J.D WOMEN'S COLLEGE PATNA
BOTANY DEPARTMENT
Course Outcomes – Program Outcomes (CO & PO) Mapping

Program Outcomes (PO): M.Sc. Botany

M.Sc. Botany is a two-year postgraduate programme to impart advanced knowledge on modern biology. Other than providing students with indispensable knowledge, the programme curriculum fosters problem-solving and critical thinking skills that prepare students to take on any challenges.

Under this programme the students gain insights into the key research areas of Botany. The programme encompasses a balance of both theoretical and practical sessions which enables the students to apply their learning and develop end results.

The programme focuses on career-oriented subjects like Microbial Biotechnology, Plant tissue culture, Enzyme Technology and Genetics, Plant breeding and Crop improvement etc.

Programme Specific Outcome

- **PSO1.** Students completing the course will be able to understand different aspects of botany such as Phycology, Mycology, Microbiology, Bryophytes and pteridophytes.

- PSO2 The student completing the course will understand the diversity and phylogeny of the gymnosperm, taxonomy of angiosperms and concepts and processes in plant anatomy, developmental biology.

- **PSO3**.After successful completion of the course, a student is able to understand different fields of Botany like systematics, evolution, ecology, physiology, biochemistry, plant interactions with microbes and insects, anatomy, morphology, reproduction, genetics and molecular biology of various life-forms. They have an edge over other students as they will be trained in skill enhancement courses like Biofertilizer technology.
- **PSO4**. The student completing the course is able to classify various life forms of plants, design and execute experiments related to basic studies on environment ecology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology etc.

- **PSO5** The student completing the course is capable of executing short-term research projects/dissertations using tools and techniques in any of the basic specializations of Botany under supervision.

Course Outcome

Semester: I

SI. No.	Paper /Course	Title	Course outcome
1.	MBOTCC-I	Phycology, Mycology and Bryology	On successful completion of this course, students will be able to know about the- CO1: Thallus organisation of algae, fungi and bryophytes, and their salient features. CO2: Different kinds of algal, fungal, lichen and bryophyte diversity and their economic implication. The course has importance in the areas of academics and research.
2.	MBOTCC-2	Microbiology and Plant Pathology	Students will learn- **CO1**: Methods in microbiology, develop theoretical and technical skills of basic microbiology (sterilize, isolate, culture, preserve microbes), the structure of bacteria and viruses. CO2: The diversity of micro-organisms, their classification, structure and growth. CO3: Applied aspects of microbial diversity in various fields e.g.: pharmaceuticals, agriculture etc. CO4: Ways and means of combating plant diseases so as to minimize economic loss. The course has importance in the areas of academics, research, and employability.
3.	MBOTCC-3	Pteridophyte, Gymnosperms and Palaeobotany	Students will get in-depth knowledge of- **CO1**: The plant diversity (esp. In pteridophytes, and gymnosperms) and understanding the evolutionary trends through the study of palaeobotany. **CO2**: The evolutionary diversification of early land plants and morphological and reproductive innovations in pteridophytes and gymnosperms. The course has importance in the areas of academics and research.
4.	MBOTCC-4	Practical	Students will learn and perform practical on- CO1: Use of sterilization instruments, media preparation. CO2: Isolation and study of microorganisms. CO3: Study of common fungal diseases, vegetative habits, anatomy and reproductive morphology of common pteridophytes and gymnosperms. The course has importance in the areas of academics, research, and employability.

Semester: II

SI. No.	Paper /Course	Title	Course outcome
5.	MBOTCC-5	Biofertilizer Technology	On successful completion of this course, students will be able to know about the- **CO1**: Biofertilizers and their use. CO2: Isolation, identification, purification, mass production of microorganisms used in biofertilizers, and also on quality control of commercial biofertilizers. CO3: Biofertilizers' applied aspects for the enhancement of soil fertility and crop productivity and ideal way for sustainable development. **The course has importance in the areas of academics, research, and employability.**
6.	MBOTCC-6	Taxonomy, Anatomy & Embryology	Students will get in-depth knowledge of- CO1: Classifications and interaction between taxonomy, anatomy & embryology. CO2: Different methods of naming plants, different principles of nomenclature etc. CO3: Phylogeny and phylogenetic systematic, methods used in molecular systematic studies. CO4: Embryology, and its role in taxonomy.
7.	MBOTCC-7	Physiology & Biochemistry	Students will learn- CO1: The mechanism of osmotic relations, metabolism, growth and morphogenesis. CO2: Energy transduction mechanism and biochemical energetics in plants. CO3: Enzymes, their structure, role and properties. **The course has importance in the areas of academics and research.**
8.	MBOTCC-8	Plant tissue culture, Ethnobotany, Biodiversity and Biometry	After completing the course, students will get to know about- CO1: Ways of conservation and propagation of economically important and endangered plants. CO2: Biodiversity, their types, patterns, loss, conservation and its importance. CO3: Biometric tools like measurement of variability and test of significance of data etc. CO4: Cell and tissue culture, ethnopharmacology, and ethnoecology. The course has importance in the areas of academics, employability and research.

9.	MBOTCC-9	Practical	Students will get practical knowledge on- CO1. Preparation of culture media, explant culture and callus initiation. CO2: Family description of some locally available plants and their taxonomic classification. CO3: Physiological studies like determination of water potential, estimation of protein, paper chromatography etc. CO4: Staining and study of xylem, phloem and pollen etc. **The course has importance in the areas of academics, research, and employability.**

Semester III

SI. No.	**Paper /Course**	**Title**	**Course outcome**
10.	MBOTCC-10	Cell biology & Cytogenetics	Students will learn- CO1: Cell theory, ultrastructure and chemical composition of the cell. CO2: Cell cycle, apoptosis, and its control mechanism. CO3: Concepts of Mendelian genetics, sex determination and extranuclear inheritance. CO4: Basics of microscopy and micro-densitometry. **The course has importance in the areas of academics, research, and employability.**
11.	MBOTCC-11	Molecular Biology	On successful completion of the course, students will learn- CO1: The structure and function of the protein and nucleic acid, DNA organization and its packaging. CO2: Principle mechanisms of genome replication, maintenance, function and regulation of expression. **The course has importance in the areas of academics, research, and employability.**
12.	MBOTCC-12	Recombinant DNA technology	Students will learn- CO1: Manipulating DNA molecules to produce genetic combinations which are of value to science, medicine & various industries. CO2: rDNA technology, cloning vectors, passenger DNA, methods of DNA transfer, DNA fingerprinting, IPR etc. **The course has importance in the areas of academics, research, and employability.**
13.	MBOTCC-13	Plant ecology and environmental biology	Students will have knowledge about- CO1: Organism and population concept, interactions among populations. CO2: Community structure and community dynamics. CO3: Concept of ecosystem, ecosystem energetic, environmental pollution. CO4: Importance of environmental awareness.

			The course has importance in the areas of academics, research, and employability
14.	MBOTCC-14	Practical	Students will gain practical knowledge on- CO1: Modern instruments used in botany, cytological techniques. CO2: Karyotype analysis. CO3: Basic recombinant DNA technology, DNA amplification. CO4: Electrophoresis, spectroscopy, centrifugation, isolation of microorganisms etc. CO5: Ecological adaptations. **The course has importance in the areas of academics, research, and employability.**

Semester: IV

SI. No.	**Paper /Course**	**Title**	**Course outcome**
15	MBOTEC-1	Cytogenetics and Crop improvement	Students will gain advanced knowledge on- CO1: Haploidy, aneuploidy, polyploidy, chromosome banding pattern. CO2: Mutations, transposons, epigenetics, epigenomics, human genetic diseases. CO3: Traditional and modern methods of crop improvement and plant breeding. **The course has importance in the areas of academics, research, and employability.**
16	MBOTEC-1	Applied Microbiology and Plant Pathology	Students will have in depth knowledge of- CO1: Industrial application of microbial diversity, study of causal organism of plant pathogens and their control. CO2: Fermentation technology, plant pathology etc. CO3: Solid waste treatment, composting and land filling. CO4: Wastewater treatment, bioremediation, biogas production. **The course has importance in the areas of academics, research, and employability.**
17	MBOTEC-2	Project Dissertation	Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. The students are exposed to cutting-edge technologies to achieve a solution and learn to process scientific data using biostatistics. Students should be able to demonstrate considerable improvement in the following areas –

			- In-depth knowledge of the chosen area of research. - Capability to critically and systematically integrate knowledge to identify the issues that must be addressed within the framework of the specific thesis. - Competence in research design and planning. - Capability to create, analyse and critically evaluate different technical solutions. - Ability to conduct research independently. - Ability to perform analytical techniques/experimental methods. - Project management skills. - Report writing skills. - Problem-solving skills. - Communication and interpersonal skills. **The course has importance in the areas of academic, research and employability.**

Sem	Subject	PO / CO	PO1	PO2	PO3	PO4	PO5
I	Phycology,Mycology& Bryology	CO1	X				
		CO2	X				
	Microbiology& Plant Pathology	CO1	X				
		CO2					X
		CO3				X	
		CO4					X
	Pteridophyta,Gymnosperm& Paleobotany	CO1	X	X			
		CO2					X
	Practical 1	CO1				X	
		CO2	X				
		CO3				X	
		CO4					X
II	Biofertilizer Technology	CO1			X		
		CO2				X	
		CO3					X
	Taxonomy,Anatomy& Embryology	CO1		X			
		CO2		X			
		CO3				X	
		CO4					X
	Physiology &Biochemistry	CO1			X		
		CO2			X		

		CO3				X	
		CO4					X
	Plant Tissue Culture, Ethnobotany, Biodiversity& Biometry	CO1				X	
		CO2				X	
		CO3					X
		CO4					X
	Practical 2	CO1					X
		CO2		X			
		CO3				X	
		CO4					X
III	Cell Biology& Cytogenetics	CO1				X	
		CO2				X	
		CO3				X	
		CO4					X
	Molecular Biology	CO1			X		
		CO2				X	
	Recombinant DNA Technology	CO1			X		
		CO2				X	
	Plant Ecology &Environmental Science	CO1			X		
		CO2				X	
		CO3			X		
		CO4				X	
	Practical 3	CO1				X	
		CO2			X		
		CO3				X	
		CO4				X	
		CO5				X	
IV	Cytogenetics &Crop Improvement	CO1			X		
		CO2				X	
		CO3					X
	Applied Microbiology & Plant Pathology	CO1	X				
		CO2			X		
		CO3					X
		CO4				X	X
	Project Dissertation	CO1				X	X

CBCS-based syllabus for M.Sc. Chemistry (2 Years) Programme

It is two years Master's Degree Programme. There shall be four semesters to complete programme, i.e. 1st, 2nd, 3rd and 4th semester. Each semester shall consist of 15 weeks of academic work equivalent to 90 actual teaching days.

This programme will have three types of courses, i.e. core course and Elective course.

Core course (CC)- The core courses are those courses whose knowledge is deemed essential for the students registered for a particular Master's degree programme.

Elective course (EC)- The elective course can be chosen from a pool of papers in 2nd and 4th semester.

Each course will have 100 marks in full and divided into 70 marks for end-semester exam and 30 marks for internal assessment work. Internal assessment will be in two internal exams of l0 marks each 5 marks for seminar/internal project and 5 marks for attendance/discipline.

M.Sc. Chemistry (Two years Course)

Course Structure

M.Sc. Ist Semester

Serial No.	Courses	Code	Description	Credits	Max. Marks (100)
1	Core Course I	MSCCHE CC-1	Inorganic Chemistry-1	5	100
2	Core Course II	MSCCHE CC-2	Physical Chemistry-1	5	100
3	Core Course III	MSCCHE CC-3	Organic Chemistry-1	5	100
4	Core Course IV	MSCCHE CC-4	Practical (Physical)	5	50+50
5	AECC-1		Environmental Sustainability and Swachchchha Bharat Abhiyan Activities	3+2	50+50

M.Sc. IInd Semester

Serial No.	Courses	Code	Description	Credits	Max. Marks (100)
6	Core Course V	MSCCHE CC-5	Advances in Chemistry	5	100
7	Core Course VI	MSCCHE CC-6	Inorganic Chemistry-II	5	100
8	Core Course VII	MSCCHE CC-7	Physical Chemistry-II	5	100
9	Core Course VIII	MSCCHE CC-8	Organic Chemistry-II	5	100
10	Core Course IX	MSCCHE CC-9	Practical (Organic)	5	50+50
11	AEC-1	-		5	50+50

M.Sc. IIIrd Semester

Serial No.	Courses	Code	Description	Credits	Max. Marks (100)
12	Core Course X	MSCCHE CC-10	Application of Spectroscopy	5	100
13	Core Course XI	MSCCHE CC-11	Bio-inorganic Chemistry	5	100
14	Core Course XII	MSCCHE CC-12	Environmental Chemistry and Green Chemistry	5	100
15	Core Course XIII	MSCCHE CC-13	Bio-organic Chemistry	5	100
16	Core Course XIV	MSCCHE CC-14	Practical (Inorganic Chemistry)	5	50+50
17	AECC-2		Human values and professional ethics & Gender sensitization	3+2	50+50

M.Sc. IVth Semester

Serial No.	Courses	Code	Description	Credits	Max. Marks (100)
18	Elective Course-1	MSCCHE EC-1a	Inorganic Chemistry Special	5	100
19	Elective Course-1	MSCCHE EC-1b	Physical Chemistry Special	5	100
20	Elective Course-1	MSCCHE EC-1c	Organic Chemistry Special	5	100
21	Elective Course-2	MSCCHE EC-2a	Inorganic Chemistry Special Practical	5	50+50
22	Elective Course-2	MSCCHE EC-2b	Physical Chemistry Special Practical	5	50+50
23	Elective Course-2	MSCCHE EC-2c	Organic Chemistry Special Practical	5	50+50
24	DSE-1 or GE-1			5	100

Lesson Plan / Teaching Plan for M. Sc Chemistry Semester-I
Session (2022-2023)

Lesson Plan for Core Course - I: Inorganic Chemistry			
CC -I	**Inorganic Chemistry**	**Credits:** 5	**Full Marks:** 70
Teacher: Dr. Khushbu Singh			
Unit I	**Molecular Structure and Bonding (Weeks 1-3)**		
Week 1	**VSEPR Theory and Walsh Diagram**		
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 1: Introduction to VSEPR Theory	Understand the Valence Shell Electron Pair Repulsion (VSEPR) theory for triatomic molecules	Introduction to the (VSEPR) theory. Basic VSEPR shapes: linear, trigonal planar, tetrahedral, trigonal bipyramidal, and octahedral.	Predict shapes of various molecules using VSEPR theory. Examples: Water, ammonia, carbon dioxide
Lecture 2: Walsh Diagrams for Triatomic Molecules	Understand the Overview of Walsh diagrams and their importance in predicting molecular orbitals and geometry.	Walsh diagrams: Construction and molecular geometry prediction for triatomic molecules. Examples: H_2O, CO_2	Draw Walsh diagrams for simple triatomic molecules.
Lecture 3: dπ-pπ Bonding and Bent Rule	Explore dπ-pπ Bonding and Bent Rule.	dπ-pπ Bonding: Interaction between metal d-orbitals and ligand p-orbitals. Bent Rule: Explanation and application. Examples: Transition metal complexes	Solve problems related to hybridization and Bent's rule.
Lecture 4:	Revision class	Application of VSEPR theory. dπ-pπ bonding discussion with examples.	Predict the shape, geometry and bond angle for different polyatomic molecule. Discuss dπ-pπ bonding in SO_4^{2-}, SO_3, PO_4^{3-}.
Lecture 5:	Problem solving class	VSEPR, Bent Rule, dπ-pπ Bonding	Solve questions related to these topics
Week 2	**Energetics of Hybridization**		
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 6:	Discuss the types of	sp, sp^2, sp^3, dsp^2, d^2sp^3	Solve problems

Hybridization: Basic introduction and types with example	hybridization	hybridizations. Examples: Methane, ethylene, complex ions	related to hybridization
Lecture 7: Energetics of hybridization	Determine the energy of hybridization	Energetics of hybridization: Overview and implications.	Problems related to hybridization, bond angle, bond strength etc
Lecture 8: Limitations of Crystal Field Theory (CFT)	Identify and discuss the limitations of CFT and analyze MO diagrams.	Limitations of CFT: Key shortcomings. comparison with Molecular Orbital Theory (MOT) Examples: Complexes that don't fit CFT predictions	Solve problems related to Complexes that don't fit CFT predictions
Lecture 9: Molecular orbital theory - key concepts	Revision session of Homonuclear diatomic molecules	Molecular orbital diagram of O_2, N_2 etc with its bond order, bond length and bond strength	Solve problems related to applications of Molecular orbital theory
Lecture 10:	Problem solving class	Topics: Hybridization, CFT, MOT	Solve problems related to Hybridization, CFT, MOT
Week 3	**Molecular Orbital Theory (MOT)**		
Lecture	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 11: MOT for Hetero-nuclear Diatomic Molecules	Explore the MOT for Hetero-nuclear Diatomic Molecules: Overview and implications.	MO diagrams, bonding and antibonding orbitals Examples: CO, NO	Construct and analyze MO diagrams for selected molecules.
Lecture 12: MOT for Hetero-nuclear Triatomic Molecules	Explore the MOT for Hetero-nuclear Triatomic Molecules: Overview and implications.	MO diagrams, bonding and antibonding orbitals Examples: H_2O, CO_2	Construct and analyze MO diagrams for selected molecules.
Lecture 13: MOT for σ- and π-Bonding	σ- and π-bonding interactions in metal complexes	Molecular Orbital Theory (MOT) for σ- and π-bonding. Examples: O_2, N_2	Construct and analyze MO diagrams for selected molecules.
Lecture 14:	Review the key topics of first unit along with group discussion	Walsh Diagram, Bent rule, CFT limitations, MOT	Solve problems related to these topics

Lecture 15:	Class test of molecular structure and bonding	VSEPR, Walsh Diagram, Bent Rule, Hybridization, CFT, MOT	Solve problems related to the mentioned topics
Unit II	**Magnetochemistry (Weeks 4-5)**		
Week 4	**Basic Concepts**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 16: Electron-Electron Interaction	Study the basics of electron-electron interactions.	Electron-electron interactions: Principles and effects.	
Lecture 17: Rules governing electronic transitions	Study the selection rules for electronic transitions in complexes	Spin selection rule, Laporte selection rule, Beer Lamberts law, Width of absorption band	Solve problems based on selection rules
Lecture 18: Term Symbols	Study the basics of term symbols.	Term symbols: Calculation and interpretation of term symbols for metal complexes	Calculate term symbols and interpret their significance in metal complexes. Examples: $[Fe(CN)6]^{4-}$, $[Co(NH3)6]^{3+}$
Lecture 19: Spin-Orbit Coupling	Study the basics of spin-orbit coupling.	Spin-orbit coupling and its impact on magnetic properties.	Calculate Spin-orbit splitting in transition metals
Lecture 20:	Revision class	Term symbols, Spin-Orbit Coupling	Calculate term symbols and interpret their significance in metal complexes. Calculate Spin-orbit splitting in transition metals
Week 5	**Magnetic Properties**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 21: Orbital contribution: Effect of the ligand field	Study the basic introduction about the ligand field effect on orbital contribution	Ligand field effect on orbital contribution in octahedral and tetrahedral complexes	
Lecture 22: Quenching of Orbital	Quenching of Orbital Contribution and Anomalous Magnetic	Orbital contribution to magnetism, anomalous moments	Examine and discuss case studies of anomalous magnetic

Contribution and Anomalous Magnetic Moments	Moments	Examples: La^{3+}, Ce^{3+}	moments in metal complexes.
Lecture 23: Magnetic Properties of Inner Transition Elements	Analyze magnetic properties, including anomalous magnetic moments and their significance.	Magnetism in lanthanides and actinides Examples: Gadolinium, Uranium	Examine and discuss case studies of anomalous magnetic moments in metal complexes.
Lecture 24: Magnetic Properties and Anomalies	Analyze magnetic properties, including anomalous magnetic moments and their significance.	Anomalous magnetic moments: Causes and explanations.	Examine and discuss case studies of anomalous magnetic moments in metal complexes.
Lecture 25:	Review the key concepts	Quenching of Orbital Contribution and Anomalous Magnetic Moments and Magnetism in lanthanides and actinides	Solve problems related to magnetic moment in Transition and inner Transition metal complexes
Unit III	**Metal-Ligand Equilibrium in Solution (Weeks 6-7)**		
Week 6	**Formation Constants and Stability Trends**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 26: Thermodynamic and kinetic stability of complexes, Stepwise and Overall Formation Constants	Explain the basics behind the Thermodynamic and kinetic stability of complexes, Stepwise and Overall Formation Constants	Thermodynamic and kinetic stability of complexes, Stepwise and Overall Formation Constants Examples: $[Ni(NH3)6]^{2+}$, $[CuCl4]^{2-}$	Calculate formation constants and discuss trends in stability
Lecture 27: Relation between Stepwise and Overall Formation Constants	Derive the relation between Stepwise and Overall Formation Constants	Relationship between Stepwise and Overall Formation Constants, Irving – Williams series	.
Lecture 28: Factors Affecting Stability	Understand the factors affecting stability.	Factors affecting stability: Nature of metal ion and ligand.	Calculate formation constants and discuss trends in stability.
Lecture 29:	Understand the factors	Chelate effect and its	Calculate formation

Chelate effect	affecting stability.	thermodynamic origin.	constants and discuss trends in stability.
Lecture 30:	Review the key concepts based on stability of complexes	Problems based on stability of complexes and chelate effect	Discuss the trends in stability of complexes
Week 7	**Experimental Methods for Determining Formation Constants**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 31: Methods for Determining Formation Constants using pH-metry.	Learn methods for determining formation constants using pH metry.	pH-metry: Principles and applications.	Perform calculations and interpret data from pH-metry.
Lecture 32: Methods for Determining Formation Constants using spectrophotometry	Learn methods for determining formation constants using spectrophotometry.	Spectrophotometry: Techniques and analysis. Calibration curves	Perform calculations and interpret data from spectrophotometry.
Lecture 33:	Mid-Term Exam		
Unit IV	**Reaction Mechanism of Transition Metal Complexes (Weeks 8-10)**		
Week 8	**Kinetics and Mechanisms**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 34: Inert and Labile Complexes	Study the concept of labile and inert complex.	Inert vs. labile complexes, kinetic aspects.	Calculate kinetic aspects of $[Co(NH3)6]^{3+}$ vs. $[CoCl4]^{2-}$
Lecture 35: Inert and Labile Complexes	Study VBT explanation of lability and inertness, Taube's explanation of lability and inertness	VBT explanation of lability and inertness, Taube's explanation of lability and inertness	……
Lecture 36: Kinetic application of VBT and CFT	Study the kinetic application of VBT and CFT	Kinetic application of VBT and CFT	Analyze reaction mechanisms.
Lecture 37: Types of reaction undergone by complexes	Study the basics of different types of reaction of the complexes	Ligand substitution reaction, Electron transfer reaction	
Lecture 38: Kinetics of Octahedral	Study the kinetics of octahedral substitution reactions and related	Mechanisms of substitution in octahedral complexes	Analyse reaction mechanisms.

Substitution	mechanisms.	Examples: $[Co(NH3)5Cl]^{2+}$	
Week 9	**Kinetics of Substitution Reactions**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 39: Acid and Base Hydrolysis	Study the kinetics of octahedral substitution reactions and related mechanisms.	Mechanisms, rates of hydrolysis reactions. Examples: Hydrolysis of $[Fe(H2O)6]^{3+}$	Discuss examples and applications.
Lecture 40: CB Mechanism and Evidence of CB mechanism,	Study the kinetics of octahedral substitution reactions and related mechanisms.	Concerted base mechanism,	Discuss examples and applications.
Lecture 41: Anation reaction, reaction without M_L bond cleavage	Study the kinetics of octahedral substitution reactions and related mechanisms.	Anation reaction, reaction without M_L bond cleavage	
Lecture 42:	Review the key concepts related to S_N1, S_N2, S_N1CB and Anation reaction	Key concepts related to S_N1, S_N2, S_N1CB and Anation reaction	Discuss the topics with examples
Lecture 43:	Class test		
Week 10	**Electron Transfer Reactions**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 44: substitution reactions in square planar complexes,	Explore the trans effect	The trans effect: Theories and applications. Examples: $[PtCl4]^{2-}$	Discuss examples and applications of the trans effect.
Lecture 45: Introduction to Electron transfer reaction	Explore the theories of electron transfer reactions.	Electron transfer reactions: Inner and outer sphere mechanisms Examples: $[Fe(bipy)3]^{2+}$	Discuss examples and applications of the electron transfer mechanisms.
Lecture 46: Inner and Outer Sphere reaction with mechanism	Detailed mechanism of Inner and outer sphere mechanism	Mechanism of Inner and outer sphere mechanism, Difference between Inner and outer sphere reactions	Discuss examples and applications of the electron transfer mechanisms
Lecture 47: Marcus-Hush theory	Explore theory of Marcus-Hush theory	Marcus-Hush theory.	Discuss examples and applications of the Marcus-Hush theory.

Lecture 48:	Revision class	Nucleophilic Substitution Reaction, Trans effect, Electron transfer reactions	Discuss examples of mentioned reactions.
Unit V	**Isopoly and Heteropoly Acids and Salts (Weeks 11)**		
Week 11	**Isopoly and Heteropoly Acids and Salts**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 48: Introduction to Isopoly Acids and Salts	Study isopoly and salts.	Structure and properties of isopoly acids	Draw and analyze the structures of isopoly and heteropoly anions.
Lecture 49: , Introduction to Isopoly Acids and Salts focusing on Mo and W compounds	Study of Isopoly Acids and Salts focusing on Mo and W compounds	Isopoly Acids and Salts focusing on Mo and W compounds. Examples: $[MoO4]^{2-}$, $[W6O19]^{2-}$	
Lecture 50: Introduction to Heteropoly Acids and Salts	Study heteropoly acids and salts, focusing on Mo and W compounds.	Structure and properties of heteropoly acids Examples: $[SiW12O40]^{4-}$	Draw and analyze the structures of isopoly and heteropoly anions.
Lecture 51: Structure of Isopoly and Heteropoly Anions.	Study detailed structure and bonding of isopoly and heteropoly acids and salts.	Detailed structure and bonding Examples: Structure analysis techniques	Draw and analyze the structures of isopoly and heteropoly anions.
Lecture 52:	Revision class	Isopoly and Heteropoly Acids and Salts	Discussed questions based on the mentioned topic
Week 12	**Mid Semester Exam and Presentation**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 53:	Prepare for exam	2nd Mid-term exam	
Lecture 54:		Presentation	
Lecture 55:		Presentation	
Week 13	**Review and Exam Preparation**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 56:	Review key concepts, problem-solving sessions	Comprehensive Review of All Units	
Lecture 57:	Review key concepts,	Comprehensive Review	

	problem-solving sessions	of All Units	
Lecture 58:	Review key concepts, problem-solving sessions	Comprehensive Review of All Units	
Week 14	**Mock Exam and Discussion**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 59:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 60:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 61:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Assessment	Throughout the semester, based on each unit	Short quizzes after each unit to test understanding.	Problem sets and case studies.

Lesson Plan for Core Course - II: Physical Chemistry			
CC -II	**Physical Chemistry**	**Credits:** 5	**Full Marks:** 70
Teacher: Dr. Kumari Seema			
Unit I	**Macromolecules and Polymer Science (Week- 1-3)**		
Week 1	**Introduction, Kinetics and Mechanism of Polymerisation.**		
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 1: Introduction to Polymers	Understand the types of polymers and their importance in chemistry and industry	Types of Polymers: • Natural Polymers: Examples (e.g., proteins, nucleic acids, polysaccharides). • Synthetic Polymers: Types and examples (e.g., addition polymers like polyethylene, condensation polymers like nylon). • Specialty Polymers: Conductive polymers, biodegradable polymers, etc.	Exercises on identifying and classifying polymers from given examples. Group activity: Classify various given polymers based on different criteria.
Lecture 2: Classification of Polymers Types of Polymers	Discuss thermoplastics vs. thermosetting polymers.	Based on source: Natural, Synthetic, and Semi-Synthetic Polymers Based on structure: Linear, Branched, Cross-linked Based on polymerization mechanism: Addition vs. Condensation polymers	Write a brief report comparing addition and condensation polymers with examples.
Lecture 3: Copolymers	Brief discussion on polymer composites and their applications.	Types of copolymers: alternating, block, random, graft Importance of copolymerization in tailoring properties	Find and describe the properties and applications of a commonly used copolymer.
Lecture 4: Polymer Blends	Polymer blends and alloys: why blending is done	Example-based discussion on commercial copolymers (e.g., SBR, Nylon 6,6).	
Lecture 5: Kinetics of Polymerization	Learn about the kinetics of polymerization.	• Rate laws and reaction rates for different types of polymerizations. • Factors Affecting Polymerization: Temperature, pressure, catalysts, and monomer concentration.	Discuss the impact of different variables on polymerization rates and mechanisms.
Week 2	**Kinetics and Mechanisms of Polymerization**		
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**

Lecture 6: Mechanisms of Polymerization	Learn about the mechanisms of polymerization.	□ Types of polymerizations: Addition (chain-growth) and Condensation (step-growth) □ Overview of chain-growth polymerization: initiation, propagation, termination □ Initiate a discussion on the factors affecting polymerization rate.	□ Illustrate the process of addition polymerization using ethylene to polyethylene as an example.
Lecture 7: Free Radical Polymerization	Learn about the mechanisms of polymerization.	□ Detailed mechanism of free radical polymerization □ Initiation: thermal, photochemical, and redox methods □ Propagation and termination reactions □ Inhibitors and retarders □ Discuss the effects of inhibitors on the reaction rate and polymer structure	□ Draw the free radical polymerization process on the board, breaking down each step.
Lecture 8: Ionic Polymerization (Cationic and Anionic)	Research anionic polymerization and find an industrial use case for a polymer produced by this method.	□ Mechanism of cationic polymerization □ Mechanism of anionic polymerization □ Differences between radical and ionic polymerizations □ Industrial applications of ionic polymerizations (e.g., living polymers) □ Compare chain termination in radical vs. ionic polymerizations.	□ Draw and explain the mechanism for isobutylene polymerization via cationic polymerization.
Lecture 9: Step-Growth Polymerization	□ Analyze the polymerization process of polyesters (e.g., PET) and polyamides (e.g., Nylon).	□ Differences between chain-growth and step-growth polymerization □ Mechanism of step-growth (condensation) polymerization □ Kinetics of step-growth polymerization: Carothers' equation	□ Group work: Solve problems on Carothers' equation for determining the degree of polymerization.
Lecture 10:		Research anionic polymerization and find an industrial use case for a polymer produced by this method.	Write a summary on the role of catalysts in step-growth polymerization.
Week 3	**Molecular Mass of Polymers**		
Lecture	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 11: Number-Average and Weight-Average Molecular Mass	□ Perform calculations of Mn and Mw from a given polymer distribution	□ Definition of number-average molecular mass (Mn) □ Definition of weight-average molecular mass (Mw) □ Differences between Mn and Mw, and the concept of polydispersity index	Find examples of polymers with high and low PDI values, explaining their uses and properties.

	dataset.	(PDI) □ Discuss why PDI is important for polymer properties.	
Lecture 12: Determination of Molecular Mass by Osmometry	Calculation of molecular mass using the osmotic pressure equation.	□ Principle of osmometry: osmotic pressure and its relation to Mn □ Types of osmometry: membrane and vapor pressure □ Practical applications of osmometry in polymer science	Provide an example where osmometry is used to determine polymer properties in research or industry.
Lecture 13: Determination of Molecular Mass by Viscosity	□ Concept of intrinsic viscosity and its relation to molecular mass	□ Mark-Houwink equation: [η] = K(Mw)^a □ Applications of viscosity measurements in polymer characterization	Solve viscosity-related problems using real polymer data from literature.
Lecture 14: Principles of Light Scattering	□ Discuss how light scattering helps in understanding polymer size and structure.	□ Rayleigh scattering: relation to molecular mass □ Basics of static and dynamic light scattering □ Determination of Mw using light scattering.	Research on dynamic light scattering and its importance in polymer science.
Lecture 15: Applications of Light Scattering	□ Applications of light scattering in determining polymer structure in solution	□ Analyse a research paper that uses light scattering for polymer mass determination. □ Discuss how light scattering techniques are used in biopolymers (e.g., proteins). □ Real-world examples of polymer characterization using light scattering	Present a case study where light scattering was crucial in understanding a polymer's physical properties.
UNIT II	**Electro Chemistry (Week- 4-6)**		
Week 4	**Electrode Potential, Chemical Potential, and Activity**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 16: Electrode Potential Basics	Explain the derivation of the Nernst equation from the relationship between Gibbs free energy and electrochemical cells**.**	• Definition of electrode potential • Standard electrode potential (E^o) • Relationship between electrode potential and Gibbs free energy (ΔG).	Solve example problems using the Nernst equation to calculate electrode potential for various cell reactions.
Lecture 17: Nernst equation	Explain the derivation of the	• Nernst equation: $E = E^o - (RT/nF)\ln Q$	Calculate the electrode potential

derivation	Nernst equation from the relationship between Gibbs free energy and electrochemical cells**.**		of a given electrochemical cell under non-standard conditions.
Lecture 18: Electrode Potential and Chemical Potential	Illustrate the connection between the Nernst equation and chemical potential.	• Definition of chemical potential (μ). • Connection between electrode potential and chemical potential. • Relationship between activity (a) and concentration (C): a=γCa = γCa=γC, where γ is the activity coefficient. • Impact of chemical potential on the electrode potential	Group work on solving electrochemical cell problems involving concentration changes and activities. Research how chemical potential is used in determining the electrode potential for real-world applications.
Lecture 19: Activity and Its Role in Electrode Potential	Discuss how activity is measured in practical electrochemical systems.	• Definition of activity in electrochemistry • Activity vs. concentration and why activity is used in real systems • Examples of how activity affects electrochemical reactions	Perform calculations comparing electrode potentials using concentration and activity.
Lecture 20: Deriving the Nernst equation with activity terms.	Discuss how activity is measured in electrochemical systems.	Deriving the Nernst equation with activity terms.	Write a short essay explaining the importance of activity in electrochemical cell calculations.
Week 5	**Debye-Hückel Theory of Conductance**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 21: Introduction to the Debye-Hückel Theory	Solve a set of problems based on the Debye-Hückel Limiting Law for	□ Overview of ionic solutions and electrostatic interactions □ Ionic atmosphere and how it affects the movement of ions □ Derivation of the Debye-Hückel	□ **Solve** problems using the Debye-Hückel Limiting Law to calculate activity coefficients in dilute solutions.

	different electrolyte concentrations.	Limiting Law	□ Explain the physical meaning of ionic strength (I) and its importance.
Lecture 22: Application of Debye-Hückel Theory	Calculation of ionic strength and activity coefficients for different electrolyte solutions.	□ Practical applications of the Debye-Hückel theory in determining conductance □ Limiting molar conductivity (Λ^0) and its relationship with ion concentration □ Role of the theory in weak electrolytes and strong electrolytes	Group activity: Discussion on how the Debye-Hückel theory is used in analyzing real solutions.
Lecture 23: Modifications of Debye-Hückel Limiting Law	Discussion on how finite ion size impacts ion conductance in real-world applications.	□ Finite ion size and its impact on the ionic atmosphere □ Debye-Hückel-Onsager equation and its modifications for concentrated solutions □ Incorporation of finite-size ions in the theory	Problem-solving session: Calculate activity coefficients using modified Debye-Hückel theory.
Lecture 24: Ion-solvent interactions and activity coefficients	Solve problems involving activity coefficients with solvent effects.	• Interaction between ions and solvent molecules • How ion-solvent interactions affect activity coefficients and conductance • Concept of solvation and its role in electrochemical reactions.	□ Group discussion on real-world examples where ion-solvent interactions are crucial, such as in biological systems (e.g., ion transport in cells).
Lecture 25: Discussion	Research the limitations of the Debye-Hückel theory and write a one-page report on how these limitations are addressed in modern electrochemical studies.	Analyze a research paper where the modified Debye-Hückel law is used for concentrated solutions and summarize the findings.	Find an example of ion-solvent interaction in a chemical or biological process and write a short summary on how it affects electrochemical behavior.
Week 6	**Butler-Volmer Equation**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 26: Introduction to the Butler-Volmer Equation	Step-by-step derivation of the equation.	□ Overview of electrochemical kinetics and the need for the Butler-Volmer equation □ Derivation of the Butler-Volmer equation:	Revise the class work

Lecture 27: Introduction to the Butler-Volmer Equation	Explanation of the terms	Explanation of the terms: exchange current density (i_0), overpotential (η), charge transfer coefficient (α)	Solve a problem set based on calculating current densities in electrochemical reactions using the Butler-Volmer equation.
Lecture 28: Butler-Volmer Equation: Equilibrium and Non-equilibrium Conditions	Understanding equilibrium conditions	**Understanding equilibrium conditions:** zero overpotential ($\eta = 0$) Non-equilibrium conditions and their impact on current density Role of exchange current density in determining reaction rates	Solve problems related to equilibrium and non-equilibrium current densities. Discuss the significance of exchange current density in electrochemical cells.
Lecture 29: Introduction to the Tafel Plot	Analyze real-world electrochemical systems using the Tafel plot. Construct a Tafel plot from given data and determine the Tafel slope.	Tafel equation Plotting overpotential (η) vs. log of current density (i) Importance of Tafel slope in understanding electrochemical kinetics Relationship between the Tafel equation and the Butler-Volmer equation	Find experimental data from a research article related to Tafel plots and interpret the Tafel slope in the context of reaction kinetics.
Lecture 30: Applications of the Butler-Volmer Equation and Tafel Plot	Exchange current density and Tafel plot analysis	Use of Butler-Volmer equation and Tafel plots in fuel cells, batteries, and corrosion studies Case studies on industrial applications Limitations of the Butler-Volmer model in complex systems	Use of Butler-Volmer equation and Tafel plots in fuel cells, batteries, and corrosion studies
UNIT-III	**Chemical Dynamics**		
Week 7			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 31: Mechanisms and dynamics of consecutive and opposing reactions	Derivation of rate equations for opposing reactions.	Definition and examples of opposing (reversible) reactions: $A \rightleftharpoons B$ Equilibrium constant (K) and its relation to forward and reverse rates	Write a short essay on how opposing reactions apply to reversible chemical processes in

			nature or industry.
Lecture 32: Mechanisms and dynamics of consecutive and opposing reactions	Derivation of rate equations for consecutive reactions.	□ Definition and examples of consecutive reactions □ Rate equations for consecutive reactions: A → B → C □ Steady-state approximation for intermediate formation	Work on example problems involving consecutive reaction mechanisms.
Lecture 33: Mechanisms and dynamics of consecutive and opposing reactions	Dynamic equilibrium and time-dependent concentration profiles	□ Application in multi-step reaction mechanisms (e.g., radioactive decay)	
Lecture 34: Introduction to Activated complex theory of unimolecular reactions	Overview of transition state theory (activated complex theory)	• Energy profile of a reaction: reactants, transition state (activated complex), and products • Unimolecular reactions and their energy barriers • Rate constants and reaction rates derived from activated complex theory	Draw potential energy diagrams showing the activated complex and transition state.
Lecture 35: Application of Activated Complex Theory to Real Systems	Discussion on how activated complex theory is applied in catalysis and enzyme reactions.	□ Application of activated complex theory to gas-phase unimolecular reactions (e.g., Lindemann mechanism) □ Comparison of activated complex theory with collision theory □ Role of entropy and enthalpy in determining the rate of unimolecular reactions	Solve problems on rate constants using the Eyring equation.
Week 8	**Photolysis, Photo-dimerization, and Auto-oxidation**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 36: Mechanism and dynamics of acetaldehyde photolysis	Illustrate and explain the photolysis mechanism of acetaldehyde with reaction steps.	□ Mechanism of photolysis: absorption of light energy, bond dissociation □ Example: photolysis of acetaldehyde □ Energy transfer mechanisms in photochemical reactions	Solve problems on quantum yield in photochemical reactions.
Lecture 37: Mechanism and dynamics of acetaldehyde photolysis	Illustrate and explain the photolysis mechanism of acetaldehyde.	□ Mechanism of photolysis: absorption of light energy, bond dissociation □ Energy transfer mechanisms in photochemical reactions	□ Example: photolysis of acetaldehyde
Lecture 38:	Diagrammatic	□ Mechanism of photo-dimerization:	□ Example:

Photo-dimerization of anthracene	representation of photo-dimerization of anthracene.	reaction of two monomers under light exposure	photo-dimerization of anthracene
Lecture 39: Polymerization reactions	Explain the photo-polymerisation process using the example of a light -activated polymer.	• Polymerization induced by light: chain reactions, radical formation, and propagation.	Write a summary on the role of light in polymerization reactions and its industrial applications (e.g., UV curing).
Lecture 40: Auto-oxidation reactions	Discussion on the role of auto-oxidation in biological systems.	□ Mechanism of auto-oxidation: initiation, propagation, termination □ Example: auto-oxidation of hydrocarbons □ Importance in industrial and environmental chemistry	Research a real-world example of auto-oxidation (e.g., spoilage of fats) and explain how it occurs.
Week 9	**Homogeneous Catalysis and Enzyme Kinetics**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 41: Homogeneous catalysis	Diagrammatic representation of catalytic cycles and intermediate formation.	□ Definition and mechanism of homogeneous catalysis □ Kinetics of catalytic reactions □ Examples of homogeneous catalysts in industrial processes (e.g., hydroformylation)	Write a report on an industrial application of homogeneous catalysis and explain how the catalyst affects the reaction rate.
Lecture 42: Kinetics of enzyme catalysis	Michaelis-Menten equation: derivation and significance	Enzyme-substrate complex formation, reaction rates, and rate constants	Solve problems using the Michaelis-Menten equation to determine Vmax and Km.
Lecture 43: Kinetics of enzyme catalysis	discussion on enzyme inhibitors and their role in controlling biochemical pathways.	Factors affecting enzyme activity: temperature, pH, inhibitors.	Research a specific enzyme and explain its catalytic mechanism in a biological context (e.g., DNA polymerase).
Lecture 44: Study of fast reactions using	Overview of flow methods: continuous flow,	□ Applications in determining the kinetics of fast reactions □ Examples of reactions studied by flow	Summarize the advantages of using flow

flow Methods	stopped flow	methods	methods over conventional kinetic studies, citing a specific example.
Lecture 45: Study of fast reactions using relaxation methods	Analyze relaxation data and calculate rate constants for fast reactions.	□ Temperature-jump (T-jump) and pressure-jump (P-jump) methods □ Use of relaxation methods to study rapid reaction equilibria □ Examples: relaxation studies in acid-base reactions and ligand binding	Discussion on how T-jump and P-jump methods are applied in studying biological systems.
Unit IV	**Chemical Thermodynamics (Week: 10-11)**		
Week 10	**Partial Molar Properties in Ideal Mixtures and fugacity**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 46: Introduction to Partial molar properties in ideal mixtures	Derivation: Total property of a mixture	□ Definition and significance of partial molar properties (e.g., partial molar volume, enthalpy, Gibbs free energy) □ Chemical potential as a partial molar Gibbs free energy	Example problem: Calculation of partial molar volume for an ideal binary mixture.
Lecture 47: Chemical Potential and Variation with Temperature & Pressure	Application of chemical potential in ideal and real mixtures	□ Introduction to chemical potential (μ) □ Relationship between chemical potential and Gibbs free energy	Calculate the variation of chemical potential with temperature and pressure for a given system.
Lecture 48: Derivation of the Gibbs-Duhem equation for an ideal system.		□ Variation of chemical potential with temperature and pressure using Gibbs-Duhem equation	Practice the class work
Lecture 49: Introduction to Fugacity and Fugacity Variation with Temperature and Pressure	Derive the fugacity equation for real gases using the chemical potential. Discuss phase transitions using fugacity and how it helps predict phase changes.	□ Definition of fugacity and its relationship to pressure and chemical potential □ Fugacity of real gases and comparison to ideal gas behaviour □ Introduction to the fugacity coefficient (ϕ) □ Dependence of fugacity on temperature and pressure □ The Clapeyron equation and its role in phase equilibrium □ Fugacity in phase transitions (solid-	Solve problems to calculate fugacity for a gas using fugacity coefficients. Find the fugacity of nitrogen gas at high pressure using data provided. Use the Clapeyron equation to calculate the

		liquid-gas) Calculation of fugacity using thermodynamic data	fugacity of a substance during a phase change (e.g., vaporization).
Lecture 50: Fugacity in Gas Mixtures	Derivation of fugacity expressions for a component in a gas mixture.	Fugacity in gas mixtures and its determination from partial pressures Ideal vs. non-ideal gas mixtures: How fugacity coefficients are used in non-ideal gas mixtures	Calculate the fugacity of each component in a gas mixture at a given temperature and pressure.
Week 11	**Activity and Duhem-Margules Equation**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 51: Introduction to Activity and Activity Coefficients	Discussion on the physical meaning of activity and its importance in chemical reactions.	Definition of activity and activity coefficient (γ) Relation between activity, concentration, and pressure: Activity in ideal vs. real solutions	Solve example problems calculating activity and activity coefficients.
Lecture 52: Activity Variation with Temperature and Pressure	Derive the temperature and pressure dependence of activity from thermodynamic principles.	Dependence of activity on temperature and pressure Derivation of the temperature and pressure dependence of activity coefficients Application of activity in phase equilibria	Problem-solving session: Calculate activity for a real solution as temperature changes.
Lecture 53: The Duhem-Margules Equation and Its Application	Apply the Duhem-Margules equation to calculate the activity coefficients for a binary liquid mixture	Introduction to the Duhem-Margules equation. Importance of the Duhem-Margules equation in describing non-ideal solutions Application of the Duhem-Margules equation in predicting activity coefficients in binary mixtures	Solve problems on calculating activity coefficients using the Duhem-Margules equation.
Lecture 54: Application of Duhem-Margules Equation in Real Systems	Prediction of phase behavior and separation processes (e.g., distillation)	Practical applications of the Duhem-Margules equation in industrial processes	Case study: Use the Duhem-Margules equation to design a distillation column for a binary mixture.
Lecture 55: Review and	Group discussion and	Review of partial molar properties and fugacity	Prepare a quiz on partial molar

Advanced Problem-Solving	Q&A session on challenging concepts.	Review of activity and Duhem-Margules equation	properties, fugacity, and the J-equation.
Unit V	**Statistical Thermodynamics (Week- 12-14)**		
Week 12	**Introduction and Fundamental Concepts**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 56: Introduction to Statistical Thermodynamics	Definitions: Thermodynamic probability and relation to macroscopic observables. quantities.	□ Overview of Statistical Thermodynamics and its significance in macroscopic and microscopic systems. □ Introduction to states, phase space, and the concept of a microstate and macrostate.	Read about the different types of ensembles and provide real-life examples of each.
Lecture 57: Ensembles in Statistical Mechanics		□ Microcanonical **Ensemble**: Fixed energy, volume, and particle number (E, V, N) □ Definition of thermodynamic probability for isolated systems	Calculate the number of microstates for an isolated system
Lecture 58: Boltzmann Distribution Law, Canonical Ensemble and the Concept of Temperature	Derivation of the Boltzmann distribution from the canonical ensemble.	□ Canonical **Ensemble**: Fixed temperature, volume, and particle number (T, V, N) □ Probability distribution of energy levels using the **Boltzmann Distribution Law** □ Derivation of the canonical partition function.	Apply the Boltzmann Distribution Law to a system of particles.
Lecture 59: Grand Canonical Ensemble and Chemical Potential	Derivation of the grand canonical partition function.	□ Grand **Canonical Ensemble**: Fixed temperature, volume, and chemical potential (T, V, μ) □ Introduction to chemical potential and its role in open systems.	Discuss real-life systems described by the grand canonical ensemble.
Lecture 60: Thermodynamic Probability and Boltzmann Planck Equation	Apply the Boltzmann-Planck equation to calculate entropy in a simple system (e.g., ideal gas).	□ Further exploration of **thermodynamic probability** and how it governs system behavior. □ Boltzmann-**Planck Equation**: Relationship between entropy and probability. □ Entropy maximization and equilibrium conditions.	calculate probabilities for different energy levels.
Week 13	**Partition Function and Its Significance**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 61: Partition Function and	How thermodynamic properties are	□ Definition and significance of the Partition Function (Z). □ Derivations: Internal Energy,	Derive the expression for Helmholtz Free

Thermodynamic Quantities	derived from the partition function.	Helmholtz Free Energy, Entropy.	Energy using the partition function.
Lecture 61: Translational Partition Function	Deriving the **Translational Partition Function**.	□ Partition function for monatomic ideal gases. □ Connection to thermodynamic quantities like pressure and internal energy.	Derive internal energy and pressure for an ideal gas using the translational partition function.
Lecture 63: Rotational Partition Function	**Rotational Partition Function** for diatomic molecules.	• Quantum mechanical treatment of rotational motion. • Low-temperature vs high-temperature behavior of rotational states.	Calculate the rotational partition function for a diatomic molecule (e.g., H_2).
Lecture 64: Vibrational Partition Function	**Vibrational Partition Function** for diatomic molecules.	□ Harmonic oscillator model for vibrational motion. □ Vibrational contribution to thermodynamic quantities.	Derive the vibrational energy for a diatomic molecule at room temperature.
Lecture 65: Electronic Partition Function and Overall Partition Function	**Electronic Partition Function** for diatomic molecules.	**Electronic Partition Function**: Contribution of electronic energy levels to the total partition function. Combining translational, rotational, vibrational, and electronic partition functions to describe a complete system.	Combine the different types of partition functions to derive the total partition function for a diatomic molecule.
Week 14	**Applications of Statistical Thermodynamics**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 66: Thermodynamic Functions from Partition Function	Applying partition functions to predict phase transitions.	Deriving thermodynamic quantities from the partition function: Free energy, entropy, and heat capacity.	Calculate the heat capacity of a system using its partition function.
Lecture 67: Sakur-Tetrode Equation and Applications	Derivation of the Sakur-Tetrode Equation for monatomic gases.	□ Applications of the Sakur-Tetrode equation to calculate entropy. □ Discussion on how the equation can be used to understand real gas behaviour**.**	Use the Sakur-Tetrode equation to calculate the entropy of a noble gas.
Lecture 68: Application of partition functions in monatomic and diatomic		□ Case study: Application of statistical thermodynamics to monatomic and diatomic molecules. □ Calculation of thermodynamic properties of simple gases (e.g., Helium, Oxygen).	Calculate the partition function and use it to determine the thermodynamic properties of an ideal gas.

molecules			
Lecture 69: Statistical Approach to Thermodynamic Properties	Relationship between partition functions and measurable thermodynamic quantities.	□ Entropy, energy, and specific heat capacity derived statistically. □ Real-world applications in predicting gas behavior at high and low temperatures.	Compare classical and statistical approaches to calculating heat capacities of gases.
Lecture 70: Advanced Applications and Review	Advanced applications of statistical thermodynamics in real-world systems.	Review of key concepts: Ensembles, partition functions, Boltzmann Distribution, and thermodynamic properties.	Use of statistical mechanics in predicting chemical reaction rates, phase transitions, and more.
Week 15	**Review and Exam Preparation**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 71:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 72:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 73:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 74:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 75:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Assessment			

Lesson Plan for Core Course - III: Organic Chemistry			
CC -III	**Organic Chemistry**	**Credits:** 5	**Full Marks:** 70
Teacher:			
Unit I	**Nature of Bonding in Organic Molecules (Week 1-2)**		
Week 1			
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 1: Introduction to Delocalized Chemical Bonding	Introduction to delocalized bonding: Conjugation and resonance. Stability of molecules due to resonance.	Conjugation: Definition, types (linear, cross conjugation). Resonance: Resonance structures, resonance hybrid, and resonance energy.	Draw resonance structures of simple molecules (e.g., phenol, aniline) and identify the most stable structure.
Lecture 2: Hyperconjugation and Tautomerism	Drawing hyperconjugation in alkenes and stability order of alkenes. Mechanisms of tautomeric interconversion.	**Hyperconjugation**: Concept and examples Effects of hyperconjugation on stability, bond lengths, and acidity. **Tautomerism**: Keto-enol tautomerism, amide-imidic acid tautomerism.	Explain hyperconjugation in isopropyl benzene. Compare keto and enol forms for acetone.
Lecture 3: Aromaticity in Benzenoid Compounds	Introduction to aromaticity and the concept of cyclic delocalization.	Criteria for aromaticity (Hückel's Rule): **4n+2 π-electron rule**. Benzenoid **Compounds**: Properties of benzene and other aromatic compounds (e.g., naphthalene, anthracene).	Apply Hückel's rule to benzene, naphthalene, and anthracene. Identify whether compounds like pyridine and furan are aromatic based on Hückel's rule.
Lecture 4: Aromaticity in Non-Benzenoid Compounds	Explanation of aromaticity in non-benzenoid compounds. Discussion of alternant and non-alternant hydrocarbons.	**Non-Benzenoid Compounds**: Definition and examples (e.g., azulene, tropylium ion). Drawing structures of non-benzenoid aromatic systems and discussing their aromaticity.	Draw the structure of azulene and explain why it's aromatic.
Lecture 5: Huckel's Rule and Anti-Aromaticity	Deep dive into **Hückel's Rule** for determining aromaticity. Anti-aromatic systems follow **4n π-electron rule**.	Anti-**Aromaticity**: Definition, examples, and characteristics (e.g., cyclobutadiene, cyclooctatetraene). Energy levels of molecular orbitals in anti-aromatic	Explain why cyclooctatetraene is not aromatic but adopts a tub-shaped conformation to avoid anti-

		systems.	aromaticity.
Week 2			
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 6: Annulenes and Aromaticity in Larger Systems	Discussion on aromaticity in larger conjugated cyclic systems.	Definition and properties of **Annulenes** (e.g., [10]-annulene, [18]-annulene). Stability and aromaticity of annulenes.	Analyze the structure of [14]-annulene and discuss its aromaticity or anti-aromaticity.
Lecture 7: Homo-Aromaticity and Aromatic Stabilization	Discuss real examples of homo-aromatic systems (e.g., cyclopropyl cation).	□ Introduction to **Homo-Aromaticity**: What makes a compound homo-aromatic. □ Stability comparison between aromatic, anti-aromatic, and homo-aromatic systems.	Provide a detailed structure of a homo-aromatic molecule and explain its stability.
Lecture 8: PMO Approach to Aromaticity	Problem-solving session applying PMO theory to various conjugated systems.	**Perturbation Molecular Orbital (PMO) Theory**: Basics and how it differs from traditional approaches. Application of PMO theory to explain aromaticity.	Use PMO theory to explain the aromaticity of benzene.
Lecture 9: Molecular Orbital (MO) Theory and Aromaticity	Drawing molecular orbital diagrams for benzene and analyzing its aromatic stability.	□ Molecular orbital theory applied to conjugated systems. □ Energy levels of molecular orbitals in aromatic, anti-aromatic, and non-aromatic compounds.	Draw the molecular orbital diagram of cyclopropenyl cation and explain its aromaticity.
Lecture 10: Review and Problem-Solving Session	Review of key concepts from the entire unit: Delocalized bonding, aromaticity, resonance, hyperconjugation.	□ Solving complex problems related to aromaticity in both benzenoid and non-benzenoid compounds. □ Discussion on exceptions to Hückel's Rule.	Prepare for a quiz on the key concepts of aromaticity and bonding.
Unit II:	**Stereochemistry (Week 3-5)**		
Week -3	**Introduction to Stereochemistry**		
Lecture	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 11: Introduction to Stereochemistry and Chirality	Identifying chiral molecules and symmetry elements in given examples.	□ Chirality: Definition, importance in chemistry, examples. □ Elements of Symmetry:	Identify chiral centers and symmetry elements in 2-butanol, methane, and ethane.

		Plane of symmetry, center of symmetry, improper axes.	
Lecture 12: Molecules with More Than One Chiral Center	Drawing diastereomers of tartaric acid, meso compounds.	□ Molecules with multiple chiral centers. □ Diastereomers vs. Enantiomers. □ Examples: Tartaric acid, glucose, and more.	Identify the number of stereoisomers in 2,3-dibromobutane and 2,3-butanediol.
Lecture 13: Determination of Relative and Absolute Configuration	Assigning configurations to stereocenters. Practice problems assigning R/S configurations.	□ Relative **Configuration** (D/L system). □ Absolute **Configuration**: R/S notation, Cahn-Ingold-Prelog rules.	Assign the configuration to stereocenters in lactic acid and 2-bromobutane.
Lecture 14: Methods of Resolution of Racemic Mixtures	Calculation of optical purity and EE in example problems.	• **Resolution**: Techniques for separating enantiomers. • Chemical resolution, enzymatic methods, kinetic resolution.	Calculate the optical purity for a mixture of 70% R and 30% S enantiomers.
Lecture 15: Methods of Resolution of Racemic Mixtures		Optical Purity and Enantiomeric Excess (EE).	
Week 4	**Asymmetric Synthesis and Its Importance**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 16: Prochirality, Enantiotopic, and Diastereotopic Groups	Identify prochiral centers and enantiotopic faces in molecules like ethanol and acetone.	□ Prochirality: Definition and examples. □ Enantiotropic and Diastereotopic Groups: Identification and importance.	Identify enantiotopic hydrogens in propanol.
Lecture 17: Asymmetric Synthesis and Its Importance	**Asymmetric Synthesis**: Definition, importance in producing enantiomerically pure compounds.	Discuss examples of important industrial asymmetric synthesis reactions. Key reactions: Sharpless epoxidation, asymmetric hydrogenation.	Research an industrial process involving asymmetric synthesis.
Lecture 18: Conformational Analysis of	Draw chair conformations and predict the most stable	• Conformational **Analysis**: Chair and boat forms of	Predict the stability of methylcyclohexane

Cycloalkanes (Six-Membered Rings)	conformer.	cyclohexane. • Axial vs. Equatorial positions, stability of different conformers.	conformers and explain why.
Lecture 19: Conformational Analysis of Decalins	Describe the impact of conformation on the reactivity of cis- and trans-decalin.	□ Conformation of **Decalins**: Cis and trans-decalin, their properties. □ Effect of conformation on reactivity and stability.	Draw and compare the conformations of cis- and trans-decalin.
Lecture 20: Effect of Conformation on Reactivity	Analyze how conformation impacts reactivity in the substitution reactions of cyclohexyl derivatives.	□ How molecular conformation impacts chemical reactivity. □ Examples: Substitution and elimination reactions.	Predict the reactivity of substituted cyclohexanes in an elimination reaction.
Week 5			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 21: Optical Activity in the Absence of Chiral Carbon	Identifying optically active biphenyls and allenes and Conditions for chirality in these systems.	Optical Activity in molecules without a chiral center: Biphenyls, Allenes, and Spiranes.	Draw the structure of an optically active allene and explain its chirality.
Lecture 22: Chirality Due to Helical Shape	Explore the stereochemistry of helical molecules and predict their optical activity.	Chirality in Helical Molecules: Introduction and examples (e.g., helicenes).	Draw the structure of helicene and explain why it exhibits chirality.
Lecture 23: Stereospecific Reactions	Discussion on examples of stereospecific reactions (e.g., catalytic hydrogenation, E2 elimination).	**Stereospecific Reactions**: Mechanism and examples. Impact of stereochemistry on reactivity and selectivity in organic reactions.	Identify a stereospecific reaction and explain the stereochemical outcome.
Lecture 24: Stereoselective Reactions	Discussion on examples of stereoselective reactions (e.g., catalytic hydrogenation, E2 elimination).	**Stereoselective Reactions**: Mechanism and examples. Difference between stereospecific and stereoselective reactions.	Predict the stereochemical outcome of a nucleophilic substitution reaction involving a chiral substrate.
Lecture 25: Advanced Topics in Stereochemistry	How stereochemistry affects drug design and function in pharmaceutical chemistry.	Case studies in advanced stereochemistry.	Research and summarize the stereochemistry of a drug like thalidomide or

			ibuprofen.
Unit III	**Reaction Mechanism: Structure and Reactivity (Week 6-8)**		
Week 6	**Introduction to Reaction Mechanisms**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 26: Types of Reactions:	Overview of Types of Reactions: Difference between Kinetic and Thermodynamic Control.	of Types of Reactions: Substitution, elimination, addition, rearrangement, and redox. Examples of kinetic and thermodynamic products (e.g., enol-keto tautomerism).	Research an example of a thermodynamically favored reaction and a kinetically favored one.
Lecture 27: Hammond's Postulate and Transition States	Drawing and interpreting energy diagrams for exergonic and endergonic reactions.	Hammond's **Postulate**: Understanding the correlation between transition state and reactants/products. Potential **Energy Diagrams**: Reactants, products, transition states, intermediates.	Create potential energy diagrams for the SN1 and SN2 reactions.
Lecture 28: Curtin-Hammett Principle	Analyze a reaction where the Curtin-Hammett principle applies.	Introduction to the **Curtin-Hammett Principle**: Understanding when two intermediates lead to different products. Examples where the principle applies (e.g., conformational equilibria).	Apply the Curtin-Hammett principle to predict product distribution in a given reaction.
Lecture 29: Transition States and Intermediates	Difference between **Transition States** and **Intermediates**.	Methods to identify and study intermediates (e.g., spectroscopy, trapping).	Identify transition states and intermediates in the electrophilic addition reaction of alkene.
Lecture 30: Methods of Determining Reaction Mechanisms	Analyze a mechanism using kinetic data. **Reaction kinetics** as a tool to determine reaction order and rate laws.	Experimental methods to elucidate mechanisms: **Kinetic studies**, **Isolation of intermediates**, **Spectroscopy**.	Outline steps to determine the mechanism of a reaction using kinetic studies.
Week 7			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 31:	Identify isotope effects	Introduction to Isotope	Case study: Isotope

Isotope Effects in Mechanisms	in a simple organic reaction and explain their significance.	Effects: Primary and secondary isotope effects. Application of isotope effects in reaction mechanism studies (e.g., D/H exchange).	effects in substitution reactions.
Lecture 32: Generation, Structure, stability and reactivity of Carbocations	Discuss how structure influences the stability and reactivity of carbocations (e.g., methyl vs. tertiary).	Generation of **Carbocations**: Common methods (e.g., heterolysis). Structure and stability of carbocations: Hyperconjugation, inductive effects	Draw the structures of several carbocations and predict their relative stabilities.
Lecture 33: Generation, Structure, stability and reactivity of **Carbanions**	Compare the stability of carbanions in different molecules (e.g., acetylide anion vs. methyl anion).	• Formation and structure of **Carbanions**. • Factors affecting carbanion stability: Inductive and resonance effects.	Predict the stability of carbanions in substituted alkenes and alkynes.
Lecture 34: Free Radicals: Structure and Reactivity	Case study: Free radical halogenation of alkanes.	**Free Radicals**: Generation, structure, and stability. Reactions involving free radicals: Addition, substitution.	Draw the mechanism of free radical chlorination of methane.
Lecture 35: Carbenes and Nitrenes		Introduction to **Carbenes**: Generation, structure, singlet and triplet carbenes. Nitrenes: Formation and reactivity.	Explain the differences in reactivity between singlet and triplet carbenes.
Week 8	**Effect of Structure on Reactivity**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 36: Effect of Structure on Reactivity	Examine the effect of electron-donating and electron-withdrawing groups on reactivity.	• Influence of molecular structure on reaction rates and reactivity. • **Electronic Effects**: Inductive, resonance, hyperconjugation. • **Steric Effects**: How bulky groups influence reaction pathways.	Predict the reactivity of substituted benzenes in electrophilic substitution.

Lecture 37: The Hammett Equation	Analyze a reaction using Hammett plots and data.	Introduction to the **Hammett Equation**: Quantitative analysis of substituent effects. Substituent constants (σ) and reaction constants (ρ).	Calculate the ρ value for a reaction and explain its significance.
Lecture 38: Linear Free Energy Relationships (LFER)	Apply LFER to study the effect of substituents in a nucleophilic substitution reaction.	• Understanding **Linear Free Energy Relationships (LFER)**. • How the Hammett equation fits within LFER principles.	Identify reactions where LFER is applicable.
Lecture 39: The Taft Equation	Compare the Taft equation with the Hammett equation in predicting reaction behavior.	Introduction to the **Taft Equation**: Understanding steric and polar effects in reactions. Taft's constants and their application in predicting reaction outcomes.	Solve problems using the Taft equation to predict reaction rates.
Lecture 40: Review and Problem-Solving Session	Problem-solving session with focus on advanced mechanism determination.	Comprehensive review of all major concepts:	Prepare for the final quiz on reaction mechanisms, focusing on structure and reactivity relationships.
Unit IV:	**Aliphatic and Aromatic Nucleophilic Substitution**		
Week 9	**Introduction to Nucleophilic Substitution**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 41: Introduction to Nucleophilic Substitution	Overview of Aliphatic Nucleophilic Substitution.	Introduction to SN2 and SN1 mechanisms: Key concepts, differences, and examples.	Discuss common examples of SN1 and SN2 reactions (e.g., methyl bromide with hydroxide).
Lecture 42: Mixed SN1 and SN2 Mechanisms	Compare the reaction conditions that favor mixed SN1/SN2 reactions.	Introduction to **mixed SN1/SN2 mechanisms**: When both mechanisms may be operative. Conditions that influence the pathway selection.	Research examples of reactions showing mixed mechanisms.
Lecture 43: SN i (Substitution	Predict the stereochemistry of the	Mechanism and characteristics of **SNi**	Discuss the stereochemistry of

Nucleophilic Internal)	product for an SNi reaction.	reactions. □ Importance of stereochemistry and inversion/retention in the product.	substitution reactions.
Lecture 44: Single Electron Transfer (SET) Mechanisms	Draw mechanisms involving SET pathways.	• Introduction to **SET** in nucleophilic substitution. • Examples of radical pathways in substitution reactions.	Identify a radical nucleophilic substitution and explain its mechanism.
Lecture 45: Neighbouring Group Participation (NGP)	Show examples where NGP assists the reaction (e.g., alkyl halides).	□ Neighbouring **group participation (NGP)**: Definition and types. □ Participation by **π bonds** and **σ bonds**.	Research anchimeric assistance and provide an example.
Week 10			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 46: Anchimeric Assistance	Analyze a reaction with anchimeric assistance and discuss its stereochemistry.	□ Detailed discussion of anchimeric assistance in substitution. □ Impact on reaction rates and stereochemistry.	Find real-world reactions where anchimeric assistance significantly affects the mechanism.
Lecture 47: Classical and Non-Classical Carbocations	Compare the stability of different carbocations and how they influence substitution.	□ Understanding **classical carbocations** and **non-classical carbocations**. □ Discussion of **phenonium ions** and their stability.	Draw and explain the difference between classical and non-classical carbocations.
Lecture 48: Factors Affecting Reactivity in Nucleophilic Substitution	Predict reactivity in a given nucleophilic substitution with different leaving groups.	Effect of substrate structure, nucleophile, leaving group, and solvent on reactivity.	Case study: Comparison of nucleophiles and their reactivity in SN1/SN2 reactions.
Lecture 49: Ambident Nucleophiles and Regioselectivity	Examine examples of ambident nucleophiles (e.g., cyanide ion, enolates).	□ Introduction to **ambident nucleophiles**: How and why they attack different sites. □ Regioselectivity in substitution reactions.	Identify a reaction where regioselectivity plays a key role and explain why.
Lecture 50: Substitution at Allylic, Aliphatic	Discuss specific examples such as allylic bromination and	□ Nucleophilic **substitution** at unique positions: Allylic, aliphatic	Draw mechanisms for substitution at allylic and vinylic

Trigonal, and Vinylic Carbons	vinylic substitution.	trigonal, and vinylic. Examples and discussion on reactivity in these contexts.	positions.
Week 11	**Aromatic Nucleophilic Substitution: Overview**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 51: Introduction to Aromatic Nucleophilic Substitution	Analyze conditions that favor aromatic nucleophilic substitution (e.g., strong electron-withdrawing groups).	Key differences from aliphatic. ArSN1 and ArSN2 mechanisms.	Predict the products of an ArSN2 reaction with a given substrate and nucleophile.
Lecture 52: Benzyne and SRN1 Mechanisms	Mechanism and examples of **Benzyne** formation in nucleophilic substitution.	**SRN1** mechanism: Radical involvement in nucleophilic substitution.	Draw the benzyne mechanism and discuss factors affecting benzyne formation.
Lecture 53: Factors Affecting Reactivity in Aromatic Substitution	Analyze the effect of different substituents on aromatic nucleophilic substitution rates.	Substrate structure, leaving group, and nucleophile effects in **aromatic nucleophilic substitution**.	Research and present a reaction where aromatic nucleophilic substitution was influenced by a specific substituent.
Lecture 54: Rearrangement Reactions: Von-Richter,		Introduction to the **Von-Richter**, Mechanisms and applications of these	
Lecture 55: Sommelet-Hauser, and Smiles		Introduction to the **Sommelet-Hauser**, and **Smiles rearrangements**. Mechanisms and applications of these	
Unit V:	**Aliphatic Electrophilic Substitution, Aromatic Electrophilic Substitution, and Elimination Reactions**		
Week 12	**Introduction to Aliphatic Electrophilic Substitution**		
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 56: Overview of Aliphatic Electrophilic Substitution.	Discuss the basic principles of electrophilic substitution reactions and provide simple examples.	Introduction to **SE2** and **SE1** mechanisms.	Draw the mechanisms for SE2 and SE1 reactions and compare their key features.

Lecture 57: Electrophilic Substitution Accompanied by Double Bond Shifts	Analyze how the substrate structure and solvent impact the reactivity of electrophilic substitution reactions.	□ Double bond shifts in electrophilic substitution. □ Effect of substrate, leaving group, and solvent polarity on reactivity.	Research examples of electrophilic substitution reactions where a double bond shift occurs.
Lecture 58: Introduction to Aromatic Electrophilic Substitution	Overview of **Aromatic Electrophilic Substitution** and comparison with aliphatic substitution.	The **Arenium Ion Mechanism**: Key steps and energy profile. Draw the arenium ion mechanism for a specific reaction and predict the product.	Show an example of an aromatic electrophilic substitution (e.g., nitration of benzene) and draw the mechanism.
Lecture 59: Orientation and Reactivity in Aromatic Electrophilic Substitution	Role of electron-donating and electron-withdrawing groups in directing **ortho**, **meta**, and **para** positions.	Factors influencing orientation and reactivity in aromatic substitution. Discuss examples of reactions where substituents direct to different positions on the aromatic ring.	Predict the major products for electrophilic substitution on toluene and nitrobenzene.
Lecture 60: Ortho/Para Ratio and Ipso Attack	Research the factors that increase the ortho/para ratio in a specific reaction.	□ Detailed analysis of the **ortho/para ratio** in electrophilic substitution. □ Introduction to **ipso attack** and its significance.	Discuss examples where ipso attack is significant in aromatic substitution
Week 13			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 61: Diazonium Coupling Reaction	**Diazonium coupling**: Mechanism and importance in organic synthesis.	Walkthrough of the mechanism for diazonium coupling with an aromatic compound. Applications of diazonium salts in producing azo compounds.	Provide examples of dyes synthesized via diazonium coupling reactions**.**
Lecture 62: Vilsmeier Reaction	Draw the mechanism of the Vilsmeier reaction for a given aromatic compound.	□ Introduction to the Vilsmeier reaction. □ Mechanism and application of the Vilsmeier reaction in aromatic formylation.	Mechanism walkthrough with a focus on electrophilic aromatic substitution.
Lecture 63: Gattermann-Koch Reaction	Show a detailed energy profile for the Gattermann-Koch reaction.	Mechanism of the Gattermann-Koch reaction and its use in formylation of benzene rings.	Predict the products of a Gattermann-Koch reaction with a substituted benzene ring.
Lecture 64:	Draw the mechanism	□ Introduction to	Discuss examples of

Introduction to Elimination Reactions: E2 Mechanism	for an E2 elimination reaction and discuss the stereochemistry.	Elimination Reactions. Detailed study of the E2 mechanism: Characteristics, stereochemistry, and kinetics.	E2 eliminations and their stereoselectivity.
Lecture 65: E1 Mechanism	Compare and contrast E1 and E2 mechanisms, focusing on the stability of intermediates.	Detailed study of the E1 mechanism: Characteristics, intermediates, and factors influencing the reaction.	Draw the E1 mechanism for a specific compound and predict the major product.
Week 14			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 66: ElcB Mechanism	Discuss an example where the ElcB mechanism is operative and show the stepwise pathway.	Introduction to the ElcB mechanism and its differences from E1 and E2. Conditions that favour the ElcB pathway.	Research an example of an elimination reaction following the ElcB mechanism.
Lecture 67: Orientation of the Double Bond in Elimination Reactions	Apply Zaitsev's and Hofmann's rules to predict the major product of an elimination reaction.	Factors determining the **orientation of the double bond** in elimination reactions. Zaitsev's Rule vs. Hofmann's Rule.	Predict the major product for an elimination reaction involving a bulky base.
Lecture 68: Reactivity in Elimination Reactions	Analyze the role of a strong vs. weak base in E1 and E2 reactions.	Effect of substrate structure, base, leaving group, and solvent on the reactivity of elimination reactions.	Compare the reactivity of different leaving groups in an elimination reaction.
Lecture 69: Pyrolytic Elimination Mechanism	Show the mechanism of pyrolytic elimination and discuss the effect of temperature.	Introduction to **pyrolytic elimination**: Mechanism and examples. Pyrolysis of esters, amines, and other functional groups.	Research the pyrolytic elimination of esters and draw the mechanism.
Lecture 70: Summary and Review	Work through practice problems on substitution and elimination mechanisms.	Problem-solving session to consolidate understanding.	Prepare for a quiz on the mechanisms and factors affecting substitution and elimination reactions.
Week 15	**Review and Exam Preparation**		
Lecture	**Objective**	**Topics Covered**	**Activity/**

			Assignments
Lecture 71:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 72:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 73:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 74:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Lecture 75:	Review key concepts, problem-solving sessions	Practice exam questions, discuss answers and clarify doubts	
Assessment			

Lesson Plan for Core Course - I: Chemistry			
CC -IV	**Physical Chemistry Lab**	**Credits:** 5	**Full Marks:** 70
Teacher:			
Unit I			
Week 1			
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 1: **Lecture 2:** **Lecture 3:**		To determine the distribution coefficient of Acetic acid Between water and benzene by partition method.	
Week 2			
Lecture /Topic	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 4: **Lecture 5:** **Lecture 6:**		To determine the distribution coefficient of Acetic acid Between water and benzene by partition method.	
Week 3			
Lecture	**Objective**	**Topics Covered:**	**Activity/ Assignments**
Lecture 7: **Lecture 8:** **Lecture 9:**		To determine the distribution coefficient of Benzoic acid Between water and benzene by partition method.	
Week 4			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 10: **Lecture 11:** **Lecture 12:**		Determination of rate constant of hydrolysis of methyl acetate in acid medium.	
Week 5			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 13: **Lecture 14:** **Lecture 15:**		The study of saponification of ethyl acetate by sodium hydroxide and determination of rate constant.	
Week 6			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 16: **Lecture 17:** **Lecture 18:**		Determination of rate constant by inversion of cane sugar by	

		polarimetrically	
Week 7			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 19: **Lecture 20:** **Lecture 21:**		Determination of Dissociation constant of acetic acid.	
Unit IV			
Week 8			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 22: **Lecture 23:** **Lecture 24:**		Determination of Acid-base titration.	
Week 9			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 25: **Lecture 26:** **Lecture 27:**		Determination of Solubility product of sparingly soluble salt.	
Week 10			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 28: **Lecture 29:** **Lecture 30:**		Water equivalent of calorimeter and determination of Heat of solution of potassium nitrate.	
Week 11			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 31: **Lecture 32:** **Lecture 33:**		Water equivalent of calorimeter and determination of Heat of neutralization of strong acid and strong base.	
Week 12			
Lecture	**Objective**	**Topics Covered**	**Activity/ Assignments**
Lecture 34: **Lecture 35:**		Water equivalent of calorimeter and determination of Basicity of polybasic acids.	
Week 13	**Review and Exam Preparation**		
Week 14			
Assessment			

COURSE OUTCOME

M.A ECONOMICS

FIRST SEMESTER

Course Title: Micro Economics Analysis I

Course code: CC 01

Credits: 5

Outcome: The paper aims to understand the economic behaviour of individuals, firms, and markets. It is mainly to equip the students with a rigorous and comprehensive understanding of the various aspects of consumer behaviour and demand analysis, production theory and behaviour of costs, the theory of traditional markets, and the equilibrium of firms.

Course Title: Macro Economics Analysis I

Course code: CC 02

Credits: 5

Outcome: Macro Economics-I paper provides an elementary theoretical foundation of key issues and policies. The paper attempts to discuss the functional relationships between aggregates. It helps understand the overall structure of the economy in theoretical and contemporary perspectives for Ist semester postgraduate students.

Course Title: Quantitative Method I

Course code: CC 03

Credits: 5

Outcome: Outcome of this paper is to develop a mathematical approach in analysis of economic problems. It mainly focuses on mathematical techniques which are directly useful in economic analysis. All the techniques are explained with examples of economics.

Course Title: History of Economic Thought

Course Code: CC 04

Credits: 5

Outcome: The course explores the development of economic theories and ideas from ancient to modern times. It examines key contributions from thinkers like Adam Smith, Karl Marx, John

Maynard Keynes, and others, tracing the evolution of concepts such as capitalism, socialism, and market economies. Students learn to critically analyze the historical context of economic theories, understand their impact on contemporary economic policies, and gain insights into the philosophical and ethical underpinnings of economic thought. The course fosters a deep understanding of how past economic ideas shape current economic practices and debates.

Course Title: Environments Sustainability (3 credits) & Swachchha Bharat Abhiyan Activities (2 credits)
Course Code: AECC 1
Credits: 5
Outcome: The course focuses on understanding sustainable practices and the significance of cleanliness initiatives in India. It examines environmental challenges like pollution, waste management, and resource conservation, while also exploring the goals and impact of the Swachh Bharat Abhiyan. Students learn to design and implement sustainability projects, analyze policies promoting environmental health, and engage in community-based cleanliness activities. The course aims to cultivate a strong sense of environmental responsibility, equipping students with the knowledge and skills to contribute to sustainable development and the Swachh Bharat mission.

SECOND SEMESTER

Course Title: Indian Economy – Issues & Policies – 1
Course Code: CC 05
Credits: 5
Outcome: Issues in the Indian Economy shall provide basic knowledge on national income accounting, various issues involved in agricultural, industrial, trade sectors, public institutions, and finally human resources development.

Course Title: Economics of Growth & Development – 1
Course Code: CC 06
Credits: 5
Outcome: The paper provides the fundamental foundation of basic growth and development issues, approaches, and models. The paper attempts to discuss the structure and change in

variables. It helps understand the overall static and dynamic perspectives of the economy in a purely theoretical perspective.

Course Title: Micro Economics Analysis II

Course code: CC 07

Credits: 5

Outcome: The paper aims to analyze the economic behaviour of individuals, firms, and markets. It is mainly to equip the students with a rigorous and comprehensive understanding of the various aspects of consumer behaviour and Economic Welfare, Firm's behaviour, and the theory of imperfect markets and equilibrium in different conditions.

Course Title: Macro Economics Analysis II

Course code: CC 08

Credits: 5

Outcome: Macro Economics paper provides a theoretical foundation of some advanced issues and policies. The paper attempts to discuss the functional relationships between economic aggregates. It helps understand the overall structure of the economy in a theoretical perspective at higher level.

Course Title: Statistical Methods

Course code: CC 09

Credits: 5

Outcome: The paper aims to familiarise the students with basic statistical techniques. The whole syllabus is divided into two parts; descriptive and inferential statistics, with major emphasis on inferential statistics. Statistical techniques are discussed with examples from economics.

THIRD SEMESTER

Course Title: Indian Economy – Issues & Policies – II

Course Code: CC 10

Credits: 5

Outcome: This section of the Indian Economy will provide knowledge on Population and employment, along with various issues involved in social aspects like poverty, inequality, regional imbalance, child labor, etc. Moreover, the fiscal, financial, and external sectors including the Bihar Economy.

Course Title: Economics of Growth & Development – II

Course Code: CC 11

Credits: 5

Outcome: The paper lays the groundwork for understanding issues in economic growth and development, exploring various approaches and models like internal and international migration- Todaro model, choice of technique, and Solow- Swan models of growth. It examines the structure and changes in key variables, offering insights into both static and dynamic aspects of the economy from a purely theoretical perspective.

Course Title: Public Economics

Course Code: CC 12

Credits: 5

Outcome: Considering the increasing role of Government in the economy, this course aims to generate theoretical and empirical understanding of students about different aspects of Governmental activities and their rationality. It covers fundamental concepts of public economics, public expenditure, public revenue, and public debt with special reference of the Indian economy.

Course Title: International Economics

Course Code: CC 13

Credits: 5

Outcome: To provide a strong theoretical background to the students on subject of international trade. It also helps understand the empirical aspects such as trade reforms and their impact on the Indian economy.

Course Title: Research Methodology

Course Code: CC 14

Credits: 5

Outcome: This is a course for studying various methods for conducting social science research. It deals with various approaches, methods, tools and techniques. Further, it deals with basic knowledge on computers, data, and estimation of statistical tools by using software and analyzing the results of economic relationships, and testing economic hypotheses. By the end of the course, the student should be able:

• To become familiar with basic knowledge of research methodology and sampling techniques.

• To become familiar with basic knowledge of computers, with statistical software, to draw distributive tables, graphs, and trend lines.

• To estimate the parameters of multiple regressions with the help of software and interpret

FOURTH SEMESTER

Course Title: Agricultural Economics

Course Code: EC I

Credits: 5

Outcome: The paper makes students aware of different theories on agricultural development to cement their skills in undertaking research in the field of agricultural economics. It provides details views of the process of agricultural development in the country since independence.

Course Title: Financial Economics

Course Code: EC I & II

Credits: 5 + 5

Outcome: Taking in to account to the fast development of Indian financial sector and increasing role of monetary policy, paper aims to generate theoretical and applied understanding of monetary economics. Whole syllabus is divided in to three parts. First two modules cover the advanced economic theories and rest two covers financial institutions and monetary policy, respectively.

Course Title: Industrial Economics I & II

Course Code: EC I & II

Credits: 5 + 5

Outcome: This is a course for Industrial economics that deals with basic to advanced concepts of industry, market products, industrial locations, and industrial marketing.

M.A. HISTORY

PROGRAM OUTCOME

The learning outcome achieved at the end of the programme is as follows:

PO-1) The students get a deeper understanding about History. They learn about the background of the earliest civilizations of the world. They are introduced to the medieval history of Europe, discussing the topics of feudalism, crusade etc. and the rise of Islam and its development in subsequent centuries. They learn about emergence of USA as a world power and its role in contemporary world.

PO-2) Students develop detailed knowledge of Indian history from ancient to the contemporary period. The course sensitizes them to appreciate the notions of continuity and change. They will have knowledge of political, social, economic and cultural history and also of science and technology. They will finally learn about the changes in the world. They will learn about various Historians. The course will help them to know about Bihar's History.

PO-3) The history of the subjugation of the country by Britain sensitize them to the dangers of having internal divisions in the country. The students are familiarized with revolutionary phenomenon's of the world

PO-4) The history of the European and other Asian countries including the history of two world wars and emergence of totalitarian regimes inculcates in them the urgent need for scientific and rational thinking and teaches them to work for a better world.

PO-5) The students get prepared to appear in competitive exams.

PO-6) The students develop knowledge about Dalit tribal and Environment movements. They will also know about Indian theatre, Cinema, Media and above all Human Rights.

M.A. HISTORY

COURSE OUTCOME

Semester I

After completion of course a student will learn.

CC – 1 Histography.

Course Outcome - To introduce the students to major approaches in theorising historians and their writings.

CC – 2 History of Early Civilization and Medieval world.

Course Outcome - To generate awareness about the facts of early civilization and distinctive features of medieval world.

CC – 3 Early Medieval India

Course Outcome - Enhance understanding for the subject through tours to historical sights. The course will help students to gain insight about Early Medieval India. It will help them to prepare for competitive examination.

CC – 4 Science and Technology in India.

Course Outcome - To develop ability to contextualize Science and Technology to interrelate it with historical development and enhance their research skills.

Semester – II

CC – 5 History of Ideas.

Course Outcome - To deal with different thoughts and ideas of philosophers and identify their influence and interrelations on life.

CC – 6 History of Europe and Modern World

Course Outcome - To learn about world history. European nations ruled over a large part of the world so, it is important to learn about their history. It helps for pursuing higher studies.

CC – 7 History of Bihar (from the earliest time).

Course Outcome - This helps the student to obtain knowledge about their state, it helps in competitive exams.

CC – 8 Society and Economy in Indian History.

Course Outcome - Students will develop an understanding of society and economy of India, which will help them later in competitions.

Semester – III

CC – 10 National movement in India.

Course Outcome - The course aims to help students understand nationalism in India. It is important for students to learn the specific historical context of the strugglers against colonial rule in India.

CC – 11 Indian Historians.

Course Outcome - They can learn about the rise of Indian Historians, their writings and views on different aspects of History.

CC – 12 South Asia - 1950 onwards.

Course Outcome - This course will help the students understand the South Asian History and Modern World. The students will learn to evaluate events and development that has shaped South Asia.

CC – 13 USA (1860 – 1990).

Course Outcome - The students are familiarized with American History. Teaching of History of USA is a new thing so students get a wider perspective of the subject. They get an insight into the process of emergence of strongest world power.

CC – 14 Revolution and Revolutionary thought.

Course Outcome - The students are familiarized with the revolutionary phenomenon in the world. They learn to discern the similarities and the specifics of these revolutions.

Semester – IV

Elective Course – 1

Course Outcome: -

- **Popular Movements - Students will learn about the Dalit, Tribal, Gender and Environment Movements of India. This will give them insight into the movements and how its saved history.**

Elective Course – 2

Course Outcome: –

a) **Indian Theatre**
b) **Indian Cinema**
c) **Media**
d) **Human Rights – During the course student will acquaint themselves with aspects of human rights, their importance and this will help them in competitive exams.**

CO & PO Mapping of M.A. (History Hons.)

		PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
M. A. Sem. I	CO – 1						
	CO – 2						
	CO – 3						
	CO – 4						
M. A. Sem. II	CO – 5						
	CO – 6						
	CO – 7						
	CO – 8						
M. A. Sem III	CO – 10						
	CO – 11						
	CO – 12						
	CO – 13						
	CO – 14						
M. A. Sem IV	CO – 15						
	CO – 16						

M.A. HOME SCIENCE

Course Outcome - Programme Outcome (CO PO Mapping)

PO. No.	Programme Outcome Upon completion of Home Science Degree Programme, the graduates will be able to
PO-1	Understand and appreciate the role of interdisciplinary sciences in the development and well- being of individuals, families and communities.
PO-2	Develop professional skills in food, nutrition, textiles, housing, product making, communication technologies and human development.
PO-3	understand the concept of communication, different media and role of interpersonal, group and mass communication in making communication effective and barriers in communication.
PO-4	Acquire scientific skills in the management of resources and develop basic skills for career options in the fields of dietetics, interior designing, textile and fashion designing.
PO-5	Acquire academic skills with an aptitude for higher studies / research/entrepreneurship in any branch of the programme.

Course Outcome (CO)

FIRST SEMESTER (M. A.)

Course Title - : Advance Nutrition

Course Code -CC I

CO 1 - Able to understand the techniques of measuring energy expenditure in individuals. Critically evaluate and derive requirements for specific macronutrients.

Course Title - : Advance Study of Human Development

Course Code - CC II

CO 2 - Describe developmental tasks during infancy, preschool and middle childhood years. To develop an awareness of important aspects of all development stages during this phase.

Course Title - : Concept of Home Management

Course Code - CC III

CO 3 - Know Management system and Family resource management and the important features of management process.

Course Title - : Research Methodology and Statistics

Course Code - CC IV

CO 4 - Understand the background and need of research and discuss the research process. Demonstrate knowledge of the scientific method, purpose and approaches to research.

SECOND SEMESTER (M. A.)

Course Title - : Therapeutic Nutrition

Course Code -CC I

CO 1 - Interpret dietary modification for different diseases. Plan dietary counselling and prepare diet menu.

Course Title - : Maternal and Infant Nutrition

Course Code - CC II

CO 2 - Understand the inter-relationship between nutrition, growth and development during a life cycle.

Course Title - : Communication Technology

Course Code - CC III

CO 3 - Understand various aspect of communication technology and identify different forms of communication.

Course Title - : Women's Studies

Course Code - CC IV

CO 4 - Create awareness about the status of women in India. Understand the personal and civil laws related to women and know existing Women's Welfare Programmes.

Course Title - : Management of textile crafts and apparel industry

Course Code -Paper V

CO V - Understand the origin of different techniques and designs with reference to colours, motifs, layouts of different traditional textiles of India.

THIRD SEMESTER (M. A.)

Course Title - : Food Processing

Course Code -CC I

CO 1 - Understand food standard and related laws regarding food safety and quality.

Course Title - : Food Science and experimental food

Course Code - CC II

CO 2 - Gain knowledge about food science and acceptability of food. Learn the properties, sources and uses of carbohydrate and protein. Learn various cooking and preservation method to retain/enhance the nutritional quality.

Course Title - : Institutional food management

Course Code - CC III

CO 3 - State and discuss planning and management of food service system.

Course Title - : Community Nutrition

Course Code - CC IV

CO 4 - Familiarize with the concept of public health nutrition and acquire skills in nutritional assessment.

FOURTH SEMESTER (M. A.)

Course Title - : Practical Approach to Writing Research Activities

Course Code - EC-1

CO 1 - Acquaint with the research method application and preparation of research proposals and report writing.

Course Title - : Internship / Dissertation / Project / Seminar

Course Code - EC-II

CO 2 - Learn effective project organizational skills along with discussion, result, interpretation and paper writing.

CO PO Mapping of M. A. of Home Science

	PO	PO-1	PO-2	PO-3	PO-4	PO-5
	CO					
Sem.-I	CO- 1		X		X	
	CO -2	X	X			
	CO -3				X	X
	CO -4	X				X
Sem.-II	CO -1		X		X	
	CO -2	X	X			
	CO -3			X		
	CO -4	X				
	CO -5		X			X
Sem.-III	CO -1		X		X	
	CO -2		X		X	
	CO -3				X	X
	CO -4		X		X	
Sem.-IV	CO -1				X	X
	CO-2					X

J.D.WOMEN'S COLLEGE,PATNA

DEPARMENT OF MATHEMATICS

Masters of Science(Mathematics)

Program Outcome

PO-1) This provides the importance of mathematics and its techniques to solve different types of real life applications and provide the limitations of such techniques and the validity of the results.

PO-2) This provides a way to propose new mathematical and statistical questions and suggest possible software packages and/or computer programming such as Mathematica, Matlab, C,C++ etc. to find the solutions to these questions.

PO-3) This also provide a platform for acquiring career in higher studies for mathematical and statistical knowledge.

PO-4) This generates the skills for the appropriate professional activities and demonstrate highest standards of ethical issues in mathematics.

PO-5) The students may able to use computer calculations as a tool to carry out scientific investigations and develop new variants of the acquired methods, if required by the problem at hand.

PO-6) After studying this course, the students are supposed to learn following theories and concepts:

- Group theory,
- Basic concepts of ring theory
- Basic concepts of Field theory
- Basic concepts of Module theory
- Basic Galois theory
- Convergence of Sequence and series
- Use of uniform convergence
- Integration in higher dimension
- Function of several variables
- Stoke's theorem
- Vector space
- Inner product spaces
- Transformations
- Bilinear forms
- Sylvester's theorem
- Basic concepts of graphs

- Lattice Theory
- Lattice Theory and Boolean algebra
- Extended
- Boolean Algebra
- Application of Boolean algebraSet theory
- Basic concept of Fuzzy Set theory
- Basic concept of Graph theory
- Number TheoryArithmetic of Complex numbers
- Integration in contour
- Series in complex domain
- Bilinear transformation
- existence and uniqueness of solution of initial value problem
- Volterra and Fredholm integral equation
- Solution of a family of Initial value problems
- Successive approximations
- Outer measure and Measurability
- Difference between Riemann and Lebesgue integrals
- Function of bounded variation
- Integration and measure
- Uniform Convergence and completeness
- Basic concept of topological spaces
- countability and separability
- Compactness
- Connectedness
- Regular and Normal spaces
- Congruences and their related theorems
- Mobius inversion formula and congruences of higher degree
- Different theorems related to higher degree residue
- Continued fraction and their approximation
- Convergence in abstract spaces
- Weak convergence and their consequences
- Normed linear spaces
- Hilbert spaces and Banach spaces
- Introduction to different type of operators
- Introduction of fluid motion
- Equations of motion
- Use of complex analysis in fluid motion
- Circular motion in fluid
- Motion due to circular and rectilinear vertices
- Generalised co-ordinates and degree of freedom
- Canonical equations and principle of least actions
- normal Co-ordinates and vibrations
- Brackets and transformations
- Calculus of variation and shortest distance
- Basics of L.P.P.
- Integer programming
- Wolfe's and Beale's methods
- Game theory

- Mathematical formulation of inventory theory
- Queuing Theory and different models
- Uncertainty theory
- Fano-encoding procedure and encoding
- Group replacement policy and scrap policy
- Utility of machines and their job taken
- UFD
- Field extensions
- Separable Extension
- Galois theorem on solvability

M.A MUSIC

Programme outcomes (PO) of M.A. Music

1. Constructs strong foundation and in-depth knowledge of Classical Music.
2. Introduced aesthetics and social significance of the Music.
3. Imparts knowledge of folk traditions.
4. Ability to be pursue for advance research in Music. 5. Ensures the employability after post graduations.
5. Ensures the employability after post graduations.

Course Outcomes (M.A. Music Vocal)

SEMESTER - 1

Paper – 1 General and Applied Music -I (Theory)

- Enhances knowledge about prescribed ragas and talas of Indian classical music and develops ability to write notation.
- Enhances knowledge about historical development of Raga of Indian classical music.
- Enhances knowledge about various education systems and Gharanas in Indian classical music.
- Enhances knowledge about classification of various musical Instruments of Indian Music.

Paper – 2 History of Indian Music (Vedic Period to 13th Century) - 1 (Theory)

- Spreads awareness about different aspects of music as described in Ancient treatise of India.
- Enhances knowledge about the various aspects of music described in Mahakavyakal and medieval period.
- Enhances knowledge about historical development of swaras.
- Enhances knowledge about various aspects of music as described in treatise of medieval period.

SEMESTER - 2

Paper – 1 General and Applied Music -I (Theory)

- Enhances knowledge about prescribed ragas and talas of Indian classical music and develops ability to write notation.
- Enhances knowledge about classification of various Ragas of Indian Music.
- Enhances knowledge about interdisciplinary areas of Music .
- Enhances knowledge about classification of various musical Instruments of Indian Music.

Paper – 2 History of Indian Music (Vedic Period to 13th Century) -2 (Theory)

- Spreads awareness about different aspects of music as described in Vedic treatise of India.
- Enhances knowledge about the various concepts of music as described in Ancient and Medieval period.
- Enhances knowledge about Shruti –Swaras relationship as described in historical Musical treatise.
- Enhances knowledge about various aspects of music as described in treatise of medieval period.

Paper – 3 Viva-Voce & Comparative Study of Ragas (Practical)

- Increases confidence to perform as a mature and sensible artist.
- Ability to differentiate the various ragas and enhances the skills to make notation and improvise ragas with their creativity
- Enhances knowledge and ability to demonstrate prescribed talas on hands.
- Develops ability to make notation.

- Develops the teaching abilities in students and make them self dependent in various areas i.e. performing , improvisation

Paper – 4 STAGE PERFORMANCE (Practical)

- Enhances knowledge of prescribed Ragangs and imparts Creativity and Systematic improvisation ability in students.
- Develops ability to perform Various classical vocal forms
- Develops ability to perform semi classical vocal forms.
- Enhances ability to perform Tarana.

Paper – 5 Basic Ragas (Practical)

- Develops the teaching abilities in students and make them self dependent in various areas
- i.e. performing , improvisation ,
- Develops ability to compose bandish .
- Develops ability to make notation.
- Enhances knowledge and ability to demonstrate prescribed talas on hands.

SEMESTER – 3

Paper – 1 Applied Music Theory and Musical Compositions-I (Theory)

- Enhances knowledge about prescribed ragas and talas of Indian classical music and develops ability to write notation.
- Enhances knowledge about classification of various Ragas of Indian Music.
- Enhances knowledge about interdisciplinary areas of Music.
- Enhances knowledge about classification of various musical Instruments of Indian Music

Department of philosophy

Programme outcomes and Course outcomes of M.A. Philosophy

PO 1- Students learn to think logically and develop critical, analytical and comprehensive knowledge.

PO 2-Devoloping the expressive and communicative power of logical reasoning and understanding.

PO 3- Students learn comparative understanding of Indian and western perspectives on philosophical issues.

PO 4-Students develop an analytical approach and critically evaluate real life situation by analysing key factors and issues.

PO 5- Understanding the application of philosophical knowledge and to build a better nation and ensure social equality, human dignity, human rights and learn to co-exist peacefully.

PO 6- Critically analyse the hypothesis, theories, techniques and definition offered by philosophers and acquiring the capacity to develop new direction and new hypothesis, while doing research work.

PO 7-Value inculcation among students, they learn about ethical, social, political, aesthetics and environmental values.

Course Outcomes (CO) of M.A. Philosophy

After Completion of the course, the students will able to:

M.A.	**Code**	**Course**	CO	**Statements**
Sem I	9218-CC-01	Indian Epistemology	CO1	Understand the Indian process of knowledge and wisdom including truth and errors concepts of Indian schools of philosophy
			CO2	Recognize the characteristic of knowledge, such as how we know and the conditions of justification of knowledge
			CO3	Critically evaluate real life situation by analysing key factors and issue
			CO4	Understand the six important sources of knowledge.
Sem I	9218-	Contemporary	CO1	Develop a better orientation towards

	CC 02	Indian Philosophy		Indian Philosophical heritage with a rational point of view.
			CO2	Understand and interpret issues concerning trends of contemporary Indian philosophy
			CO3	Students achieve the philosophical clarity of Indian tradition in philosophy.
			CO4	Evaluate and justify the theories of various contemporary social philosophers.
	9218-CC 3	Ancient Greek, Medieval and Modern Philosophy	CO1	Critically evaluate real life situation by analysing key factors and issue
			CO2	Understand the origin of Greek philosophy and the development of philosophy from ancient to the modern period.
			CO3	Understanding the metaphysical and epistemological aspects of western philosophy.
			CO4	Students acquainted the difference between medieval and modern philosophy.
	9218 CC 4	Indian and Western Ethics	CO1	Understand Indian moral philosophy in comparison with western framework.
			CO2	Students will be able to compare the ethical issues of philosophy related to east and west.
			CO3	Evaluate human conduct in the light of moral principles.
			CO4	Recognize the principle of Dharma and Karma.
Sem II	9218-CC 5	Western Logic	CO1	Understand the basic logical concepts and language of logic.
			CO2	Asses the important of Symbolic Logic or modern logic.

			CO3	Acquaint with logical syllogism and its application in other fields
			CO4	Develop potentiality towards logical reasoning.
	9218-CC 6	Western Epistemology	CO1	Explain various theories related to the knowledge in western perspective.
			CO2	Understand the concept of knowledge, belief and knowledge of other minds.
			CO3	Examine the theories of truth and judgement related knowledge.
			CO4	Understand the nature and role of scepticism in knowledge justification.
	9218-CC-07	Gandhian Thoughts	CO1	Understand the Gandhian thoughts and virtues towards. humanity
			CO2	Recognize the basic concepts of peace and conflicts through nonviolence.
			CO3	Appreciate the Gandhian Principles of life, peaceful methods and apply it.
			CO4	Student will able to analyse, perceive, understand and appreciate Gandhian socially relevant ideas.
	9218 CC-08	Indian Metaphysics	CO1	Acquaint deep knowledge of Indian Metaphysical concepts.
			CO2	Students will be able to learn in depth analysis of Brahma, Atman and relationship between them and world.
			CO3	Achieve the unique concept of world, God self and Absolute of different schools.
			CO4	Students reexamine the critique of metaphysics as offered by some Indian and Western thinkers.
	9218-cc-09	Indian Linguistic Trends	CO1	Understand Language origin, structure and functioning of language in ancient Indian philosophy.
			CO2	Learn the application of linguistics in other areas of philosophy.

			CO3	Describe and evaluate the different theories of word meanings and sentence meanings.
			CO4	Recognize the concept of Apohavada and Abhava.
Sem III	9218-CC-10	Contemporary Western Philosophy	CO1	Develop a better orientation towards western philosophical heritage with a rational point of view.
			CO2	Understand and interpret issues concerning trends of contemporary western philosophy.
			CO3	Achieve philosophical clarity of western tradition in philosophy.
			CO4	critical evaluate contemporary western thoughts.
	9218-CC-11	Western Analytical Philosophy	CO1	Able to analyse and evaluate critically the language used in philosophy.
			CO2	Develop analytical and reflective thinking.
			CO3	Achieve openness to new ideas concerning Phenomenological thoughts of western philosophy.
			CO4	Students explore analytic trends in western philosophy, embrace linguistic approaches to philosophical problem
	9218 CC-12	Indian Logic	CO1	Students will understand the correlation between logic, epistemology and metaphysics.
			CO2	Understand the Indian process of reasoning (tarka)
			CO3	Learn about types, components and methods of inferential reasoning as conceived by Indian logicians.
			CO4	Learn about the fallacies of inference(hetvabhasa)identified by Indian logicians.
	9218 CC-13	Philosophy of Religion I	CO1	Able to move away from irrational blind faith and dogmas.

			CO2	Develop the notion to think philosophically about 'God', 'Religion' and the main questions.
			CO3	Evaluate the philosophy of humanism in religious context.
			CO4	Recognise the values mention in the religion regarding freewill, karma and rebirth.
	9218 CC-14	Philosophy of Religion II	CO1	Students understand the key concepts of soul and salvation.
			CO2	Learn to explain the evidence related to problem of evil.
			CO3	Understand how philosophical theories about self-related to religious believes.
			CO4	Students learn to discuss at lest one form of religious atheism, pluralism.
Sem IV	9218 EC-01	Sacred Text S.Radhakrishnan's Bhagwad Geeta Dhammapda	CO1	Developed a comprehensive understanding of Bhagwad Geeta, their application in various field of life.
			CO2	Develop insights into ethics and values to promote meaning full impact in organizations.
			CO3	Students will have developed a comprehensive knowledge of Dhammapada text, their moral teachings and their relevance in human life.
			CO4	Able to analyse and interpret the stories apply the teaching to real life situations in the context of Buddhism.
	9218 EC16	Project work /Dissertation	CO1	Able to prepare synopsis for research work.
			CO2	Develop skill to select appropriate method for their research work and carryout the research work in systematic way.
			CO3	Understand to frame hypothesis regarding their dissertation.

Attainment and mapping of programme outcomes and course outcomes of M.A. Philosophy

J D WOMEN'S COLLEGE

PATLIPUTRA UNIVERSITY

DEPARTMENT OF POLITICAL SCIENCE

P.G. POLITICAL SCIENCE

COURSE OUTCOME

COURSE OUTCOME

Semester-1

MPOL-CC-1 POLITICAL THEORY

OUTCOME-To introduce the students to major approaches in theorizing political life and the major concepts in the discourse of Politics.

MPOL-CC-2 WESTERN POLITICAL THOUGHT

OUTCOME-To generate a political awareness among the students about the distinctive features of western political thought.

MPOL-CC-3 COMPARATIVE POLITICS: CONCEPTS & MODEL

OUTCOME-This paper deals with the theoretical approaches to the study of comparative poritics.

MPOL-CC-4 INTERNATIONAL RELATIONS: THEORIES &APPROACHES

OUTCOME -To deal with different approaches and methods of studying International Relations

SEMESTER-II

MPOL-CC-5- INTRODUCTION TO PUBLIC ADMINISTRATION

OUTCOME-To help the students to obtain a suitable conceptual perspective on Public Administration.

MPOL-CC-6-FOREIGN POLICY OF MAJOR POWERS

OUTCOME-To provide a background to the problems of global governance and factors affecting them.

MPOL-CC-7--CONTEMPORARY ISSUES IN INTERNATIONAL RELATIONS

OUTCOME-to provides insights into significant issues that are largely the legacies of Cold War.

MPOL-CC-8-INDIAN POLITICAL THOUGHT

OUTCOME-To generate a critical awareness among the students about distinctive features of tradition of Socio-Religious and political Thought in India.

MPOL-CC-9 POLITICAL PROCESSES AND GOVERNANCE IN INDIA

OUTCOME-The social and economic processes that underlie the functioning of the political system in India

SEMESTER-III

MPOL-CC-10-POLITICAL INSTITUTIONS AND PRACTICES IN INDIA

OUTCOME- The objective of this course will be on contemporary institutional forms and practices, their historical underpinnings, will also be studied through an exploration of the debates that endure from the past.

MPOL-CC-11-RESEARCH METHODOLOGY

OUTCOME-An attempt is made to relate social science research methods to other courses in syllabus of Political Science.

MPOL-CC-12-STATE POLITICS

OUTCOME-The Indian Politics is multi-cultural and every state in India is a microcosm of Macro Indian politics. We see different trends in State Politics.

MPOL-CC-13-INDIA'S FOREIGN POLICY

OUTCOME-The focus of this paper is the theoretical perspective of the role of compulsions, constraints and conditions, which actually has framed the country's foreign policy for the past five decades.

MPOL-CC-14-POLITICAL AND SOCIAL MOVEMENTS

OUTCOME-to inform the students of the meaning and importance

of the Political and Social movements and to let them know the reasons

SEMESTER-IV

MPOL-CC-15-INDIAN ADMINISTRATIVE SYSTEM

OUTCOME -The purpose of this paper is to acquaint the students with the knowledge of administrative pattern in the Indian federal structure together with its historicity.

MPOL-CC-16-INTRODUCTION TO INTERNATIONAL LAW

OUTCOME -To study the nature, content and the different aspects of international Law pertaining to legal principles of recognition, jurisdiction. Law of Sea, diplomatic immunities and privileges, treaty of obligation and crimes against humanity.

CHOICE BASED CREDIT SYSTEM FOR THE UNIVERSITIES OF BIHAR

PROGRAM: MASTERS IN PSYCHOLOGY

SESSION: 2018-2019

PROGRAM CODE: 9221- (01- 18)

PROGRAM SPECIFIC OUTCOME:

PSO 1- To create an in-depth understanding of the core concepts of Psychology.

PSO 2-To enhance knowledge of psychology and its application to create harmony among internal and external environment

PSO 3- To create research oriented theoretical foundation

PSO 4-To help students to get acquainted with recent advances in the field of Psychology

COURSE CODE	COURSE	COURSE OUTCOME
CC1	ADVANCED GENERAL PSYCHOLOGY	**CO 1**-To understand the concepts of psychological concepts, theories and research methods **CO 2-**To get familiar with biological, cognitive, social and cultural factors in influencing human behaviour **CO 3-**To apply psychological principals to diverse population and contexts. **CO 4-**To understand and apply advanced psychological theories and models
CC2	ADVANCED SOCIAL PSYCHOLOGY	**CO 1**-Understanding the social psychological theories concepts and research **CO 2**= Understanding and Application of social psychological concepts in real life

CC3	**RESEARCH METHODOLOGY**	**CO 3-**To design and conduct research studies using various methods of statistical analysis **CO 4-**To evaluate the psychological research and its application **CO 5**-To create ability to design and conduct the research studies
CC4	**EXPERIMENTS IN PSYCHOLOGY**	**CO 1**-Understanding the fundamental principles and methods of experimental psychology **CO 2**-Familiarity with the research designs, experiments and statistical analyses **CO 3-**To collect and analyse data effectively **CO 4**-To interpret and report the research findings effectively
CC5	**COGNITIVE PSYCHOLOGY**	**CO 1**-To understand the fundamental principles and theories of cognitive psychology **CO 2**-To gain Knowledge of cognitive processes including perception, attention, memory, language and problem solving **CO 3**-To develop critical and curious mindset in understanding human behaviour **CO 4**-TO communicate complex cognitive concepts effectively
CC6	**NEUROPSYCHOLOGY**	**CO 1-**Understanding the fundamental principles and theories of neuropsychology **CO 2-**Familiarity with brain structure and functions **CO 3**-To get familiar with neurophysiological basis of behaviour

CC7	**PSYCHOPATHOLOGY**	**CO 1-**Provides in- depth examination of the major types of psychopathologies including anxiety mood, personality and other psychotic disorders. **CO 2-**To define the significance of psychopathology in understanding mental health **CO 3-** Acquaintance with major types of psychopathologies including their symptoms diagnosis and assessment **CO 4-**To evaluate the effectiveness of different treatment approaches
CC8	**STATISTICS FOR PSYCHOLOGY**	**CO 1-**To help analyse and interpret psychological data using statistical techniques **CO 2-**To understand the fundamentals of statistical analysis in Psychology **CO 3**-To get acquainted with different parametric and non- parametric
CC9	**PSYCHOLOGICAL ASSESSMENT**	**CO 1-**To diagnose mental health conditions accurately. **CO 2-**To clarify diagnostic uncertainties and complexities **CO 3**-Monitoring of treatment progress and adjustment of plans **CO 4**-Identification of research gaps and areas
CC10	**HEALTH PSYCHOLOGY**	**CO 1-**To understand the psychological factors that influence physical health, illness and wellness. **CO 2-**To gain Knowledge about biopsychosocial models of health and illness. **CO 3-**To know the psychological aspects of chronic illness, such as pain management, coping strategies, and quality of life.

CC11	**COUNSELLING PSYCHOLOGY**	**CO 1**-To provide an introduction to the principles and practices of counselling psychology, including the theoretical foundations, assessment and intervention strategies **CO 2**-To understand the importance of empathy, genuineness and unconditional positive regard. **CO 3-**To understand counselling process, establishing therapeutic relationship and implementing interventions
CC12	**EDUCATIONAL PSYCHOLOGY**	**CO 1**-To explore the psychological principles and theories that underlie learning, teaching, and educational experiences. **CO 2**-To understand the role of assessment in education, including the use of standardized tests and authentic assessments. **CO 3-**To apply educational psychology principles to real world teaching and learning scenarios **CO 4**-To develop an understanding of individual differences in learning, including learning styles abilities and disabilities
CC13	**HUMAN RESOURSCE MANAGEMENT**	**CO 1**-To help in applying psychological principles to the management of human resources in organizations. **CO 2-**To analyse the psychological factors that influence employee behaviour, motivation and performance.

		CO 3-To develop training and development programs that address individual differences and learning styles. **CO 4-**To design effective recruitment and selection strategies that incorporate psychological principles
CC14	**GENERAL COUNSELLING SKILLS**	**CO 1-**Develop evidence- based interventions and techniques. **CO 2**-To develop effective communication skills and inter- personal skills. **CO 3-** To develop empathy, self-awareness and self-reflection skills. **CO 4**-Ability to work with diverse population and present with various mental health concerns
EC1	**SPECIALIZATION IN CLINICAL PSYCHOLOGY**	**CO 1**-To help understanding the theories and practices of clinical psychology **CO 2-** To diagnose mental health disorders using the DSM-5 classification system. **CO 3-**To design and implement evidence – based treatments for various mental health disorders. **CO 4-**To evaluate the effectiveness of clinical interventions using research-based methods. **CO 5**-To create cultural sensitivity and social justice in counselling.
EC2	**PSYCHOTHERAPY**	**CO 1-**To get familiar with different types of psychotherapy **CO 2-**To understand the importance of ongoing learning, professional development, and self-care **CO 3-**To conceptualize and manage cases.

CHOICE BASED CREDIT SYSTEM FOR THE UNIVERSITIES OF BIHAR

PROGRAM: MASTERS IN PSYCHOLOGY

SESSION: 2019-2020

PROGRAM CODE: 9221- (01- 18)

PROGRAM SPECIFIC OUTCOME:

PSO 1- To create an in-depth understanding of the core concepts of Psychology.

PSO 2-To enhance knowledge of psychology and its application to create harmony among internal and external environment

PSO 3- To create research oriented theoretical foundation

PSO 4-To help students to get acquainted with recent advances in the field of Psychology

COURSE CODE	COURSE	COURSE OUTCOME
CC1	ADVANCED GENERAL PSYCHOLOGY	**CO 1**-To understand the concepts of psychological concepts, theories and research methods **CO 2-**To get familiar with biological, cognitive, social and cultural factors in influencing human behaviour **CO 3-**To apply psychological principals to diverse population and contexts. **CO 4-**To understand and apply advanced psychological theories and models
CC2	ADVANCED SOCIAL PSYCHOLOGY	**CO 1**-Understanding the social psychological theories concepts and research **CO 2**= Understanding and Application of social psychological concepts in real life

CC3	**RESEARCH METHODOLOGY**	**CO 3-**To design and conduct research studies using various methods of statistical analysis **CO 4-**To evaluate the psychological research and its application **CO 5**-To create ability to design and conduct the research studies
CC4	**EXPERIMENTS IN PSYCHOLOGY**	**CO 1**-Understanding the fundamental principles and methods of experimental psychology **CO 2**-Familiarity with the research designs, experiments and statistical analyses **CO 3-**To collect and analyse data effectively **CO 4**-To interpret and report the research findings effectively
CC5	**COGNITIVE PSYCHOLOGY**	**CO 1**-To understand the fundamental principles and theories of cognitive psychology **CO 2**-To gain Knowledge of cognitive processes including perception, attention, memory, language and problem solving **CO 3**-To develop critical and curious mindset in understanding human behaviour **CO 4**-TO communicate complex cognitive concepts effectively
CC6	**NEUROPSYCHOLOGY**	**CO 1-**Understanding the fundamental principles and theories of neuropsychology **CO 2-**Familiarity with brain structure and functions **CO 3**-To get familiar with neurophysiological basis of behaviour

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CC14	**GENERAL COUNSELLING SKILLS**	**CO 1-**Develop evidence- based interventions and techniques. **CO 2**-To develop effective communication skills and inter- personal skills. **CO 3-** To develop empathy, self-awareness and self-reflection skills. **CO 4**-Ability to work with diverse population and present with various mental health concerns
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SESSION: 2020-2021

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SOCIOLOGY (M.A. COURSE OUTCOME)

Course Outcome	Mapping with Course
This will help the students to attain basic understanding and the scope of the subject, recent trends of social development helps the students in enhancing their theoretical understanding and applying it to understand the social interaction process in everyday life.	P.G. Sem-1, Paper-1-Principles of Sociology
This course is designed so that the students attain basic as well as advanced theoretical knowledge of sociology like Conflict theory, Neo-Marxian theory, Symbolic Interactionism and its relevance in understanding and applying it to deal with the contemporary social issues. It helps the students to develop philosophical, logical ,rational and critical thinking in their understanding of multifarious aspects of society.	P.G. Sem-1, Paper-2 Classical Sociology+ P.G. Sem-1, Paper-3 Perspectives in Indian Sociology
This helps the students to understand the rural Indian society and the role of caste as an institution of Indian society, the rural urban dichotomy and continuum .The students are also able to examine and evaluate the changing trends in rural power structure.	P.G. Sem-1, Paper4-Rural Sociology
The students get acquainted with the philosophy behind conducting social research, the students learn to apply different kinds of research design and tools , techniques in accordance with the need of the research.	P.G. Sem-2, Paper-5-Research Methods in Sociology
The students get aware about the impact of population on society and the factors behind change in population. They also get informed about the important issues related to population.	P.G. Sem-2, Paper-6 Sociology of Population Studies
The students get sensitized about gender issues, the grave issue of gender inequality and violence against women and social construction of gender in society.	P.G. Sem-2, Paper-7 Gender and Society
The students' knowledge get enhanced about the emerging social issues and changing social relations due to urbanisation and the changing trends in the urban social institutions. They are also able to understand the sociological meaning of work and leisure, various aspects of industrial relations and issue of job satisfaction	P.G. Sem-2, Paper-8-Urban Sociology+ P.G. Sem-3, Paper-12, Industrial Sociology
The students get familiarised about sociological and legal delinquency, causes of crime, Theories of punishment. The students are able to get acquainted with multifarious causes of various social problems and the issues of marginalised community. The students also get acquainted with various government steps to resolve such issues.	P.G. Sem-2, Paper-9-Crime and Society, + P.G. Sem-3,Paper-11-Social Problems in India+ . P.G. Sem-3, Paper-14-Sociology of Marginalized Communities
Through this paper, the students are able to understand the theories and factors of social change. The students are able to understand social change through sanskritisation, westernisation, modernization and globalisation .They also get acquainted with various theories of development.	P.G. Sem-3, Paper-13-Sociology of change and development

Program Specific Outcomes (PSO) of M.Sc. Zoology

PSO1: Developing deeper understanding of key concepts of biology at biochemical, molecular and cellular level, physiology and reproduction at organismal level, and ecological impact on animal behavior.

PSO2: Elucidation of animal-animal, animal-plant, animal-microbe interactions and their consequences to animals, humans and the environment.

PSO3: Strengthening of genetics and cytogenetics principle in light of advancements in understanding human genome and genomes of other model organisms.

PSO4: Description of expression of genome revealing multiple levels of regulation and strategies to manipulate the same in the benefit of the mankind.

PSO5: Learning handling DNA sequence data and its analysis which equip students to get employed in R&D in the industry involved in DNA sequencing services, diagnostics, and microbiome analysis.

PSO5: Understanding relationships of variations in phenotypic expression of genomes and their genomewide interaction with other organisms.

PSO6: Development of an understanding of zoological science for its application in medical , aquaculture and modern medicine.

PSO7: Development of theoretical and practical knowledge in handling the animals and using them as model organism

PSO8: Maintenance of high standards of learning in animal sciences

Course Outcomes

Semester – 1

Course: CC 1 FUNCTIONAL BIOLOGY OF INVERTEBRATES AND CHORDATES

CO1: Description of internal transport and gas exchange

CO2: Regulation of heart-beat and blood pressure, neural and chemical regulation of respiration, Gas transfer in air and water.

CO3: Perception of circulatory and respiratory responses to extreme conditions

CO4: Discerning acid –base balance, Regulation of body pH.

CO5: Developing the concept of animal adaptation by exploring the diversity of functional

characteristics of various kinds of organisms which is closely related to evolutionary processes and environmental changes.

CO5: Perception of Osmoregulation, Kidney functions and diversity, Extra-renal osmoregulatory organs,

Patterns of nitrogen excretion.

CO6: Concept of thermoregulation - Heat balance in animals, Adaptations to temperature extremes, torpor, Aestivation and hibernation, Counter current heat exchangers.

CO7: Understanding of adaptations to Stress- basic concept of environmental stress, acclimatization, avoidance and tolerance, stress and hormones.

CO8: Description of sensing the environment- photoreception, chemoreception, mechano-reception, echolocation, endogenous and exogenous biological rhythms, chromatophores and bioluminescence.

CO9: Understanding of feeding mechanisms and their control, effect of starvation.

CO10: Description of muscle physiology – striated and smooth muscle, adaptations of muscles for various activities, neuronal control of muscle contraction, electric organs.

Course CC2 – Molecular Cell Biology

CO1: Description of transport acrossthe plasma membrane, mechanism of diffusion, movement of water, Donnan equilibrium ,ion movements and cell function, acidification of cell organelles and stomach.

CO2: Understanding transepithelial transport, maintenance of cellular pH, cell excitation, bulk transport,

receptor mediated endocytosis, protein sorting and targeting to organelles, molecular mechanism of the

secretory pathway, secretion of neurotransmitters.

CO3: Description of cellular shape, motility and energetics- cytoskeletal elements in cell shape and motility, structure and dynamics, role in cell locomotion and mitosis.

CO4: A study of intercellular communication, extracellular matrix, cell- cell and cell-matrix adhesion, gap

junctions, cellular energetics, oxidation of glucose and fatty acids, the proton motive force, F0F1 ATP synthase, mechanism and regulation of ATP synthesis.

CO5: Description of life cycle of a cell - cell cycle and its regulation, checkpoints in the mammalian cell

cycle.

CO9: Description of cell regulatory mechanisms- regulatory and control mechanisms in a mammalian cell

at the biochemical level, key concepts about cellular signaling mechanisms

CO10: Overview of proliferative, survival and death pathways, desensitization of receptors, signaling

and toxins

CO11: Description of siRNA and miRNA basics, regulation of transcription and translation of proteins by

miRNA.

Course CC3 – Genetics

CO1: Understanding of Mendel's principle, its extension and chromosomal basis.

CO2: Determination of gene action from genotype to phenotype including penetrance and expressivity,

gene interaction, epistasis, pleiotropy; nature of the geneand its functions.

CO3: Evolution of the concept of the gene and fine structure of gene using rII locus.

CO4: Capability to perform gene mapping using 3- point test cross in Drosophila, gene mapping in

humans by linkage analysis in pedigrees.

CO5: Imparting knowledge regarding gene mutation, types of gene mutations, methods for detection

ofinduced mutations, P- element insertional mutagenesis in Drosophila, DNA damage and repair.

CO6: Developing concept of regulation of gene activity in prokaryotes and eukaryotes at transcriptional

and posttranscriptional level.

CO7: Describing structural and functional organization of a typical eukaryotic gene, transcription factors,

enhancers and silencers, and non-coding genes.

CO8: Depicting the mechanism of sex determination and dosage compensation in human and other

model organisms.

CO9: Developing skills in human genetics with capability for karyotyping and nomenclature of

metaphase chromosome bands.

CO10: Description of human genome and mapping.

COURSE CC 4

CO 1 -Squash preparation using drosophila larvae for polytene chromosomes.

CO 2-Experimental demonstration of enumeration of RBC and WBC.

CO3-Identification of vertebrate and invertebrate slides.

CO4-PREPERATION of linkage map based on data from drosophila crosses.

Course CC5 – ENVIRONMENTAL SCIENCE

CO1: An overview of evolutionary ecology and environmental concepts

CO2: Understanding the characteristics of population and population dynamics.

CO3: A study of life history pattern, fertility rate and age structure.

CO4: Illustration of competition and coexistence, intra-specific and inter-specific interactions, scramble

and contest competition model, mutualism and commensalism, prey-predator interactions.

CO5: Description of nature of ecosystem, production, food webs, energy flow, biogeochemical cycles,

resilience of ecosystem and ecosystem management.

CO6: Understanding the biosphere, biomes and impact of climate on biomes.

CO7: An overview of the environmental stresses and their management, global climatic pattern, global

warming, atmospheric ozone, acid and nitrogen deposition, coping with climatic variations.

CO8: Description of the major classes of contaminants. Impact of pesticides and other chemicals in

agriculture, industry and hygiene and their disposal.

CO9: Impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers

of environmental health. Biodegradation and bioremediation of chemicals.

Course CC6 –BIOINSTRUMENTATION AND BIOSTATISTICS

CO1: Introduction to basic components of computers, Software (operating systems) and application

software used in biological and statistical studies

CO2: Understanding the principle and working of microscopy ,ph meter ,colorimeter and other instruments.

CO3 Study of basic separation techniques

CO4-STUDY OF DIFFERENT biostatistical methods.

Course CC7 – BIOCHEMISTRY

CO1: Understanding of the living state, metabolism as the defining characteristic of living organisms,

molecular approach to understanding life forms and living processes.

CO2: Concept of biomolecule identification, separation and quantization, dynamic state of body

constituents, experimental approaches to study metabolism.

CO3: Conceptualization of metabolic pathways and their linkage, metabolism of primary metabolites –

monosaccharides, lipids, amino acids and nucleotides.

CO4: Description of nature of enzymes – kinetics, reaction mechanism of chymotrypsin and lysozyme,

purification and physico – chemical characterization, regulation of enzyme activity.

CO5: Developing concept of metabolic basis of nutrition, metabolic basis of specialized tissue function.

CO6: Elucidation of metabolic disorders, metabolic basis of diagnostics, metabolism and adaption,

CO7: Description of regulation of metabolism at molecular, cellular and organismic levels, enzymes and

receptors as drug targets.

Course CC8 : BIOSYSTEMATICS AND EVOLUTION

CO1: An insight to the overview of evolutionary biology, concept of organic evolution during pre- and

post- Darwin era evolution and molecular biology- a new synthesis.

CO2: A concept of – “from molecules to life”, life originated from RNA, introns as ancient component of

genes

CO3: Understanding of the universal common ancestor and tree of life, three domain concept of living

kingdom

CO4: Illustration of the molecular phylogeny, construction of phylogenetic trees using molecular data,

construction of phylogenetic trees by using 16S rRNA gene sequences and concept of speciation in

bacteria.

CO5: Description of molecular divergence and molecular clocks and molecular drive, complication in

inferring phylogenetic trees.

CO6: Description of origin and diversification of bacteria and archea; diversification of genomes, origin

of genomes by horizontal gene transfer; role of plasmid, transposons, integrons and genomic islands in

DNA transfer.

CO7: Study of origin and diversification of eukaryotes, early fossilized cells, evolution of eukaryotic cell

from prokaryotes- a case of symbiosis, evolution of eukaryotic genomes; gene duplication and

divergence.

CO8: Conceptualization of mode of speciation, evolution, systematics, biological classification,

origination, extinction, and causes of differential rates of diversification.

CO9: Illustration of current status and future of biodiversity, human evolution.

CO10: Understanding genomics and humanness, current issues in human evolution.

COURSE -CC 9:

CO1 STUDY OF BIOCHEMICAL EXPERIMENTS.

CO2 UNDERSTANDING THE EVOLUTIONARY SIGNIFICANCE OF ARCHAEOPTERIX…Homology and analogy and others.

CO3 Preperation of temporary mount of some specimen.

CO3 MEASUREMENT OF PH..ESTIMATION OF DISSOLVED 02

Course CC 10 – VERTEBRATE IMMUNOLOGY

CO1: An overview of the immune system, principles of innate and adaptive immunity. Evolution of

innate andadaptive immune system.

CO2: Understanding of antigen recognition by immune cells,role of TLRs.

CO3: Conceptualization of generation of diversity in immunoglobulins and T- cell receptor gene

rearrangement.

CO4: Illustration of antigen processing and presentation to T lymphocytes by antigen presenting cells

and understanding the role of MHC complex.

CO5: An overview of development and survival of lymphocytes, humoral immune response, production

of effector T- cells and effector mechanisms.

CO6: Description of effector mechanisms, NK and NKT cell functions.

CO7: Conceptualization of regulation of immune response, mucosal immunity, immunological memory,

cytokines and chemokines. T- cell mediated regulation of immune response, Immunological tolerance

and anergy.

CO8: Importance of immunity in health and disease: introduction to infectious disease, innate immunity

to infection, adaptive immunity to infection, evasion of the immune response by pathogens.

CO9: Description of consequence of immunodeficiency leading to diseases such as inherited acquired

immunodeficiency diseases.

CO10: Illustration of allergy and hypersensitivity diseases, autoimmunity, transplant rejection and

responses to alloantigens.

CO11: An understanding of manipulation of immune responses for the benefit of mankind, vaccines

Course CC 11– GAMETE AND DEVELOPMENTAL BIOLOGY

CO1: Understanding of sex determination and differentiation and its mechanism

CO2: Elucidation of stem cell renewal in testis during spermatogenesis, structural and molecular events,

and respective experimental approaches

CO3: Description of regulation of testicular functions.

CO4: Epididymal maturation of spermatozoa; Capacitation, Signal transduction pathway in acrosome

reaction;

CO5: Illustration of different types of male sterility includingazoospermia,

oligozoospermia,asthenozoospermia, and varicocele with specific emphasis on the genetic and

molecular basis

CO5: Understanding of detailed follicular development and selection evaluating the role of extra-and

intra-gonadal factors in folliculogenesis.

CO6: Description of oocyte maturation its regulationand follicular atresia.

CO7:Knowledge of regulation of reproductive cycle in female: menstrual cycle in human, estrous cycle in

rat, estrous behavior in cycling animals.

CO8: Development of mechanistic understanding of female reproductive disorder: amenorrhea,

polycystic ovary.

CO9: Familiarity with the process of fertilization with a comparative account of different events involved.

CO10: Generating awareness on contraception leading to prevention of polyspermy: surgical, hormonal and immunocontraception.

Course CC12 – VERTEBRATE ENDOCRINOLOGY

CO1: General understanding of anatomical and structural organization of neuroendocrine organs and nervous system.

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CO2: Imparting knowledge regarding neurophysiology, electrical properties of neurons and propagation of nerve impulses.

CO3: Description of Synapse, neurotransmition and neuromodulation

CO4: Detailed understanding of the hypothalamo- hypophyseal axis, hypothalamo- vascular system and role of hormones.

CO5: Knowledge of regulation of hypothalamic and pituitary hormone secretion.

CO6: Imparting knowledge on physiological and mechanistic role of neurohypophysis and regulation of neurohypophyseal hormones.

CO7: Conceptualization of feed-back inhibition and feed-forward activation of neurohypophyseal hormones.

CO 8: Understanding the nature of hormonal action and its experimental methods of evaluation.

CO 9: Elucidation of biosynthesis of protein hormones and molecular mechanisms of regulation.

CO 10: Knowledge of signal discrimination, signal transduction and signal amplification in hormone regulated physiological processes.

CO11: Acquaintance with receptor antagonists and their applications.

and humans.

Course CC13– ANIMAL BEHAVIOUR

CO1: An overview of animal behavior, orientation to primary and secondary orientation; kinesis –

orthokinesis, klinokinesis; taxis – different kinds of taxis; sun-compass orientation, dorsal- light reaction.

CO2: Devising conservation strategies for different animal species. Learning and instincts: conditioning,

habituation, sensitization, reasoning.

CO3. Developing compassion towards other animals as well as other individuals, group selection, kin

selection and inclusive fitness, cooperation, and alarm call.

CO4. Evaluating other individuals of the society and taking decisions.

COURSE CC14

CO1 -Determination of blood group using ABD antisera

CO2 -Identification of endocrinological and embryological slides.

CO3- Study of behavioural aspects of specimen provided.

Course EC 1B AND 2B – FISH AND INLAND FISHERIES

CO1: A detailed understanding of evolutionary strategies and morphological innovations, gene and

genome duplication, evolutionary genetics, biogeographical distribution of major groups of fishes.

CO2: An overview of adaptations of fishes to environmental extremes- temperature, pressure, stressors.

CO3: Understanding growth and metabolism of fishes by regulation of food intake by neuropeptides and

hormones, environmental factors and feed intake.

CO4: Evaluation of defense mechanism in fishes and their regulation.

CO5: Learning of fish reproduction for better yield in fish farming.

Course ZOOL 4202 – Aquatic Resources and Their Conservation

CO1: Learning classification of riverine fisheries and their hydrological conditions.

CO2: A detailed understanding of cold water fisheries, biology of important cold water fishes of India for

better production of fishes in extreme condition.

CO3: Learning fishing techniques for localizing catches- remote sensing, sonar, radar; crafts and gears.

CO4: An overview of post harvest technique to prevent fish spoilage for better preservation and quality

control.

CO5: Learning the management of aquatic pollution, waste managementand fisheries extension

services.