, Adders and subtractors, Half Adders, Full adders,	**10**

Suggested Reading

1. M.K. Baagde, S.P. Singh and Kamal Singh : Elements of Electronics
2. B.L. Theraja : Basic Electronics
3. V.K. Mehta : Elements of Electronics
4. J.D. Ryder : Networks, Lines and Fields
5. J.D. Ryder : Electronic Fundamentals and Applications.
6. Millman and Halkias : Integrated Electronics

Suggested Online Link:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

This course can be opted as an elective by the students of following subjects: The course can be opted as an elective, which is open to all students.

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Class Test/ Assignment (25 marks)

Course Prerequisites: Passed Semester V

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<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td></td><td colspan="2">1. Transistor Bias Stability
2. Comparative Study of CE, CB and CC amplifier
3. Clippers and Clampers
4. Study of Emitter Follower
5. Frequency response of single stage RC coupled amplifier
6. Frequency response of single stage Transformer coupled amplifier
7. Effect of negative feedback on frequency response of RC coupled amplifier
8. Study of Schmitt Trigger
9. Study of Hartley oscillator
10. Study of Wein Bridge oscillator
11. Study of Logic Gates
12. Verification of De Morgan's Theorem
13. Study of Half Adder
14. Study of Full Adder</td><td>60</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, “Advanced Practical Physics for Students”, Methuen & Co., Ltd., London, 1962.
2. S. Panigrahi, B. Mallick, “Engineering Practical Physics”, Cengage Learning India Pvt. Ltd., 2015.
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2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

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Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File (15 marks)

PREREQUISITE: Passed Semester V.

Further Suggestions:

• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.

DRAFT

National Education Policy-2020

Common Minimum Syllabus for all Uttarakhand State Universities and Colleges for Post-Graduation.

PROPOSED STRUCTURE OF PG PHYSICS SYLLABUS

2021

Year	Sem.	Course Code	Paper Title	Theory/ Practical	Credits
Bachelor (Research in Physics)					
FOURTH YEAR	VII		**Mathematical Physics**	Theory	(04)
			Classical Mechanics	Theory	(04)
			Quantum Mechanics	Theory	(04)
			Communication Electronics	Theory	(04)
			Practical	Practical	(04)
	VIII		**Atomic and Molecular Spectra**	Theory	(04)
			Electrodynamics	Theory	(04)
			Elementary Particle Physics	Theory	(04)
			Condensed Matter Physics	Theory	(04)
			Elective Paper [one from the list] EL3**	Theory	(04)
			Practical	Practical	(04)
Master in Physics					
FIFTH YEAR	IX		**Advanced Quantum Mechanics**	Theory	(04)
			Plasma Physics	Theory	(04)
			Advanced Electronics -I/Astrophysics -I/High Energy Physics-I/ Spectroscopy-I	Theory	(04)
			Advanced Electronics -II/Astrophysics -II/High Energy Physics-II/ Spectroscopy-II	Theory	(04)
			Practical	Practical	(04)
	X		**Nuclear Physics**	Theory	(04)
			Digital Electronics and Computer Architecture	Theory	(04)
			Advanced Electronics -III/Astrophysics -III/High Energy Physics-III/ Spectroscopy-III	Theory	(04)
			Advanced Electronics -IV/Astrophysics -IV/High Energy Physics-IV/ Spectroscopy-IV	Theory	(04)
			Practical	Practical	(02)

**Elective (04 Credit, one from the list EL3) To be opted in Semester VIII
1. Statistical Physics
2. Bio Physics
3. Medical Physics
4. Atmospheric Physics
5. Nano Materials and Applications

Subject prerequisites:
Bachelor in Science with Physics as major subject.

Programme Outcomes (POs):	
Students having Degree in ***Bachelor (Research in Physics)*** should have knowledge of advanced concepts of Physics and ability to apply this knowledge in various fields of academics, research and industry. They may pursue their future career in the field of academics, research and industry.	
PO1	Competence in the methods and techniques of calculations using Mathematical Physics, Classical Mechanics, Quantum Mechanics and Communication Electronics. It will develope an analytical skill on an advanced level and will enable the student to have mathematical tools to solve complex problems of Physics. The Programme will motivate the student to know more about the matter, the universe and the recent developments in the field of science. The student will have adequate knowledge to work for the industry,, consultancy, education, and research
PO2	The students would gain substantial knowledge in various branches of physics. The programme will enable the student to explore more in the field of his/her choice like Advanced Electronics, Spectroscopy, Astrophysics and High energy Physics. The student will be well equipped with the knowledge required for different organizations, industry, R& D sector.

Programme specific outcomes (PSOs):
PG IST YEAR/ **Bachelor (Research in Physics)**
Bachelor (Research in Physics) programme provides the student the adequate knowledge, general competence, and analytical skills on an advanced level, needed in industry, consultancy, education, research, or in government organisation.

Programme specific outcomes (PSOs):
PG IIND YEAR/ **Master in Physics**
• The Master of Science in Physics programme provides student the adequate knowledge to use mathematical tools to solve complex physical problems and have the solid background and experience needed to analyze and solve advanced problems in physics. • This course would enable the student to acquire scientific skills and the practical knowledge by performing experiments in general physics and electronics. • The student would also get some research oriented experience by doing theoretical and experimental projects in the last semester under the supervision of faculty. • The course as a whole opens up several career doors for the students interested in various areas of science and technology in private, public and government sectors. Students may get job opportunities in higher education, research organizations, physics consultancy and many others. Some of the institutions where physics students can start their career are: BARC, DRDO, NPTC, IISc, ISRO, ONGC, BHEL, PRL, NPL, SINP, VECC, IITs, NITs, IIPR etc.

Year wise Structure of PG in Physics (Core and Elective Courses a

Subject: Physics

Course/Entry-Exit Levels	Year	Sem.	Paper I	Credit/hrs	Paper II	Credit/hrs	Paper III	Credit/hrs	Paper IV	Credit/hrs	Paper V	Credit/hrs
Bachelor (Research in Physics)	IV	VII	**Mathematical Physics**	4/60	**Classical Mechanics**	4/60	**Quantum Mechanics**	4/60	**Communication Electronics**	4/60		
		VIII	**Atomic and Molecular Spectra**	4/60	**Electrodynamics**	4/60	**Elementary Particle Physics**	**4/60**	**Condensed Matter Physics**	**4/60**	**Elective Paper [one from the list] EL3****	**4/60**
Master in Physics	V	IX	**Advanced Quantum Mechanics**	4/60	**Plasma Physics**	4/60	**Advanced Electronics -I/Astrophysics -I/High Energy Physics-I/ Spectroscopy-I**		**Advanced Electronics -II/Astrophysics -II/High Energy Physics-II/ Spectroscopy -II**	4/60		
		X	**Nuclear Physics**	4/60	**Digital Electronics and Computer Architecture**	4/60	**Advanced Electronics -III/Astrophysics -III/High Energy Physics-III/ Spectroscopy-III**		**Advanced Electronics -IV/Astrophysics -IV/High Energy Physics-IV/ Spectroscopy -IV**	4/60		
Comments												

Internal Assessment and External Assessment

	Internal Assessment	Marks	External Assessment	Marks

DETAILED SYLLABUS FOR BACHELOR (RESEARCH IN PHYSICS) OR P.G FIRST YEAR

BACHELOR (RESEARCH IN PHYSICS)			
Programme: BACHELOR (RESEARCH IN PHYSICS)		YEAR IV	SEMESTER VII/PAPER I
Subject: Physics			
Course code	Course Title: **Mathematical Physics**		
Course Outcomes Students would be able to understand the mathematical methods essential for solving the advanced problems in physics. It would be helpful in the development of the ability to apply the mathematical concepts and techniques to solve the problems in theoretical and experimental physics. The knowledge of mathematical physics would be beneficial in further research and development as it serves as a tool in almost every branch of science and engineering Course.			
Credits: 4			Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**			**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0			

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Special Functions Series solution of differential equations, Legendre, Bessel, Hermite, and Laguerre differential equation and related polynomial, physical integral form of polynomials and their orthogonality relations. Generating Function and recurrence relation.	**15**
UNIT II	Curvilinear Coordinates and Tensors Curvilinear Coordinates and various operators in circular, cylindrical and spherical coordinate systems, classification of Tensors, Rank of a Tensor, covariant and contra-variant tensors, symmetric and anti-symmetric Tensors, Kronecker delta symbol. Contraction of Tensor, metric Tensor and Tensor densities, covariant differentiation and Geodesic equation (variational Method).	**15**
UNIT III	Complex Variables Function of complex variable, Cauchy's Riemann differential equation, Cauchy's integral theorem, residues and Cauchy's residues theorem, singularities, evolution of residues and definite integral.	**15**
UNIT IV	Integral Transforms Fourier integral and Fourier Transform, Fourier integral theorem, finite and infinite integral, Laplace transform of elementary function (Dirac delta & Green's function), Solution of simple differential equations.	**15**

Suggested Readings: B. S. Rajput: Mathematical Physics (Pragati Prakashan, Meerut) L. I. Pipes: Mathematical Physics (McGraw Hill) P. K. Chattopadhyay: Mathematical Physics (Wiley Eastern, New Delhi) Afriken.: Mathematical methods for Physics Harper Charlie: Introduction to Mathematical Physics Mathews and Walker: Mathematical Methods of Physics (Benjamin press) Horse and Feshbach : Methods of Theoretical Physics (McGraw Hill)	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Bachelor in Science with Physics as major subject**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><td colspan="4">BACHELOR (RESEARCH IN PHYSICS)</td></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER II</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Classical Mechanics</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course students would learn to apply the Newtonian laws using various mathematical formulations to describe the motions of macroscopic objects using generalized coordinates, momentum, forces and energy. The classical mechanics would be helpful in understanding of advanced branches of modern physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Mechanics of a System of Particles Constraints and generalized coordinates, D Alembert’s principle, Lagrange equations for holonomic and non holonomic systems and their applications, conservation laws of linear momentum, energy and angular momentum.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Hamiltonian Formulation and Hamilton Jacobi Theory Hamiltonian equations of motion and their physical significance, Hamilton’s principle, principle of least action, canonical transformations Hamilton-Jacobi theory, Poisson brackets, properties of Poisson bracket, Poisson’s Theorem, Lagrange bracket.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Dynamics of a Rigid Bodies Motion of a rigid body, body and space Reference system, angular momentum and Inertia tensor, Principle axes- Principle moments of Inertia, spinning tops, Euler angles, Infinitesimal rotations.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Central Force Problem Action and angle variables, phase integral, small oscillations, Kepler’s laws of Planetary motion and their deduction, scattering in a Central field, Rutherford scattering cross section</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
H. Goldstein : Classical Mechanics

N.C. Rana & P. S. Jog : Classical Mechanics

Landau and Lifshitz : Mechanics, Pergamon Sommerfeld : Mechanics, Academic Press</td><td></td></tr>
</table>

Whittaker : Analytical Dynamics of Particles and Rigid Bodies - Cambridge Raychaudhuri : Classical Mechanics, Oxford Bhatia : Classical Mechanics, Narosa. H.M. Agrawal: Classical Mechanics, New Age International	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
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<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER III</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="3">Course Title: Quantum Mechanics</td></tr>
<tr><td colspan="4">Course Outcomes:

The course provides an understanding of the behaviour of the systems at microscopic (atomic and nuclear) scale and even smaller. Students would learn basic postulates and formulations of quantum Mechanics. The course, in fact, plays an important role in explaining the behaviour of all physical systems in the universe. The course includes the study of a brief review of foundations of quantum mechanics, matrix formulation of quantum mechanics, symmetry in quantum mechanics and approximation methods for bound states.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
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Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
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<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Non-Relativistic Quantum Mechanics and Schrödinger Equation
Schrödinger's equation, Probability and current densities, continuity equation, physical interpretation of wave function, orthogonality of eigen functions, Principle of superposition, wave packet, normalization, Schrödinger's equation in three dimensions, centrally symmetric square well and harmonic potentials, harmonic oscillator and its wave functions, Hydrogen atom.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Operator Formulation of Quantum Mechanics
State vectors and operators in Hilbert Space, Eigen values and Eigen vectors of an operator, Hermitian ,Unitary and Projection operators, commuting operators, BRA and KET Notations, Postulates of Quantum Mechanics, co-ordinate Momentum and Energy representations, dynamical behavior, Heisenberg, Schrödinger and interaction Pictures</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Theory of Angular Momentum
Orbital Angular momentum operator, its eigen value and eigen functions, space quantization, spin angular momentum, Pauli's theory of spin, Addition of angular momentum, ClebschGordan coefficients</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Approximation Methods
Time independent and Time dependent Perturbation Theory Stationary Perturbation, first and second order</td><td>15</td></tr>
</table>

	corrections, WKB approximation methods, connection formula and boundary conditions, Bohr Sommerfield quantization rule, Penetration of potential barrier, Time independent perturbation theory and its applications. Applications of time-dependent perturbation theory for constant perturbation, Fermi Golden rule, Coulomb excitation, Sudden and adiabatic approximation.	
Suggested Readings B. S. Rajput: Advanced Quantum Mechanics Schiff: Quantum Mechanics Thankppan: Quantum Mechanics Loknathan and Ghatak Quantum Mechanics		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Bachelor in Science with Physics as major subject**		
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BACHELOR (RESEARCH IN PHYSICS)		
Programme: BACHELOR (RESEARCH IN PHYSICS)	YEAR IV	SEMESTER VII/PAPER IV
Subject: Physics		
Course code……	Course Title: **Communication Electronics**	

Course Outcomes

This course helps the student to gain basic ideas of the fundamentals of communication systems. The course includes Modulation AM and FM (Transmission and reception), SSB transmission, AM detection, AGC, Radio receiver characteristics, FM transmitter, Propagation of Radio Waves ,Antenna , Fundamentals of image transmission,TV transmitter,Transmission Lines etc.The course may provide the opportunity to work in any organization related to communication.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Modulation AM and FM (Transmission and reception): Modulation, AM generation, Power consideration, Balanced modulator, SSB transmission, AM detection, AGC, Radio receiver characteristics, signal to noise ratio, FM analysis, noise considerations, generation, direct method and reactance tube method, FM transmitter, AFC, FM Propagation, phase discriminator	15
UNIT II	Propagation of Radio Waves Ground wave, sky wave and space wave propagation. Ionosphere (Ecclr- larmer theory, magneto ionic theory.	15
UNIT III	Antenna and TV Antenna, HF antenna, Yagi antenna, loop antenna, Satellite communication, parabolic reflector, dish antenna, Fundamentals of image transmission, vestigial transmission, TV camera tubes, image orthicon, vidicon, TV transmitter, TV receiver and picture tubes.	15
UNIT IV	Transmission Lines Voltage and current relations on transmission line, propagation constant, characteristic impedance, impedance matching, quarter wave T/L as impedance transformer, attenuation along coaxial cable, cables of low attenuation, propagation of radio waves between two parallel lines, wave guide modes, TE10 mode and cut off wavelength, cavity resonator, light propagation in cylindrical wave guide, step index and graded index fibers, attenuation and dispersion in fibers	15

Suggested Readings: George Kennedy & Davis: Electronics Communication Systems Millar & Beasley: Modern Electronics Communication R.R Gulani: Monochrome and colour television (Wiley Eastern Limited) Taub and Schilling: Principle of Communication Systems (TMH) Simon Gaykuti: Communication Systems (John Wiley & Sons Inc. 1994	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Bachelor in Science with Physics as major subject**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER V</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: PRACTICAL</td></tr>
<tr><td colspan="4">Course Outcomes:

Student would gain practical knowledge by performing various experiments of Electronics and Optics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">List of Experiments</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">Study of RC circuit with an AC source using phase diagrams.

Absorption Spectrum of $KMnO_4$ using Hilger-Nutting Photometer.

Young’s modulus by Interference method.

NPN and PNP Transistor Characteristics with (a) Common base (b)
Common emitter configurations/ h – parameter.

Study of RC- coupled/ Transformer Coupled Amplifier.

Study of B-H curve.

Study of Amplitude Modulation /Demodulation.

Verification of the Hartmann’s Formula.

Frank-Hertz experiment.

e/m by Zeeman effect.

Determination of susceptibility.

Study of CRO.

Velocity of Ultrasonic waves.

Linear Air track.

Leacher Wire</td><td>60</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
</table>

Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Bachelor in Science with Physics as major subject**		
Suggested Equivalent Online Courses: 1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities		

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER I</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="3">Course Title: Atomic and Molecular Spectra</td></tr>
<tr><td colspan="4">Course Outcomes
The course structure includes atomic and molecular spectroscopy. As per the course structure, the students learn basics concepts of spectroscopic principles and rules. Students would learn technique in spectroscopy and know about their applications. The course is helpful for the students to explore R & D opportunities in various areas of science and technology such as biomedical, industrial and environmental fields.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Fine structure of hydrogen spectrum, L-S and J-J coupling, Spectroscopic terms, Hund’s rule and time reversal, Pauli’s exclusion principle.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Alkali spectra, spin-orbit interaction and fine structure in alkali Spectra, Equivalent and non-equivalent electrons, Normal and anomalous Zeeman effect, Paschen Back effect, Stark effect, Hyperfine structure (qualitative).</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Molecular spectra of diatomic molecules, Born Oppenheimer approximation, elementary idea of quantization of rotational and vibrational energy, rotational spectra for rigid and non rigid rotations, vibrational spectra (harmonic and an-harmonic), intensity and selection rules and molecular constants.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Atomic Polarizability, Raman spectra, Quantum theory of Raman spectra, Determination of molecular structure, Electronic spectra, band system, Progression and sequences, band head formation, Condon parabola, Franck Condon Principle dissociation energy and its determination</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
C. B. Banwell: Fundamentals of Molecular Spectroscopy

Walker and Stranghen: Spectroscopy Vol. I, II, & III G.M.

Barrow: Introduction to Molecular Spectroscopy Herzberg: Spectra of diatomic molecules</td><td></td></tr>
</table>

Jeanne L Mchale: Molecular Spectroscopy J. M. Brown: Molecular Spectroscopy P. F. Bemath: Spectra of atoms and molecules J. M. Holias: Modern Spectroscopy K. Thyagrajan and A.K. Ghatak: Lasers: Theory and applications A Yariv: Quantum Electronics M. D. Levenson: Intoduction to non-linear laser spectroscopy B. B. Laud: Laser and non-linear optics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER II</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="3">Course Title: Electrodynamics</td></tr>
<tr><td colspan="4">Course Outcomes:
The study of electrodynamics provides basic foundation for the student to understand advance courses of physics. The course includes Basic equations of Electromagnetism, Electrostatics; Magnetostatics; Maxwell’s equation, Four Vector Formalism of Maxwell’s Equations Four vector potential, electromagnetic field tensor and Quantization of electromagnetic energy</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Electromagnetism
Basic equations; Electrostatics; Magnetostatics; Different Systems of Units, Preliminary notations, four- vectors, Lorentz transformations, time, space and light like separations, Lorentz invariants, Energy and Momentum.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Maxwell’s Equations
Maxwell’s equation, Displacement current, electromagnetic waves in conducting and nonconducting medium, Poynting theorem, boundary condition at the interface of conducting and non conducting media, propagation between parallel conducting plates. Electromagnetic wave equations</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Four Vector Formalism of Maxwell’s Equations
Four vector potential, electromagnetic field tensor, Lorentz invariance, Lorentz force, covariant form of Maxwell’s equations, four vector current, continuity equation, Gauge invariance of Maxwell equation, electromagnetic energy-momentum tensor, Motion of charge particle in electromagnetic field, Lorentz force</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Electromagnetic Radiation
Lienard-Witchert potential, conventional potential, Quantization of electromagnetic energy (virtual photon), Radiation from an Accelerated Charge, Fields of an accelerated charge; angular and frequency distributions of the emitted radiation, special cases of acceleration parallel and perpendicular (circular orbit) to velocity; Larmor’s</td><td>15</td></tr>
</table>

	formula and its relativistic Generalization; Bremstrahlung, Cerenkov radiation	
Suggested Readings Jackson: Classical electrodynamics; Wiley Eastern, New Delhi Landau and Lifshitz: Classical theory of fields; Pergameon Press Thide : Electromagnetic field Theory Panofsky and Phillips: Classical Electricity and Magnetism Landau &Lifshitz : Electrodynamics of Continuous Media		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester VII with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

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<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER III</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Elementary Particle Physics</td></tr>
<tr><td colspan="4">Course Outcomes
The course is important for the students to learn about the most fundamental building blocks of matter and radiation, interaction among elementary particles and hence to understand their behaviour. The course provides a platform for the students seeking research opportunities in high energy physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Elementary Particles History of elementary particles, Classification of elementary particles, Fundamental interactions, Resonances, Lepton and Baryon number; Isospin, Strangeness, Hypercharge, Gell - Mann Nishijima relations, Symmetries and conservation laws, Parity, Time reversal and charge conjugation, Parity violation, CP violation in mesons, CPT invariance.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Unitary Symmetries and Application in the Physics of Elementary Particles Basics of unitary groups, fundamental representation of SU(2), SU(3) diagonal generators and weights, generators of SU(2) and U(2), weight diagram of fundamental representation of SU(2), generators of SU(3) and U(3), Weight of first fundamental representation of SU(3), shift operators, I, U, V spins, complete weight diagram for the (1 0), (0 1), (3, 0), (1 1) and (2 1) representations of SU(3) , Gell Mann Okubo Mass formula.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Method of Young Tableaux and its Applications Young Tableaux and unitary symmetry, standard arrangements of young tableaux, Dimentaionality of the representations of SU(N), Multiplets of SU(N-1), subgroup of SU(N), Baryon multiplets in different representations, general rule and its application for reducing kronecker product of two representations, kronecker product of three particle state vectors.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Nuclear and Particle Detectors Basic principle of particle</td><td>15</td></tr>
</table>

	detectors, Ionization chamber, Proportional counter, Geiger-Muller Counter, Scintillation counters and-ray spectrometer, semiconductor detector, Nuclear emulsion technique, Cloud chamber, Bubble chamber	
Suggested Readings: D. H. Perkins: Introduction to High Energy Physics, Cambridge University Press, 2000 S. N. Ghoshal: Atomic and Nuclear Physics, S. Chand and Company Ltd, 1994 D. Griffiths : Introduction of Elementary Particles DB Lichtenberg: Unitary Symmetry and Elementary Particles, Academic Press, 1978 Hughes: Elementary Particles Blatt and Weiskopff : Theoretical Nuclear Physics FE Close: Quarks and Patrons P.P.Cheng and G.LF Li : Gauge Field Theory: W. E. Burcham : Nuclear Physics R. M. Singru: Introduction to experimental nuclear physics E. Segre: Experimental nuclear physics		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester VII with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

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<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER IV</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Condensed Matter Physics</td></tr>
<tr><td colspan="4">Course Outcomes:
The students will be able to develop an understanding of the lattice, different types of crystal structures, symmetries. The student would gain insight about the interior of the substances using X-ray diffraction in crystals. This course also includes elastic waves, phonons, and lattice vibrational properties and also superconductivity. The course forms a theoretical basis of experimental material science and technology.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 3 6</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Crystal Structure Interaction of radiation with matter (for elastic and en elastic scatterings of x- ray). Concept of reciprocal lattice point, calculation of reciprocal lattice point of SC, BCC. and FCC lattices, Application of reciprocal lattice point in diffraction technique. Neutron scattering and its applications. Debye Waller factor. Hyperfine interactions (isomer shift, quadrupole splitting and magnetic splitting), Mössbauer effect and its applications. Basic idea about nanomaterials and nanotechnology. fabrication of nanomaterials. modiication of crystal properties in nanodimension.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Bonding in Solids Different types of bonding in solids, covalent, metallic, Vander Waal, hydrogen bonding & ionic bonding, Madelung constant of ionic crystals, cohesive energy, Thermal expansion and thermal conductivity, anharmonicity interaction of electrons and phonons with photons (direct and indirect transitions).</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Lattice Vibrations Concept of dispersion relation, quantization of lattice vibrations (Phonons), normal modes & normal coordinates, longitudinal and transverse modes of vibration, modes of vibration of monatomic and diatomic lattices. Density of states (Phonons) , Theory of specific heat of solids : classical theory , Einstein theory and Debye theory .Theory of metals : Classical theory , free electron theory and F-D distribution function , Hall effect.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Crystal Defects, Superconductivity and Magnetism Point defects (Schottky & Frankel Defects) Imperfections, Line defects (Edge& Screw dislocations), Burger vector & Burger</td><td>15</td></tr>
</table>

	Circuit, Role of dislocation in plastic deformation and crystal growth. Introduction of superconductivity, phenomenological, semi phenomenological and microscopic theories of superconductors, Meissner effect, Type-I and type-II superconductors, Penetration depth, coherence length, Josephson effect, Isotope effect, Elementary idea of high temperature superconductors	

Suggested Readings

A. J. Dekker: Solid State Physics

S.O. Pillai : Solid State Physics

C. Kittle : Introduction to Solid State Physics

Verma &Srivastava : Crystallography for Solid State Physics

Can be opted by

Bachelor in Science with Physics as major subject

Suggested Continuous Evaluation Methods:

Course Prerequisites
Passed Semester VII with Physics as major

Suggested Equivalent Online Courses:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

<table>
<tr><th colspan="3">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV
SEMESTER VIII/PAPER V</td></tr>
<tr><td colspan="3">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="2">Course Title: PRACTICAL</td></tr>
<tr><td colspan="3">Course Outcomes:
The student will have adequate knowledge to perform the experiments of different fields of physics with clear understanding of the theory behind the experiment.
Student will know about various electronic components and learn to design some basic electronic circuits and study their applications.</td></tr>
<tr><td colspan="2">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="3">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>UNIT</td><td>List of Experiments</td><td>No. of Lectures</td></tr>
<tr><td></td><td>1. Study of the Phase measurement by superposition of voltages with LCR Circuits.
2. Study of different oscillators (Hartely, colpit, Weinbridge oscillators etc.).
3. Study of an electronically regulated power supply.
4. Study of negative Feed- back Amplifier.
5. Determination of wavelength (λ) and wavelength difference (Δλ) by Michelson Interferometer.
6. Study of different type of Resistances and Diodes.
7. Study of Photo Voltaic Cell.
8. Stefan's Constant
9. FET characteristics
10. Fresnel's Law
11. Cauchy Formula
12. Lattice Dynamic Kit
13. Study of Logic gates
14. Detection Efficiency of Diode
15. Fabry – Perot Interferometer
16. Four Probe method</td><td>60</td></tr>
<tr><td colspan="2">Can be opted by
Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="2">Suggested Continuous Evaluation Methods:</td><td></td></tr>
<tr><td colspan="2">Course Prerequisites
Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="2">Suggested Equivalent Online Courses:
1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities</td><td></td></tr>
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<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII
EL3(1)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Statistical Physics</td></tr>
<tr><td colspan="4">Course Outcomes:
The course structure includes different aspects of statistical Mechanics and Statistical models for phase transition. Study of this course will enable students a clear understanding of classical and Quantum Statistics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Elective</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 33</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Foundation of Statistical Mechanics Microscopic and macroscopic states, Density of states, Micro-canonical, Canonical and grand canonical ensembles, Canonical ensemble and Gibb’s distribution, Boltzmann–Planck method, Partition function and statistical definition of thermodynamic quantities, Computation of partition functions of some standard systems.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Statistical Properties System of linear harmonic oscillators in the canonical ensemble; Grand canonical ensemble and its partition function; Chemical potential; Partition function and distribution for perfect gas; Gibb’s paradox; Free energy, entropy, Equation of state and specific heat determination of perfect gas.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Statistical models Theory of phase transitions, First order phase transition, Second order phase transitions and higher order phase transitions (elementary discussion), Ising model, One dimensional (with exact solution), Two dimensional (with exact solution) & three dimensional model (elementary idea), Landau theory of phase transition, Weiss theory of Ferro-magnetism, Heisenberg model. Virial equation of states.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Quantum Statistics Bose-Einstein and Fermi- Dirac distributions, Degeneracy, Gas degeneration, Degenerate Bose gas, Bose Einstein condensation, Highly degenerate B-E and F-D gases; examples of Molecular Hydrogen, liquid helium and electron gas in metals.</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings
Quantum Mechanics : A.S. Davidov
Quantum Mechanics : B.S. Rajput
Quantum Mechanics : Paul Roman
Theoretical Chemistry : Glastohn
Statistical Mechanics : Landau and Lifshitz
Statistical Mechanics : Pathira
Statistical Mechanics : Huang</td><td></td></tr>
<tr><td colspan="3">Can be opted by

Bachelor in Science with Physics as major subject</td><td></td></tr>
</table>

Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII EL3(2)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Bio Physics</td></tr>
<tr><td colspan="4">Course Outcomes:
Biophysics is the field that applies the theories and methods of physics to understand how biological systems work.The student"s knowledge can be used in the sector relater to health and Medical .</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Elective</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Basic Concepts in Biophysics
Elementary ideas about the DNA structure, Forces stabilizing DNA and protein structure, sugar-phosphate backbone, nucleosides and nucleotides, three dimensional DNA structure, RNA. Proteins: primary, secondary, tertiary and quaternary structures, enzymes and their catalytic activity, DNA and protein folding, DNA denaturation, replication, mutation, intercalation, neurotransmitters, membranes.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Technique For The Study of Biological Structure and Function
Application of experimental techniques of light scattering (tomography), FTIR and Raman spectroscopy, absorption and fluorescence spectroscopy/ microscopy, anisotropy, optical activity, circular dichroism, electrophoresis,.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Photobiology
interaction of light with cell and tissues, Photosynthesis, human eye and vision optical biopsy, optical biosensors, Laser tweezers and Laser scissors Photo-dimerization, Photodynamic therapy.</td><td></td></tr>
<tr><td>UNIT IV</td><td colspan="2">Radiation Effects on Biological Systems
High doses received in a short time, Low-level doses limits, direct ionization of DNA, radiation damage to DNA, Biological effects (Genetic, Somatic, Cancer and sterlity). Bio-imaging: Ultrasound, MRI imaging, confocal fluorescence imaging and X-ray.</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:

Essentials of Biophysics: P. Narayanan.

Basic Molecular Biology: Price.</td><td></td></tr>
</table>

Quantum Mechanics of Molecular Conformations: Pullman (Ed.). Non-linear Physics of DNA: Yakushevich. Biological Physics: Nelson. Spectroscopy of biological systems Modern Spectroscopy: J.M. Hollas. Transmission Electron Microscopy of Metals: Gareth Thomas Elements of X-ray Diffraction: Bernard Dennis Cullity.	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

BACHELOR (RESEARCH IN PHYSICS)			
Programme: BACHELOR (RESEARCH IN PHYSICS)	YEAR IV	SEMESTER VIII EL3(3)	
Subject: Physics			
Course code	Course Title: **Medical Physics**		

Course Outcomes:

Medical Physics is a branch of science that uses the methods of physics to study biological processes and also working of the instruments and machines used in Medical Science .Physics uses mathematical laws to explain the natural world, and it can be applied to biological organisms and systems to gain insight into their workings. The course includes Physics of Respiratory and Cardiovascular System, Electricity in the Body and Sound/Light and also Equipment's and Modern Medicines .The course opens future prospects of the student in the field of Medical Science .

Credits: 4	Elective
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Mechanics of Human Body** Static , Dynamic an d Frictional forces in the Body, Composition, properties and functions of Bone, Heat and Temperature, Temperature scales, Clinical thermometer, Thermography, Heat therapy, Cryogenics in medicine, Heat losses from Body, Pressure in the Body, Pressure in skull, Eye and Urinary Bladder.	15
UNIT II	**Physics of Respiratory and Cardiovascular System** Body as a machine, Airways, Blood and Lungs interactions, Measurement of Lung volume, Structure and Physics of Alveoli, Breathing mechanism, Airway resistance, Components and functions of Cardiovascular systems, work done by Heart, Components and flow of Blood, Laminar and Turbulent flow, blood Pressure, direct and indirect method of measuring, Heart sounds.	15
UNIT III	**Electricity in the Body and Sound/Light In Medicine** Nervous system and Neuron ,Electrical potentials of Nerves, Electric signals from Muscles, Eye and Heart, Block diagram and working to record EMG, Normal ECG wave form, Electrodes for ECG, Amplifier and Recording device, Block diagram and working to record ECG, Patient monitoring, Pace maker. General properties of sound, Stethoscope, Generation, detection and characteristics of Ultrasound, Ultrasound imaging technique, A scan and B scan methods of ultrasound imaging,	15

	properties of light, Applications of visible UV, IR light, and Lasers in medicine, Microscope, Eye as an optical system, Elements of the Eye, Ophthalmology Instruments.	
UNIT IV	**Diagnostic X-Rays and Nuclear Medicine** Production and properties of X-rays, Basic Diagnostic X-ray Machine, X-ray image, Live X-ray image, X-ray computed Tomography, Characteristics of Radio activity, Radioisotopes and Radio nuclides, Radioactivity sources for Nuclear medicine, Basic Instrumentation and clinical applications, Principles of Radiation Therapy, Nuclear medicine imaging devices, Radiation sources.	15
Suggested Readings: Medical Physics by Department of Physics, St. Joseph's College,Trichy-2. Medical Physics by John R. Cameron and James G. Skofronick, John Wiley & Sons. Hand book of Biomedical Instrumentation : R.S.Khandpur, Tata McGraw Hill Publication Co., Delhi, 1987.		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester VII with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTERVIIIE L3(4)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Atmospheric Physics</td></tr>
<tr><td colspan="4">Course Outcomes:
The course introduces students to Earth- Atmosphere and Meteorology The course includes Environmental pollution and climate change etc. The course is useful for the students who want to work in Metereological department or wants to pursue his/her career in the field of environmental science . The course is also very important for R& D purposes.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Elective</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 33</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Introduction to Earth Atmosphere and Meteorology
Elementary concept of atmospheric sciences, atmosphere and it composition, Thermal and pressure variation in earth atmosphere, Thermal structure of the troposphere, stratosphere, mesosphere and ionosphere, Hydrostatic equation, spectral distribution of the solar radiation, Green house effect and effective temperature of earth. Meteorological process and different system, local winds, monsoons, fogs, clouds, precipitation, Cyclones and anti-cyclones, thunderstorms, Mountain Meteorology</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Atmospheric Dynamics and Thermodynamics
Introduction to atmospheric dynamics, Basic conservation laws, Applications of the basic equations, circulations and vorticity, Atmospheric oscillations, The general circulations, Tropical dynamics, Thermodynamical considerations, Adiabatic and isothermal processes, equation of state for dry and moist air, Humidity parameters, laws of thermodynamics, Entropy, Thermodynamic diagram and their uses.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Environmental pollution and climate change
Atmospheric pollution, type of pollutants, various sources of emissions, Trace gages, Production and loss processes of stratosphere ozone, Tropospheric ozone, Role of trace gases and their budget, motion of air-masses (back-air trajectory), tools for modeling (Box model and 3-D model), Atmospheric aerosols, classification and properties, concentration and size distribution, Absorption and scattering of radiation, optical phenomena in atmospheric, Modeling for aerosols, Estimations of radiative forcing. Definition of climate long term changes, possible causes of climate change-External and internal, General idea of internal dynamical processes of the atmosphere, climate modeling, Review of various climate models.</td><td>15</td></tr>
</table>

<table>
<tr><td>UNIT IV</td><td>Instrumentation and Observational Techniques
Convectional measurements of pressure, temperature, humidity, wind speed and direction, sunshine duration, radiation clouds, upper air pressure, temperature, humidity and wind measurements, Polit balloons, radiosonde, dropsonde, ozonesonde, GPS sonde. Application of radars to study the atmospheric phenomenon, LIDAR, SONAR, RASS (Radio-acoustic sounding system), Observational technique for aerosol.</td><td>15</td></tr>
<tr><td colspan="2">Suggested Readings:

S. Pettersen: An Introduction to meteorology

H. R. Byer: General Meteorology Miller, Thompson and Paterson: Elements of meteorology

J. M. Wallau and P. V. Hobbs: Atmospheric Science

J. A. Ratchiffe: Physics of upper atmosphere

R. B. Stull: An introduction to boundary layer Meteorology

D. H. Lenschow: Probing the atmospheric boundary

D. H. Lechow: Intruments and Techniques for probing the atmospheric boundary layer

A.A. Tsonis: An introduction to atmospheric Thermodynamics

H. J. Critchfield: General Climatology G. T. Trewartha: An introduction to climate</td><td></td></tr>
<tr><td colspan="2">Can be opted by

Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="2">Suggested Continuous Evaluation Methods:</td><td></td></tr>
<tr><td colspan="2">Course Prerequisites
Passed Semester VII with Physics as major</td><td></td></tr>
<tr><td colspan="2">Suggested Equivalent Online Courses:
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8</td><td></td></tr>
</table>

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTERVIIIE L3(5)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Nano Materials and Applications</td></tr>
<tr><td colspan="4">Course Outcomes:
This course introduces the essence of nano materials, their synthesis, and characterization. On successful completion of the module students should also be able to understand the optical properties and electron transport phenomenon in nanostructures. It also covers few important applications of nano materials used in this technological era.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Elective</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 33</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Nanoscale Systems
Density of states (1-D,2-D,3-D). Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Synthesis of Nanostructure Materials
Metals, Metal Oxide, Carbon based nanomaterials CNT, C60, graphene. Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, Chemical vapor deposition (CVD).Sol-Gel. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.
X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Optical Properties
Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and</td><td>15</td></tr>
</table>

	excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures.	
UNIT IV	**Electron Transport and Applications of Nanoparticles** Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects. **Applications:** Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).	15
Suggested Readings: C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.). S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company) K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited). Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester VII with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

<table>
<tr><th colspan="5">MASTER IN PHYSICS</th></tr>
<tr><td colspan="3">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER I</td></tr>
<tr><td colspan="5">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="4">Course Title: Advanced Quantum Mechanics</td></tr>
<tr><td colspan="5">Course Outcomes:
The course includes the study of scattering theory, identical particles, relativistic wave equations and quantization of wave fields. The course would describe the nature and behaviour of matter and energy at subatomic level. In particular, theory of scattering gives an understanding collision between a quantum mechanical particle and target. The study of relativistic quantum mechanics enables the students to understand the behaviour of objects moving with speeds comparable to that of light. The knowledge of this field forms the foundation for pursuing research in Quantum Field Theory and High Energy physics.</td></tr>
<tr><td colspan="4">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="4">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="5">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="3">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="3">Free particle Dirac equation
Discrepancies faced by Schrödinger equations, Klein-Gordon equation and its drawbacks, Dirac's equation for a free particle, Dirac matrices, covariant form of Dirac equation, Probability and current densities, Free particle solutions of Dirac equation, Non conservation of Orbital Angular momentum and idea of spin, Interpretation of negative energy and hole theory</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="3">Dirac particle in Electromagnetic Fields
Dirac equation in electromagnetic fields, Magnetic moment of charged particle, Gauge invariance of Dirac equation in electromagnetic fields, Non- relativistic correspondence of Dirac equation; Pauli equation, Adjoint spinors, Symmetries of Dirac Equation: Parity, Time reversal and Charge Conjugation; Lorentz covariance of Dirac Equation, , Bilinear covariants</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="3">Identical Particles and Quantum Field Theory
Identical particles, exchange degeneracy, symmetric and anti symmetric functions for many particle system Classical Fields, Schwinger's action principle, Lagrangian and Hamiltonian densities, Field equation, quantum structure of free fields and the particle concept,</td><td>15</td></tr>
</table>

	Quantization relations, Quantization of non relativistic Schrödinger matter field, System of identical bosons and fermions, Commutation and anti-commutation relations, Occupation number representation, creation and annihilation operators.	
UNIT IV	**Quantum Theory of Scattering** Scattering Theory, Scattering cross section, method of partial wave analysis, phase shift, Optical theorem, scattering length, effective range theory; low energy scattering, Resonance, scattering from a square potential well and a rigid sphere, Born approximation, Validity of Born approximation, Born approximation through time dependent perturbation, its application to square well potential.	15
Suggested Readings: Davydov : Quantum Theory Messiah : Quantum Mechanics Vols. I & II Rajput B. S. : Advanced Quantum Mechanics Ropman P. : Advanced Quantum Mechanics Trigg : Quantum Mechanics ThankappanV.K. : Quantum Mechanics Sakurai J.J. : Quantum Mechanics		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester VIII with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

<table>
<tr><th colspan="3">MASTER IN PHYSICS</th></tr>
<tr><td>Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER II</td></tr>
<tr><td colspan="3">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="2">Course Title: Plasma Physics</td></tr>
<tr><td colspan="3">Course Outcomes:
The course includes Magneto Hydrodynamics , Plasma Propagation and other topics related to plasma. Plasma physicists study plasmas, which are considered a distinct state of matter and occur naturally in stars and interplanetary space .The knowledge acquired by the student can be used in various field of Physics and thus career prospects are bright in the field of research.</td></tr>
<tr><td colspan="2">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="3">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>UNIT</td><td>TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td>Introduction to Plasma
Elementary concept of plasma: Debye Shielding, Plasma parameters, Drift of guiding center, Gradient drift, Curvature drift, Magnetic mirror, Plasma confinement</td><td>15</td></tr>
<tr><td>UNIT II</td><td>Magneto-Hydrodynamics and Fluid Plasma
Plasma Oscillation, Fluid equations for a plasma, Continuity equation, Wave Propogation in unmagnetized plasma, Magneto Hydrodynamics , Hydrodynamical description of Plasma: fundamental equation, Concept of convective derivative, hydromagnetic waves, magneto-sonic and Alfven waves.</td><td>15</td></tr>
<tr><td>UNIT III</td><td>Magneto Plasma
Wave phenomena in Magneto plasma: Polarization, Phase velocity, group velocity, cutoff, resonance for electromagnetic wave propagating parallel and perpendicular to the magnetic field Helicon, Faraday rotation,.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td>Electromagnetic Wave Propagation in Plasma
Propagation at finite angle and CMA diagram, Propagation through ionosphere and magnetosphere Derivation of moment Equation from Boltzmann Equation, Momentum balance equation, Equations of state, Two-fluid equations, Plasma resistivity</td><td>15</td></tr>
<tr><td colspan="2">Suggested Readings:
Jackson: Classical Electrodynamics; Wiley Estern, New Delhi</td><td></td></tr>
</table>

Bittencourt: Plasma Physics Chen: Plasma Physics Robert J Goldston and Paul H. Rutherford: Introduction to Plasma Physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER III a
(Specialization paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Advanced Electronics- I</td></tr>
<tr><td colspan="4">Course Outcomes:
This course helps the students to gain basic ideas of the construction and working of electronic devices and circuits . The course includes the study of IC technology, Operational amplifier as linear Analog systems and non-linear analog systems. The course is of much practical purpose for the students to learn basics of integrated circuit technology which has wide applications in computing, process control, signal processing, communication systems, digital instruments etc.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Integrated Circuit Technology
Classification of IC's, Fabrication of IC's & components, Basic monolithic integrated circuit technology, processes used in monolithic technology, active & passive components, metal semiconductor contact, thick & thin film IC's, hybrid IC's, advantages & limitations of integrated circuits</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Operational Amplifier
Basic operational Amplifier, Inverting & Non inverting OP – AMP, Common Mode Rejection Ratio (CMRR), Operational Amplifier parameters, effects of offset, frequency response and stability</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Linear Analog Systems
Circuit type of OP – AMP 741, Summing Amplifier, voltage follower, current to voltage, voltage to current converter, Integrator, Differentiator, Logarithmic Amplifier, Antilogarithmic Amplifier</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Non - Linear Analog Systems
Comparators, Discriminators, sample & hold circuits, Zero crossing detector, precision rectifier, waveform generators, OP -AMP as astable, monostable and bistable multivibrator, regenerative comparator (Schmitt trigger), IC 555 timer</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:

Coughlin: Operational Amplifiers and Linear Integrated Circuits.

Schilling and Belove: Electronic circuits Discrete and Integrated,</td><td></td></tr>
</table>

Mcgraw Hill Millman and Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Hill Millman and Halkias: Integrated Electronics K.R. Botkar: Integrated Circuits, Khanna Publishers G.K. Mithal and Ravi Mittal: Electronic Devices & Circuits, Khanna Publishers Roychaudhary and Jain: Operational Amplifier & Linear Integrated Circuits V.K. Mehta: Electronics for Scientists & Engineers Robert J Goldston and Paul H. Rutherford: Introduction to Plasma Physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER III b
(specialization
paper</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Astrophysics –I</td></tr>
<tr><td colspan="4">Course Outcomes:

The course would be important to understand the spherical astronomy, distance measurement in astrophysics, and physics of solar system and extra solar planets. The course provides an opportunity to understand the optics of the different astronomical instruments such as: telescopes, CCD camera etc. It has wide spared in use of R& D sector.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core
Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min.
Passing
Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Spherical Astronomy Celestial sphere, Celestial coordinate system (equatorial and alt-azimuth): altitude and azimuth, right ascension and declination, hour angle, sidereal time, mean solar time, summer and winter solstice, seasons. Distance measurements: AU, parsec, standard candles, distance measurement by geometric means (parallax, distances to open clusters).</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Solar System Idea of solar system, Study of planets and their satellites, Earth-Moon system, tidal forces, asteroids, meteors, comets and their origin, composition and dynamical evolution, extra solar planets and their detection.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Telescopes: Basic Optics, Types of telescopes. Telescope mounting systems. Optical telescopes, Infrared, Ultraviolet, X-ray and Gamma-ray telescopes. Schmidt telescopes. Solar telescopes. Design and construction of a simple optical telescopes. Active and adoptive optics in astronomical study.
Sky charts and their importance.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Classification of detectors, characteristics of detectors. Detectors for optical and infrared wavelength regions. Working of Charge Coupled Device (CCD). sensitivity, noise, quantum efficiency, spectral response, Johnson noise, signal to noise ratio, Application of CCD for stellar imaging, photometry and spectroscopy. Importance of space based astronomy. Observational techniques of astronomical sources from space in</td><td>15</td></tr>
</table>

	infrared, EUV, X-ray and Gamma-ray regions of the electromagnetic spectrum.	
Suggested Readings: Abhyankar K.D. : Astrophysics, Galaxies and Stars VaidyanthBasu : An Introduction to Astrophysics Motz : Astrophysics K S Krishnaswamy : Astrophysics: A Modern Perspective W. M Smart: Spherical Astronomy Mark A. Garlick: The Story of the Solar System		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester VIII with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER IX PAPER III c
Subject: Physics		
Course code	Course Title: **High Energy Physics- I**	
Course Outcomes: Students would be able understand the complex properties and behaviour of high energy particles at the microscopic level. This course would encourage students to peruse higher study and research in particle and high energy Physics.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Quantization of Scalar Fields Lagrangian Formulation, Hamiltonian and momentum densities, Neutral and Charged scalar fields and their quantization, Momentum representation and frequency splitting, Identification of various particle operators, Charge operator, Algebra of field operators, Invariant delta function and its representations, Covariant commutation relations and their properties.	15
UNIT II	Quantization of Spinor Field Lagrangian formulation for Spinor field, Hamiltonian and momentum densities, Quantization of Spinor Field, Momentum representation and frequency splitting, Identification of various particle operators, Charge operator for Spinor field, Algebra of Spinor field operators, Covariant form of anti-commutation relations.	15
UNIT III	Quantization of Electromagnetic Field Classical electromagnetic field theory and its gauge formulation, Covariant Lagrangian formulation for EM field, Quantization of EM field, Momentum representation and frequency splitting,	15
UNIT IV	Identification of various particle operators, Concept of longitudinal, temporal and transverse photons, Covariant commutation relations for EM potential operators, Problems with temporal photons and Lorentz condition, Resolution through Gupta- Bleular formulation	15
Suggested Readings: L. Ryder : Quantum Field Theory B.K. Agarwal : Quantum Mechanics and Field Theory		

F Mandel and Shaw: Quantum Field Theory P. Roman: Quantum Field Theory A. Das: Quantum Field theory M. E. Peskin, D.V. Schroeder : An Introduction to Quantum Field Theory B.S.Rajput : Advanced Quantum mechanics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX PAPER III d</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Spectroscopy-I</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course the students would study the various types of lasers, Laser spectroscopy and their applications in science and technology. Knowledge acquired by the course will be of much use for various industries and R&D sector .</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Rotational Spectra Rotational spectra: rotational energy level populations, linear, symmetric, spherical and asymmetric top molecules, rotational selection rules for linear molecules, Stark effect in molecular rotation spectra, Molecular rotation-nuclear spin coupling, Positive and negative character of the wave functions of linear molecules, Symmetric-antisymmetric character and statistical weight of homo-nuclear linear molecule.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Vibrational Spectra Vibration spectra of polyatomic molecule, coupling of rotation and vibration, perpendicular and parallel bands, Normal modes of vibration and their analysis in Cartesian coordinates, normal coordinates and their internal coordinates, calculation of vibrational frequencies and force field of H2O and CO2 molecules, anharmonicity, degenerate and non-degenerate vibrations, inversion doubling, Quantized Vibrational motion of polyatomic molecules.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Electronic Spectra Spectroscopy of Diatomic and Polyatomic Molecules: Coupling of Electronic and Rotational motion in Diatomic Molecules and Rotational structure of 1π - 1Σ and 1Σ - 1Σ transitions. Vibronic interaction and Herzberg Teller theory for absorption spectrum of benzene vapour.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Single vibronic level spectroscopy and lifetime of vibronic levels in benzene, Quantum yield, Kasha Rule and the concept of nonradiative transtions in molecules, Jablanski diagram and qualitative treatment of small molecule and large molecule limit for nonradiative transitions.</td><td>15</td></tr>
<tr><td colspan="3"></td><td></td></tr>
</table>

Suggested Readings: C.N. Banwell: Fundamentals of Molecular Spectroscopy Walker and Stranghen: Spectroscopy Vol. I, II, & III Herzberg: Spectra of diatomic molecules Jeanne L. Mchale: Molecular Spectroscopy P.F. Bemath: Spectra of atoms and molecules J.M Holias: Modern Spectroscopy K. Thyagrajan and A.K. Ghatak: Lasers: Theory and applications A Yariv: Quantum Electronics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER IV a</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Advanced Electronics- II</td></tr>
<tr><td colspan="4">Course Outcomes:
This course helps the students to gain basic ideas of the digital communication, optical communication, memory and optoelectronic devices. The course is of much practical purpose for the students to learn advanced concepts of digital communication systems.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Digital Communication
Digital signal processing, Image processing (Basic ideas only), Pulse Modulation systems, Pulse Amplitude Modulation, Pulse Width Modulation, Pulse position modulation, Pulse code modulation, Delta modulation Frequency division multiplexing (FDM), Basic idea of digital telemetry</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Optical communication
Principle of optical communication, Different modes of propagation of E. M. Wave through optical fibre, Brief concept, classification of fibres and ray path, Advantages of multimode fibres and cladding , Optical Fibre connectors, Optical Fibre communication Receiver, Brief Introduction , Signal path through optical data link, Block diagram of optical Receiver, Advantages of optical communication.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Optoelectronic devices
Light propagation in cylindrical wave guide, Bulk and thin films. Photoconductive devices (LDR), charge coupled devices (CCD), LCDS.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Memory devices
Memory devices, static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, nonvolatile-NMOS, magnetic, optical and ferromagnetic memories.</td><td>15</td></tr>
<tr><td colspan="3"></td><td></td></tr>
</table>

Suggested Readings: Coughlin: Operational Amplifiers and Linear Integrated Circuits. Mchilling and Belove: Electronic circuits Discrete and Integrated, Mcgraw Hill Millman and Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Millman and Halkias: Integrated Electronics K.R. Botkar: Integrated Circuits, Khanna Publishers G.K. Mithal and Ravi Mittal: Electronic Devices & Circuits, Khanna Publishers Malmstadt and Enke: Electronics for scientists Taub and Schilling: Principal of communication systems Simon Gayukti: Communication Systems Martin S. Roden: Analog & Digital Communication Systems V. K. Sarkar and D. C. Sarkar: Optoelectronics and Fibre Optic Communication.	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER IV b</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Astrophysics –II</td></tr>
<tr><td colspan="4">Course Outcomes:
The Course will provide the deeper understanding of the radiative transfer and the interaction of radiation with matter. It would be important to understand the physics of the death of stars. This study is crucial for the deeper knowledge of the neutron stars, white dwarfs and black holes. Their study provides the insight for the gravitational waves.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Radiation transfer: Definitions of specific intensity, mean intensity, flux and energy density; Equation of radiation transfer; solutions in some specific cases, optical depth; Thermal emission; Blackbody spectrum and its characteristics; Kirchoff's law; Einstein coefficients.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Interior Properties of Stars Hydrostatic equilibrium, Virial theorem, Polytrophic indices, Lane – Emden equation LTE, Radiative equilibrium, stability condition of convective and radiative equilibrium, Continuous spectra of stars, Stellar opacity, limb darkening, line blanketing, theory of Fraunhofer lines, curve of growth and line broadening.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Elementary theory of white dwarfs, Chandrashekhar's limit for white dwarf stars, neutron stars their birth and properties, Pulsars, black holes, low medium mass star and high mass stars, death of high mass stars, supernova remnants..</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">AGNs and Quasi-stellar Objects Theory of AGNs, Syferts, quasars and their energy generation and redshift anomaly. Different AGN models, radio lobes and jets, Gamma ray bursts.</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
Abhyankar K.D.: Astrophysics, Galaxies and Stars

Vaidyanth Basu: An Introduction to Astrophysics

motz: Astrophysics A. R. Choudhuri : Astrophysics for Physicists</td><td></td></tr>
</table>

B. D. Abhyankar : An Introduction to Astrophysics T. Padmanabhan : Astrophysical Processes	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER IX PAPER IV c
Subject: Physics		
Course code	Course Title: **High Energy Physics-II**	
Course Outcomes: The course would provide the knowledge of basic building blocks of matter and its complex properties.The students will also be able to know the complicated theory of Higgs mechanism which led to the detection of God particle in LHC experiment in the year 2012.It would open doors for the students who want to work in the field of HEP.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Lie Groups and Lie Algebra Symmetries, Groups and conservation laws, Lie groups and their generator, representation of the groups, Lie Algebra, Different dimensions and parameter groups-their generators and algebra, Simple and semi-simple Lie Algebra, Standard form of Lie Algebras, Root diagrams for groups of different rank.	15
UNIT II	Quark Model Fermi Yang model, Sakata model, Necessity of Quark model, Shortcomings of Eight fold way, Gell - Mann Zweig model, Quark-Lepton symmetry and structure of Hadrons, Need of charm quantum number and charmed quark , Elementary idea of charm, bottom and top quarks, Baryon magnetic moments in quark model, Experimental status of Quarks.	15
UNIT III	Gauge Field Theories Concept of gauge fields and gauge connections, Principle of gauge invariance, Global and local Abelian gauge invariance, U(1) gauge invariance of QED.	15
UNIT IV	Yang- Mills gauge field, Non-Abelian gauge field theory (SU(2) case), Concept of spontaneous symmetry breaking and Goldstone Bosons, Higgs Mechanism with physical examples and mass generation for gauge fields	15

Suggested Readings:

.E. Close : Quarks and Patrons

D.C. Cheng and O Neil : Elementary Particle Physics

P.Cheng and G.LF Li : Gauge Field Theory

I.J. Aitchison and A.J. Hey : Gauge theories in Particle Physics

H. Georgi : Lie Algebras in particle Physics

D. B. Lichtenberg : Unitary Symmetry and Elementary Particles, Academic Press, 1978	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER IV d</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Spectroscopy -II</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course the students would study the various types of lasers, Laser spectroscopy and their applications in science and technology. Knowledge acquired by the course will be of much use for various industries and R&D sector .</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Radiation and Matter Interaction of radiation with matter, Einstein quantum theory of radiation, Einstein’s coefficients, Momentum Transfer, Lifetime, Theory of optical frequencies , Coherence Spatial and temporal and Monochromaticity, kinetics of optical absorption, line width, line broadening mechanisms.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Basic Elements of Lasers Spontaneous emission, Stimulated emission, Possibility of amplification, laser pumping, ,Population Inversion, Three and four level scheme, Threshold condition, rate equations, Active resonators & laser modes, gain saturation.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Type of Lasers Different types of lasers, gas lasers, He-Ne laser, N2 & CO2 lasers dye lasers, solid state lasers, Nd-YAG, semiconductor lasers. Tunability of lasers</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Applications of Lasers
Basic application of laser spectroscopy, laser cooling and trapping of atoms etc.</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
.N. Banwell: Fundamentals of Molecular Spectroscopy

Walker and Stranghen: Spectroscopy Vol. I, II, & III

Herzberg: Spectra of diatomic molecules

Jeanne L Mchale: Molecular Spectroscopy

.F. Bemath: Spectra of atoms and molecules

M Holias: Modern Spectroscopy

K. Thyagrajan and A.K. Ghatak: Lasers: Theory and applications</td><td></td></tr>
</table>

A Yariv: Quantum Electronics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester VIII with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR IV</td><td>SEMESTER IX/PAPER V</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: PRACTICAL</td></tr>
<tr><td colspan="4">Course Outcomes:
The student will have adequate knowledge to perform the experiments of different fields of physics with clear understanding of the theory behind the experiment.
Student will know about various electronics experiments and some advanced experiments in Physics</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">List of Experiments</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">1. Verification of Richardson’s law.
2. Study of ESR spectra of a given sample.
3. Hall Effect
4. RCS Spectrometer
5. gamma ray spectrometer
6. Radio Receiver
7. e by Millikan’s oil drop method.
8. Temperature dependence of diode characteristics.
9. Elastic constants of a cubic crystal by ultrasonic waves.
10. Study of Multivibrators .
11. Study of transistor amplifier cum feedback amplifiers.
12. Study of absorption of $KMnO_4$ by Spectrophotometer
13. Study of different FETs and MOSFETs.
14. Study of Thermo luminance .
15. Study of VTVM.</td><td>60</td></tr>
<tr><td colspan="3">Can be opted by

Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="3">Suggested Continuous Evaluation Methods:</td><td></td></tr>
<tr><td colspan="3">Course Prerequisites
Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="3">Suggested Equivalent Online Courses:
1. Virtual Labs at Amrita Vishwa Vidyapeetham,</td><td></td></tr>
</table>

https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER I</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Nuclear Physics</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course students would know about the general properties of nuclei, nuclear forces and detectors, radioactive decay and nuclear reactions.The course builds a foundation for the students to carry out research in the field of nuclear physics, high energy physics, nuclear astrophysics, nuclear reactions and applied nuclear physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Nuclear Properties and Nuclear Models Concepts of Atomic Nuclear-Size, Shape, charge distribution, spin & parity, magnetic moment; electric quadrupole moment; binding energy; semi-empirical mass formula, mirror nuclei, Liquid drop model, Experimental evidence for shell effects, Shell model, Magic numbers, Spin orbit coupling, Single particle shell model-its validity and limitations; collective model.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Nuclear Forces and Nuclear Interactions Theory of Deuteron and nuclear level properties, nucleon - nucleon interactions, low & highenergy nucleon-nucleon scattering, Yukawa’s Meson theory of nuclear forces, Spin dependence and charge independence of nuclear forces.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Nuclear Reactions Kinds of nuclear reactions; Conservation laws; Nuclear reaction Kinematics; charge particle reaction spectroscopy; neutron spectroscopy; nuclear cross-section; compound nucleus; Nuclear transmutations, continuum theory of nuclear reaction, Nuclear fission, Chain reactions, Nuclear fusion, Thermonuclear reactions.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Nuclear Decays Basic understanding of and - decay, Fermi theory of beta decay, selection rules in -decay, Neutrino hypothesis, Parity violation in beta decay, K capture and internal conversion.</td><td>15</td></tr>
<tr><td colspan="3"></td><td></td></tr>
</table>

Suggested Readings: E. Burcham: Nuclear Physics Ervin Kapalan: Nuclear Physics Roy & Nigam: Nuclear Physics S. N. Ghoshal: Atomic and Nuclear Physics A.Enge: Nuclear Physics .D. Evans: Nuclear Physics E. Segre: Nuclei and Particles H.M. Agrawal: Nuclear Physics, PHI Learning	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER II</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Digital Electronics and Computer Architecture</td></tr>
<tr><td colspan="4">Course Outcomes:
The course enables student to get knowledge about Digital Electronics and Computer Architecture. The course includes Fundamentals of Digital Circuit, Computer Organization and Architecture , Instruction formats & Microprocessor, Data Communication, Computer and Communications.The course helps student to work for the development of technology and also the for the industry and various Government organizations.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Digital Circuit & Microprocessor Elementary idea of combinational and sequential circuits, Overview of Microcomputer organization and operation, Microprocessor evolution and types, Fundamental knowledge of Microprocessor (8085/8086), Architecture and its operation, Basic idea of logic devices for interfacing 8085/8086.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Computer Organization and Architecture Central Processing Unit, Computer organization, Instruction formats (e.g. Three address, Two address etc), addressing modes, Timing diagram, Interconnection of different units, I/0 to processor and processor to memory communication, Interrupt structures, Multiprogramming, processor features RISC, CISC, cache memory, real and virtual memory.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Data Communication Computer and Communications, Need for communication networks, Internet and World Wide Web, communication protocols, Local Area Networks, Interconnecting networks, Future of Network Technology.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Computer Network Characteristics of communication channels, Allocation of Channels, Physical Communication media, Public Switched Telephone Network, Cellular Communication Path, ATM networks</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
Morris Mano : Computer system Architecture, (PHI) (Eastern Economy Edition)</td><td></td></tr>
</table>

V. Rajaraman : Fundamentals of computers, (Prentice Hall of India) MorriesMano : Computer system architecture, (Estern Economy Edition) B. Ram: Computer fundamental-architecture and organization(New Age International Publishers) TenanBomm : Computer Network Ramesh Gaonkar : Microprocessor, Architecture, programming and application with the 8085 HafizerRehaman: Microprocessor programming and Interfacing Intel 8085 and 8086	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IXwith Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

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<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER III A</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Advanced Electronics-III</td></tr>
<tr><td colspan="4">Course Outcomes:
This course helps the students to gain advanced concepts of power supply regulation, microwave production and microwave generation which has wide applications in modern industry and Research.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Power Supply Regulation
Servomechanism, regulation using OA, Zener reference source, The 723 regulator current regulator, short circuit and over load protection, Precision rectifier,</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">IC regulated power supply.
Three terminal voltage regulations, dual Polarity regulated power supplies using 78 XX and 79 XX series regulators (Basic ideas only). Switched mode power supply (SMPS), Active filter , PLL</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Microwave production
Limitation of convectional electronics devices at UHF, Microwave frequencies, Principle of velocity modulation. Reflex klystron. Theory and uses an of cavity magnetron PIN & GUNN Diode, Detection of microwave measurement of power</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Microwave Communication
Advantages and Disadvantages of Microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on prorogation , Fresnel zone problem, ground reflection, antennas used in microwave communication system</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:

Coughlin: Operational Amplifiers and Linear Integrated Circuits.

Schilling & Belove: Electronic circuits Discrete and Integrated, Mcgraw Hill

Millman &Halkias: Electronic Fundamentals & Applications, Tata</td><td></td></tr>
</table>

Mcgraw Hill Millman &Halkias: Integrated Electronics .R. Botkar: Integrated Circuits, Khanna Publishers V.K. Mithal& Ravi Mittal: Electronic Devices & Circuits, Khanna Publishers Malmstadt &Enke: Electronics for scientists Taub & Schilling: Principal of communication systems • Simon Gayukti: Communication Systems Martin S. Roden: Analog & Digital Communication Systems Ferman: Electronic & Radio Engineering	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER III B
Subject: Physics		
Course code	Course Title: **Astrophysics-III**	
Course Outcomes: This course provides the basic physical mechanisms about the solar activities, which will help to probe the Sun- Earth connection. This study provides the knowledge of Astroseismology, classification of stars and the distribution in Galaxies.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Sun as a star : Solar spectrum, effective temperature, luminosity, photospheric absorption lines, limb darkening; energy source: Kelvin time scale, nuclear fusion; energy transport in the sun, Thomson scattering, mean free path, photon diffusion inside the Sun; photosphere, chromosphere, transition region, corona.	15
UNIT II	Quiet and Active Sun, Sunspots, their formation and magnetic field, Solar flares, Solar filaments/prominences, Coronal mass ejections (CMEs), Solar wind, Different type of solar eruptions models, Coronal heating, Origin of solar cycle.	15
UNIT III	General idea of Heliosesmology, Astroseismology, Description about p-mode and g-mode oscillations, Introduction to variable stars and their locations in H-R diagram. Classifications, Cephieds variables (classic Cephieds and W Virginis stars), RR Lyrae stars, Mira variables, Eruptive variables, Flare stars, Nebular variables, Supernovae, roAP stars	15
UNIT IV	The Milky way and Other Galaxies Distributions of stars in the Milky way, Morphology, Kinematics, Interstellar medium, Galactic center. External galaxies, Types of galaxies: spirals, ellipticals and irregulars, Hubble classification for galaxies, 21cm line, rotation cure, dark matter.	15

Suggested Readings:

Stix: The Sun: An Introduction

K. D. Abhyankar : Astrophysics: Stars and Galaxies

T. Padmanabhan : Galaxies and Cosmology Motz : Astrophysics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER III C</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Hight Energy Physics-III</td></tr>
<tr><td colspan="4">Course Outcomes:
The course would provide the knowledge of advanced concepts of HEP. The students will be able to know the complicated theory of Relativistic propagators, S matrix expansion ans S matrix formulation of QED. It would open doors for the students who want to work in the field of HEP.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Relativistic Propagators Relativistic propagators using quantized formulation of free fields, Properties of quantized scalar fields(Real and complex cases), Algebra of field operators, covariant form of the field operators algebras, (Covariant commutation relations), Meson propagator and its characteristics, Properties of quantized spinor fields, Algebras of spinor field operator, Covariant form of anti-commutation relations, Fermion propagator and its characteristics, properties of quantized EM field, Covariant commutation relations of EM field operators, Photon propagator and its characteristics, EM interaction in terms of radiation field and instantaneous coulomb fields.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Operator Products, Feynman Propagators and S-matrix Expansion Various type of operator products (Normal, Dyson products and Chronological T-products), Wick's theorem, Feynman propagators and its physical interpretation , Interacting fields, S-Matrix formulation as a perturbative series solution of collision processes, Dyson expansion of S-matrix.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">S-matrix Formulation of QED Interaction Hamiltonian in QED, Reduction of S-matrix for the case of QED, Representation and description of various first and second order processes in QED using S-matrix expansion.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Compton scattering, Moller scattering, Bhabha scattering, Electron self energy, Photon self energy, vacuum configuration in QED, Feynman diagrams and Feynman Rules in QED.</td><td>15</td></tr>
</table>

Suggested Readings: Ryder : Quantum Field Theory B.K. Agarwal: Quantum Mechanics and Field Theory F Mandel and G. Shaw: Quantum Field Theory Roman: Quantum Field Theory A. Das: Quantum Field theory M. E. Peskin, D.V. Schroeder: An Introduction to Quantum Field Theory		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester IX with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER III D</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Spectroscopy-III</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course the students would study the various types of lasers, Laser spectroscopy and their applications in science and technology. Knowledge acquired by the course will be of much use for various industries and R&D sector .</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 33</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Molecular Symmetries and Group Theory Symmetry Properties of molecule: symmetry element, symmetry operation and point group, character table, Group theory: representation of a group, reducible and irreducible representations, LCAO coefficient of a polyatomic molecule, Huckel approximation, overlap and resonance integrals, Wheal’s approximation.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Mechanism of Fluorescence Emission and decay mechanism, radiative & nonradiative processes, Jablonski diagram, Kasha rule, Fluorescence lifetime and quantum yield, stoke shift, Mirror image rule, Oscillator strength, Fluorescence polarisation and Anisotropy, Time scale of molecular processes in solution .</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Instrumentation for Fluorescence Spectroscopy Excitation and Emission spectra, An ideal spectrofluorometer Distribution in Excitation & Emission spectra, Light sources, Monochromator,</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Optical filters, Photomultiplier tubes, Photon counting versus Analog detection of Fluorescence Corrected Fluorescence spectra, Measurement of Fluorescence lifetime</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
Barrow G.M: Introduction to Molecular spectroscopy; McgrawHill

Herzberg G: Infrared and Raman Spectra of Polyatomic Molecules;

Von Nostrand Herzberg G: Spectra of Polyatomic Molecules;

on Nostrand J. R. Lackowicz: Principle of Fluorescence</td><td></td></tr>
</table>

Spectroscopy King G: Molecular Spectroscopy King G.W: Spectroscopy and Molecular Structure	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER IV A</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Advanced Electronics-IV</td></tr>
<tr><td colspan="4">Course Outcomes:
This course helps the students to gain basic ideas of the construction and working of electronic devices and circuits. The course includes the study of combinational circuits, sequential circuits and analog computation. The course is of much practical purpose for the students to learn basics of digital electronics. The digital electronics has wide applications in computing, process control, signal processing, communication systems, digital instruments etc.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Analog Computation
Solution of ordinary linear differential equations with constant coefficients, Operation modes of analog computers, repetitive operation of computers, Time scaling, amplitude scaling, Generation of functions, Simulation of time varying systems.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Boolean algebra
Canonical forms of Boolean, functions, Simplification of Boolean functions (K-map, Tabulation method), don't care conditions. Digital logic families Digital to Analog and Analog to Digital converters.;</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Combinational Circuits
Adders & Subtractors, Magnitude comparator, Code converters; Parallel adders, Encoders, Decoders, Multiplexers, Demultiplexers, Parity bit generator and checker, Read only memory (PROM, EPROM), P.L.A.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Sequential Circuits
Sequential logic- Memory element, RS, JK, JKMS, T type and Edge triggered Flip flop; Registers; Shift register; Counters—synchronous and Asynchronous; The memory unit; Semiconductor Random Access Memory; Inter-register transfer; Arithmetic; Logic and Shift Micro-operation; Fixed point and floatation point data.</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
Morris Mano: Digital Logic & Computer Design

Rajaraman: Introduction to Digital Computer design

Malvino& Leech Sloan: Computer Hardware & Organization</td><td></td></tr>
</table>

V. Rajaraman: Analog Computation & Simulation Integrated Circuits. Schilling & Belove: Electronic circuits Discrete and Integrated, Mcgraw Hill Millman &Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Hill Millman &Halkias: Integrated Electronics K.R. Botkar: Integrated Circuits, Khanna Publishers G.K. Mithal& Ravi Mittal: Electronic Devices & Circuits, Khanna Publisher	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="3">MASTER IN PHYSICS</th></tr>
<tr><td>Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER IV B</td></tr>
<tr><td colspan="3">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="2">Course Title: Astrophysics-IV</td></tr>
<tr><td colspan="3">Course Outcomes:
This course will provide the basic properties of stars, birth and the evolution of stars. In addition of this, it provides the deep understanding about the star clusters and their properties, e.g. luminosity and mass function, mass-luminosity relations etc.</td></tr>
<tr><td colspan="2">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="3">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
</table>

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Basic Properties of Stars: Mass, radius, distance, luminosity, temperature, magnitude system, Wien-displacement colour indices, filters, H-R diagram, classification of stellar spectra, luminosity classification, stellar motion, stellar populations	15
UNIT II	Star Formation and Stellar Evolution: Birth of stars, protostar, Pre-main sequence evolution: Jeans instability, star formation, Hayashi track, Zero age main sequence (ZAMS), Post-main sequence evolution: Core He burning, shell burning, red giant phase, planetary nebulae, white dwarf physics, electron degeneracy pressure, energy generation in stars – gravitational contraction, pp chain, CNO cycle and triple alpha process, stellar life, cycles-Premain sequence, main sequence, giants.	15
UNIT III	Star Cluster and their Properties : Open clusters, globular clusters and the galaxy itself are examples of 'stellar systems'; crossing time; mean potential and total potential energy in a constant density sphere; equation of motion of N-body stellar system; total momentum, angular momentum and energy as constants of motion, stellar population, population I and II type objects, inter-stellar extension, reddening determination from color color diagram, age and distance determination of star clusters, luminosity function, mass function, mass segregation, mass-luminosity relation.	15
UNIT IV	Cosmological Models: Universe at large scales – Homogeneity and isotropy – distance ladder – Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble's law - Robertson-Walker metric - Observable quantities – luminosity and angular diameter distances - Horizon distance- Dynamics of Friedman- Robertson-Walker models: Friedmann equations.	15

Suggested Readings: Abhyankar K.D. : Astrophysics, Galaxies and Stars Vaidyanth Basu : An Introduction to Astrophysics Motz : Astrophysics T. Padmanabhan : Stars and Stellar Systems L Kutner: Astronomy: A Physical Perspective	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER IV C
Subject: Physics		
Course code	Course Title: **High Energy Physics-IV**	
Course Outcomes: The course would provide the knowledge of some more advanced concepts of HEP. The students will also be able to know the detailed theory of weak interactions, electromagnetic interactions and strong interaction.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Theory of Weak Interactions Classification of weak interaction in terms of Leptonic, Semi-leptonic and Non-Leptonic weak Decays, Current-Current Interaction and VA theory, Intermediate Vector Boson (IVB) concept, Conservation of Vector Current (CVC) Hypothesis, Two Component Theory of Neutrino, W and Z bosons as weak gauge bosons.	15
UNIT II	Theory of Electromagnetic Interactions Electron Positron Annihilation into Hadrons, Electron- Nucleon Scattering, Rutherford and Mott scattering, Electromagnetic form factors of Hadrons, Structure of nucleons, Elementary Idea of Unification of Fundamental Interactions with reference to standard model of electro weak unification.	15
UNIT III	Strong Interactions Paradoxes of Naive Quark Model, Need of color quantum Number for Quarks, Color SU(3) and Gluons, Quantum Chromodynamics, Pion-Nucleon Scattering,	15
UNIT IV	Spin Classification of Hadrons and Regge Trajectories, Asymptotic freedom and Perturbative QCD, Experimental indication for quarks and gluons, String model of hadrons and confinement of Quarks.	15
Suggested Readings: E Close : Quarks and Patrons I.J. Aitchison and A.J. Hey : Gauge theories in Particle Physics F. Haltzin& A.D. Martin : Quarks and Leptons D.H. Perkins : Introduction of High Energy Physics, Cambridge University Press 2000		

P.Cheng and G.LF Li : Gauge Field Theory ED Commins : Weak Interactions D.C. Cheng and O Neil : Elementary Particle Physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisites **Passed Semester IX with Physics as major**	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER IV D
Subject: Physics		
Course code	Course Title: **Spectroscopy-IV**	
Course Outcomes: In this course the students would study the various types of lasers, Laser spectroscopy and their applications in science and technology. Knowledge acquired by the course will be of much use for various industries and R&D sector .		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Ultrashort Pulses and Dynamics of Laser Processes Production of giant pulse, Q-switching by different types of shutters, giant pulse dynamics, laser amplifiers, mode locking, mode pulling, ultra shot pulses, hole burning, holography	15
UNIT II	Non-Linear Optics Harmonic generation, phase matching, second harmonic generation, third harmonic generation, optical mixing, parametric generation of light, self focusing of light.	15
UNIT III	Multi Photon Processes Multi quantum photoelectric effect, two photon processes, frequency up-conversion.	15
UNIT IV	Stimulated Raman effect, coherent stokes & anti-stokes Raman scattering, photo acoustic spectroscopy	15
Suggested Readings: D. Levenson: Introduction to non-linear laser spectroscopy B.Laud: Laser and non-linear optics velto: Lasers Demtroder: Laser Spectroscopy		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Passed Semester IX with Physics as major**		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology,		

https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PRACTICAL</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: PRACTICAL</td></tr>
<tr><td colspan="4">Course Outcomes:
The student will have adequate knowledge to perform the experiments of different fields of physics with clear understanding of the theory behind the experiment.
Student will know about advanced experiments based on their specialization paper.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">List of Experiments: (a) Advanced Electronics
1. Study of regulated power supply (723).
2. Study of operational amplifier (741).
3. Study of Timer (555). 4. A to D and D to A converter
5. 1 of 16 Decoder/Encoder
6. Study of Multiplexer/Demultiplexer
7. Study of Logic gates (Different types)
8. Study of Comparator and Decoder
9. Study of amplitude and frequency modulations and demodulations.
10. Study of different flip- flop circuits (RS, JK, Dk type, T-type, Master slave).
11. Study of Digital combinational and sequential circuits
12. Study of Microprocessor (8085) 13. Study of SCR, DIAC, TRIAC
14. Study of IC- Based Power supply
15. Microwave experiment.
16. Shift Registers
17. Fiber Optics communication</td><td>60</td></tr>
<tr><td></td><td colspan="2">List of Experiments: (b) Astrophysics
1. Study of Hubble's law (from given data)
2. Study of constant density neutron star
3. Study of the static parameters of a Neutron Star model with inverse square density distribution
4. Study of star cluster from a given data
5. Study of Extinction coefficients</td><td>60</td></tr>
</table>

	6. Study of variability of stars	
	List of Experiments: (c) High Energy Physics 1. Characteristic curve of a GM Detector and verification of inverse square law . 2. Characteristic curve of a GM Detector and Absorption coefficient of a using aluminum GM Detector. 3. Energy spectrum of gamma rays using gamma ray spectrometer. 4. Absorption coefficient of aluminum using gama-ray spectrometer. 5. Characteristics of Scintillation Detector. 6. Study of gama-gama unperturbed angular correlations. 7. Study of particle tracks using a Nuclear Emulsion Detector. 8. Classification of tracks in interaction with Nuclear Emulsion and determination of excitation energy.	60
	List of Experiments: (b) Spectroscopy 1. Study of the vibrational levels of Iodine. 2. Measurement of the fluorescence spectra of Uranyl Nitrate Hexahydrate. 3. Determination of the intrinsic life time for a dye molecule. 4. Determination of change in dipole moment in excited state using Solvatochromic shift method. 5. Measurement of non radiative decay rate for a known sample. 6. Determination of the quantum yield of known samples using steady state spectroscopy.	60
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisites **Bachelor in Science with Physics as major subject**		
Suggested Equivalent Online Courses: 1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities		

NATIONAL EDUCATION POLICY-2020

Common Minimum Syllabus for all
Uttarakhand State Universities and Colleges for
Five Years of Higher Education

PROPOSED STRUCTURE OF
<u>UG & PG - ZOOLOGY</u>
SYLLABUS

2021

Curriculum Design Committee, Uttarakhand

Sr.No.	Name & Designation	
1.	Prof. N.K. Joshi Vice-Chancellor , Kumaun University Nainital	Chairman
2.	Prof. O.P.S. Negi Vice-Chancellor , Uttarakhand Open University	Member
3.	Prof. P. P. Dhyani Vice-Chancellor , Sri Dev Suman Uttarakhand University	Member
4.	Prof. N.S. Bhandari Vice-Chancellor, Soban Singh Jeena University Almora	Member
5.	Prof. Surekha Dangwal Vice-Chancellor, Doon University, Dehradun	Member
6.	Prof. M.S.M. Rawat Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member
7.	Prof. K. D. Purohit Advisor, Rashtriya Uchchatar Shiksha Abhiyan, Uttarakhand	Member

Syllabus Expert Committee

S. N.	Name	Designation	Department	Affiliation
1.	Prof H.C. S Bisht	Head & Convener	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
2.	Prof Ila Bisht	Head & Convener	Department of Zoology	S.S.J Campus, S.S.J University, Nainital
3.	Dr. Ahmad Pervez (Online)	Assistant Professor	Department of Zoology	S.S.D.U Rishikesh
4.	Dr. Manoj Kumar Arya	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
5.	Dr. Divya Pangtiy	Assistant Professor (Guest)	Department of Zoology	D.S.B Campus, Kumaun University, Nainital

Syllabus Preparation Committee

S.N.	Name	Designation	Department	Affiliation
1.	Prof H.C. S Bisht	Head & Convener	Department of Zoology	D.S.B Campus, Kumaun University, Nainital
2.	Prof Ila Bisht	Head & Convener	Department of Zoology	S.S.J Campus, S.S.J University, Nainital
3.	Dr. Ahmad Pervez (Online)	Assistant Professor	Department of Zoology	S.S.D.U Rishikesh
4.	Dr. Manoj Kumar Arya	Assistant Professor	Department of Zoology	D.S.B Campus, Kumaun University, Nainital

YEAR	SEMESTER	PAPER CODE	PAPERTITLE	CREDITS TH+PR
Certificate course in Clinical Diagnostics & Biochemistry				
1	I	ZOO101T	Animal Physiology and Biochemistry	4+2
	II	ZOO201T	Genetics and Cell Biology	4+2
	I &II	Minor Elective	Environmental science and Basic concepts of Ecology	4+2
Diploma in Molecular Sciences & Clinical Microbiology				
2	III	ZOO301T	Molecular Biology, Toxicology & Histology	4+2
	IV	ZOO401T	Microbiology and Animal Behaviour	4+2
	III & IV	Minor Elective	Bio-Instrumentation, Bioinformatics and Biostatistics	4+2
Degree in Bachelor of Zoology				
3	V	ZOO501T	Non-Chordate	4+1
		ZOO503T	Chordate	4+1
		Industrial Training/Survey/ Research Project	It is based on Major Papers of Semester-V	04
	VI	ZOO601T	Developmental Biology of Vertebrates	4+1
		ZOO603T	Basic mammalian Endocrinology	4+1
		Industrial Training/Survey/ Research Project	With reference to Major Papers of Semester-VI	04
Bachelor (Research) in Faculty				
4	VII	PAPER- I	Fundamentals of Immunology	4+1
		PAPER- II	Applied Immunology	4+1
		PAPER- III	Animal Ecology	4+1
		PAPER- IV	Medical Laboratory Techniques	4+1
		Industrial Training/ Survey/Research Project	With reference to Major Papers of Semester-VII	04
	VIII	PAPER- I	General Ichthyology	4+1
		PAPER- II	Applied Ichthyology	4+1
		PAPER- III	Basic Limnology	4+1
		PAPER- IV	Animal Ecology	4+1
		Industrial Training/Survey/ Research Project	With reference to Major Papers of Semester-VIII	04
	VII or VIII	Minor Elective	Chronobiology or Applied Zoology or General Biotechnology	4+1

<table>
<tr><th colspan="5">Master in Faculty (Zoology)</th></tr>
<tr><td rowspan="10">5</td><td rowspan="5">IX</td><td>PAPER- I</td><td>Systematics And Applied Entomology</td><td>4+1</td></tr>
<tr><td>PAPER- II</td><td>Biology Of Insects (Morphology, Physiology & Development)</td><td>4+1</td></tr>
<tr><td>PAPER- III</td><td>Economic Zoology And Vermicology</td><td>4+1</td></tr>
<tr><td>PAPER- IV</td><td>Wildlife Conservation</td><td>4+1</td></tr>
<tr><td>Industrial Training/Survey/ Research Project</td><td>With reference to Major Papers of Semester-IX</td><td>04</td></tr>
<tr><td rowspan="5">X</td><td>PAPER- I</td><td>Animal Biotechnology</td><td>4+1</td></tr>
<tr><td>PAPER- II</td><td>(Animal Cell Culture)+</td><td>4+1</td></tr>
<tr><td>PAPER- III</td><td>Animal Biotechnology
(Transgenics, Cloning And IPR)</td><td>4+1</td></tr>
<tr><td>PAPER- IV</td><td>Medical Laboratory Techniques Wildlife Conservation</td><td>4+1</td></tr>
<tr><td>Industrial Training/Survey/ Research Project</td><td>With reference to Major Papers of Semester-X</td><td>04</td></tr>
</table>

Course Objective (CO):

- The programme in Zoology aims to equip students with recent advances in Zoology from organismic to reductionist biology.
- It also aims to empower students to understand the challenges of society and the country that falls into the realms of Zoology, such as Aquaculture, Reproductive health, Behavior and Biological time keeping, Cancer Biology, Microbiome and their roles in health and diseases, Bioremediation of pollutants and pesticides, etc.
- It also offers students to a series of elective courses so that they can choose to specialize in the specific area of their interests in Zoology.
- The open elective has been chosen to attract students from diverse interdisciplinary areas of sciences, such as Anthropology, Environmental studies, Biomedical Sciences, etc.
- This course is designed to ignite the inquisitive mind to enter in to research in interdisciplinary areas. The fourth semester offers a total of 16 elective courses, which for logistics of programme management, are divided in to four streams, where a student has to choose a stream.
- In the entire course, the major emphasis is on skill-based training into socially relevant areas of Zoology.
- It is expected that a student after successfully completing the programme would sufficiently be skilled and empowered to solve the problems in the realms of Zoology and its allied areas.
- They would have plethora of job opportunities in the education, environment, agriculture-based, and health related sectors.
- The bright and ignited mind may enter into research in the contemporary areas of Zoological/Biological Sciences.
- The broad skills and the deeper knowledge in the field would make them highly successful and excellent researcher in advanced areas of research in the Biological sciences.

Programme Objective (POs):

PO 1	It will enhance the basic knowledge about the different systems of an organism and the clinical study of biomolecules.
PO 2	It will help students to pursue the initial fundamentals required for future projects and higher studies.
PO 3	It will help to inculcate the evolutionary basis of various animals and their development. It will also address the present situation of animal diversity.
PO 4	It will help students to identify the concepts about various Applied sciences and Medical laboratory techniques related to concerned area.
PO 5	It will help to develop the knowledge on taxonomy of insects. Also, the conservation of wild animals to enhance the economy gained by the zoological content present in the environment.
PO 6	All the above POs will lead to a mind that can develop modern technologies to address the problems and to give solution to it.

Programme Specific Objective (PSO):

CERTIFICATE COURSE IN CLINICAL DIAGNOSTICS & BIOCHEMISTRY	
YEAR 1	This will helps students to generate employment in the field of clinical & medical lab/institutions/gene bank/stem cell culture/Pharma companies etc.
DIPLOMA IN MOLECULAR SCIENCES & CLINICAL MICROBIOLOGY	
YEAR 2	This will help students to develop the scientific ability in the field of toxicological, Histological, Microbiological, Molecular labs, various Zoological Parks, National Parks, Wildlife Sanctuaries.
BACHELOR OF SCIENCE (ZOOLOGY)	
YEAR 3	This will help students to develop the basis of Animal diversity and its development, which can generate various academic/Research jobs and various other jobs in the field of In-vitro labs, case study of endocrinology in medical labs etc.

BACHELOR (RESEARCH) IN FACULTY	
YEAR 4	It will help students to pursue career in various health related departments and medical laboratories. It is beneficial for students as they can work in different Chrono-centre as per demands for biological clock management to travel across continents (both public and private sector).
MASTER IN FACULTY (ZOOLOGY)	
YEAR 5	It will help students to improvise the Agro-Pest relationship, forensic Entomology & its implication it help to conserve the environment & Ecology. Also at the same time students will be equipped to explore jobs in Zoological Research i.e. CTB, CSB, ZSI, WII etc.

Syllabus

First Year

Semester- I

Animal Physiology and Biochemistry (4+2 Credits) = 6 Credits

Animal Physiology

Nutrition: Food constituents, intracellular and extracellular digestion, Digestion and absorption of carbohydrate, fat and protein.

Respiration: Pulmonary ventilation, respiratory pigments, gaseous transport and control of respiration. With reference to dissociation of oxyhaemoglobin.

Excretion: Concept of ammonotelic, ureotelic and guanotelic animals, urine formation in mammals.

Blood vascular system: Haemopoiesis, composition and functions of blood, blood coagulation. A brief account of immunity. Types of heart, origin and conduction of heart beat. Cardiac Cycle

Nervous system: Types of Neurons Resting and action potential of nerves, synapse and transmission of nerve impulse. Neurotransmitter

Muscular system: Types of Muscles molecular and chemical basic of Muscle contraction and its Mechanism. A brief idea of tetanus and fatigue.

Biochemistry

Introduction to biological molecules: Proteins, Amino acids, Carbohydrates and Lipids- their structure, classification and significance. Metabolism of Carbohydrates. Enzymes and Vitamins.

(glycolyisis, Krebs cycle, gluconeogenesis , glyscogenesis glyogenolysis)

Mechanism of Enzyme Action, Kinetics , Inhibition & Regulation Vitamins, Types & source, deficiencies.

Practical

Suggested books:

1. Ganong: Review of Medical Physiology, Lang Medical Publ.
2. Guyton and Hall; Textbook of Medical Physiology WB Saunders.
3. Keel et al: Sampson Wright's Applied Physiology, Oxford Press.
4. C.C. Chatterjee: Human Physiology.
5. Nielson: Animal Physiology, Cambridge.
6. Jain A.K.: Textbook of Physiology, Avical Publishing Company.
7. Conn And Stumpf: Outlines of Biochemistry, John Wiley.

8. Pandey B.N: Zoology Series- Biochemistry, Physiology, Endocrinology, Tata McGraw Hill Edu Pvt Ltd, New Delhi.

Semester- II

Genetics and Cell Biology (4+2 Credits) = 6 Credits

Genetics

Mendel's life, Pre-Mendelian experiments, symbols and terminologies, Laws of dominance, segregation and independent assortment.

Linkage: Coupling and repulsion hypothesis, Morgan's view of linkage, kinds of linkage, chromosome theory of linkage.

Crossing over: Somatic and germinal crossing over, kinds of crossing over, theories of the mechanism of crossing over, significance.

Eukaryotic chromosomes- Structure, chemical composition, classification and uninemic and multinemic concept of chromosome structure.

Structure and functions of polytene and lampbrush chromosomes.

Determination of sex: chromosome mechanism, Genic balance theory, External environment and sex determination.

Sex linked inheritance: Inheritance of X-linked gene (Colour blindness and haemophilia in man), Sex linkage in Drosophila.

Mutation: Historical background, chromosomal mutation (Chromosomal aberrations), gene mutations and their interpretation.

Cell Biology

Prokaryotic and Eukaryotic cells; Ultrastructure of eukaryotic cell; Plasma membrane (Ultrastructure, chemical composition , models of plasma membrane; Specialisations of plasma membrane , functions of plasma membrane).

Structure and functions of following cell organelles: (a) Mitochondria (b) Ribosomes (c) Lysosomes (d) Centrioles (e) Golgi Complex (f) Endoplasmic reticulum. Structure and functions of Nucleus and nucleolus.

Cell division – (a) Cell cycle (b) Mitosis (Process of mitosis, mitotic poisons and significance of mitosis), (c) Meiosis (Process of meiosis, structure and functions of synaptonemal complex, significance of meiosis). An idea of cell transformation and cancer.

Practical

Suggested books:

1. Strickberger: Genetics, Prentice hall.

2. Principles of Genetics, Snustad and Simmons,John Wiley & Sons, USA.
3. Modern Genetics Anaysis: Integrating Genes and Genomes, Griffith, J.F., Gelbart, M., Lewontin, C and Miller, W.H. Freeman and Company, New York, USA.
4. Genetics, J Russell, Benjamin- Cummings Publishing Company, San Francisco, California, USA.
5. Lodish-el al, Molecular Biology
6. P.K. GUPTA, Cell Biology and Genetics.

Minor/Elective

Environmental science and Basic Concepts of Ecology

(4 CREDIT)

Environmental science

1. Introduction of environmental Science: Definition, principles and scope of environmental science, structure and composition of atmosphere, hydrosphere, lithosphere and biosphere.

2. Ecosystems: definition, structure and function of ecosystem, energy flow in an ecosystem, food chain, food web and ecological, case studies of the following ecosystem: forest ecosystem, grassland ecosystem, desert ecosystem and aquatic ecosystem.

3. Natural resources: Renewable and Non-renewable resources: land resources and land use change, land degradation soil erosion and desertification. Deforestation: causes and impacts due to mining, dam building on environment, of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources: Renewable and non-renewable energy sources, growing energy needs case studies.

4. Biodiversity and conservation: Level of biodiversity- genetic, species and ecosystem diversity, Bio geographic zones of India, biodiversity patterns and global biodiversity hot-sports. India as a mega-biodiversity nation, endangered and endemic species of India. Threats to biodiversity - Habitat loss, poaching of wildlife, man-wildlife conflict, biological invasions, conservation of biodiversity-in-situ ex-situ conservation of biodiversity.

5. Environmental Pollution: Types, causes, effects and controls, air, water, soil and noise pollution. Nuclear hazards and human health risks. Solid waste management-Control measures of urban and industrial waste. Pollution case studies.

6. Environmental Policies & Practices: Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture. Environmental laws-Environmental Protection Act- Air (Prevention & Control of Pollution) Act. Water (Prevention & Control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, International agreements-Montreal and Kyoto protocols and Conservation of Biological Diversity (CBD).

Basic Concepts of Ecology

Definition of ecology and its relation to humanity.

The environment: Abiotic factors, biotic factors, edaphic factors.

Concept of ecosystem with reference to pond, Grassland, Forest & River ecosystem. Energy flow in ecosystem. Pyramids of number, biomass and energy. Food chain- grazing and detritus, Food web and trophic levels. Biosphere: Hydrosphere, Lithosphere and Atmosphere. Biogeochemical cycles: Carbon and Nitrogen cycles.

Population: Definition and characteristics: density, natality, mortality, migration, emigration and immigration, growth and growth-curves. Dispersion and aggregation. Negative and positive interactions including commensalism, mutualism, predation, competition and parasitism.

Practical

Suggested books:

1. Odum, E.P: Fundamental of Ecology, Saunders Co. Publ. Indian Ed.
2. Chapman & Reiss: Ecology.
3. Smith, R.L: Ecology & Field Biology.
4. Singh & Kumar: Ecology and Environmental Science, Vishal Publ.
5. Odum, E.P: Fundamental of Ecology, Saunders Co. Publ. Indian Ed.
6. Ecology and Environment by P.D. Sharma.

Second Year

Semester- III

Molecular Biology, Toxicology & Histology

(4+2 Credits) = 6 Credits

Molecular Biology

Nucleic acids (DNA & RNA): DNA chemistry, nucleosides, nucleotides, polynucleotide chain, Watson and Crick DNA double helix model, identification of genetic material (DNA- as genetic material). RNA-chemistry, genetic and non-genetic RNAs. Clare leaf model of RNA Elementary knowledge of genetic code. Expression of gene-protein synthesis.

Lac operon concept. Mechanism of DNA damage & repair

Toxicology

Introduction and brief history of toxicology: General principles of toxicology, Brief history, Environmental toxicology (kinds and sources of toxic agents- animal toxins, plant toxins, pesticides, metals and food additives).

Dose response relationship: Frequency and cumulative responses, determination of TLm values, Lc_{50}, margin of safety, threshold limits.

Histology

Histology: Structure of epithelium, connective tissue, cartilage, bone, smooth,, striped and cardiac muscles, and nervous tissue as studied under light microscope.

Histological structure of gonads, liver, lung, pancreas and kidney in mammals.

Practical

Suggested books:

1. Molecular Cell Biology, Lodish et al., W.H. Freeman and Company, New York, USA.
2. Molecular Biology of the Cell, Alberts et al., Garland Science, Taylor and Francis Group, New York, USA.
3. De- Robertis- Cell and Molecular Biology.
4. Verma, P.S. and Agrawal, V.K. Molecular Biology
5. Tortora- Microbiology and Introduction.
6. Parija- Textbook of Microbiology.
7. Pelczar: Microbiology, Tata McGraw Hill.
8. Davis: Microbiology Harper & Row, Publ. Inc.
9. Textbook of Toxicology By Balram Pani.
10. "Casarett & Doull's Essentials of Toxicology", 2nd Ed. Edited by Curtis A. Klaassen & John B. Watkins III, published by McGraw Hill-Lange
11. "Handbook of Toxicology", M.J.Derelanko & C.S.Auletta, 3rd Ed. CRC Press
12. Principles of Biochemical Toxicology" by J.A.Timbrell

Semester- IV

Microbiology and Animal Behaviour (4+2 Credits) = 6 Credits

Microbiology

Introduction to microbiology: kinds of microbes, Typical structure of a bacterium, Gram positive and Gram negative bacteria and virus. With reference to (COVID)

Microbes of medical importance: Bacteriophages, Mycobacterium, Rickettsia, Actinomycetes and Mycoplasma.

A brief knowledge of AIDS.

Environmental use of microorganisms: Nutrient cycle, Metal recovery, petroleum recovery, pest control, waste water treatment and Bioremediation.

Industrial microbiology- Food production, dairy products, fermented food, alcoholic beverages, microbial spoilage, food preservation. A brief knowledge of Antibiotics.

Animal Behaviour

Patterns of behaviour: Stereotype innate behaviour: Kinases, Taxes and Reflexes. Concepts of (i) Fixed action patterns (ii) Sign or key stimulus or releasers and (iii) Innate releasing mechanism, Instinctive behaviour. Learned behaviour: Habituation, Conditioned reflexes, Selective learning , Insight learning, Imprinting, Song learning in birds. Hormonal control of Behaviour

Communication: Chemical, Visual, Auditory, Electric and tactile, Dance language of honey bees, Biological clocks. Bird migration with particular reference to the mechanisms of navigation. Introduction to Socio-biology: Social structure in primates

Practical

Suggested books:

1. Mechanism of Animal Behaviour Peter Marlar & J. Hamilton.
2. Animal Behaviour by David McFarland.
3. Animal Behaviour John Alcock.
4. Pelczar Microbiology
5. Davies Microbiology

Minor/Elective **BioInstrumentation, Bio Informatics and Biostatistics**

(4+2 Credits)

BioInstrumentation

Principles and Techniques of Microscopy; Magnification and Resolution Parameters of Light, Fluorescent Phase Contrast Scanning, Transmission Electron Microscopy, Tunneling Microscopy and Inverted Microscope, Micrometry, Colony Counting and Microtomy. Laboratory Safety Guidelines.

Centrifugation – Basic Principles of Sedimentation, Types of Centrifuges, Ultracentrifugation, Differential and Rate Zonal Separations, Organellar Separation and Flow Cytometry.

Principle & Applications of Ph Meter, Spectroscopy UV- Vis, Mass Spectrometry (MS) and X-Ray Crystallography.

Chromatographic Techniques, Paper Chromatography, Partition Chromatography, Column Chromatography, Thin Layer Chromatography, Gas Chromatography, Ion Exchange, Affinity Chromatography and Introduction to HPLC,

Electrophoresis: Capillary, Agarose, SDS & Native PAGE, Pulse Field, Immuno-Electrophoresis and Paper Electrophoresis.

PCR & Thermal Cyclers, Nucleic Acid Hybridization: Southern & Northern Blotting, Western Blotting, Autoradiography. ELISA and RIA.

Bio Informatics

Introduction to Computers, Computer Fundamentals (Hardware & Software), Input, Output Devices and Storage Devices, Web Browsers, Search Engines, Flow Charts, Methods and Types of Networks, Intra and Internet, Introduction to MS-Office.

Introduction to Bioinformatics, Scope and Application of Bioinformatics, NCBI Data Model, DNA and Protein Sequence Database, Motif Analysis, Structural Database, Structural Viewers (Rasmol, Rastop, Cn3D, CSHF Chimera, Swiss PDB Viewer, Pymol), Sequence Submission to Database, Literature Database (Pubmed, Biomed Central, Medline), Internet and Biologist. Online Study *E. coli, D. melanogaster*, Human Genome, Mice Genome. DNA Chips and their Replications.

Biostatistics

Introduction to Biostatistics, Terminology and Symbols, Research and Types of Research, Applications of Statistics in Biological Research, Data, Collection and Representation of Data (Pie Chart, Bar Diagram, Histogram, Frequency Polygon and Gantt Chart), Measures of Central Tendency (Mean, Median, Mode), Variance, Coefficient of Variation, Standard Deviation, Standard Error of Mean, Analysis of Variation (ANOVA), One Way ANOVA and Two Way ANOVA. Measures of Dispersion, Distribution Patterns (Binomial, Poisson & Normal), Tests of Significance ('T' Test, 'F' Test & Chi-Square Test), Probability, Correlation and Regression Analysis, Introduction to Statistical Software and Handling (SPSS And Excel Data Sheets).

Practical

Suggested books:

1. Introduction to Biostatistics by Dr. Pranab Kr. Banarjee.
2. Bioinstrumentation by L. Veerakumari
3. Bioinformatics: Sequence And Genome Analysis by David W. Mount.
4. Basic Bioinformatics by S. Ignacimuthu Published by Narosa Publishing House New Delhi.

Third Year

Semester- V

Non-Chordate– (4+2 Credits) = 6 Credits

Salient features and outline classification (up to orders) of various Non-chordate Phyla and related type study and topics as covered under respective Phyla.
Protozoa*: Paramecium* with particular reference to locomotion, nutrition, osmoregulation and reproduction.

Porifera: *Sycon* with reference to structure, reproduction and development. Canal system, and affinities of Porifera.

Coelenterata*: Aurelia* with reference to structure, reproduction and development. Polymorphism in Coelenterata. A brief account of Corals and Coral reefs.

Helminthes: Taxonomy, morphology (including adaptations), life cycle, pathogenicity and control measures of *Fasiola.* Parasitic adaptations in Helminthes.

Annelida*: Nereis*- External features, excretory organs and reproduction. Metamerism in Annelida, its origin and significance. Trochophore larva and its significance. Parasitic adaptations in Hirudinaria.

Arthropoda**:***Palaemon*- External features and reproduction. *Peripatus*- Its distribution and Zoological importance.

Mollusca: *Pila*- External features, Organs of Pallial complex. Reproduction. A brief account of torsion in Gastropoda.

Echinodermata: *Asterias*- External features. Water vascular system. Mode of feeding and reproduction.

Chordate– (4+2 Credits) = 6 Credits

Salient features and outline classification (up to order) of various chordate groups as covered under respective taxonomic groups.

Protochordata: Salient features of body organisation and systematic position of *Balanoglossus* and *Amphioxus* as a type and its affinities. Agnatha**:** External features of *Petromyzon*.

Pisces: Scales and fins in fishes. Parental care in fishes. Fishes in relation to man.

Amphibia: General characters and affinities of Gymnophiona . Parental care in Amphibia.

Reptilia A brief knowledge of extinct reptiles. Poisonous and non- poisonous snakes. Poison apparatus of snake. Snake venom and anti-venom. Adaptive radiation in reptiles. Adaptations of reptiles to desert life.

Aves: Flightless birds and their distribution. Flight adaptations in birds.

Mammalia: General organisation, distribution and affinities of Prototheria. Economic importance. Adaptive radiation with particular reference to aquatic mammals.

Practical

Suggested books:

1. Barnes: Invertebrate Zoology (4^{th} ed.), Holt- Saunders, 1980.
2. Hickman, Roberts & Hickman: Integrated principles of Zoology (7^{th}) ed Times- mirror, Mosby
3. Kotpal R.L: Modern Textbook Of Zoology : Invertebrates. Rastogi
4. Nigam: Biology of Non-Chordates, Nagin Chand.
5. Parker TJ & haswell WA: Textbook of zoology Vol I & II, Mcmillan.
6. Hyman L: Invertebrate Series, Academic Press

Semester- VI

Developmental Biology of Vertebrates (4+2 Credits) = 6 Credits

Gametogenesis: Spermatogenesis and Oogenesis including structure, differentiation and longevity of gametes. Chemical and metabolic events during gamete formation. Types of eggs.

Fertilization: Significance of fertilization, approximation of gametes, Capacitation, Acrosome reaction, formation of fertilization membrane, egg activation, Blockage to polyspermy.

Cleavage: Patterns, control of cleavage patterns, chemical changes during cleavage, totipotency. Blastulation and Gastrulation: A complete study in frog and chick.

Fate maps, their formation and significance.

Foetal membranes: Their formation and functions in chick.

Retrogressive metamorphosis: As exhibited by an ascidian.

Regeneration: Morphallaxis and Epimorphosis, Blastema and its significance, mechanisms as exhibited by invertebrates *(Hydra* and *Planaria*) and Vertebrates (Limb regeneration in Amphibia).

Placentation in mammals.

Embryonic Induction: Origin, structure and significance of primary organizer.

Practical

Suggested books:

1. Gilbert: Development Biology Sinauers Ass. Publ. Massachusetts.
2. Wolpert: Analysis of Biological development, Oxford.
3. Kolthoff, Analysis of Biological development, McGraw- Hill Science, New Delhi, India.
4. Balinsky: Introduction to Embryology Saunders co. Philadelphia and London.
5. Berill: Development Biology Tata McGraw Hill.

General Endocrinology (4+2Credits) = 6 Credits

Endocrine system: A brief knowledge of the structure and hormonal functions of the glands namely, Pituitary, Thyroid, Pancreas, Adrenal, Testis and Ovary. Elementary knowledge of the Dwarfism, gigantism, acromegaly, diabetes insipidus , Goitre, Cretinism, Myxoedema, Diabetes mellitus and Addison's disease.

Fourth Year

Semester- VII

Fundamentals of Immunology (4+1Credits) = 5 Credits

Unit - I

Introduction and Historical Background: Cells and Organs of Immune System

- Definition, Overview of Immune System- Anatomical, Physiological and Inflammatory Barriers. Major Contribution of Following Scientists- Edward Jenner, Jacob Henle, Louis Pasteur, Joseph Lister, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Emil Von Behring, Jules Bordet, Karl Landsteiner, Jules Freund, Peter Gorer And George Snell, Tiselius & Kabat, Gerald Eldelman & Rodeny Porter, Cesar Milstein & Georges Kohler, Peter Doherty & Rolf Zinkernagel
- Hematopoiesis – Formation of B-Lymphocytes and T-Lymphocytes and Its Regulation. Cells of The Immune System- NK Cells, B-Lymphocytes, T-Lymphocytes, Granulocytic Cells, Dendritic Cells Primary Lymphoid Organs and their Functional Role- Bone Marrow and Thymus. Secondary Lymphoid Organs and Its Functional Role- Lymph Nodes, Spleen, Mucosal-Associated Lymphoid Tissue [MALT], Intraepithelial Lymphocytes [IEL], Cutaneous-Associated Lymphoid Tissue [CALT]

Unit - II

Antigen and Immunogen, Structure and Function of Immunoglobulins, Structure and Function of MHC:

Antigen- Definition and Its Properties. Immunogen-Definition and Its Properties. Antigenecity Vs. Immunogenicity and Factors Affecting It. Haptens and Adjuvants. Basic Structure of Immunoglobulin. Classes of Immunoglobulin and Its Biological Activities. Major Histocompatibility Complex [MHC] - Structure, Types and Function. Regulation of

MHC Expression. Production of Monoclonal Antibodies, Its Mechanism [De Novo and Salvage Pathway] and Application in Research and Health.

Unit - III

Primary And Secondary Line Of Defence [Innate And Acquired Immunity], Antigen-Antibody Interactions:

Innate Immunity- Phagocytic Barriers. Antigen Presenting Cells. Antigen Processing and Presentation. Acquired Immunity- B-Cell Mediated Immunity, T-Cell Mediated Immunity Its Mechanism and Regulation. Immune Memory of B-Lymphocytes.

Structure of Antibody, Treatment of Antibody with Pepsin, Papain, B-Mercaptoethanol and DMSO. Interaction of Antigen-Antibody- Antibody Affinity, Antibody Avidity, Cross Reactivity, Precipitation Reactions and Agglutination Reactions.

Unit - IV

Immune Effector Mechanism, Allergy And Hypersensitivity:

Cytokines- Properties and Its Receptors. Cytokine Secretion by Th1, Th2 And Th17 Subsets And Its Function. The Complement System: Its Components, Functions, Activation and Regulation. Complement Deficiencies.

Allergy and Hypersensitivity: Gell and Coombs Classification, IgE Mediated [Type I] Antibody-Mediated Cytotoxicity [Type II], Immune Complex-Mediated [Type III] and T_{DTH}-Mediated [Type IV] Hypersensitivity.

Paper II Applied Immunology (4+1Credits) = 5 Credits

Unit - I

Immune Response to Infectious Diseases:

Mechanism of Immune Response During: Viral Infections [Influenza, HIV], Bacterial Infections [*Corynebacteria* and *Mycobacterium*] Protozoan Infection [*Plasmodium, Trypanosoma* and *Leishmania*], Helminthes Infections [*Ascaris* and *Schistosoma*].

Unit - II

Disease of Immune System And Vaccines:

Mechanism of Autoimmune Diseases- Systematic Lupus Erythromatous [SLE], Myasthenia Gravis, Rheumatoid Arthritis, Celiac Disease. Cancer of Blood Cells- Lymphoma and Leukemia [Hodgkin and Non-Hodgkin]. Vaccines- Historical Background, Routine Vaccines, DNA Vaccines, Snake-Antidotes. Production of Monoclonal Antibodies and Its Mechanism.

Unit - III

Immunotechnology:

Separation of Immune Cells by Flow cytometry [FACS]: Its Principle and Application. Principle and Application of Immunoprecipitation. Functioning and Application of Microscopes: Immunofluorescence and Confocal. Principle and Application of *in-Situ* Hybridization Technology-FISH [Fluorescence *In-Situ* Hybridization] and GISH [Genome *in-Situ* Hybridization]. Principle, Methodology and Application of Following Techniques- ELISA [Enzyme Linked Immunosorbent Assay], RIA [Radio Immuno Assay], Western Blotting. Allergy Evaluation: Principle and Methodology of Skin Prick Test for Allergy.

Unit - IV

Transplantation Immunology:

Transplantation- History, Graft Vs. Host Rejection Studies for Specific Transplantation I.E Skin Graft, Kidney, Liver and Heart With Reference to Hyperacute, Acute and Chronic Rejection and Its Mechanism. Immunosuppression- Definition, Drugs Used for Immunosuppression and Its Mechanism of Action. Xenotransplantation- Definition and Its Application. HLA Phenotyping, Lymphoproliferation Assay, Its Working Principle and Applications. Blood Groups- MN, ABO Blood Group and Blood Transfusion.

Paper III Animal Ecology (4+1Credits) = 5 Credits

Unit-I

- Ecology: Its Relevance to Human Welfare, Subdivisions and Scope. The Environment: Physical Environment; Biotic Environment; Biotic and Abiotic Interactions.
- Habitat and Niche: Concept of Habitat and Niche; Niche Width and Overlap; Fundamental and Realized Niche; Resource Partitioning; Character Displacement.

- Ecosystem's Structure and Function: Forest and Lake's Biotic and Abiotic Components, Primary and Secondary Productivity, Movement of Energy and Materials, Energy Efficiency Thermal Stratification and Circulation and Lake's Typology.

Unit-II

- Limiting Factors: Laws of Limiting Factors, Impact of Temperature, Moisture and pH on Organisms. Structure and Function of Some Indian Ecosystems: Terrestrial (Forest, Grassland) and Aquatic (Fresh Water, Marine and Eustarine).
- Population Ecology: Characteristics of a Population; Population Growth Curves; Population Regulation; Life History Strategies (r And k Selection); Concept of Meta-Population – Demes and Dispersal, Interdemic Extinctions, Age Structured. Altruism (Hamilton's Rule).
- Community Ecology: Community Attributes Namely Dominance, Various Types of Diversity Indices (Lincoln Peterson Index, Simpson Index, Shannon Weiner Index, Berger Parker Index and Brillouin Index). Similarity Coefficient and Niche Concept, Community Nomenclature. Lotka-Voltera Model of Species Competition.

Unit-III

- Stressed Water Ecosystems: Point and Non-Point Sources of Pollution, Assessment of Freshwater Pollution Using Various Parameters. Water Quality Monitoring Using Abiotic Factors (E.G. Ph, Oxygen, Nitrate, Ammonia, Phosphate, BOD), Bio-Monitoring (Phytoplankton, Zooplankton and Zoo Benthos), Environmental Impact Assessment (EIA)-Impact Of Environmental Stress on Biotic And Abiotic Factors.
- Eutrophication: Its Causes, Assessment, Consequences and Control. Indicators of Pollution and Eutrophication.
- Species Interactions: Types of Interactions, Interspecific Competition, Herbivory, Carnivory, Pollination and Symbiosis.

Unit-IV

- Ecological Succession: Types; Mechanisms; Changes Involved In Succession; Concept Of Climax.
- Biogeography: Major Terrestrial Biomes; Theory of Island Biogeography; Bio-Geographical Zones of India.

- Applied Ecology: Environmental Pollution; Global Environmental Change; Biodiversity: Status, Monitoring and Documentation; Major Drivers Of Biodiversity Change; Biodiversity Management Approaches. Global Conventions on Environmental Pollution (Kyoto Protocol, Montreal Protocol, Earth Summit 2002 and Copenhagen Accord).
- Conservation Biology: Principles of Conservation, Major Approaches to Management, Indian Case Studies on Conservation /Management Strategy (Project Tiger, Biosphere Reserves and Lakes).

Paper IV Medical Laboratory Techniques

(4+1Credits) = 5 Credits

Unit I

- Basic Laboratory Principles - Code of Conduct of Medical Laboratory Personnel. Organization and Functioning of Clinical Laboratory. Safety Measures - Safety Equipment's, Safety Symbols.
- Hazards in the Laboratory (Chemical Hazards, Clinical Hazards, Electrical Hazards, Biological Hazards. Waste Disposal.

Unit II

- Introduction of Common Laboratory Equipment's: Hot Air Oven, Incubator, Autoclave, Water Bath and Centrifuges
- Microscope - Fundamentals of Microscopy, Resolution and Magnification, Light Microscopy, Electron Microscopy, PCR Machine (Thermal Cycler), Electrophoresis Unit and UV Trans Illuminator Etc.

Unit III

- Specimen Collection, Processing and Analytical Techniques Collection and Preservation of Blood, Urine, Stool, Sputum, Pus, Body Fluids and Swab.
- Preparation of Blood Smears. Sources of Biological Variations and Pre-Analytical Variables.

Unit IV

- Preparation of Reagents: Buffers and pH, Normal, Percent and Molar Solution, Normal Saline -Methods of Measuring Liquids.
- Clinical Laboratory Records - Modern Laboratory Set Up - Quality Control: Accuracy, Precision, and Reference Values.
- Disposal of Biomedical Waste
- Laboratory Safety Protocols and Guidelines

Semester- VIII

Paper I General Ichthyology (4+1Credits) = 5 Credits

Unit I

- Classification of Fishes, Systematic Position, Habit and Habitat, Morphology, Distribution, Significance and Affinities of Holocephali and Dipnoi.
- Fins, Their Origin and Evolution; Locomotion in Fishes.
- Histomorphology and Elementary Physiology (A) Digestive System (With Particular Reference to Food And Feeding Habits of Freshwater Fishes) (B) Excretory System (With Particular Reference to Acid Base Balance and Osmoregulation.) (C) Accessory Respiratory Organs in Fishes.

Unit II

- General Survey of the Marine, Estuarine and Inland Capture Fisheries of India with Particular Reference to Fishery Resources of Uttaranchal. Methods of Fishing: Fishing Gears and Crafts. Cold Water Fishery Sewage-Fed Fishery and Shell –Fish Fishery.
- Nutrition and Growth Including Age and Growth Relationship, Chemical Composition of Fish Flesh, Length –Weight Relationship, Natural Food and Artificial Feed and Their Role in Fish Culture. Plankton and Benthos in Relation to Fish Production

Unit III

- Electric Organs in Fishes.
- Brief Knowledge of Sexual Dimorphism, Courtship And Parental Care. Migratory Instincts, Hill Stream Adaptations
- Reproduction in a Major Carps- Structure Of Gonad, Spawning, Early Development And Metamorphosis. Microscopic Structure And Hormonal Functions Of The Following Endocrine Glands: Pituitary, Thyroid, Pancreas, Adrenal, Corpuscles Of Stannins, Ultimobranchial Glands, Caudal Neurosecretory System And Sex Hormones. Current Trends In Induced Breeding In Fishes.

Unit IV

- Brief Knowledge of Sense Organs: Organs of Smell, Eyes, Hearing, Ampulla of Lorenzeni, Bio- Luminescence, Sound Production and Lateral Line System.
- Parental Care in Fishes. Venomous and Non-Venomous Fishes. Fish Pheromones. Coloration in Fishes.

Paper IIApplied Ichthyology (4+1Credits) = 5 Credits

Unit I

- Important Cultivable Fishes
- Important Cultivable Shellfishes
- Biology of Cultivated Fish and Shellfish

Unit II

- Ecology and Productivity of Fish Ponds. Pollution in Relation to Fisheries.
- Carp Culture: Mono Culture, Poly Culture and Composite Fish Culture. Live Fish Culture. Management Practices: Weed, Insect and Carnivorous Fishes.

Unit III

- Maturation and Fecundity, Spawning and Seed Collection, Induced Breeding, Hatching Techniques and Hatcheries, Nursery Management, Packing and Transport of Fish.

Unit IV

- Integrated Aquaculture: Fish-Cum Poultry, Fish-Cum Duckery, Fish-Cum Piggery, Paddy-Cum Fish Culture And Dairy-Cum Fish Culture. Induced Spawning and Hybridization. Factors Responsive for Induced Breeding, Hypophysation . Use of Different Synthetic and Natural Hormones.
- Larvivorus Fishes and Public Health. Fish Diseases and Their Management. Exotic Fishes and Their Merits and Demerits, Cryopreservation of Gametes and Embryos. Ornamental Fish Culture.

Paper III Basic Limnology (4+1Credits) = 5 Credits

Unit I

- Introduction and Development of Limnology in India
- Inland, Waters Distribution of Inland Waters: Ponds, Lakes, Streams, River

Unit II

- Lakes: Thermal Classification of Lakes, Famous Lakes of India and World, Nature of Inland Water Environment.
- Physical Characteristics: Pressure, Compressibility, Density Mobility, Buoyancy, Movement of Water Thermal Stratification Light, Color and Turbidity

Unit III

- Chemical Characteristics: Dissolved Gases – Oxygen, Carbon Dioxide and Other Dissolved Gases Dissolved Solids and Dissolved Organic Matter Influence of Physical and Chemical Conditions on Living Organisms in Inland Water Bodies.
- Planktonic Organisms: Classifications of Organisms in Water Distribution of Plankton Food For Plankton Organisms

Unit IV

- Biological Productivity, Circulation of Food Material, Classification of Lakes Based on Productivity, Laws of Minimum, Biotic Potential and Environmental Resistance, Quantitative Relations in a Standing Crop
- Water Pollution, Eutrophication, Algal Blooms, Water Borne Diseases and Drinking Water Parameters
- Bioremediation of Polluted Water Bodies.

Paper IV Animal Ecology (4+1Credits) = 5 Credits

Unit-I

- Ecology: Its Relevance to Human Welfare, Subdivisions and Scope. The Environment: Physical Environment; Biotic Environment; Biotic and Abiotic Interactions.

- Habitat and Niche: Concept of Habitat and Niche; Niche Width and Overlap; Fundamental and Realized Niche; Resource Partitioning; Character Displacement.

- Ecosystem's Structure and Function: Forest and Lake's Biotic and Abiotic Components, Primary and Secondary Productivity, Movement of Energy and Materials, Energy Efficiency Thermal Stratification Circulation and Lake's Typology.

Unit-II

- Limiting Factors: Laws of Limiting Factors, Impact of Temperature, Moisture and pH on Organisms. Structure and Function of Some Indian Ecosystems: Terrestrial (Forest, Grassland) and Aquatic (Fresh Water, Marine, Eustarine).

- Population Ecology: Characteristics of a Population; Population Growth Curves; Population Regulation; Life History Strategies (r and k Selection); Concept of Meta-Population – Demes and Dispersal, Interdemic Extinctions, Age Structured. Altruism (Hamilton's Rule).

- Community Ecology: Community Attributes Namely Dominance, Various Types of Diversity Indices (Lincoln Peterson Index, Simpson Index, Shannon Weiner Index, Brillouin Index and Berger Parker Index). Similarity Coefficient and Niche Concept, Community Nomenclature.

Unit-III

- Stressed Water Ecosystems: Point and Non-Point Sources of Pollution, Assessment of Freshwater Pollution Using Various Parameters. Water Quality Monitoring Using Abiotic Factors (E.G. pH, Oxygen, Nitrate, Ammonia, Phosphate, BOD), Bio-Monitoring (Phytoplankton, Zooplankton and Zoo Benthos), Environmental Impact Assessment (EIA)- Impact of Environmental Stress on Biotic and Abiotic Factors.

- Eutrophication: Its Causes, Assessment, Consequences and Control. Indicators of Pollution and Eutrophication.

- Species Interactions: Types of Interactions, Interspecific Competition, Herbivory, Carnivory, Pollination and Symbiosis.

Unit-IV

- Ecological Succession: Types; Mechanisms; Changes Involved in Succession; Concept of Climax.
- Biogeography: Major Terrestrial Biomes; Theory of Island Biogeography; Bio-Geographical Zones of India.
- Applied Ecology: Environmental Pollution; Global Environmental Change; Biodiversity: Status, Monitoring and Documentation; Major Drivers of Biodiversity Change; Biodiversity Management Approaches. Global Conventions on Environmental Pollution (Kyoto Protocol, Montreal Protocol, Earth Summit 2002 and Copenhagen Accord).

- Conservation Biology: Principles of Conservation, Major Approaches to Management, Indian Case Studies on Conservation /Management Strategy (Project Tiger, Biosphere Reserves and Lakes).

Practical

Suggested books:

1. Srivastava CBL: Fish Biology, Narendra Publishing House.
2. Singh HR: Advance in Fish Biology, Hindustan Publishing Corp.

3. Munshi & Munsi: Fundamental of Freshwater Biology. Narendra Publishing House.
4. Kyle: The biology of Fishes.
5. Khanna & Singh: Fish and Fisheries.

Minor/Elective

Chronobiology (4+1Credits) = 5 Credits

Introduction to chronobiology. Evolution of biological timing system; Clocks, genes and evolution; Adaptive functional significance of biological clocks.

Studying biological clocks; Biological Rhythms - Ultradian, Tidal/Lunar, Circadian and Circannual rhythms; Temperature effects and compensation; Perception of natural zeitgeber signals; Geophysical environment - Seasons; proximate and ultimate factors.

Entrainment, masking and zeitgeber cycles; parametric and non-parametric entrainment; Entrainment models; Phase shift, Phase response curves (PRC) and phase transition curves (PTC); Organization of circdian system in multicellular animals; Concept of central and peripheral Clock system in multicellular animals; SCN suprachiasmatic nucleus as the main vertebrate clock, concept of core and shell.

Diversity and complexity of the clock system, Melatonin: input and output signal of the clock system. Photoreception and photo-transdustion. Human Health and diseases-chronopharmacology, chronomedicine, chronotherapy.

or

Applied Zoology (4+1Credits) = 5 Credits

Parasitic protozoa and Helmeinthes: *Ancylostoma*, *Schistosoma,Ascaris, Filaria* (including periodicity).

Detailed information on:

(a) Aquaculture

(b) Sericulture

(c) Apiculture

(d) Lac culture

Section – B

Bionomics and control measures of the common pests of fruits (*Papilio demoleus* and *Quadraspidiotus perniciosus*), Vegetables (*Thrips tabaci* and *Aulacophora foveicollis*) and stored grains (*Callosobruchus chinensis* and *Trogoderma granarium*). Polyphagous pests (Locust and Termites).

Pest management, including insect pest control and integrated pest management. A note on Bioethics.

Economic importance of birds and mammals.

Common Pest of Uttarakhand.

or

General Biotechnology (4+1Credits) = 5 Credits

Origin and definition, scope and importance of Biotechnology. Recombinant DNA technology and Genetic engineering. Restriction enzymes and cloning techniques used in recombinant DNA technology, DNA fingerprinting. Biochips.

Biotechnological innovations in the area of medical, agricultural industrial & forensic sciences.

Fifth Year

Semester- IX

Paper I Systematics And Applied Entomology **(4+1Credits) = 5 Credits**

Unit I

- Ancestry and Evolution of Insects
- Classification of Insects
- Principles of Construction and Use of Dichotomous Keys in Insect Identification
- Methods of Collection, Preservation and Culture of Insects
- Parental Care in Insects

Unit II

- Brief Knowledge of Habit, Habitats and General Characters of the Following Orders With Special Reference to the Families Mentioned: Thysanura (Machilidae, Lepismatidae), Collembola, Odonata, Orthoptera (Acrididae, Tettigonidae, Gryllidae), Phase Theory in Locusts, Phithioptera (Anoplura, Mallophaga), Isoptera, Thysanoptera, Heteroptera (Pentatomidae, Belostomatidae), Homoptera (Aphidae, Coccidae), Coleoptera (Coccinellidae, Curculionidae), Lepidoptera (Noctuidae, Nymphalidae), Hymenoptera (Ichneumonidae, Formicidae); Diptera (Muscidae, Syrphidae)

Unit III

- Principles and Practices of Pest Control:
- Pest Control Procedures: Natural Control, Applied Control (Cultural, Biological and Insecticidal)
- Modes of Action of Insecticides, Factors Affecting Toxicity of Insecticides
- Non-Insecticidal Methods : Antifeedents, Attractants and Repellents, Feeding Deterrents, Chemosterilants, Pheromones and Insect Growth Regulators (IGR's)
- Integrated Pest Management (IPM)
- Insecticide Application Equipments: Sprayers, Dusters, Granule Applicators

Distribution, Habit and Habitats, Life-Cycle, Nature of Damage and Control of Pests of: **Stored Grains** (*Sitophilus Oryzae, Tribolium Castaneum, Callosobruchus Chinensis*); **Sugarcane** (*Pyrilla Perpusilla, Chio Infuscatellus*); **Paddy** *(Leptocorisa Acuta*, *Hieroglyphus Banian/Nigrorepletus*), C**otton** (*Dysdercus Koengii, Pectinophora Gossypiella*); **Cereals** *(Heliocoverpa Armigera, Agrotis Ypsilon)* **Vegetables***((Raphidopalpa (=Aulacophora) Foveicollis, Pieris Brassicae*); **Fruits**(*Bactrocera* (= *Dacus) Cucurbitae, Papilio Demoleus*)**;** **Forests** (**Defoliator**: Tasar Silkworm, *Antheraea Paphia*; **Sap-Sucker** Of Khamer Or Gamhar, *Tingis Beesoni*; **Teak Borer**, *Aeolesthes Holosericea*); And **Polyphagous Pests** (Locusts, Termites)

Unit IV

Lac Industry: Strains of Lac Insects, Lac Cultivation, Composition and Uses of Lac

Apiculture: Kinds of Honey Bees and Bee Hives, Structure of Typical Bee Hive Organization of Honey Bees, The Language of Honey Bees, Bee Keeping Methods, Economic Importance and Diseases of Honey Bees. Parasites of Honey Bee (*Varroa Destructor, Varroa Jacobsoni* and *Galleria Mellonella*).

Sericulture: Mulberry and Non-Mulberry Sericulture, Composition Processing of Silk and Silk Industry in India. Diseases of Silkworm (White Muscadine and Pebrine Disease).

Life-Cycle and Control of Insects of Medical Importance of Man and Animals: House Flies, Mosquitoes, *Phelbotomus* (Sandfly) and *Tabanus* (Horse Fly)

Paper II Biology of Insects (Morphology, Physiology & Development) (4+1Credits) = 5 Credits

Unit I

- Integument: Structure, Functions and Modifications of Insect Cuticle, Moulting and Sclerotization
- Structure of an Insect Head, Thorax and Abdomen; Appendages of Head (Mouthparts and Antennae) and Thorax (Legs and Wings)
- Structure of a Wing of an Insect, Types of Wings, Hypothetical Wing Venation, Wing-Coupling Mechanisms and Flight Mechanism
- Structure and Modifications of Male and Female Genitalia in Insects

Unit II

- Structure and Modifications of Alimentary Canal;Food and Feeding Mechanism of a Generalised Insect With Special Reference to Physiology of Digestion in Different Insects
- Structure and Functions of Blood and Mode of Circulation in Insects
- Principal Organs of Excretion of Insects Found in Different Habitats, Physiology of Excretion With Special Reference to Osmoregulation in Insects

Unit III

- Structure and Functioning of Various Types of Respiratory Organs, Modes of Respiration, Physiology of Respiration in Terrestrial, Aquatic and Endoparasitic Insects
- Generalized Plan of Nervous System in Insects and Its Modifications
- Neuroendocrine System in Insects and The Role Of Neurosecretion In Various Metabolic Activities, Metamorphosis and Development of Insects

- Structure and Functions of Different Types of Visual and Sound Producing Organs in Insects

Unit IV

- Structure, Function and Physiology of Mechanoreceptors and Chemo Receptors in Insects
- Bioluminescence: Light Producing Organs, Mechanism and Significance of Light Production in Insect
- Structure of Pheromone Producing Glands, Different Types of Pheromones and their Chemical Nature
- Structure and Modification of Male and Female Reproductive Systems in Insects
- Development: Structure of Egg, Maturation, Cleavage, Blastokinesis, Formation of Germ Layers and Segmentation; Different Types of Larvae and Pupae, Polyembryony and Parthenogenesis in Insects

PAPER III Economic Zoology and Vermicology

(4+1Credits) = 5 Credits

Unit I

- The General Study of Parasites in Terms of Morphology, Mode of Transmission, Symptoms, Prevention and Control.
- Types of Parasites Unicellular Parasite. Protozoans (*Entamoeba Histolytica, Plasmodium* Spp.,) *Trypanosoma* Spp. *Leishmenia* Spp. Etc.) *Giardia* and Vector Biology.

- Study: Multicellular Parasites, Platyhelminthes (Tape Worms and Liver Flukes) Aschelminthes (Ascaris) Nematoda- *Sea Eligans*.

Unit II

- Pests and Parasites, Apiculture, Sericulture, Lac Culture, Pisciculture, Dairy and Farming's Products.
- Pesticides (Organchlorines, Arganophosphates, Carbanates, Pyrethroids, Triazmes, Bardeux Nixture), Mode of Action of Pesticides, Advantages and Disadvantages of Pesticides Hazards of Pesticides,
- Biological Methods of Pest Control.

Unit III

- Earthworm Diversity: Classification Earthworm Types: White Worm Behavior of Earthworms As Indicators of Soil Fertility, Earthworms As Bioreactors; Earthworms and Plant Growth, Organic Matter-Dynamics and Nutrient Cycling, Feeding Habit and Food
- Vermicomposting :Advantages of Vermicomposting, Vermicomposting in Daily Life, Vermiculture Vs. Vermicomposting, Chemical Compostion of Vermicompost

Vermicomposting at Home and Agricultural Farm; The Business of Worms; Interaction of Vermicompost Earthworms.

Unit IV

- Earthworm Bio-Technology:Fundamentals of Sustainability; Enrichment of Vermicompost and Earthworms for Sustainable Production, Earthworms in Bio-Remediation, Earthworms in Alternative Medicine, Earthworm Meal Production Transgenic Earthworms.
- Organic Farming: Eco-Friendly Farming System Technologies. Evaluation Study of Ecological Constraints (Climatic and Edaphic,). Appropriate Technologies, in Agro-Forestry, Natural-Management, Planted Forests, (Ranching, Farmers Perception to Organic Farming and any Case Study).

Paper IV Wildlife Conservation (4+1Credits) = 5 Credits

Unit I

- Indian Wildlife: Introduction, Distribution of Wildlife in Ecological Subdivision of India, IUCN Categories
- Protected Area Network: National Parks, Wildlife Sanctuaries, Biosphere Reserves and Zoos in India, Gene Pool, Habit, Habitat and Breeding Biology of Few Mammals (Viz., Elephant and Tiger).

Unit II

- Reasons For Wildlife Depletion: Habitat Fragmentation, Habitat Destruction, Commercial Wildlife Exploitation, Overgrazing Etc.,
- Wildlife Conservation (Policies and Programmes), Special Projects for Endangered Species (Project Tiger, Gir Lion Sanctuary Project and Crocodile Breeding Project).

Unit III

- Principle and Practice of Wildlife Management: Management of Special Habitats; Riparian Zones, Grasslands Introduction to Conservation Biology, Conservation Values and Ethics of Conservation of Natural Resources.

- Conservation of Biodiversity, Patterns and Processes, Concepts of Biodiversity, Levels of Biodiversity, Genetic Diversity, Intra Specific Diversity, Species Richness, Richness of Higher Taxa, Ecosystem and Biome Diversity.

Unit IV

- International Conventions on Conservation (Ex-Situ and in-Situ Conservation, Conservation Breeding (E.G. Vulture, Pygmy Hog, Gharial, Etc.), Institutions and their Role in Conservation (Zoos, Natural History Museums and Collections, Zoological Survey of India and Its Regional Centres.
- National and International Zoological Institutes, Societies and Academic Bodies.
- Brief Account of Wildlife Acts and Their Amendments in India and World. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Semester- X

Paper I Animal Biotechnology (Animal Cell Culture)

(4+1Credits) = 5 Credits

Unit I

- Animal Cell Culture: Equipment and Materials for Animal Cell Culture Technology. Design and Layout of Culture Room, Sterilization and Aseptic Techniques.
- Culture Medium: Natural Media, Synthetic Media, Sera. Introduction to Balanced Salt Solutions and Simple Growth Medium. Brief Discussion on the Chemical, Physical and Metabolic Functions of Different Constituents of Culture Medium, Role of Carbon Dioxide, Serum and Supplements in Animal Cell Culture.
- Characteristics of Cells in Culture: Contact Inhibition, Anchorage Dependence and Cell-Cell Communication.

Unit II

- Mechanical and Enzymatic Disaggregation of Tissue and Setting up of Primary Cultures, Candling of Eggs, Preparation of Chick Fibroblast, Culture of Lymphocytes For Chromosomal Studies. Roller and Suspension Culture Techniques. Large-Scale Production of Cells Using Bioreactors, Micro- Carries and Perfusion Techniques.
- Measurement of Viability and Cytotoxicity. Biological Characterization of the Cultured Cells, Karyotyping, Cryopreservation and Revival. Detection of Contaminants in Cell Cultures.

Unit III

- Fermentation Technology for the Growth of Animal Cells and their Products (Bioreactors, Hollow Fiber Reactors, Air-Lift Fermentors, Chemostats and Microarriers). Established Cell Line Cultures: Definition of Cell Lines, Maintenance and Management; Cell Adaptation.
- Stem Cell Cultures, Embryonic Stem Cells and their Applications. Somatic Cell Genetics. Organ and Histotypic Cultures.
- Cell Cloning, Cell Synchronization and Cell Manipulation. Various Methods of Separation of Cell Types, Advantages and Limitations; Flow Cytometry. Production and Characterization of Monoclonal Antibodies and their Application.

Unit IV

- Commercial Applications of Animal Cell Culture: Cell Culture Based Vaccines, Tissue Culture as a Screening System; Cytotoxicity, *in-vitro* Testing of Drugs and Diagnostic Tests. Mass Production of Biologically Important Compounds (E.G. Vaccines and Pharmaceutical Proteins).
- Production of Recombinant Hemoglobin, Blood Substituents, Artificial Blood. Harvesting of Products, Purification and Assays. Three Dimensional Cultures and Tissue Engineering (Artificial Skin and Artificial Cartilage).

Paper II Animal Biotechnology(Transgenics, Cloning And IPR)

(4+1Credits) = 5 Credits

Unit I

- Gene Transfer Technology in Animals: Viral And Non-Viral Methods, Sperm Mediated Gene Transfer, Transfection of Animal Cell Lines and their Immortalization, Gene Knock Out Animal Models, Current Status of Production of Transgenic Animals.
- Animal Cloning: Techniques, Relevance, Case Studies and Ethical Issues.

Unit II

- In Vitro Fertilization (IVF) and Embryo Transfer (ET) Technology in Humans; Superovulation, Micromanipulation, IVF And Embryo Culture in Farm Animals (E.G. Cow); Embryo Transfer In Cattle, Gene Transfer or Transfection (Using Eggs And Cultured Stem Cells): Targeted Gene Transfer; Transgenic Animals (Mice, Sheep, Pigs, Rabbits, Goats, Cows and Fish).

Unit III

- Introduction to Biosafety Regulations; Primary Containment for Biohazards and Biosafety Levels, Biosafety Guidelines – Government of India. Definition of Genetically Modified Organisms (Gmos) & Living Modified Organisms (Lmos); Roles of Institutional Animal

Ethical Committee, Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC) Etc.

- Prevention of Cruelty on Animals Act Govt. of India, Concept of Bioethics, Public Concerns on Human Genome Research and Transgenics – Genetic Testing and Screening, Ethics in Clinical Trials and Good Clinical Practices(GCP), Ethical, Legal and Social Implications (ELSI) & Human Genome Project; Ethics in Human Cloning and Patenting Human Genes.

Unit IV

- Intellectual Property Rights and Its Types-Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs, Basics of Patents (Types, Patent Application and Specifications), Concept of Prior Art and Patent Filling Procedures, Process Patent Vs Product Patent.
- Introduction to General Agreement on Tariffs and Trade (GATT), World Trade Organization (WTO), World Intellectual Property Organization (WIPO) and Trade Related Intellectual Property Rights (TRIPS).

Paper III **Medical Laboratory Techniques** (4+1Credits) = 5 Credits

Unit I

- Basic Laboratory Principles - Code of Conduct of Medical Laboratory Personnel. Organization and Functioning of Clinical Laboratory. Safety Measures - Safety Equipment's, Safety Symbols.
- Hazards in the Laboratory (Chemical Hazards, Clinical Hazards, Electrical Hazards, Biological Hazards. Waste Disposal.

Unit II

- Introduction of Common Laboratory Equipment's: Hot Air Oven, Incubator, Autoclave, Water Bath, Centrifuges
- Microscope - Fundamentals of Microscopy, Resolution and Magnification, Light Microscopy, Electron Microscopy, PCR Machine (Thermal Cycler), Electrophoresis Unit and UV Trans Illuminator Etc.

Unit III

- Specimen Collection, Processing and Analytical Techniques Collection and Preservation of Blood, Urine, Stool, Sputum, Pus, Body Fluids and Swab.
- Preparation of Blood Smears. Sources of Biological Variations, Pre-Analytical Variables.

Unit IV

- Preparation of Reagents: Buffers and pH, Normal, Percent and Molar Solution, Normal Saline - Methods of Measuring Liquids.
- Clinical Laboratory Records - Modern Laboratory Set Up - Quality Control: Accuracy, Precision, and Reference Values.
- Disposal of Biomedical Waste
- Laboratory Safety Protocols and Guidelines

Paper IV Wildlife Conservation(4+1Credits) = 5 Credits

Unit I

- Indian Wildlife: Introduction, Distribution of Wildlife in Ecological Subdivision of India, IUCN Categories
- Protected Area Network: National Parks, Wildlife Sanctuaries, Biosphere Reserves and Zoos in India, Gene Pool, Habit, Habitat and Breeding Biology of Few Mammals (Viz., Elephant and Tiger).

Unit II

- Reasons for Wildlife Depletion: Habitat Fragmentation, Habitat Destruction, Commercial Wildlife Exploitation, Overgrazing Etc.,
- Wildlife Conservation (Policies and Programmes), Special Projects for Endangered Species (Project Tiger, Gir Lion Sanctuary Project and Crocodile Breeding Project).

Unit III

- Principle and Practice of Wildlife Management: Management of Special Habitats; Riparian Zones, Grasslands Introduction to Conservation Biology, Conservation Values and Ethics of Conservation of Natural Resources.

- Conservation of Biodiversity, Patterns and Processes, Concepts of Biodiversity, Levels of Biodiversity, Genetic Diversity, Intra Specific Diversity, Species Richness, Richness of Higher Taxa, Ecosystem and Biome Diversity.

Unit IV

- International Conventions on Conservation (*Ex-Situ and in-Situ* Conservation, Conservation Breeding (E.G. Vulture, Pygmy Hog, Gharial, Etc.), Institutions and Their Role in Conservation (Zoos, Natural History Museums and Collections, Zoological Survey of India and Its Regional Centres).
- National and International Zoological Institutes, Societies and Academic Bodies
- Brief Account of Wildlife Acts and their Amendments in India and World. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).