DDU GORAKHPUR UNIVERSITY, GORAKHPUR

DEPARTMENT OF MATHEMATICS AND STATISTICS

National Education Policy-2020

Syllabus

of

MATHEMATICS

(Effective from Academic Session 2024-2025)

For

UG Four Year Programme

(UG Honors/UG Honors with Research)

UG Four Year Programme (UG Honors/UG Honors with Research)

For Mathematics based on National Education Policy-2020 in Choice Based Credit System (CBCS)

The proposed curriculum is expected to provide the students a good overall knowledge of science covering various aspects. They will not only be able to understand the important techniques but also able to apply some commonly used techniques to other fields.

The course of UG Four Year Programme (UG Honors/UG Honors with Research) For Mathematics will be spread in four years – 1st, 2nd, 3rd and 4th Year. Each of which will have two semester examinations and therefore will be eight semester examinations.

Subject Prerequisites

To study this subject a student must had the subject(s) Mathematics in class 12th.

Eligibility for Admission

For UG in Mathematics following candidates are eligible for admission.

Eligibility for admission in this course, the student must have subject Mathematics in class 12th.

Program Duration

The duration of the UG Four Year Programme (UG Honors/UG Honors with Research) For Mathematics the candidates admitted in semester-1st will be of four academic years (8 semesters). There are two regular semesters in an academic year.

Examination and Assessment

As prescribed by the University (as per common ordinance for examination and assessment).

Programme Objectives

The UG Four Year Programme (UG Honors/UG Honors with Research) For Mathematics aims to provide:

a) In-depth of knowledge in Mathematics through understanding of key mathematical concepts, principles, theories and their applications.

b) Inculcate strong interest in learning of mathematics.

c) Evolve broad and balanced knowledge and understanding of definitions, key concepts, principles and theorems in Mathematics.

d) Enable learners/students to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics.

e) Develop in students the ability to apply relevant tools developed in mathematical theory to handle issues and problems in social and natural sciences.

f) Provide students with sufficient knowledge and skills that enable them to undertake further studies in mathematics and related disciplines.

g) Sufficient subject matter competence and enable students to prepare for various competitive examinations such as IIT-JAM, GATE, GRE, UGC-CSIR, NET/JRF and Civil Services Examinations etc.

Framework of Four Year UG Programme (UG Honors)

Year	Semester	Major1 (Subject-1) Mathematics			Major 2 (Subject-2) From Same Faculty	Minor (Subject- 3) From Same/ Other Faculty	SEC/ Vocational	AEC/ CoCurricular	Disseratation/ Research Project/ Field Work/ Survey	Total Credits	Award Degree
		Course Code	Course Title	Credits	Credits	Credits	Credits	Credits	Credits		
1	I	MAT- 101F	Differential Calculus and Integral Calculus	4	6	6	3	2	---	23	Certificate in Faculty (46 Credits)
		MAT- 102F	Practical	2							
	II	MAT-103F	Matrices and Differential Equations	3	6	6	3	2	---	23	
		MAT- 104F	Geometry	3							
2	III	MAT- 201F	Algebra	3	6	6	3	2	---	23	Diploma in Faculty (92 Credits)
		MAT- 202F	Mathematical Methods	3							
	IV	MAT- 203F	Differential Equations	3	6	6	---	2	3*	23	
		MAT- 204F	Mechanics	3							
3	V	MAT- 301F	Ring Theory and Linear Algebra	4	10	---	---	---	---	20	UG Degree (132 Credits)
		MAT- 302F	Tensor Analysis	3							
		MAT- 303F	Differential Geometry	3							
	VI	MAT- 304F	Metric Spaces and Complex Analysis	4	10	---	---	---	---	20	
		MAT- 305F	Numerical Analysis and Operations Research	4							
		MAT- 306F	Practical	2							
4	VII	MAT- 401F	Groups and Canonical Forms	4	---	---	---	---	---	20	UG Honors (172 Credits)
		MAT- 402F	Topology	4							
		MAT- 403F	Differential and Integral Equations	4							
		MAT- 404F	Complex Analysis	4							
		MAT- 405F	Real Analysis	4							
	VIII	MAT- 406F	Fields and Modules	4	---	---	---	---	---	20	
		MAT- 407F	Differential Geometry of Manifolds	4							
		MAT- 408F	Partial Differential Equations	4							
		MAT- 409F	Operations Research	4							
		MAT- 410F	Fluid Dynamics	4							

Note: **1**.SEC (Skill Enhancement Course/ Vocational Course).

2. AEC (Ability Enhancement Course/ CoCurricular Course).

3.* The student has to opt one project from subject-1/ subject-2/ subject-3.

Framework of Four Year UG Programme (UG Honors with Research)

Year	Semester	Major1 (Subject-1) Mathematics			Major 2 (Subject-2) From Same Faculty	Minor (Subject- 3) From Same/ Other Faculty	SEC/ Vocational	AEC/ CoCurricular	Disseratation/ Research Project/ Field Work/ Survey	Total Credits	Award Degree
		Course Code	Course Title	Credits	Credits	Credits	Credits	Credits	Credits		
1	I	MAT- 101F	Differential Calculus and Integral Calculus	4	6	6	3	2	---	23	Certificate in Faculty (46 Credits)
		MAT- 102F	Practical	2							
	II	MAT- 103F	Matrices and Differential Equations	3	6	6	3	2	---	23	
		MAT- 104F	Geometry	3							
2	III	MAT- 201F	Algebra	3	6	6	3	2	---	23	Diploma in Faculty (92 Credits)
		MAT- 202F	Mathematical Methods	3							
	IV	MAT- 203F	Differential Equations	3	6	6	---	2	3*	23	
		MAT- 204F	Mechanics	3							
3	V	MAT- 301F	Ring Theory and Linear Algebra	4	10	---	---	---	---	20	UG Degree (132 Credits)
		MAT- 302F	Tensor Analysis	3							
		MAT- 303F	Differential Geometry	3							
	VI	MAT- 304F	Metric Spaces and Complex Analysis	4	10	---	---	---	---	20	
		MAT- 305F	Numerical Analysis and Operations Research	4							
		MAT- 306F	Practical	2							
4	VII	MAT- 401F	Groups and Canonical Forms	4	---	---	---	---	---	20	UG Honors with Research (172 Credits)
		MAT- 402F	Topology	4							
		MAT- 403F	Differential and Integral Equations	4							
		MAT- 404F	Complex Analysis	4							
		MAT- 405F	Real Analysis	4							
	VIII	Opt any two course of the following			---	---	---	---	---	20	
		MAT- 406F	Fields and Modules	4							
		MAT- 407F	Differential Geometry of Manifolds	4							
		MAT- 408F	Partial Differential Equations	4							
		MAT- 409F	Operations Research	4							
		MAT- 410F	Fluid Dynamics	4							
		Disseratation/ Research Project									
		MAT- 411F	Disseratation/ Research Project	12	---	---	---	---	12		

Note: **1.**SEC (Skill Enhancement Course/ Vocational Course).
2. AEC (Ability Enhancement Course/ CoCurricular Course).
3.* The student has to opt one project from subject-1/ subject-2/ subject-3.

Course Structure of Mathematics as Major Subject in UG Honors Programme

SEMESTER-WISE TITLES OF THE PAPERS OF MATHEMATICS AS MAJOR SUBJECT IN UG PROGRAMME				
Year	**Course Code**	**Course Title**	**Theory/Practical**	**Credits**
FIRST		**SEMESTER-I**		
	MAT- 101F	Differential Calculus and Integral Calculus	Theory	**4+0**
	MAT- 102F	Practical	Practical	**0+2**
		SEMESTER-II		
	MAT- 103F	Matrices and Differential Equations	Theory	**3+0**
	MAT- 104F	Geometry	Theory	**3+0**
SECOND		**SEMESTER-III**		
	MAT- 201F	Algebra	Theory	**3+0**
	MAT- 202F	Mathematical Methods	Theory	**3+0**
		SEMESTER-IV		
	MAT- 203F	Differential Equations	Theory	**3+0**
	MAT- 204F	Mechanics	Theory	**3+0**
THIRD		**SEMESTER-V**		
	MAT- 301F	Ring Theory and Linear Algebra	Theory	**4+0**
	MAT- 302F	Tensor Analysis	Theory	**3+0**
	MAT- 303F	Differential Geometry	Theory	**3+0**
		SEMESTER-VI		
	MAT- 304F	Metric Spaces and Complex Analysis	Theory	**4+0**
	MAT- 305F	Numerical Analysis and Operations Research	Theory	**4+0**
	MAT- 306F	Practical	Practical	**0+2**
FOURTH		**SEMESTER-VII**		
	MAT- 401F	Groups and Canonical Forms	Theory	**4+0**
	MAT- 402F	Topology	Theory	**4+0**
	MAT- 403F	Differential and Integral Equations	Theory	**4+0**
	MAT- 404F	Complex Analysis	Theory	**4+0**
	MAT- 405F	Real Analysis	Theory	**4+0**
		SEMESTER-VIII		
	MAT- 406F	Fields and Modules	Theory	**4+0**
	MAT- 407F	Differential Geometry of Manifolds	Theory	**4+0**
	MAT- 408F	Partial Differential Equations	Theory	**4+0**
	MAT- 409F	Operations Research	Theory	**4+0**
	MAT- 410F	Fluid Dynamics	Theory	**4+0**

Course Structure of Mathematics as Major Subject in UG Honors with Research Programme

SEMESTER-WISE TITLES OF THE PAPERS OF MATHEMATICS AS MAJOR SUBJECT IN UG PROGRAMME				
Year	**Course Code**	**Course Title**	**Theory/Practical**	**Credits**
FIRST		**SEMESTER-I**		
	MAT- 101F	Differential Calculus and Integral Calculus	Theory	**4+0**
	MAT- 102F	Practical	Practical	**0+2**
		SEMESTER-II		
	MAT- 103F	Matrices and Differential Equations	Theory	**3+0**
	MAT- 104F	Geometry	Theory	**3+0**
SECOND		**SEMESTER-III**		
	MAT- 201F	Algebra	Theory	**3+0**
	MAT- 202F	Mathematical Methods	Theory	**3+0**
		SEMESTER-IV		
	MAT- 203F	Differential Equations	Theory	**3+0**
	MAT- 204F	Mechanics	Theory	**3+0**
THIRD		**SEMESTER-V**		
	MAT- 301F	Ring Theory and Linear Algebra	Theory	**4+0**
	MAT- 302F	Tensor Analysis	Theory	**3+0**
	MAT- 303F	Differential Geometry	Theory	**3+0**
		SEMESTER-VI		
	MAT- 304F	Metric Spaces and Complex Analysis	Theory	**4+0**
	MAT- 305F	Numerical Analysis and Operations Research	Theory	**4+0**
	MAT- 306F	Practical	Practical	**0+2**
FOURTH		**SEMESTER-VII**		
	MAT- 401F	Groups and Canonical Forms	Theory	**4+0**
	MAT- 402F	Topology	Theory	**4+0**
	MAT- 403F	Differential and Integral Equations	Theory	**4+0**
	MAT- 404F	Complex Analysis	Theory	**4+0**
	MAT- 405F	Real Analysis	Theory	**4+0**
		SEMESTER-VIII		
	Opt any two course of the following			
	MAT- 406F	Fields and Modules	Theory	**4+0**
	MAT- 407F	Differential Geometry of Manifolds	Theory	**4+0**
	MAT- 408F	Partial Differential Equations	Theory	**4+0**
	MAT- 409F	Operations Research	Theory	**4+0**
	MAT- 410F	Fluid Dynamics	Theory	**4+0**
		Disseratation/ Research Project		
	MAT- 411F	Disseratation/ Research Project	Project	**0+12**

UG Honors:
UG Honors opt only those students who passed UG Degree.

UG Honors with Research:
UG Honors with Research opt only those students who secured 75% marks in first six semester in UG Degree.

Programme Exit Options:
The mandatory number of credits which have to be secured for the purpose of award of Certificate in Faculty/ Diploma in Faculty/UG Degree/ UG Honors/ UG Honors with Research are listed in the following table.

S. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award	Exit Options
1	Certificate in Faculty	After successful completion of Semester II	**46**	Exit option-**1**
2	Diploma in Faculty	After successful completion of Semester IV	**92**	Exit option-**2**
3	UG Degree	After successful completion of Semester VI	**132**	Exit option-**3**
4	UG Honors	After successful completion of Semester VIII	**172**	----
OR				
4	UG Honors with Research **(For students who secured 75% marks in first six semester)**	After successful completion of Semester VIII	**172**	----

Subject Prerequisites:
To study this subject a student must had the subject(s) Mathematics in class 12th.

Program Outcomes (POs)

PO1: It is to give foundation knowledge for the students to understand basics of mathematics including applied aspects for the same.

PO2: It is to develop enhanced quantitative skills in pursuing higher mathematics and research as well.

PO3: Students will be able to develop solution-oriented approach towards various issues related to their environment.

PO4: Students will become employable in various government and private sectors.

PO5: Scientific temper in general and mathematical temper in particular will be developed in students.

Year	Semester	Program Specific Outcomes (PSOs)
First	SEM-I	**PSO1**. Student should be able to possess recall basic idea about mathematics which can be displayed by them.
	SEM-II	
Second	SEM-III	**PSO2**. Student should have adequate exposure to many aspects of mathematical sciences.
	SEM-IV	
Third	SEM-V	**PSO3**. Student is equipped with mathematical modeling ability, critical mathematical thinking, problem solving skills, etc. and apply his/her skill and knowledge in various field of studies including Science, Engineering, Commerce and Management etc.
	SEM-VI	
Fourth	SEM-VII	**PSO4**. To encourage students for research studies in Mathematics and related fields.
	SEM-VIII	

FIRST YEAR (SEMESTER-I)

DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS

Class: UG	**Year:** FIRST	**Semester:** FIRST
Subject: MATHEMATICS		
Course Code: MAT- 101F	**Course Title:** DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

CO1: The program outcome is to give foundation knowledge for the students to understand basics of mathematics including applied aspect for developing enhanced quantitative skills and pursuing higher mathematics and research as well.

CO2: By the time students complete the course; they will have wide ranging application of the subject and have the knowledge of real valued functions along with sequence. They will also be able to know about convergence of sequence. Also, they have knowledge about curvature, envelopeand evolutes, Riemann integral.

CO3: The main objective of the course is to equip the student with necessary analytic and technical skills.By applying the principles of differential calculus and integral calculus he/she learns to solve a variety of practical problems in science and engineering.

CO4: The student is equipped with standard concepts and tools at an intermediate to advance level that will serve him/her well towards taking more advance level course in mathematics.

Course prerequisites:

To study this course, a student must have the subject Mathematics in class 12th.

Unit	Topics
	PART-A **DIFFERENTIAL CALCULUS**
I	Definition of a sequence, Theorems on limits of sequences, Bounded and Monotonic sequences, Convergent sequence, Cauchy's convergence criterion, Balzano Weierstrass theorem for sequence, Cauchy sequence, Cauchy's first and second theorems on limits, limit superior and limit inferior of a sequence, Cantor's theorem on nested intervals, subsequence.
II	Limit, Continuity and differentiability of function of single variable, Cauchy's definition, Heine's definition, equivalence of definition of Cauchy and Heine, Uniform continuity, Borel's theorem, Bolzano's theorem, Intermediate value theorem, Extreme value theorem, Darboux's intermediate value theorem for derivatives, Chain rule.
III	Rolle's theorem, Lagrange and Cauchy Mean value theorems, mean value theorems of higher order, Taylor's theorem with various forms of remainders, Successive differentiation, and Leibnitz theorem, Maclaurin's and Taylor's series expansion.
IV	Partial differentiation, Homogeneous function, Euler's theorem on homogeneous function, Deduction from Euler's theorem, Jacobians and its properties, Asymptotes, Curvature, Envelops and Evolutes.

Unit	Topics
	PART-B **INTEGRAL CALCULUS**
V	Lower and upper bounds, Supremum and infimum of the subsets of R and its basic properties, Completeness of R. Riemann integral and its properties, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration.
VI	Beta and Gamma functions, Tracing of curves in Cartesian and Polar forms, Improper integrals, their classification and convergence, Comparison test, μ-test, Abel's test, Dirichlet's test, quotient test.
VII	Areas of Curve, Lengths of curve, Volumes of solid of revolution, Multiple integrals: Double and Triple integrals, Change of order of double integration, Area as a double integral in Cartesian form, Dirichlet's theorem, and Liouville's theorem for multiple integrals.
VIII	Vector Differentiation, Point function, Vector differential operator, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Second order differential operator, Laplacian operator. Vector Integration, Line integral, Circulation, Work done by a force, Surface integral, Volume integral, Gauss, Green, Stokes theorems with prove and related problems.

Books Recommended: (Part-A Differential Calculus)

1. R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons
2. T.M. Apostal, Calculus Vol. I, John Wiley & Sons Inc.
3. Gorakh Prasad, A text book on Differential Calculus, Pothishala Private Ltd., Prayagraj
4. S. Balachandra Rao & C. K. Shantha, Differential Calculus, New Age Publication.
5. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002.
6. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.

Books Recommended: (Part-B Integral Calculus)

1. T.M. Apostal, Calculus Vol. II, John Wiley Publication
2. Gorakh Prasad, A text book on Integral Calculus, Pothishala Private Ltd., Prayagraj
3. Shanti Narayan & Dr. P.K. Mittal, Integral Calculus, S.Chand
4. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FIRST YEAR (SEMESTER-I)
PRACTICAL

Class: UG	**Year:** FIRST	**Semester:** FIRST
Subject: MATHEMATICS		
Course Code: MAT- 102F	**Course Title:** PRACTICAL	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	

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

Course outcomes:

CO1. The main objective of the course is to equip the student to plot the different graphs and solve the different types of equations by plotting the graphs using different computer software such as Sage Math/Mathematica /MATLAB / /Maple / Scilab /C programming / R programming etc.

CO2. After completion of this course student would be able to know the Plotting the graphs.

CO3. Student would be able to Sketching parametric curves: Trochoid, Cycloid, Epicycloid.

CO4. Student would be able to find numbers between two real numbers and plotting of finite and infinite subsetof R, Matrix operations.

Course prerequisites:

To study this course, a student must have the subject Mathematics in class 12th.

Topics

- **Practical / Lab work to be performed in Computer Lab.**
- **List of the practicals to be done using Sage Math / Mathematica /MATLAB / Maple / Scilab / R programming / Python / C programming etc.**

1. Plotting the graphs of the following functions:

i. ax

ii. $[x]$ (greatest integer function)

iii. $x^{2n}; n\epsilon\ N$

iv. $x^{2n-1}; n\epsilon\ N$

v. $\frac{1}{x^{2n-1}}; n\epsilon\ N$

vi. $\frac{1}{x^{2n}}; n\epsilon\ N$

vii. $\sqrt{ax+b}$,$|ax+b|$

viii. $|x|\ for\ x \neq 0$

ix. $e^{x}\ for\ x \neq 0$

x. $e^{-x}\ for\ x \neq 0$

2. Plotting the graph of the following functions:
$\log_e x$, sin x, cos x, tan x.

3. Plotting the graph of the following functions: sin hx, cos hx, tan hx.
4. Sketching parametric curves: Trochoid, Cycloid, and Epicycloid.
5. By plotting the graph find the solution of the equation: $x = e^x$, $x^2 + 1 = e^x$, $1 - x^2 = e^x$, $x = \log_{10}(x)$, $\cos(x) = x$, $\sin(x) = x$, $\cos(y) = \cos(x)$, $\sin(y) = \sin(x)$.
6. Plotting the graphs of polynomial of degree 2, 3, 4 and 5.
7. Matrix operations: i. Addition, ii. Multiplication, iii. Inverse, iv. Transpose.
8. Complex number and their representations: i. Addition, ii. Multiplication, iii. Division, iv. Modulus.
Internal Evaluation Methods (Max. Marks: 25) Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.
External Evaluation Methods (Max. Marks: 75) Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.
Any remarks: • At least two Computer Programmers and two Computer Operators must be assigned in computer lab. • There should be a Computer Lab with minimum of 25 computer systems for 50 students with licensed and Free Open Source softwares related to this course.

FIRST YEAR (SEMESTER-II)

MATRICES AND DIFFERENTIAL EQUATIONS

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: MATHEMATICS		
Course Code: MAT- 103F	**Course Title:** MATRICES AND DIFFERENTIAL EQUATIONS	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: The topics of the course are included in such a way that they focus on developing mathematical skills in matrices and eigen values from basic level to depth of knowledge.

CO2: The student will be able to find the rank, eigen values of matrices and study the Differential Equations, Formation of differential equations.

CO3: The students will be capable of learn and visualize the fundamental ideas about the rank, eigen values of matrices and Orthogonal Trajectories.

CO4: On successful completion of the course students have gained knowledge about matrices, differential equations and their properties. They have the foundation for higher course in Matrices and differential equations.

Course prerequisites:

To study this course, a student must have the subject Mathematics in class 12th.

Unit	Topics
	MATRICES AND DIFFERENTIAL EQUATIONS
I	Elementary operations on Matrices, Rank of a Matrix, Echelon form of a Matrix, Normal form or Canonical form of a Matrix, Inverse of a Matrix by elementary operations. Complex matrix, Conjugate of matrix, Transpose of Conjugate of matrix, Hermitian matrix and Skew-Hermitian matrix, Periodic matrix, Idempotent matrix, Unitary matrix. System of linear homogeneous and non-homogeneous equations, Consistency and Inconsistency of a system of linear equations, Theorems on consistency of a system of linear equations.
II	Vector, Linear Dependence and Independence of vectors, Dependence and Independence of vectors of vectors by rank method. Eigen values, Eigen vectors and characteristic equation of a matrix, Orthogonal Vectors. Algebraic Multiplicity, Geometric Multiplicity, Regular eigen value, Caley-Hamilton theorem and its use in finding inverse of a matrix, Diagonalisation of square matrix, Power of matrix by Diagonalisation.
III	Order and Degree of a Differential Equations, Formation of differential equations, General Solution, Particular Solution, Geometrical meaning of a differential equation, Equation of first order and first degree, Equation in which the variables are separable, Equation Reducible to Variable separable form, Homogeneous differential equations, Equations Reducible to Homogeneous form.

IV	Exact differential equations and equations reducible to the exact form, Linear differential equations, Equations Reducible to Linear form; First order higher degree differential equations solvable for p, y, x. Clairaut's differential equation, Singular Solutions, Determination of singular solution, Orthogonal Trajectories, Trajectories in Cartesian form and Polar form.

Books Recommended:

1. Felix R. Gantmacher, The Theory of Matrices, AMS Chelsea Publishing.
2. Roger A. Horn, Charles R. Johnson, Matrix Analysis, Cambridge University Press.
3. Thomas S. Shores, Applied linear algebra and matrix analysis, Springer
4. G.F. Simmons, Differential Equations, Tata Mcgraw Hill Publishing Company Ltd.
5. M. D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Company Ltd., New Delhi.
6. Richard Bronson, Gabriel B. Costa, Schaum's Outline of Differential Equations, McGraw-Hill Education
7. Zafar Ahsan, Differential equations and their applications, PHI.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FIRST YEAR (SEMESTER-II)

GEOMETRY

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: MATHEMATICS		
Course Code: MAT- 104F	**Course Title:** GEOMETRY	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: The topics of the course are included in such a way that they focus on developing mathematical skills in geometry and three-Dimensional Coordinates from basic level to depth of knowledge.

CO2: The student will be able to find the concepts of three-Dimensional geometry. The course in geometry intends to develop problem solving skills for solving various types of concepts in three-Dimensional geometry.

CO3: The students will be capable of learn and visualize the fundamental ideas about coordinate geometry and learn to describe some of the surfaces by using analytical geometry.

CO4: On successful completion of the course students have gained knowledge about regular geometrical figures and their properties. They have the foundation for higher course in Geometry.

Course prerequisites:

To study this course, a student must have the subject Mathematics in class 12th.

Unit	Topics
	GEOMETRY
I	Three-Dimensional Coordinates in space, Distance between two points, Direction cosines and direction ratios, Projection of a segment on a straight line, Projection of the join of two points on a straight line, Angle between two lines, Distance of a point from a line.
II	Plane, General equation of plane, Equation of the plane in various forms, Equation of a plane through given points, Straight line in three dimensions, Coplanar lines, The image of a point in a plane, shortest distance between two lines.
III	Sphere, Equation of a sphere whose center is given, Intersection of two spheres, Intersection of sphere and a straight line, Cone, Equation of cone, Equation of right circular cone, enveloping cone.
IV	Cylinder, Right circular cylinder, Enveloping cylinder, Central conicoid, properties of the central conicoid in standard form, the ellipsoid, the hyperboloid one sheet, the hyperboloid of two sheets, intersection of line and a central conicoid, tangent plane, condition of tangency, director sphere, normal to a conicoid, polar plane, diametral plane.

Books Recommended:

1. R. J. T. Bell, An Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., New Delhi, 1994.
2. Shanti Narayan, P.K. Mittal, Analytical Solid Geometry, S. Chand & Company, New Delhi, 2008.
3. M.M. Tripathi, Coordinate Geometry: Polar Coordinates Approach, Narosa Publishing House, New Delhi
4. P.R. Vittal, Analytical Geometry 3D, Pearson.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-III)

ALGEBRA

Class: UG	**Year:** SECOND	**Semester:** THIRD
Subject: MATHEMATICS		
Course Code: MAT- 201F	**Course Title:** ALGEBRA	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: Group theory is one of the building blocks of modern algebra. Objective of this course is tointroduce students to basic concepts of Group theory and their properties.

CO2: A student learning this course gets a concept of Integers, Group and their properties.This course will lead the student to basic course in advanced mathematics particularly in Algebra.

CO3: The course gives emphasis to enhance students' knowledge of Permutation groups and Normal subgroups.

CO4: On successful completion of the course students would have acquire knowledge about Integers, Group and will help him/her in going for higher studies and research.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG First Year Programme.

Unit	Topics
	ALGEBRA
I	Properties of Integers, Divisor, Division algorithm. Greatest Common Divisor, Euclidean algorithm, Fundamental theorem of arithmemetic, Congruences and residue classes. Euler $\emptyset$ −function and its properties, Euler's, Fermat's and Wilson's theorem.
II	Algebraic Structure, Definition of a group with examples and simple properties, Subgroups, Generators of a group, Cyclic groups, Order of an element of a group, Centre of group.
III	Permutation groups, Cyclic permutation, Transposition, Even and odd permutations, The alternating group, Cayley's theorem, Coset decomposition, Lagrange's theorem and its consequences.
IV	Homomorphism and isomorphism, Kernel of homomorphism, Normal subgroups, Simple group, Quotient groups, Fundamental theorem of homomorphism, Theorems on isomorphism.

Books Recommended:

1. I. N. Herstein , Topics in Algebra, Wiley Eastern Ltd, New Delhi, 1975.
2. Joseph. A. Gallian, Contemporary Abstract Algebra, Cengage Learning India Private Limited,Delhi., Fourth impression, 2015.
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 1983.
4. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publication House, India.
5. David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa 1989.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-III)

MATHEMATICAL METHODS

Class: UG	**Year:** SECOND	**Semester:** THIRD
Subject: MATHEMATICS		
Course Code: MAT- 202F	**Course Title:** MATHEMATICAL METHODS	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: Laplace transforms and Fourier transforms is one of the building blocks of modern mathematics. Objective of this course is tointroduce students to basic concepts of limit and continuity of function of two variables, Fourier series and their properties.

CO2: A student learning this course gets a concept of Laplace transforms, Fourier transforms and their properties. This course will lead the student to basic course in advanced mathematics particularly in function of two variables.

CO3: The course gives emphasis to enhance students' knowledge of function of two variables, Laplace transforms and Fourier series, Fourier expansion of piecewise monotonic functions, Calculus of variations, Fourier series for even and odd functions.

CO4: On successful completion of the course students would have acquire knowledge about function of two variables**,** Laplace transforms, Fourier series, Calculus of variations and will help him/her in going for higher studies and research.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG First Year Programme.

Unit	Topics
	MATHEMATICAL METHODS
I	Limit and Continuity of functions of two variables, Differentiation of function of two variables, Taylor's theorem for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange multiplier method. Exponential functions, hyperbolic functions, logarithm of a complex number, general exponential function. Inverse Circular function of complex quantities, inverse hyperbolic functions.
II	Laplace transform, Existence theorem for Laplace Transform, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Heaviside expansion formula. Initial and Final value theorem, Unit step function and their properties. Laplace transform of periodic function, Unit impulse function, Inverse Laplace transforms, Convolution theorem, Solution of ordinary differential equation by using Laplace transform.
III	Periodic functions, Fourier series, Fourier expansion of piecewise monotonic functions, Fourier series for even and odd functions, Half - range expansions. Fourier transforms (finite and infinite) and properties of fourier transform.

IV	Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives.

Books Recommended:

1. T.M. Apostal, Mathematical Analysis, Pearson
2. G. F. Simmons, Differential Equations with Application and Historical Notes, Tata -McGrawHill
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. A.C. Srivastava, Engineering Mathematics, PHI Publication.
5. N. Kumar, An Elementary Course on Variational Problems in Calculus, Narosa Publications, New Delhi.
6. A. S. Gupta, Text Book on Calculus of Variation, Prentice-Hall of India, New Delhi.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-IV)

DIFFERENTIAL EQUATIONS

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: MAT- 203F	**Course Title:** DIFFERENTIAL EQUATIONS	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: The objective of this course is to familiarize the students with various methods of solving differential equations, partial differential equations and to have qualitative applications.

CO2: A student doing this course is able to solve differential equations and is able to model problems in nature using ordinary differential equations. After completing this course, a student will be able to take more courses on differential equations. These entire courses are important in engineering and industrial applications for solving boundary value problems.

CO3: The object of the course is to give students knowledge of basic differential equations, partial differential equations such as Simultaneous Differential Equation and Total differential equation.

CO4: The student, after completing the course can go for higher quality problems in Differential Equation. This will be helpful in getting employment in industry.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG First Year Programme.

Unit	Topics
	DIFFERENTIAL EQUATIONS
I	Linear differential equation with constant coefficients, Homogeneous Linear differential equations (Cauchy-Euler differential equation), Equations Reducible to Homogeneous linear form (Legendre's linear differential equations).
II	Second order linear differential equations: Use of a known solution to find another (reduction of order), reduction to normal form, Changing the independent variable, method of variation of parameters.
III	Ordinary Simultaneous Differential Equation, Method of solving simultaneous linear differential equation with constant coefficients, Solution of simultaneous differential equation in a different form.
IV	Total differential equation, Necessary and sufficient condition for Integrability of total differential equation, Methods for solving the total differential equation: Solution by inspection, one variable regarded as constant, homogeneous equations, method of auxiliary equations.

Books Recommended:

1. G.F. Simmons, Differential Equations with Application and Historical Notes, Tata–McGraw- Hill
2. B. Rai, D.P. Choudhary & H. J. Freedman, A Course of Ordinary Differential Equations, Narosa
3. M. D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Company Ltd., New Delhi.
4. L.E. Elsgolts, Differential Equation and Calculus of variations, University Press of the Pacific.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-IV)

MECHANICS

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: MAT- 204F	**Course Title:** MECHANICS	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: The objective of this course is to familiarize the students with various methods of finding Forces in three dimensions. Poinsot's central axis. Wrenches. Null lines and null planes. Conjugate lines and conjugate forces and to have qualitative applications.

CO2: A student doing this course is able to model problems in nature using Statics & Dynamics. After completing this course, a student will be able to take more courses on Virtual work, Stable and unstable equilibrium, Catenary, Catenary of uniform strength etc. These entire courses are important in engineering and industrial applications.

CO3: The object of the course is to give students knowledge of basic mechanics such as motion under other laws and forces.

CO4: The student, after completing the course can go for higher quality problems in mechanics such as hydrodynamics. This will be helpful in getting employment in industry.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG First Year Programme.

Unit	Topics
	MECHANICS
I	Forces in three dimensions. Poinsot's central axis. Wrenches. Null lines and null planes. Conjugate lines and conjugate forces.
II	Analytical conditions of equilibrium of coplanar forces, Virtual work, Stable and unstable equilibrium, Catenary and its properties.
III	Motion in a straight line: velocity and acceleration, Accelerations in terms of different coordinate systems. Motion in a plane: velocity and acceleration along radial and transverse direction, velocity and acceleration along tangential and normal directions, Elastic strings.
IV	Motion in resisting medium, Projectile motion in resisting medium. Moments and products of inertia. The momental ellipsoid. Equimomental systems. Principle axes. Central orbits. Apses and apsidal distances. Kepler's laws of planetary motion, Motion of a particle in three dimensions.

Books Recommended:

1. R.C. Hibbeler, Engineering Mechanics-Statics, Pearson.
2. S L Loney, The Elements of Statics & Dynamics Part-I (Statics), Arihant.
3. S L Loney, The Elements of Statics & Dynamics Part-II (Dynamics), Arihant.
4. A. Nelson, Engineering Mechanics Statics and Dynamics, Tata McGraw Hill
5. J.L. Synge & B.A. Griffith, Principles of Mechanics, Tata McGraw Hill

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

SECOND YEAR (SEMESTER-IV)
PROJECT

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: As prescribed by the University	**Course Title:** PROJECT	
Credits:0+3	**The student can opt any one as a project from subject-1/ subject-2/ subject-3 (Major-1/ Major-2/ Minor-3) in semester-IV**	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course Outcomes:

CO 1. The objective of course is to write a project on the specific topic.

CO 2. The student shall be able to do their research work in different interdisciplinary areas.

CO 3. After completing the course, the student shall be able to understand some advanced mathematical techniques.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Semester-I, II and III Programme.

PROJECT

Candidate/Students should write a project on the specific topic based on any one core/major papers opted by the student in semester- I, II, III and IV. The students has been allotted a supervisor in this research project on their topic, given by the concern faculty. The project should be typed.

Evaluation Methods (Max. Marks: 100)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-V)

RING THEORY AND LINEAR ALGEBRA

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: MAT- 301F	**Course Title:** RING THEORY AND LINEAR ALGEBRA	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

CO1: Objective of this course is to sustain the students in Abstract Algebra of almost Advanced Level.

CO2: Ring theory and Linear Algebra is a basic course in almost all branches of science. The objective of this course is tointroduce a student to the basics of Abstract Algebra, Linear Algebra and some of its applications.

CO3: After successful completion of course, students will enable themselves to knowledge of Polynomial rings over commutative rings, vector spaces**.**

CO4: Student will use this knowledge in computer science, finance mathematics and industrial mathematics. After completion of this course students will appreciate its interdisciplinary nature.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Unit	Topics
	PART-A **RING THEORY**
I	Introduction to rings, integral domains and fields, Characteristic of a ring, Ring homomorphism, Ideals and quotient rings.
II	Field of quotients of an integral domain, Euclidean domain, Prime and maximal ideals, principal ideal domain, Principal ideal rings, Polynomial rings over commutative rings.
III	Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion, Unique factorization in Z[x].
IV	Divisibility in integral domains, Irreducible, Primes, Unique factorization domains, Euclidean domains.

Unit	Topics
	PART-B **LINEAR ALGEBRA**
V	Vector spaces, Vector Subspaces, Linear combination, Linear independence and dependence of vectors, same and same spaces, Basis and Dimension, Quotient space.
VI	Linear transformations, The Algebra of linear transformations, Rank Nullity theorem, their representation as matrices.
VII	Linear functionals, Dual space, Dual Basis and Dimension, Bilinear and Quadratic forms.
VIII	Change of basis, diagonal forms, triangular forms, Inner product spaces and norms, Orthogonal vectors, Orthonormal sets and bases.

Books Recommended :(Part-A Ring Theory)

1. I. N. Herstein, Topics in Algebra, Wiley
2. Joseph. A. Gallian, Contemporary Abstract Algebra, Cengage Learning India Private Limited, Delhi.,Fourth impression, 2015.
3. David S. Dummit, & Richard M. Foote, Abstract Algebra (3rd ed.) (2016), Student Edition. WileyIndia.

Books Recommended :(Part-B Linear Algebra)

1. K. Hoffman and R. Kunze, Linear Algebra (2nd ed.), Prentice-Hall of India.
2. Gilbert Strang, Linear Algebra and its Applications, Cengage Learning, 2018.
3. Stephen H. Friedberg, Arnold J. Insel, & Lawrence E. Spence (2003). Linear Algebra (4th ed.). Pearson.
4. Serge Lang, Linear Algebra (3rd ed.) (1987), Springer
5. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-V)

TENSOR ANALYSIS

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: MAT- 302F	**Course Title:** TENSOR ANALYSIS	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: The course is aimed at exposing the students to foundations of tensor analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.

CO2: After completion of this course the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful to the student in understanding pure mathematics and in research.

CO3: Students will be able to know the concepts of tensor, basic concepts and developments of differential geometry which will prepare the students to take up further applications in the relevant fields.

CO4: The course enables the students the basics of tensor and differential geometry for further application in higher studies**.**

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Unit	Topics
	TENSOR ANALYSIS
I	Tensor : Transformation of coordinates, Contravariant and covariant vectors and tensors, Scalar invariants, Mixed tensors, Symmetric and skew –symmetric tensor, Algebra of tensors, Contraction and inner product, Quotient law, Reciprocal tensors.
II	Associated tensors, Length of a vector, Unit Vector, Null vector and orthogonal vector, Riemannian Metric and Space and Christoffel symbols.
III	Covariant differentiation of vector and tensor, Ricci's theorem, Gradient of scalar, Divergence of a contravariant vector, covariant vector and conservative vector, Divergence of a contravariant tensor of order two, Divergence of a mixed tensor of type (1,1), Laplacian of an invariant, curl of a covariant vector
IV	Riemannian curvature tensor and their properties, Flat space, Ricci tensor and scalar curvature, Einstein space and Einstein tensor.

Books Recommended:

1. David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.
2. R. S, Mishra, A Course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt.Ltd, Allahabad.
3. P.K.Nayak, Tensor Calculus and Differential Geometry, PHI Learning Private Limited, Delhi.
4. D.C.Kay, Tensor Calculus, Sahaum's Outlines.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-V)

DIFFERENTIAL GEOMETRY

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: MAT- 303F	**Course Title:** DIFFERENTIAL GEOMETRY	
Credits: 3+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 3-0-0		

Course outcomes:

CO1: The course is aimed at exposing the students to foundations of tensor analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.

CO2: After completion of this course the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful to the student in understanding pure mathematics and in research.

CO3: Students will be able to know the concepts of curve, basic concepts and developments of differential geometry which will prepare the students to take up further applications in the relevant fields.

CO4: The course enables the students the basics of tensor and differential geometry for further application in higher studies.

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Unit	Topics
	DIFFERENTIAL GEOMETRY
I	Local theory of curves –space curves, Regular curve and Plane curve, twisted curve, equation of a plane and straight line, equation of curves in space, length of a curve, tangent to curve, Order of contact between curves and surfaces, osculating plane , equation of osculating plane, equation osculating plane at a point of curve of intersection of two surfaces. Tangent, principal normal and binormal, normal plane and rectifying plane.
II	Curvature and torsion, Serret-Frenet formulae, Direction cosines of the principal normal and binormal, Osculating sphere. Involutes and evolutes of curves, curve on surface, Regular point and Singularities of surface, transformation of parameters, Parametric curves, tangent plane and normal line, First fundamental form and arc length. Angle between two curves on surface.
III	Special tensors and its properties, orthogonal trajectories, Differential equation of orthogonal trajectories. Second fundamental form of surface, Geometric interpretation of the second fundamental form, Gauss and Weingarten equation, Identities based on Weingarten equation.
IV	Normal curvature and its equation, Meusnier's theorem. Principal directions and curvatures. Mean curvature, Gaussian Curvature, Minimal surface. Definition of Geodesics and differential equation of geodesics on a surface.

Books Recommended:

1. Somasundaram, Differential Geometry, Narosa Publishing House
2. Andrew Pressley, Elementary Differential Geometry,Springar Verlag,2014
3. M. P. do Carmo, Differential geometry of curves and surfaces, Prentice Hall 1976.
4. Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998.
5. S. Montiel and A. Ros, Curves and Surfaces, American Mathematical Society, 2005.
6. B. O'Neill, Elementary Differential Geometry, Elsevier 2006 .

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-VI)
METRIC SPACES AND COMPLEX ANALYSIS

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: MAT- 304F	**Course Title:** METRIC SPACES AND COMPLEX ANALYSIS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

CO1: The course is aimed at exposing the students to foundations of analysis which will be useful in understanding various physical phenomena and gives the student the foundation in mathematics.

CO2: After completion of this course the student will have rigorous and deeper understanding of fundamental concepts in Mathematics. This will be helpful to the student in understanding pure mathematics and in research.

CO3: Students will be able to know the concepts of metric space, basic concepts and developments of analysis which will prepare the students to take up further applications in the relevant fields.

CO4: The course enables the students the basics of metric spaces and contour integration for further application in higher studies.

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Unit	Topics
	PART-A **METRIC SPACES**
I	Definition of a Metric Space, Examples of Metric Space, Bounded and Unbounded Metric Space, Pseudo-metric, Subspace of a Metric Space, Diameter of a Subset of a Metric Space, Distance of a Point from a Non-empty set, Distance between two Non-empty Subsets of a Metric Space. Open and Closed Spheres, Neighborhood of a point, Interior Point and Interior of a Set, Open sets, Equivalent Metrics, Exterior, Frontier and Boundary of a Set, Limit Point and Isolated Point, Derived Set, Closed Set, Closure of a Set , Dense Sets and Separable Spaces.
II	Subspace of a Metric Space, Examples, Sequence in a Metric Space, Convergence in a Metric Space Cauchy Sequence, Complete Metric Space, Isometry and Isometric Space.
III	Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem.
IV	Cover, Compact Sets and compact Space, Finite Intersection Property and Compactness, Continuity and Compactness, Sequentially Compactness. Separated Sets, Disconnected Space and Disconnected Sets, Connected Space and Connected Sets, Components.

Unit	Topics
	PART-B **COMPLEX ANALYSIS**
V	Complex numbers as ordered pairs, geometric representation of complex number, Stereographic projection, Continuity and Differentiability of complex functions, Analytic functions, Cauchy Riemann equations, Harmonic functions.
VI	Complex integration, Cauchy-Goursat theorem, Cauchy's Integral formula, Formulae for first, second and nth derivatives, Cauchy's Inequality, Liouville's Theorem.
VII	Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic, De Morgan and Cauchy's condensation test, Taylor Series, Laurent Series and its examples.
VIII	Zeroes and poles of order m, Isolated singular points, Types of isolated singular points , Residues, Residues at poles and its examples, Residue at infinity, Cauchy's residue theorem, Evaluation of improper real integrals, Definite integrals involving sines and cosines.

Books Recommended: (Part-A Metric Spaces)

1. Shanti Narayan, A Course of Mathematical Analysis, S. Chand Publication.

2 .Satish Shirali and H. L Vasudeva. Metric Spaces, (2009), Springer, First Indian Print.

3. S, Kumaresan. Topology of Metric Spaces (2nd ed.), (2014). Narosa Publishing House. New Delhi.

4. G. F. Simmons, Introduction to Topology and Modern Analysis (2004), Tata McGraw Hill. New Delhi

Books Recommended: (Part-B Complex Analysis)

1. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand Publications.

2. J.W.Brown and R.V. Churchill Complex variables and Applications, McGraw-Hill Higher Education.

3. T.M. Apostal, Calculus Vol. I, John Wiley & Sons Inc.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-VI)

NUMERICAL ANALYSIS AND OPERATIONS RESEARCH

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: MAT- 305F	**Course Title:** NUMERICAL ANALYSIS AND OPERATIONS RESEARCH	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

CO1: The aim of this course is to teach the students the application of various numerical techniques, application of linear programming for variety of problems occurring in daily life. At the end of the course the student will be able to understand the basic concept of Numerical Analysis, the basic concept of linear programming and to solve Algebraic and differential equation.

CO2: The main outcome will be that students will be able to handle problems and finding approximated solution. Later he can opt for advance course in Numerical Analysis and linear programming in higher Mathematics.

CO3: The student will be able to solve various problems based on numerical techniques. After successful completion of this paper will enable the students to apply the basic concepts of numerical techniques problems, transportation problems and its related problems to apply in further concepts and application of Numerical Analysis and operation research.

CO4: After successful completion of this course students have basic knowledge of Numerical Analysis and operation research for higher study and Research.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Unit	Topics
	PART-A **NUMERICAL ANALYSIS**
I	Error in numerical computations, Calculus of finite differences, Difference operators, Fundamental theorem of differential calculus, Interpolation with equal and unequal intervals, Newton's forward and backward interpolation formulae, Divided difference interpolation formula, Lagrange's interpolation formula.
II	Solutions of algebraic and transcendental equations, Direct and iterative methods, Bisection method, Regula-falsi method, Newton- Raphson method, Iteration method. Solution of simultaneous linear equations: Gauss-elimination method, Guass-Jordan method, LU decomposition method, Guass-Seidel method.

III	Numerical differentiation derivatives using forward and backward formula, Numerical Integration, General Quadrature formula, Trapezoidal rule, Simpson's one-third and three-eight formulae and Weddle's rules.
IV	Numerical solution of ordinary differential equation, Picard method, Taylor series method, Euler's method, Modified Euler's method, Runge-Kutta method.
Unit	**Topics**
	PART-B **OPERATIONS RESEARCH**
V	Developing mathematical models, Mathematical programming, Linear programming, Convex sets, Convex and concave functions, Theorems on convexity, Linear programming problem (LPP), Simple and general LPP, Solutions of simple LPP by graphical method, Analytical solution of general LPP, Canonical and standard forms of LPP, Slack and surplus variables.
VI	Solution of general LPP by Simplex method. Use of artificial variables in simplex method, Big-M method and Two-Phase method, Concept of duality in linear programming, Theorems on duality, Dual simplex method.
VII	Transportation problem, Solution of transportation problem, Methods for finding Initial basic feasible solution of transportation problem, Optimal solution of transportation problem by modified distribution (MODI) method, Degeneracy in transportation problem, Maximization transportation problem. Assignment problem, Balanced and unbalanced assignment problems. Solution of assignment Problem, Hungarian Method, Maximization Assignment problem.
VIII	Game Theory: Competitive game, Two-Person Zero-Sum (Rectangular) game, Minimax-maximin criteria, Saddle points, Solution of rectangular game with and without saddle points, Huge rectangular games, Dominance rules, Solution of huge rectangular games using rules of dominance, Graphical method for 2xn and mx2 games without saddle points.

Books Recommended:(Part-A Numerical Analysis)

1. M. K. Jain, S.R.K. Iyengar & R.K. Jain, Numerical Methods for Engineering and scientificcomputation
2. S. S. Sastry, Introductory methods of Numerical Analysis

Books Recommended: (Part-B Operation Research)

1. Taha, Hamdy H, Opearations Research- An Introduction, Pearson Education.
2. V. S. Verma, Linear Programming and Game Theory, Neelkamal Prakashan, Gorakhpur, 2011.
3. Kanti Swarup , P. K. Gupta , Man Mohan Operations research, Sultan Chand & Sons
4. Hillier Frederick S and Lieberman Gerald J., Operations Research, McGraw Hill Publication.
5. Winston Wayne L., Operations Research: Applications and Algorithms, Cengage Learning, 4th Edition.
6. Hira D.S. and Gupta Prem Kumar, "Problems in Operations Research: Principles and Solutions", S Chand & Co Ltd.
7. Kalavathy S., Operations Research, S. Chand.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

THIRD YEAR (SEMESTER-VI)

PRACTICAL

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: MAT- 306F	**Course Title:** PRACTICAL	
Credits: 0+2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		

Course outcomes:

CO1. The main objective of the course is to equip the student to solve the transcendental and algebraic equations, system of linear equations, Interpolation, Numerical Integration, ordinary differential equations, ordinary difference equations by using different computer software such as Sage Math/Mathematica /MATLAB / /Maple / Scilab /C programming / R programming etc.

CO2. After completion of this course student would be able to solve the transcendental and algebraic equations.

Course prerequisites:

- To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.
- To study this course, a student must have the course MAT- 305F in UG third year.

Topics

- **Practical / Lab work to be performed in Computer Lab.**
- **List of the practicals to be done using Sage Math / Mathematica /MATLAB / Maple / Scilab / R programming / Python / C programming etc.**

1. Solution of transcendental and algebraic equations by

i. Bisection method
ii. Regula Falsi method
iii. Newton Raphson method
iv. Iteration method

2. Solution of system of linear equations by

i. LU decomposition method
ii. Gaussian elimination method
iii. Gauss-Seidel method

3. Interpolation by

i. Newton's forward Interpolation
ii. Newton's backward Interpolation
iii. Lagrange Interpolation
iv. Divided difference interpolation formula

4. Numerical Integration by

i. Trapezoidal Rule
ii. Simpson's one third rule

5. Numerical Integration by i. Simpson's three-eight rule ii. Weddle's Rule
6. Solution of ordinary differential equations by i. Euler method ii. Runge Kutta method
7. Solution of ordinary difference equations by Picard method.
8. Solution of ordinary difference equations by Taylor series method.
Internal Evaluation Methods (Max. Marks: 25) Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.
External Evaluation Methods (Max. Marks: 75) Practical External Evaluation shall be based on Viva-voce, Practical Exercises and Overall performance. {As prescribed by the University (as per common ordinance for examination and assessment)}.
Remarks: • At least two Computer Programmers and two Computer Operators must be assigned in computer lab. • There should be a Computer Lab with minimum of 25 computer systems for 50 students with licensed and Free Open Source softwares related to this course.

FOURTH YEAR (SEMESTER-VII)

GROUPS AND CANONICAL FORM

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: MAT- 401F	**Course Title:** GROUPS AND CANONICAL FORM	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

CO 1. The aim of this course is to understand Group theory covering a wide area of research in abstract algebra.

CO 2. The students shall be able to understand Sylow's theorems, group homomorphism, isomorphism etc. are used to define the structureof groups as well as it is applicable in physical and chemical sciences.

CO 3. After the completion of the course, the students shall be able to gain conceptual understanding of the course for qualifying various competitive exams such as CSIR-NET (JRF), IAS,PCS and other teaching jobs.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	GROUPS AND CANONICAL FORM
I	Groups: Conjugacy relation. Normalizer of an element, Class equation of a finite group, Center of a group, Fundamental theorems on isomorphism of groups, Automorphisms, Inner automorphism.
II	Maximal subgroups, Commutator subgroups, Composition series, Examples of Composition series and normal series. Jordan-Holder theorem, Solvable groups, Solvable subgroups, Nilpotent groups.
III	External and internal direct product of groups, Cauchy's theorem for finite group, Cauchy's theorem for abelian group, Groups of order p^2 and pq, Sylow's p subgroups, Sylow's first, second and third theorems. Application of Sylow's theorems to find the number of Sylow's p subgroups of a finite groups.
IV	Canonical forms: Similarity of linear transformations, Invariant subspaces, Reduction to triangular forms, Nilpotent transformations, Index of nilpotency, Invariants of a nilpotent transformation, The primary decomposition theorem, Jordan blocks and Jordan forms.

Books Recommended:

1. I.N. Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi.
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul Basic Abstract Algebra (Second Edition), Cambridge University Press, Indian Edition.
3. Surjeet Singh and Qazi Zameeruddin: Modern Algebra, Vikas Publishing House. Pvt. Ltd.
4. K.B. Datta:Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi,.
5. S. Kumaresan: Linear Algebra, A Geometric Approach, Prentice Hall of India.
6. A.R. Vasishtha & A.K. Vasishtha: Modern Algebra, Krishna Prakashan Media (P) Ltd., Meerut.
7. H.K.Pathak: Abstract Algebra, Shiksha Sahitya Prakashan.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

TOPOLOGY

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: MAT- 402F	**Course Title:** TOPOLOGY	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course outcomes:

CO 1. The aim of this course is to understand the concept of theory of continuous curve, differentiable and Riemannian manifold and lie groups with their applications.

CO 2. The students shall be able to understand the theory of Banach and Hilbert spaces and their operators.

CO 3. After the completion of the course**,** they are able to understand abstract Harmonic analysis on locally compact groups.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	TOPOLOGY
I	Definition and examples of topological spaces. Closed sets. Closure. Dense subsets. Neighbourhoods. Interior, exterior and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology. Neighbourhood Systems.
II	Continuous functions and homeomorphism, The Pasting lemma. First and second countable spaces. Lindelof's theorems. Separable spaces. Second Countability and Separability.
III	Separation axioms T_0, T_1, T_2, T_3, T_4; their characterizations and basic properties. Urysohn Lemma. Tietze extention theorem.
IV	Compact sets and their properties. Finite intersection property, Bolzano Weierstrass property. Continuous functions and compactness, Sequential compactness, countable compactness and their comparison. One point compactification. Connected spaces. Connectedness on the real line. Components. Locally connected Spaces.

Books Recommended:

1. George F. Simmons : Introduction to Topology and Modern Analysis, Mc Graw-Hill Book Company.
2. J.L. Kelley : General Topology, Van Nostrand, Reinhold Co., New York.
3. K.D. Joshi: Introduction to General Topology, Wiley Eastern Ltd.
4. James R Munkres : Topology, Prentice Hall of India Pvt. Ltd., New Delhi.
5. Willard: General Topology Addison-Wesley, Reading.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

DIFFERENTIAL AND INTEGRAL EQUATIONS

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: MAT- 403F	**Course Title:** DIFFERENTIAL AND INTEGRAL EQUATIONS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The students shall be able to learn the series solution of differential equation of second order with variable coefficients.

CO 2. The aim of this course is to understand initial and boundary value problems.

CO3. After the completion of the course, the students shall be able to solve linear Volterra and Fredholm integral equations using appropriate methods and understand the relationship between integral and differential equations.

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	DIFFERENTIAL AND INTEGRAL EQUATIONS
I	Series solution of differential equations of second order with variable coefficients and emergence of special functions, orthogonal sets of function, orthogonality of some special functions, Hermite orthogonality of a set of complex valued functions, Sturm-Liouville equation, Sturm-Liouville problem, Hypergeometric differential equation, Papperitz symbol, Pochhammer symbol, Hypergeometric function, Solution of Gauss's Hypergeometric Differential Equation, differentiation of Hypergeometric functions, Hermite's differential equation and its solution, Hermite's polynomials, generating function for $H_n(x)$, Rodrigue's formula for $H_n(x)$, orthogonality of Hermite's polynomials, recurrence formulae for Hermite's polynomials.
II	Legendre's differential equation and its solution, Legendre's functions, Rodrigue's formula for $P_n(x)$, generating function for $P_n(x)$, Laplace definite integrals for $P_n(x)$, orthogonality of Legendre's polynomials, recurrence formulae for Legendre's polynomials, Beltrami result. Bessel's differential equation and its solution, Bessel's functions, generating function for $J_n(x)$, differential equations reducible to Bessel's differential Equations, orthogonality of Bessel's functions, recurrence formulae for Bessel's polynomials.

III	Introduction of integral equations, linear integral equations, types of linear integral equations, types of Kernels, conversion of differential equations to integral equations, L_2 kernels and L_2 functions, eigen values and eigen functions, solution of Volterra integral equations by successive approximations and successive substitution methods.
IV	Fredholm integral equations of first and second kinds, solution of Fredholm integral equations by Successive approximations and successive substitution methods, Neumann Series, Volterra solution of Fredholm integral equation of second kind, reduction of Volterra integral equation into differential equation.

Books Recommended:

1. V. S.Verma, Series Solution and Special Functions, Neel Kamal Prakashan, Gorakhpur, 2017.
2. V. S.Verma, Fundamentals of Integral Equations Neel Kamal Prakashan, Gorakhpur, 2018.
3. M D Raisinghania, Mathematical methods, Kedarnath, Ramnath, Meerut, 1996.
4. JN Sharma, RK Gupta, Special functions, Krishna Prakashan Media (P) Ltd, 2020.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

COMPLEX ANALYSIS

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: MAT- 404F	**Course Title:** COMPLEX ANALYSIS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to understand the use of this course in different field of mathematical Analysis.

CO 2. The students shall be able to think and develop new ideas in complex analysis.

CO 3. After the completion of the course, the students shall be able to get benefit of this course in various national and international competitive examinations.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	COMPLEX ANALYSIS
I	Conformal Mapping, Mobius (Bilinear) transformations: involving circles and half-planes, fixedpoint, cross ratio, Transformations $w=z^2$, $w = \tan^2(z/2)$.
II	Power series and its convergence. Analyticity of power series, singularity of power series, Gamma function. Zeta Function.
III	Analytic continuation. Uniqueness of analytic continuation. Power series method of analyticcontinuation. Natural boundary.
IV	Maximum-modulus theorem. Schwarz's lemma. Hadamard's three-circles theorem. Borel-Cartheodory theorem. Pharagmen- Lindelof theorem.

Books Recommended:

1. E.C. Titchmarsh: Theory of Functions, Oxford University Press, London.
2. Mark J. Ablowitz and A.S. Fokas: Complex Variables: Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.
3. R.V. Churchill & J.W. Brown. Complex Variables and Applications, 5th Edition McGraw-Hill,New York, 1990.
4. Shanti Narayan: Theory of Functions of a Complex Variable, S. Chand & Co., New Delhi.
5. S. Ponnusamy, Foundation of Complex Analysis, Narosa Publication.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VII)

REAL ANALYSIS

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: MAT- 405F	**Course Title:** REAL ANALYSIS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to demonstrate ability to think critically by proving mathematical conjectures and establishing theorems.

CO 2. The student shall be able to demonstrate an intuitive and computational understanding of bounded variation, Uniform convergence and power series through solving application problem.

CO 3. After the completion of the course, the student shall be able to enter into wide area of research in analysis and differential geometry. Also get benefit of this course in various national and international competitive examinations.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	REAL ANALYSIS
I	Functions of Bounded Variation and some properties of function of bounded variation, Lipschitz condition and function. Variation function, Positive Variation function, Negative Variation function and The Jordan Decomposition theorem.
II	Definition and Existence of Riemann- Stieltjes integrals. Properties of the integral, integration anddifferentiation, the first and second mean value theorem, the fundamental theorem of integral calculus, change of variable and Integration by parts for Riemann- Stieltjes. Relation between Riemann and Riemann- Stieltjes integral. Riemann- Stieltjes integrals and bounded variation.
III	Sequences of functions of real numbers and its related examples. Pointwise convergence and uniform convergence. CauchyCriterion of uniform convergence, M_n test, Weierstrass M- test, everywhere continuous but nowhere differentiable functions. Dini's Criterion of uniform convergence. Uniform convergence and continuity. Continuity of limit function. Uniform convergence and Riemann Stieltjes integration, Uniform convergence and differentiation.

IV	Abel's and Dirichlet's tests for uniform convergence. Connections between Riemann-Stieltjes integrals, uniform convergence and bounded variation. Curves, Rectifiable curves, Additive and Continuity properties of arc length. Power series, Radius of convergence and interval of convergence, Formulas for determining the radius of convergence, Uniqueness theorem for power series, First and Second form of Abel's theorem and Tauber's theorem for power series.

Books Recommended:

1. Walter Rudin: Principles of Mathematical Analysis (3rd edition), McGraw-Hill, Kogakusha, 1976 International Student Edition.
2. H. L. Royden: Real Analysis, Macmillan Pub. Co. Inc. New York, 4th Edition, 1993.
3. Richard Johnson Baugh: Foundation of Mathematical Analysis.
4. H. K. Pathak: Real Analysis, Shiksha Sahitya Prakashan.
5. Apostol: Mathematical Analysis, Narosa Publishing House.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

FIELDS AND MODULES

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: MAT- 406F	**Course Title:** FIELDS AND MODULES	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to think and develop new ideas in this subject.
CO 2. The student shall be able to understand the applications of this course in different field of Science and Technology
CO 3. After the completion of the course the student shall be able to get benefit of this course in various national and international competitive examinations.

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	FIELDS AND MODULES
I	Field theory: Extension Fields. Algebraic and transcendental extensions. Splitting Field. Separableand inseparable extensions.
II	Normal extension. Perfect Fields. Finite Fields.
III	Automorphisms of extensions. Galois group. Fundamental theorem of Galois Theory. Construction with ruler and compass. Solution of polynomial equations by radicals.
IV	Modules, Cyclic modules. Simple modules. Semi-simple modules. Schuler's lemma. Free modules. Noetherian and artinian modules. Hilbert basis theorem.

Books Recommended:

1. I.N. Herstein : Topics in Algebra, Wiley Eastern Ltd., New Delhi.
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul : Basic Abstract Algebra (Second Edition), Cambridge University Press, Indian Edition.
3. Surjeet Singh and Qazi Zameeruddin: Modern Algebra, Vikas Publishing House. Pvt. Ltd.
4. K.B. Datta : Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
5. S. Kumaresan : Linear Algebra, A Geometric Approach, Prentice Hall of India.
6. A.R. Vasishtha & A.K. Vasishtha : Modern Algebra, Krishna Prakashan Media (P) Ltd., Meerut .
7. H.K.Pathak: Abstract Algebra, Shiksha Sahitya Prakashan.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

DIFFERENTIAL GEOMETRY OF MANIFOLDS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: MAT- 407F	**Course Title:** DIFFERENTIAL GEOMETRY OF MANIFOLDS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to understand the basic of this course and think & develop new ideas in this course.

CO 2. The student shall be able to demonstrate an intuitive and computational understanding of Tensor Algebra, Differentiable manifold, Riemannian Manifold, Exterior algebra and Submanifolds & Hypersurfaces.

CO 3. After the completion of the course the student shall be able to enter into wide area of research in differential geometry and its applications in physical sciences and Cosmology. Also get benefit of this course in various national and international competitive examinations.

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	DIFFERENTIAL GEOMETRY OF MANIFOLDS
I	Tensor Algebra: Contravariant and covariant vector. Tensor product of vector spaces, tensor, contravariant, covariant and mixed tensor of second order. Tensor of type (r, s), tensor product oftensors. Symmetric and skew symmetric tensors, contraction. Definition and examples of differentiable manifold, Differentiable functions, Differentiable curves.
II	Tangent space, Vector fields, Lie bracket. Principal Fibre Bundle, cross section, Linear Frame Bundle, Associated Principal Bundle, Vector Bundles, Bundle Homomorphism, Tangent Bundle, Fundamental Vector Field. Invariant view point of connections. Covariant differentiation.
III	Torsion. Curvature. Parallelism. Difference tensor of two connections. Lie derivative. RiemannianManifold. Riemannian connection. Riemannian curvature tensor and Ricci tensor. Idenitities of Bianchi. Sectional curvature and Schur's theorem.
IV	Exterior product of two vectors. Exterior algebra of order r. Exterior derivative. Cartans's structural equations. Submanifolds and Hypersurfaces. Normals. Gauss's formula. Weingarten equations.

Books Recommended:

1. R. S. Mishra, A Course in Tensors with Applications to Riemanian Geometry, Pothishala, Allahabad, 1965.
2. Y. Matsushima, Differentiable Manifolds, Marcel Dekker, 1972.
3. B. B. Sinha, An Introduction to Modern Differential Geometry, Kalyani Prakashan, New Delhi, 1982.
4. Y. Talpiert, Differential Geometry with applications to Mechanics and Physics, Marcel Dekkar Inc. 2001.
5. N.J. Hicks, Notes on Differential Geometry, D. Van Nostrand Inc., 1965.
6. U.C.De and A.A.Shaaikh, Differential Geometry of Manifolds, Narosa Publishing House, New Delhi 2007.
7. K.S.Amur ,D.J.Shetty and C.S.Bagewadi, An Introduction to Differential Geometry , Narosa Publishing House, New Delhi 2010.
8. S. Shahshahani, An Introductory Course on Differentiable Manifolds, Dover Publication Inc. New York, 2016.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

PARTIAL DIFFERENTIAL EQUATIONS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: MAT- 408F	**Course Title:** PARTIAL DIFFERENTIAL EQUATIONS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to learn formation and classification of partial differential equations.

CO 2. The student shall be able to solve partial differential equations using different methods.

CO 3. After the completion of the course, the student shall be able to use the method of separation of variables to solve Laplace, diffusion and wave equations.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	PARTIAL DIFFERENTIAL EQUATIONS
I	Introduction of partial differential equations, formation of partial differential equations, partial differential equations of order one and its classification, Lagrange's partial differential equation of order one and its solution, general methods of solution of Lagrange's equation, method of grouping and method of multipliers, linear partial differential equation of order one with n independent variables.
II	Non-linear partial differential equations of order one, complete integral, particular integral, singular integral and general integral with geometrical interpretations, standard forms of non-linear partial differential equations of order one and their solutions, non-linear partial differential equations of order one reducible to standard forms, compatible system of partial differential of first order, Charpit's and Jacobi's method for solving non-linear partial differential equation of order one.
III	Formation of partial differential equation of higher order, linear homogeneous partial differential equation with constant coefficients of second order, linear non-homogeneous partial differential equation with constant coefficients of second order, Euler-Cauchy partial differential equation.

IV	Linear partial differential equations with variable coefficients, classification of linear partial differential equations of second order and canonical forms, solution of non-linear partial differential equations of second order by Monge's method, method of separation of variables for solving Laplace, diffusion and wave equations.

Books Recommended:

1. V.S.Verma, A Text Book of Partial Differential Equations, Neelkamal Prakashan, Gorakhpur, 2019.
2. I.N. Sneddon, Elements of Partial Differential Equations, Courier Corporation, 2006.
3. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
4. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

OPERATIONS RESEARCH

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: MAT- 409F	**Course Title:** OPERATIONS RESEARCH	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to apply it in different sectors of research field like game theory, job sequencing, network analysis, dynamical programming etc.

CO 2. The student shall be able to do their research work in different interdisciplinary areas.

CO 3. After the completion of the course, the student shall be able to get hired by most of the companies as OR technician since companies require OR experts to get maximum output out of minimum resources.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	OPERATIONS RESEARCH
I	Inventory Control: Introduction, Classification of Inventory, Economic parameter associated withinventory problems, Deterministic and Probabilistic models with without lead time.
II	Sequencing Problems: Assumptions for seqnencing problem. Processing n jobs on two machines, n jobs on three machines, 2 jobs on m machines, Problem of Replacement, Individuals and Groupreplacement policies
III	Network analysis: Basic concepts and definition. Network drawing and analysis Critical path method. Labelling method. Methods based on time estimates to find critical path. Concept of slackand float. Resource levelling and time-cost trade-off analysis. Time-cost optimization procedure. Project crashing. PERT. Requirements for application of PERT technique. Practical limitations inusing PERT. Diffferences in PERT and CPM.

IV	Non-Linear Programming: Introduction and defintions. Formulation of non-Linear programming problems, General non-linear programming problems. Kuhn-Tucker conditions, Lagrangian Method, Constrained optimization with equality constraints. Constrained optimization with inequality constaints. Saddle point problems Saddle points and NLPP. Wolfe's and Beale's methodto solve Quadratic Progamming problem.

Books Recommended:

1. S.D. Sharma: Operations Research, Kedar Nath Ram Nath & Company.
2. S.S. Rao: Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
3. J.K. Sharma: Operations Research – Theory and Applications, Macmillan India Ltd.
4. H.A. Taha: Operations Research – An Introduction, Macmillan Publishing Co., Inc., New York.
5. Kanti Swarup, P.K. Gupta, Man Mohan: Operations Research, Sultan Chand and sons, New Delhi.
6. B.S. Goel, S.K. Mittal: Operations Research, Pragati Prakashan, Meerut.
7. P.K. Gupta, D.S. Hira: Operatons Research – An Introduction, S. Chand & CompanyLtd., New Delhi.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)

FLUID DYNAMICS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: MAT- 410F	**Course Title:** FLUID DYNAMICS	
Credits: 4+0	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course Outcomes:

CO 1. The aim of this course is to effectively write mathematical solutions in a clear and concise manner.

CO 2. The student shall be able to demonstrate an intuitive and computational understanding of Fluid motion, Lagrangian and Eulerian methods, Euler's and Lagrange's Equation of continuity, Newton's law of viscosity Navier-Stokes equations of motion, Steady viscous flow between parallel planes.

CO 3. After the completion of the course, the student shall be able to research in applied mathematics, cosmology and use the knowledge in qualifying various competitive exams like CSIR-NET

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

Unit	Topics
	FLUID DYNAMICS
I	General idea of fluids, Properties of fluids, Fluid motion, Kinds of motion, Methods of describing fluid motion, Lagrangian and Eulerian methods, Relation between Lagrangian and Eulerian methods, Streamlines, Path lines, Streak lines, Velocity potential, Vorticity vector, Vortex lines, Boundary surface, Equation of continuity by Euler's and Lagrange's methods, Equivalence between Eulerian and Lagrangian forms of equations of continuity, Equation of continuity in other coordinate systems, Symmetrical forms of equation of continuity.
II	Euler's and Lagrange's equation of motion, Lamb's hydrodynamical equations, Conservative field of force, Euler's equations of motion in cylindrical and Spherical polar coordinates, Equations of motion under impulsive force, Energy equation, Pressure equation, Bernaulli's equation and its applications, Euler's momentum theorem, D'Alermbert's paradox.

III	Newton's law of viscosity, Kinds of fluids, Nature of stress. Stress components in a real fluid, Symmetry of stress tensor, Transformation of stress components, Stress invariants, Relations between Cartesian components of stress, Rate of strain quadric, Principal stresses, Stoke's law of viscosity, Relations between stress and rate of strain.
IV	General motion of a fluid elements, Navier-Stokes equations of motion, Steady viscous flow between parallel planes. Steady flow through a tubes of uniform circular cross-sections. Steady flow between concentric rotating cylinders, Diffusion of vorticity, Energy dissipation due to viscosity, Reynold's number and its physical significance.

Books Recommended:

1. J.K. Goyal and K.P. Gupta: Fluid Dynamics, Pragati Prakashan, Meerut, 2017

2. N. Curle and H. J. Davis: Modern Fluid Dynamics, D. Van Nostrand Company Ltd. London, 1968.

3. G.K. Batchelor: An Introduction to Fluid Dynamics, Cambridge University Press, Cambridge, 2000

4. F. Chorlton: A Text Book of Fluid Dynamics, CBS Publishers and Distributors, New Delhi, 2002.

Internal Evaluation Methods (Max. Marks: 25)

As prescribed by the University (as per common ordinance for examination and assessment).

External Evaluation Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

FOURTH YEAR (SEMESTER-VIII)
DISSERTATION/ RESEARCH PROJECT

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: MAT- 411F	**Course Title:** DISSERTATION/ RESEARCH PROJECT	
Credits:0 +12	Core Compulsory	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course Outcomes:

CO 1. The objective of course is to write a dissertation/research project on the specific topic.

CO 2. The student shall be able to do their research work in different interdisciplinary areas.

CO 3. After completing the course, the student shall be able to understand some advanced mathematical techniques.

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.

DISSERTATION/ RESEARCH PROJECT

Candidate/Students should write a dissertation/research project on the specific topic based on any one core/major papers opted by the student in any semester. The students has been allotted a supervisor in this dissertation/research project on their topic, given by the concern faculty. The dissertation/research project should be typed and its presentation on Power Point.

Evaluation Methods (Max. Marks: 100)

As prescribed by the University (as per common ordinance for examination and assessment).

NAAC Grade A^{++} Accredited (CGPA-3.78)

भौतिकी विभाग, दीनदयाल उपाध्याय गोरखपुर विश्वविद्यालय,गोरखपुर

Syllabus
as per
Ordinance, Four Years B.Sc. Programme 2024

Department of Physics

Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur

SESSION: 2024-2025

The Ordinance, 4-year B.Sc. program 2024 of Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur laid down the following guidelines:

Types of Courses:

Student has to choose two Major disciplines (subjects) from their Faculty and study them for three years (six semesters).

Additionally, they will choose a minor discipline (subject) either from their Faculty or from other Faculties and study it for the first two years (four semesters).

Additional Course Requirements:[1]

Every student must opt for the following courses:

- One Skill Enhancement/Vocational course per semester from a pool of courses offered by the University in the first three semesters (Semesters I, II, III).
- One Ability Enhancement/Co-curricular Course per semester from a pool of courses offered by the University in the first four semesters (Semesters I, II, III, IV).
- Undertake a Research Project/Dissertation/Internship/Fieldwork/Survey in one of their major disciplines (subjects) in the semester IV.

Special Requirements for B.Sc. (Honours with Research):[2]

Students opting for the four-year B.Sc. Degree (Honours with Research) must prepare a Major Research Project or Dissertation in the semester VIII.

Exit Options:[3]

In the 4-year B.Sc. Program, students have an exit option at different levels, including Certificate, Diploma, B.Sc. Degree, B.Sc. Honors Degree, and B.Sc. Honors with Research Degree.

Year Completed	Total Credits	Degree	Options
1	46	Certificate	EXIT
2	92	Diploma	EXIT
3	132	B.Sc. Degree	EXIT
4	172	B.Sc. Honors	EXIT

Or

4	172	B.Sc. Honors with Research	EXIT

These guidelines provide a structured framework for students pursuing the 4-year B.Sc. program at Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur ensuring a comprehensive academic experience with opportunities for specialization and skill development.

Reference:

[1]From Article 3 subsection- 3.3,3.4 & 3.5 of 4 Year UG Ordinance of DDUGU

[2]From Article 3 subsection- 3.6 of 4 Year UG Ordinance of DDUGU

[3]From Appendix - Aof 4 Year UG Ordinance of DDUGU

Course Structure for Four Years B.Sc. Programme

SEMESTER-WISE TITLES OF COURSES ALONGWITH CREDITS			
YEAR	**COURSE CODE**	**PAPER TITLE**	**CREDIT**
1st Year		**Semester-I**	
	PHY- 101F	Mathematical Physics & Newtonian Mechanics	4 + 0
	PHY- 102F	Practical (Mechanical Properties of Matter)	0 + 2
	SEC-PHY-1	--	3
	AEC-PHY-1	--	2
		Semester-II	
	PHY- 103F	Thermal Physics & Semiconductor Devices	4 + 0
	PHY- 104F	Practical (Thermal Properties of Matter & Electronic Circuits)	0 + 2
	SEC-PHY-2	--	3
	AEC-PHY-2	--	2
2nd Year		**Semester-III**	
	PHY- 201F	Electromagnetic Theory & Optics	4 + 0
	PHY- 202F	Practical (Demonstrative Aspects of Electricity & Magnetism)	0 + 2
	SEC-PHY-3	--	3
	AEC-PHY-3	--	2
		Semester-IV	
	PHY- 203F	Modern Physics & Electronics	4 + 0
	PHY- 204F	Practical (Basic Electronics Instrumentation)	0 + 2
	AEC-PHY-4	--	2
	PHY- 205F	Research Project / Dissertation / Internship / Fieldwork / Survey	3
3rd Year		**Semester-V**	
	PHY- 301F	Classical Mechanics & Statistical Mechanics	4 + 0
	PHY- 302F	Quantum Mechanics & Spectroscopy	4 + 0
	PHY- 303F	Practical (Demonstrative Aspects of Optics & Lasers)	0 + 2
		Semester-VI	
	PHY- 304F	Solid State Physics & Nuclear Physics	4 + 0
	PHY- 305F	Analog & Digital - Principles & Applications	4 + 0
	PHY- 306F	Practical (Analog & Digital Circuits)	0 + 2

YEAR	COURSE CODE	PAPER TITLE	CREDIT
4th Year		**Semester-VII**	
	PHY- 401F	Mathematical Physics	4 + 0
	PHY- 402F	Classical Mechanics	4 + 0
	PHY- 403F	Quantum Mechanics	4 + 0
	PHY- 404F	Electronics	4 + 0
	PHY- 405F OR PHY- 406F	Physics Practical – Electronics Physics Practical - Optics	0 + 4
		Semester-VIII	
	PHY- 407F	Thermodynamics and Statistical Physics	4 + 0
	PHY- 408F	Electromagnetic Theory and Plasma Physics	4 + 0
	PHY- 409F	Solid State Physics	4 + 0
	PHY- 410F	Group Theory and Molecular Spectra	4 + 0
	PHY- 405F OR PHY- 406F	Physics Practical – Electronics Physics Practical - Optics	0 + 4

For students who secured 75% marks in First Six Semesters

YEAR	COURSE CODE	PAPER TITLE	CREDIT
4th Year		**Semester-VII**	
	PHY- 401F	Mathematical Physics	4 + 0
	PHY- 402F	Classical Mechanics	4 + 0
	PHY- 403F	Quantum Mechanics	4 + 0
	PHY- 404F	Electronics	4 + 0
	PHY- 405F OR PHY- 406F	Physics Practical – Electronics Physics Practical - Optics	0 + 4
		Semester-VIII	
	PHY- 407F	Thermodynamics and Statistical Physics	4 + 0
	PHY- 408F	Electromagnetic Theory and Plasma Physics	4 + 0
	PHY- 411F	Major Research Project/Dissertation	12

Semester I

PHY - 101F: Mathematical Physics & Newtonian Mechanics **Credits 4+0**

Course Outcomes (COs):

CO1 Recognize the difference between scalars, vectors, pseudo-scalars and pseudo-vectors.
CO2 Understand the physical interpretation of gradient, divergence and curl.
CO3 Comprehend the difference and connection between Cartesian, spherical and cylindrical coordinate systems.
CO4 Know the meaning of 4-vectors, Kronecker delta and Epsilon (Levi Civita) tensors.
CO5 Study the origin of pseudo forces in rotating frame.
CO6 Study the response of the classical systems to external forces and their elastic deformation.
CO7 Understand the dynamics of planetary motion and the working of Global Positioning System (GPS).
CO8 Comprehend the different features of Simple Harmonic Motion (SHM) and wave propagation.

Part A

Unit 1 Vector Algebra

Coordinate rotation, reflection and inversion as the basis for defining scalars, vectors, pseudo-scalars and pseudo-vectors (include physical examples). Component form in 2D and 3D. Geometrical and physical interpretation of addition, substraction, dot product, wedge product, cross product and triple product of vectors. Position, separation and displacement vectors.

Unit 2 Vector Calculus

Geometrical and physical interpretation of vector differentiation, Gradient, Divergence and Curl and their significance. Vector integration, Line, Surface (flux) and Volume integrals of vector fields. Gradient theorem, Gauss-divergence theorem, Stoke-curl theorem, Greens theorem and Helmholtz theorem (statement only). Introduction to Dirac delta function.

Unit 3 Coordinate Systems

2D & 3D Cartesian, Spherical and Cylindrical coordinate systems, basis vectors, transformation equations. Expressions for displacement vector, arc length, area element, volume element, gradient, divergence and curl in different coordinate systems. Components of velocity and acceleration in different coordinate systems. Examples of non-inertial coordinate system and pseudo-acceleration.

Unit 4 Introduction to Tensors

Principle of invariance of physical laws w.r.t. different coordinate systems as the basis for defining tensors. Coordinate transformations for general spaces of nD, contravariant, covariant & mixed tensors and their ranks, 4-vectors. Index notation and summation convention. Symmetric and skew-symmetric tensors. Invariant tensors, Kronecker delta and Epsilon (Levi Civita) tensors. Examples of tensors in physics.

Part B

Unit 1 Dynamics of a System of Particles

Review of historical development of mechanics up to Newton. Background, statement and critical analysis of Newton's axioms of motion. Dynamics of a system of particles, centre of mass motion, and conservation laws & their deductions. Rotating frames of reference, general derivation of origin of pseudo forces (Euler, Coriolis & centrifugal) in rotating frame, and effects of Coriolis force.

Unit 2 Dynamics of a Rigid Body

Angular momentum, Torque, Rotational energy and the inertia tensor. Rotational inertia for simple bodies (ring, disk, rod, solid and hollow sphere, solid and hollow cylinder, rectangular lamina). The combined translational and rotational motion of a rigid body on horizontal and inclined planes. Elasticity, relations between elastic constants, bending of beam and torsion of cylinder.

Unit 3 Motion of Planets & Satellites

Two particle central force problem, reduced mass, relative and centre of mass motion. Newton's law of gravitation, gravitational field and gravitational potential. Kepler's laws of planetary motion and their deductions. Motions of geo-synchronous & geo-stationary satellites and basic idea of Global Positioning System (GPS).

Unit 4 Wave Motion

Differential equation of simple harmonic motion and its solution, use of complex notation. Damped and forced oscillations, Quality factor. Composition of simple harmonic motion, Lissajous figures. Differential equation of wave motion. Plain progressive waves. Principle of superposition of waves, stationary waves, phase and group velocity. Fourier series and Fourier coefficients (simple examples)

Suggested Readings

PART A

1. Murray Spiegel, Seymour Lipschutz, Dennis Spellman, "Schaum's Outline Series: Vector Analysis", McGraw Hill, 2017, 2e
2. A.W. Joshi, "Matrices and Tensors in Physics", New Age International Private Limited, 1995, 3e
3. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

PART B

1. Charles Kittel, Walter D. Knight, Malvin A. Ruderman, Carl A. Helmholz, Burton J. Moyer, "Mechanics (In SI Units): Berkeley Physics Course Vol 1", McGraw Hill, 2017, 2e
2. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 1", Pearson Education Limited, 2012
3. Hugh D. Young and Roger A. Freedman, "Sears & Zemansky's University Physics with Modern Physics", Pearson Education Limited, 2017, 14e
4. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

PHY - 102F: Practical (Mechanical Properties of Matter) **Credits 0+2**

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the mechanical properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Moment of inertia of fly wheel.
2. Compound pendulum; Acceleration due to gravity and radius of gyration.
3. Modulus of rigidity by Maxwell's needle.
4. Young's modulus of rectangular bar by cathetometer or optical lever method
5. To determine the force constant of a spiral spring by statical and dynamical methods
6. To determine height of building and draw zero-error graph of sextant.
7. Elastic constants by Searle's apparatus.
8. Surface tension of water by Jaeger's method.
9. Coefficient of viscosity of water by Poiseuille's method.
10. Frequency of electrically maintained tuning fork.
11. Frequency of A.C. mains using sonometer.

Semester II

PHY – 103F: Thermal Physics & Semiconductor Devices **Credits 4+0**

Course Outcomes (COs):

CO1 Recognize the difference between reversible and irreversible processes.
CO2 Understand the physical significance of thermodynamical potentials.
CO3 Comprehend the kinetic model of gases w.r.t. various gas laws.
CO4 Study the implementations and limitations of fundamental radiation laws.
CO5 Utility of AC bridges.
CO6 Recognize the basic components of electronic devices.
CO7 Design simple electronic circuits.
CO8 Understand the applications of various electronic instruments.

PART A

Unit 1 Zeroth & First Law of Thermodynamics

State functions and terminology of thermodynamics. Zeroth law and temperature. First law, internal energy, heat and work done. Work done in various thermodynamical processes. Enthalpy, relation between C P and C V . Carnot's engine, efficiency and Carnot's theorem. Efficiency of internal combustion engines (Otto and diesel).

Unit 2 Second & Third Law of Thermodynamics

Different statements of second law, Clausius inequality, entropy and its physical significance. Entropy changes in various thermodynamical processes. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell's relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule-Thompson effect.

Unit 3 Kinetic Theory of Gases

Kinetic model and deduction of gas laws. Derivation of Maxwell's law of distribution of velocities and its experimental verification. Degrees of freedom, law of equipartition of energy (no derivation) and its application to specific heat of gases (mono, di and poly atomic).

Unit 4 Theory of Radiation

Blackbody radiation, spectral distribution, concept of energy density and pressure of radiation. Derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law.

PART B

Unit 1 DC & AC Circuits

Growth and decay of currents in RL circuit. Charging and discharging of capacitor in RC, LC and V RCL circuits. Network Analysis. Thevenin's and Norton's theorems. AC Bridges - measurement of inductance (Maxwell's and Anderson's bridges) and measurement of capacitance (Schering's and de Sauty's bridges).

Unit 2 Semiconductors & Diodes

P and N type semiconductors, qualitative idea of Fermi level. Formation of depletion layer in PN junction diode, field & potential at the depletion layer. Qualitative idea of current flow mechanism in forward & reverse biased diode. Diode fabrication. PN junction diode and its characteristics, static and dynamic resistance. Principle, structure, characteristics and applications of Zener, Tunnel, Light Emitting, Point Contact and Photo diodes. Half and Full wave rectifiers, calculation of ripple factor, rectification efficiency and voltage regulation. Basic idea about filter circuits and voltage regulated power supply.

Unit 3 Transistors

Bipolar Junction PNP and NPN transistors. Study of CB, CE & CC configurations w.r.t. active, cutoff & saturation regions; characteristics; current, voltage & power gains; transistor currents & relations between them. Idea of base width modulation, base spreading resistance & transition time. DC Load Line analysis and Q-point stabilisation. Voltage Divider Bias circuit for CE amplifier. Qualitative discussion of RC coupled amplifier (frequency response not included).

Unit 4 Electronic Instrumentation

Multimeter: Principles of measurement of dc voltage, dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Cathode Ray Oscilloscope: Block diagram of basic CRO. Applications of CRO to study the waveform and measurement of voltage, current, frequency & phase difference.

Suggested Readings

PART A

1. M.W. Zemansky, R. Dittman, “Heat and Thermodynamics”, McGraw Hill, 1997, 7e
2. F.W. Sears, G.L. Salinger, “Thermodynamics, Kinetic theory & Statistical thermodynamics”, Narosa Publishing House, 1998
3. Enrico Fermi, “Thermodynamics”, Dover Publications, 1956
4. S. Garg, R. Bansal, C. Ghosh, “Thermal Physics”, McGraw Hill, 2012, 2e
5. Meghnad Saha, B.N. Srivastava, “A Treatise on Heat”, Indian Press, 1973, 5e

PART B

1. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, “Electronic Devices and Circuits”, McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, “Solid State Electronic Devices”, Pearson Education India, 2015, 7e
4. J.D. Ryder, “Electronic Fundamentals and Applications”, Prentice-Hall of India Private Limited, 1975, 5e
5. A. Sudhakar, S.S. Palli, “Circuits and Networks: Analysis and Synthesis”, McGraw Hill, 2015, 5e
6. S.L. Gupta, V. Kumar, “Hand Book of Electronics”, Pragati Prakashan, Meerut, 2016, 43e

PHY – 104F: Practical (Thermal Properties of Matter & Electronic Circuits) Credits 0+2

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the thermal and electronic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Mechanical Equivalent of Heat by Callender and Barne's method
2. Value of Stefan's constant
3. Verification of Stefan's law
4. Characteristics of P-N junction.
5. Characteristics of Zener diode.
6. Measurement of inductance of a coil using Anderson's bridge.
7. Measurement of capacity and power factor of a capacitor using Schering's Bridge.
8. Study the behaviour of LCR circuit.
9. Characteristics of p-n-p transistor in common-emitter configuration.
10. Characteristics of p-n-p transistor in common-base configuration.
11. Study of resonance of digital display (LCR) in series and parallel circuit to find its resonance frequency.

Semester III

PHY – 201F: Electromagnetic Theory & Optics **Credits 4+0**

Course Outcomes (COs):

CO1 Better understanding of electrical and magnetic phenomenon in daily life.
CO2 To troubleshoot simple problems related to electrical devices.
CO3 Comprehend the powerful applications of ballistic galvanometer.
CO4 Study the fundamental physics behind reflection and refraction of light (electromagnetic waves).
CO5 Study the working and applications of Michelson and Fabry-Perot interferometers.
CO6 Recognize the difference between Fresnel's and Fraunhofer's class of diffraction.
CO7 Comprehend the use of polarimeters.
CO8 Study the characteristics and uses of lasers.

PART A

Unit 1 Electrostatics

Electric force between two charges. General expression for Electric field in terms of volume charge density (divergence & curl of Electric field), general expression for Electric potential in terms of volume charge density and Gauss law (applications included). Study of electric dipole. Electric fields in matter, polarization, auxiliary field D (Electric displacement), electric susceptibility and permittivity.

Unit 2 Magnetostatics

Magnetic force between two current elements. General expression for Magnetic field in terms of volume current density (divergence and curl of Magnetic field), General expression for Magnetic potential in terms of volume current density and Ampere's circuital law (applications included). Magnetic fields in matter, magnetisation, auxiliary field H, magnetic susceptibility and permeability.

Unit 3 Time Varying Electromagnetic Fields

Faraday's laws of electromagnetic induction and Lenz's law. Displacement current, equation of continuity and Maxwell-Ampere's circuital law. Self and mutual induction (applications included). Maxwell's equations and their physical significance.

Unit 4 Electromagnetic Waves

Electromagnetic energy density and Poynting vector. Plane electromagnetic waves in linear infinite dielectrics, dispersive & non- dispersive media. Reflection and refraction of homogeneous plane electromagnetic waves, law of reflection, Snell's law, Fresnel's formulae (Reflection and transmission coefficient for normal incidence).

PART B

Unit 1 Interference

Conditions for interference and spatial & temporal coherence. Division of Wavefront - Fresnel's Biprism and Lloyd's Mirror. Division of Amplitude - Parallel thin film, wedge shaped film and Newton's Ring experiment. Interferometer - Michelson and Fabry-Perot.

Unit 2 Diffraction

Fresnel's and Fraunhofer's class of diffraction. Fresnel's Half Period Zones and Zone plate. Fraunhofer diffraction at a single slit, N-slits and Diffracting Grating. Resolving Power of Optical Instruments - Rayleigh's criterion and resolving power of telescope.

Unit 3 Polarisation

Polarisation by dichronic crystals, birefringence, Nicol prism, retardation plates. Analysis of polarized light. Optical Rotation - Fresnel's explanation of optical rotation and Half Shade & Biquartz polarimeters.

Unit 4 Lasers

Characteristics and uses of Lasers. Qualitative analysis of Spatial and Temporal coherence. Conditions for Laser action and Einstein's coefficients. Ruby and He-Ne Lasers (qualitative discussion)

Suggested Readings

PART A

1. D.J. Griffiths, "Introduction to Electrodynamics", Prentice-Hall of India Private Limited, 2002, 3e
2. E.M. Purcell, "Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2", McGraw Hill, 2017,2e
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 2", Pearson Education Limited, 2012
4. D.C. Tayal, "Electricity and Magnetism", Himalaya Publishing House Pvt. Ltd., 2019, 4e

PART B

1. Francis A. Jenkins, Harvey E. White, "Fundamentals of Optics", McGraw Hill, 2017, 4e
2. Samuel Tolansky, "An Introduction to Interferometry", John Wiley & Sons Inc., 1973, 2e
3. A. Ghatak, "Optics", McGraw Hill, 2017, 6e

PHY – 202F: Practical (Demonstrative Aspects of Electricity & Magnetism) Credits 0+2

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the electric and magnetic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Determine unknown resistance using Carey Foster's bridge.
2. Determination of high resistance by method of leakage.
3. Reduction factor of Helmholtz galvanometer.
4. Variation of magnetic field along the axis of Helmholtz coil
5. Verification of Child's law.
6. Current sensitivity of a dead-beat moving coil galvanometer.
7. Charge sensitivity of a ballistic galvanometer by capacity discharge method.
8. Calibration of energy meter using ammeter and voltmeter.
9. Time constant using charging discharging of capacitor.
10. Earth Inductor: Horizontal component of earth's magnetic field

Semester IV

PHY – 203F: Modern Physics & Electronics **Credits 4+0**

Course Outcomes (COs):

CO1 Recognize the difference between the structure of space & time in Newtonian & Relativistic mechanics.
CO2 Understand the physical significance of consequences of Lorentz transformation equations.
CO3 Comprehend the wave-particle duality.
CO4 Develop an understanding of the foundational aspects of Quantum Mechanics.
CO5 Study the comparison between various biasing techniques.
CO6 Study the classification of amplifiers.
CO7 Comprehend the use of feedback and oscillators.
CO8 Comprehend the theory and working of optical fibers along with its applications.

PART A

Unit 1 Relativity-Experimental Background

Michelson-Morley experiment and significance of the null result. Einstein's postulates of special theory of relativity. Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations (4-vector formulation included). Consequences of Lorentz Transformation Equations (derivations & examples included)

Unit 2 Relativity-Relativistic Kinematics

Concept of Simultaneity (Relativity of simultaneity); Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Acceleration; Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein's mass & energy relation) and Energy & Momentum.

Unit 3 Inadequacies of Classical Mechanics

Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves and their experimental verification by Davisson-Germer's experiment and Thomson's experiment.

Unit 4 Introduction to Quantum Mechanics

Matter Waves: Mathematical representation, Wavelength, Concept of Wave group, Group (particle) velocity, Phase (wave) velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule.

PART B

Unit 1 Transistor Biasing

Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing V circuits for CE configuration: Fixed Bias (Base Resistor Method), Emitter Bias (Fixed Bias with Emitter Resistor), Collector to Base Bias (Base Bias with Collector Feedback) &, Voltage Divider Bias. Discussion of Emitter-Follower configuration.

Unit 2 Amplifiers

Classification of amplifiers based on Mode of operation (Class A, B, AB, C & D), Stages (single & multi stage, cascade & cascode connections), Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification) and Frequency capabilities (AF, IF, RF & VF). Theory & working of RC coupled voltage amplifier (Uses of various resistors & capacitors, and Frequency response) and Transformer coupled power amplifier (calculation of Power, Effect of temperature, Use of heat sink & Power dissipation). Calculation of Amplifier Efficiency (power efficiency) for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers.

Unit 3 Feedback & Oscillator Circuits

Feedback Circuits: Effects of positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types and their uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback and their comparison between different negative feedback connection types. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self-sustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators.

Unit 4 Introduction to Fiber Optics

Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture, qualitative discussion of fiber losses and applications of optical fibers.

Suggested Readings

PART A

1. A. Beiser, Shobhit Mahajan, “Concepts of Modern Physics: Special Indian Edition”, McGraw Hill, 2009, 6e
2. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, “Modern Physics for Scientists and Engineers”, Prentice-Hall of India Private Limited, 2003, 2e
3. R.A. Serway, C.J. Moses, and C.A. Moyer, “Modern Physics”, Cengage Learning India Pvt. Ltd, 2004, 3e
4. R. Resnick, “Introduction to Special Relativity”, Wiley India Private Limited, 2007
5. R. Murugeshan, Kiruthiga Sivaprasath, “Modern Physics”, S. Chand Publishing, 2019, 18e

PART B

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e

2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e

3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e

4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e

5. John M. Senior, "Optical Fiber Communications: Principles and Practice", Pearson Education Limited, 2010, 3e

6. John Wilson, John Hawkes, "Optoelectronics: Principles and Practice", Pearson Education Limited, 2018, 3e

7. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

PHY – 204F: Practical (Basic Electronics Instrumentation) **Credits 0+2**

Course Outcomes (COs):

Basic Electronics instrumentation has the most striking impact on the industry wherever the components / instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Measurement of dc and ac voltages and frequency using cathod ray oscilloscope.
2. To study the characteristics of R-C network.
3. To study the characteristics of a rectifier circuit.
4. To study the characteristics of an unregulated power supply.
5. To study the characteristics of low/high pass filter.
6. To study the characteristics of interstage audio transformer.
7. To determine the dispersive power of the material of prism by spectrometer
8. Specific rotation of cane sugar using Polarimeter.
9. Resolving power of telescope
10. Resolving power of plane transmission grating
11. To determine the wavelength of sodium light by grating.

Semester V

PHY – 301F: Classical Mechanics and Statistical Mechanics **Credits 4+0**

Course Outcomes (COs):

CO1 Understand the concepts of generalized coordinates and D'Alembert's principle.
CO2 Understand the Lagrangian dynamics and the importance of cyclic coordinates.
CO3 Comprehend the difference between Lagrangian and Hamiltonian dynamics.
CO4 Study the important features of central force and its application in Kepler's problem.
CO5 Recognize the difference between macrostate and microstate.
CO6 Comprehend the concept of ensembles.
CO7 Understand the classical and quantum statistical distribution laws.
CO8 Study the applications of statistical distribution laws.

PART A

Unit 1 Constrained Motion

Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle.

Unit 2 Lagrangian Formalism

Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation.

Unit 3 Hamiltonian Formalism

Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation.

Unit 4 Central Force

Definition and properties (with prove) of central force. Equation of motion and differential equation of orbit. Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and derivation of Kepler's laws. Laplace-Runge- Lenz vector (Runge-Lenz vector) and its applications.

PART B

Unit 1 Macrostate & Microstate

Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.

Unit 2 Concept of Ensemble

Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.

Unit 3 Distribution Laws

Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi-Dirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.

Unit 4 Applications of Statistical Distribution Laws

Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).

Suggested Readings

PART A

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017

PART B

1. F. Reif, "Statistical Physics (In SI Units): Berkeley Physics Course Vol 5", McGraw Hill, 2017, 1e
2. B.B. Laud, "Fundamentals of Statistical Mechanics", New Age International Private Limited, 2020, 2e
3. B.K. Agarwal, M. Eisner, "Statistical Mechanics", New Age International Private Limited, 2007, 2e

PHY – 302F: Quantum Mechanics & Spectroscopy **Credits 4+0**

Course Outcomes (COs):

CO1 Understand the significance of operator formalism in Quantum mechanics.
CO2 Study the eigen and expectation value methods.
CO3 Understand the basis and interpretation of Uncertainty principle.
CO4 Develop the technique of solving Schrodinger equation for 1D and 3D problems.
CO5 Comprehend the success of Vector atomic model in the theory of Atomic spectra.
CO6 Study the different aspects of spectra of Group I & II elements.
CO7 Study the production and applications of X-rays.
CO8 Develop an understanding of the fundamental aspects of Molecular spectra.

PART A

Unit 1 Operator Formalism

Operators: Review of matrix algebra, definition of an operator, special operators, operator algebra and operators corresponding to various physical-dynamical variables. Commutators: Definition, commutator algebra and commutation relations among position, linear momentum & angular momentum and energy & time. Simple problems based on commutation relations.

Unit 2 Eigen & Expectation Values

Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. Hermitian Operators: Definition, properties and applications. Prove of the hermitian nature of various physical-dynamical operators.

Unit 3 Uncertainty Principle & Schrodinger Equation

Uncertainty Principle: Commutativity & simultaneity (theorems with proofs). Non commutativity of operators as the basis for uncertainty principle and derivation of general form of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physical- dynamical parameters and its applications.
Schrodinger Equation: Derivation of time independent & time dependent forms, Schrodinger equation as an eigen equation, Deviation & interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation.

Unit 4 Applications of Schrodinger Equation

Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted).

PART B

Unit 1 Vector Atomic Model

Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical & geometrical interpretations of various quantum numbers for single & many valence electron systems. LS & jj couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.

Unit 2 Spectra of Alkali & Alkaline Elements

Spectra of alkali elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line.

Unit 3 X-Rays & X-Ray Spectra

Nature & production, Continuous X-ray spectrum & Duane-Hunt's law, Characteristic X-ray spectrum & Mosley's law, Fine structure of Characteristic X-ray spectrum.

Unit 4 Molecular Spectra

Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band. P,Q, R

Suggested Readings

PART A

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Pearson Education, India, 2004, 2e
2. E. Wichmann, "Quantum Physics (In SI Units): Berkeley Physics Course Vol 4", McGraw Hill, 2017
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 3", Pearson Education Limited, 2012
4. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e

PART B

1. H.E. White, "Introduction to Atomic Spectra", McGraw Hill, 1934
2. C.N. Banwell, E.M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw Hill, 2017, 4e
3. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e
4. S.L. Gupta, V. Kumar, R.C. Sharma, "Elements of Spectroscopy", Pragati Prakashan, Meerut, 2015, 27e

PHY – 303F: Practical (Demonstrative Aspects of Optics & Lasers) **Credits 0+2**

Course Outcomes (COs):

Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Focal length of thin lenses and their combination by Nodal slide.
2. Wavelength of light using bi-prism.
3. Wavelength of light by Newton's rings method.
4. Breadth of single slit by diffraction of light using spectrometer.
5. Wavelength of light using double slit experiment (using spectrometer)
6. Refractive index using Brewster's law.
7. To determine the wavelength and separation between D1 and D2 line with the help of Michelson Interferometer.
8. To determine the Young's modulus by Cornue's Fringes or Newton's rings.
9. To determine the velocity of ultrasonic wave by diffraction method.
10. To determine the diameter of a thin wire by interference in a wedge shape air film.
11. To determine the wavelength of sodium light by interference due to three/ four slits.

Semester VI

PHY – 304F: Solid State Physics & Nuclear Physics **Credits 4+0**

Course Outcomes (COs):

CO1 Understand the crystal geometry w.r.t. symmetry operations.
CO2 Comprehend the power of X-ray diffraction and the concept of reciprocal lattice.
CO3 Study various properties based on crystal bindings.
CO4 Recognize the importance of Free Electron & Band theories in understanding the crystal properties.
CO5 Study the salient features of nuclear forces & radioactive decays.
CO6 Understand the importance of nuclear models & nuclear reactions.
CO7 Comprehend the working and applications of nuclear accelerators and detectors.
CO8 Understand the classification and properties of basic building blocks of nature.

PART A

Unit 1 Crystal Structure

Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride.

Unit 2 Crystal Diffraction

X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices.

Unit 3 Crystal Bindings

Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals- London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant.

Unit 4 Lattice Vibrations

Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity. Free Electron Theory: Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals.
Band Theory: Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of solids on the basis of band theory.

PART B

Unit 1 Nuclear Forces & Radioactive Decays

General Properties of Nucleus: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. Nuclear Forces: General characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series.

Unit 2 Nuclear Models & Nuclear Reactions

Nuclear Models: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included).
Nuclear Reactions: Bethe's notation, types of nuclear reaction, Conservation laws, Cross-section of nuclear reaction, nuclear fission and fusion(qualitative), Nuclear reactors.

Unit 3 Accelerators & Detectors

Accelerators: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.

Unit 4 Elementary Particles

Fundamental interactions & their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime.

Suggested Readings

PART A

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993
3. R.K. Puri, V.K. Babbar, "Solid State Physics", S. Chand Publishing, 2015

PART B

1. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008
2. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017
3. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019

PHY – 305F: Analog & Digital- Principles & Applications **Credits 4+0**

Course Outcomes (COs):

CO1 Study the drift and diffusion of charge carriers in a semiconductor.
CO2 Understand the Two-Port model of a transistor.
CO3 Study the working, properties and uses of FETs.
CO4 Comprehend the design and operations of SCRs and UJTs.
CO5 Understand various number systems and binary codes.
CO6 Familiarize with binary arithmetic.
CO7 Study the working and properties of various logic gates.
CO8 Comprehend the design of combinational and sequential circuits.

PART A

Unit 1 Semiconductor Junction

Expressions for Fermi energy, Electron density in conduction band, Hole density in valence band, Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Expressions for Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Expressions for Current (diode equation) and Dynamic resistance for PN junction.

Unit 2 Transistor Modeling

Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power).

Unit 3 Field Effect Transistors

JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain III Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs).

Unit 4 MOSFET: Construction and Working of DE-MOSFET (N channel & P channel) and E- MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E- MOSFET; Comparison of JFFET and MOSFET.

PART B

Unit 1 Number System

Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation.

Unit 2 Binary Arithmetic

Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.

Unit 3 Logic Gates

Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, EX-OR & EX-NOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of EX-OR & EX- NOR gates as pairty checker. Boolean Algebra. Karnaugh Map.

Unit 4 Combinational & Sequential Circuits

Combinational Circuits: Half Adder, Full Adder, Parallel Adder, Half Substractor, Full Substractor. Data Processing Circuits: Multiplexer, Demultiplexer, Decoders & Encoders. Sequential Circuits: SR, JK & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.

Suggested Readings

PART A

1. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e
2. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e
3. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e
4. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e
5. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

PART B

1. D. Leach, A. Malvino, Goutam Saha, "Digital Principles and Applications", McGraw Hill, 2010, 7e
2. William H. Gothmann, "Digital Electronics: An Introduction to Theory and Practice", Prentice-Hall of India Private Limited, 1982, 2e
3. R.P. Jain, "Modern Digital Electronics", McGraw Hill, 2009, 4e

PHY – 306F: Practical (Analog & Digital Circuits) **Credits 0+2**

Course Outcomes (COs):

Analog & digital circuits have the most striking impact on the industry wherever the electronics instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments.

Lab Experiment List

1. Verification of Richardson-Dushman equation and evaluation of work function of cathode material.
2. To draw the characteristics and to determine the parameters of a field effect transistor (FET).
3. Characteristics of MOSFET
4. Verification of truth table of OR, AND and NOT gates.
5. Study and Verification of AND gate using TTL IC 7408
6. Study and Verification of OR gate using TTL IC 7432
7. Study and Verification of NAND gate and use as Universal gate using TTL IC 7400
8. Study and Verification of NOR gate and use as Universal gate using TTL IC 7402
9. Study and Verification of NOT gate using TTL IC 7404
10. Study and Verification of Ex-OR gate using TTL IC 7486

Semester VII

PHY – 401F: Mathematical Physics **Credits 4+0**

Course Objectives: Understanding mathematical functions and solution methods useful in various branches of Physics.

Course Outcomes:

CO1. The students will understand various functions and solutions to differential equations.
CO2. The foundation for understanding of Classical and Quantum Mechanics will be laid.
CO3. The techniques learnt will be useful in different branches of Physics.

Unit – I

Special Functions: Second order linear differential equations; Solution by series expansion; Legendre, Bessel, Hermite and Laguerre differential equations, their solutions and properties, Spherical Harmonics**.**

Unit – II

Fourier Transform: Dirac Delta function, Fourier Transform, Sine and Cosine transform, Linearity, Change of Scale, Translation, Modulation, simple applications.
Green Function: Green's function as a technique to solve linear ordinary differential equations, Homogeneous and Inhomogeneous boundary conditions, Solution of Poisson equation using Green's function technique, Symmetry property.

Unit – III

Complex Variables I: General function of complex variable, Cauchy-Riemann differential equation and analyticity, conformal mapping (translation, rotation, inversion), Cauchy's integral formula, Taylor's and Laurent's series, singularity poles.

Unit – IV

Complex Variables II: Residue theorem. Evaluation of definite integrals, around (i) unit circle and (ii) infinite semi-circle; using Jordan's lemma with poles lying on real axis, and of integrals involving multiple valued function-branch point.

References:

1. Mathematical Methods for Physicists by G. Arfken, H. Weber and F.E. Harris (Elsevier)
2. Mathematics for Physicist by P. Dennery and A. Krzynicki (Dover Publication)
3. Special Functions and their Applications by N.N. Lebedev (Dover Publication)
4. Mathematical Methods for Physics and Engineering by K.F. Riley, M.P. Hobson and S.J.Bence (Cambridge University Press)
5. Mathematical Physics by B. S. Rajput (Pagati Prakashan)
6. Complex Variables and Applications by J.W. Brown and R. V. Churchill (McGraw-Hill)

PHY – 402F: Classical Mechanics **Credits 4+0**

Course Objectives: Understanding basic methods of mechanics and use of Lagrangian and Hamiltonian approach.

Course Outcomes:

CO1. The students will understand dynamics of particles and conservation laws.

CO2. The understanding of different mechanical problems and their solutions will be developed.

Unit - I

Vectors: Curvilinear Coordinates, Gradient, Divergence and Curl, Laplace equation in spherical polar and cylindrical polar coordinates and their solution, Green's theorem, Gauss and Stokes Theorems.

Tensors: Covariant and Contravariant vectors, Tensors – Addition, Multiplication, Contraction, Symmetry properties; Tensor density, Pseudo-tensors.

Unit-II

Mechanics of a system of particles: Generalized coordinates and Constraints, Generalized coordinates, D' Alembert's principle, Lagrange's Equation, symmetry and cyclic coordinates. Hamilton's principle, Least action principle, Langrange's equations, symmetry properties and Noether's theorem, Lagrangian formulation for elementary mechanical systems - free particle, simple and double pendulum.

Unit-III

Two Body Problem: Reduction to one-body problem, reduced mass, Virial Theorem, planetary orbits.

Scattering: Collision between particles, disintegration of particles, elastic collisions, scattering, Rutherford's formula.

Small oscillations: Damped and Forced oscillations, coupled vibrations.

Unit-IV

Hamiltonian Formulation: Hamilton equations, canonical transformations, Poisson's bracket, Symplectic approach to canonical transformations; Hamilton Principle function, Hamilton-Jacobi equation, conservation theorem in Poisson brackets. Harmonic Oscillator Problem, Hamilton characteristic Function, separation of Action angle variables, Central Force problem.

References:

1. Vector Analysis and Introductory Tensor Analysis by M.R. Spiegel (Schaum Series)
2. Matrices and Tensors in Physics by A.W. Joshi (New Age)
3. Classical Mechanics by H. Goldstein (Narosa, New Delhi)
4. Classical Mechanics by K.C. Gupta (Wiley Eastern)
5. Classical Mechanics by L.D. Landau (Elsevier)
6. Classical Mechanics by N.C. Rana and P.S. Joag (Tata-McGraw-Hill)

PHY – 403F: Quantum Mechanics **Credits 4+0**

Course Objectives: Understanding concepts of quantum mechanics and solving operator equations for different quantum problems.

Course Outcomes:

CO1. The students will understand wave mechanical formulation of quantum particles and various rules arising out of it.
CO2. The understanding of different formulations of quantum mechanics laying foundations for the study of molecules, atoms and fundamental particles

Unit-I

Wave Mechanical formulation: Schrodinger wave equation, Hermitian operators and observables, Discreet and continuous spectrum, Dirac delta function, Commuting observables and related algebra, Pure and mixture states; Simple applications: potential well, barrier potential, tunnel effect, unbound states: reflection and transmission of waves.

Unit - II

Identity of Particles: Distinguishability of identical particles, exchange degeneracy and operator, construction of symmetric and antisymmetric wave functions, Pauli's exclusion principle and Slater's determinant, Electron spin hypothesis, spin matrices and eigen value equations, symmetric and antisymmetric wave functions for hydrogen molecule.

Unit - III

Matrix formulation: Dirac's bra and ket notations, Hilbert Space, Orthonormality and completeness relations (discrete and continuous), linear and real operators, eigen value equations and related theorems, degeneracy, projection operators and measurement, application to Harmonic Oscillator, Equivalence of wave and matrix mechanics.

Unit - IV

Theory of Angular momentum: Orbital, spin and total angular momentum operators: eigen value equations and matrix representations, Ladder operators, commutation relations, Addition of angular momenta, Clebsch-Gordon coefficients.

References:

1. Quantum Mechanics, Vol. I & II by Albert Messiah (Dover Publication)
2. The Principles of Quantum Mechanics by P.A.M. Dirac (Oxford University Press)
3. Quantum Mechanics by L.I. Schiff (Tata-McGraw-Hill)
4. Modern Quantum Mechanics by J.J. Sakurai (Addison Wesley)
5. Introduction to Quantum Mechanics by D.J. Griffths (Pearson Education)
6. Quantum Mechanics by C. Cohen-Tannoudji, B. Diu and F. Laloe (Wiley VCH)
7. Quantum Mechanics by B. K. Agarwal and Hari Prakash (Prentice-Hall, India)

PHY – 404F: Electronics **Credits 4+0**

Course Objectives: Understanding functions of electronic devices and circuit logic.

Course Outcomes:

CO1. The students will understand electronic circuits and control using various devices.
CO2. The students will understand simple logic and control via logic circuits.

Unit - I

Power Electronics: SCR: Basic structure, I-V characteristics and two- transistor model of SCR, SCR controlled half and full wave rectifier circuit and their analysis. UJT, equivalent circuit, I-V characteristics, Saw tooth wave generation. Elements of SMPS.

Unit - II

Operational Amplifier: IC-741 -Block diagram, operation, Characteristics of op-amp; inverting and non-inverting inputs: Input offset current and Input offset voltage, differential amplifier, CMRR, Slew rate and power band width, op-amp as an amplifier. Application of Op-amp: summer, integrator and differentiator. Timer: IC-555 -Block diagram, Astable and Monostable operations, applications of IC-555 as VCO.

Unit - III

Boolean Algebra and Gates: Boolean algebra, composite function and their algebraic simplification, De-Morgan's theorem ,duality in Boolean algebra, Universality of NAND and NOR gates. SOP and POS forms, karnaugh map, design of logic circuits, X-OR gate and its applications, half adder and full adder, parallel adder, look ahead carry.

Unit - IV

Elements of Logic Families: Transistor as a switch, FAN IN , FAN OUT, Noise Immunity, propagation delay, RTL, DTL, TTL logic, Sourcing and Sinking logic, TTL loading and Fan out, ECL logic.

References:

1. Switch Mode Power Conversion by K. Kit Sum (Marcel Dekker).
2. Power Electronics by P.C. Sen (Tata Mc Graw-Hill)
3. Pulse, Digital and Switching Wave Forms by J. Milman and H. Taub (McGraw-Hill)
4. Op-amp and Linear Integrated Circuits by R.A. Gayakwad (Prentice-Hall India)
5. Integrated Circuits by J. Millman and C.C. Halkias (Tata-McGraw-Hill)
6. Digital Principle and Application by A.P. Malvino and D.P. Leach (McGraw-Hill)
7. Modern Digital Electronics by R.P. Jain (Tata McGraw-Hill)

*** The following two courses PHY-405 and PHY-406 are mandatory. One course will be allotted in the VII semester and the other in VIII semester.**

PHY – 405F: Physics Practical-Electronics **Credits 0+4**

Course Objectives: The student will handle instruments, take readings and analyze the results, to understand various concepts and applications.

Course Outcomes:

CO1. Learning circuit fundamentals and making connections to study properties of electronic devices.
CO2. Learn to present observations, results and analysis in suitable and presentable form.

LIST OF EXPERIMENTS

Students will be required to perform at least five experiments from each course. They will have to maintain record books of experiments done.

1. Study of regulator circuits
2. Study of switch mode power supply (SMPS)
3. Study of characteristic of SCR and controlled rectification by SCR.
4. Study of RC coupled amplifier
5. Study of emitter follower
6. Study of phase shift oscillator
7. Study of multivibrator: Use of 555
8. Study of saw tooth wave generation by UJT
9. Study of characteristics of operational amplifier
10. Study of TTL gates
11. Study of combinational logic circuits
12. Study of super heterodyne receiver
13. Study of linear and square wave detector
14. Microwave measurement: Mode analysis and standing wave ratio

PHY – 406F: Physics Practical- Optics **Credits 0+4**

Course Objectives: The student will handle instruments, take readings and analyze the results, to understand various concepts and applications.

Course Outcomes:

CO1. Hands on experience with optical instruments and understanding concepts of physical optics.
CO2. Learn to present observations, results and analysis in suitable and presentable form.

LIST OF EXPERIMENTS

Students will be required to perform at least five experiments from each course. They will have to maintain record books of experiments done.

1. Use of constant deviation spectrograph
2. Use of Fabry-Perot interferometer
3. Use of concave grating
4. He-Ne Laser
5. e/m by Zeeman effect
6. EPR of free radicals
7. Programming on PC
8. Velocity of ultrasonic wave
9. Hall effect
10. Magnetic Susceptibility
11. Measurement of dipole moment
12. Use of scintillation counter
13. Determination of Dielectric Constant
14. Double slit/Triple slit/ Four slit Wedge shape

Semester VIII

PHY – 407F: Thermodynamics and Statistical Physics **Credit 4+0**

Course Objectives: Understanding laws of thermodynamics and microscopic statistical description.

Course Outcomes:

CO1. The students will understand laws of thermodynamics and relation between macroscopic and microscopic properties.

CO2. The students will be able to apply the concepts in different states of matter.

Unit – I

Second law of thermodynamics, Entropy and Probability, Thermodynamic Potentials, Thermodynamic Equilibrium, Third law of thermodynamics, First and Second order phase transistions: Clausius - Clapeyron and Ehrenfest's equations; Chemical potential and phase equilibria, Gibb's phase rule.

Unit – II

Thermodynamic properties of liquid Helium II, The lambda - transition, London's explanation, Quantum liquid, Tisza two fluid model, Landau spectrum, concept of second sound.
Conditions for Equilibrium, Entropy of an Ideal Boltzmann gas, Gibb's paradox, Sackur - Tetrode equation.

Unit – III

Canonical and Grand Canonical Ensembles, Entropy of a system in contact with heat reservoir, Ideal gas in canonical ensemble, Maxwell velocity distribution, Grand canonical ensemble, Thermodynamics of photons, Translational, Rotational and Vibrational partition functions of a molecule and their applications.

Unit – IV

Thermodynamical properties, Black body radiation, Bose - Einstein Condensation, Ideal Fermi - Diarc gas, Fermi temperature, applications of degeneracy to free electrons in metals, Magnetic susceptibility, White dwarfs and Chandrashekhar limit.

References:

1. A Treatise on Heat by M.N. Saha and B.N. Srivastava (Indian Press Limited, Allahabad)
2. Heat and Thermodynamics by M.W. Zemansky and R.H. Dittman (McGraw Hill)
3. Fundamentals of Statistical and Thermal Physics by F. Reif (McGraw-Hill)
4. Statistical Mechanics by K. Huang (John Wiley & Sons)
5. Statistical Mechanics by R.K. Pathria (Elsevier)
6. Statistical Mechanics and Properties of Matter by E.S.R. Gopal (Macmillan Ltd., Delhi)
7. Statistical Mechanics by B. K. Agarwal and M. Eisner (Wiley Eastern)

PHY – 408F: Electromagnetic Theory and Plasma Physics **Credit 4+0**

Course Objectives: Understanding Physics of Electromagnetic waves and plasma state.

Course Outcomes:

CO1. The students will understand nature of Electric and Magnetic fields, Electromagnetic waves and plasma state.
CO2. The students will be able to apply the concepts in various branches of Physics.

Unit – I
Maxwell Equations: Microscopic and Macroscopic fields, Macroscopic Maxwell equations, Fields **D** and **H**, Dielectric tensor, Principal dielectric axes.
Potential and Gauges: Scalar and vector potentials, Gauge transformation, Lorentz guage and Transverse gauge, Maxwell equations in terms of electromagnetic potentials.

Unit - II
Propagation of Electromagnetic Waves: Propagation of electromagnetic waves in free space, conducting and non-conducting medium, skin depth, Boundary conditions on EM Fields, Reflection and refraction at a plane interface between dielectrics.
Polarisation of EM Waves: Fresnel's Formula, Normal- and anomalous- Dispersion, metallic reflection. EM Wave in bound media: rectangular and circular wave guides, TE, TM and TEM Modes, Cut-off frequency and Wavelength.

Unit – III
Plasma State: Plasma state of matter, Motion of charge particles in uniform E & B fields, non-uniform fields, drifting motion, electrostatic and magnetostatic lenses; Time varying E & B fields, Adiabatic invariants, Plasma confinements(Pinch effect, Mirror confinement,Van Allen Belts), Elementary idea of fusion technology.

Unit – IV
Hydrodynamics of Plasma: Hydrodynamical description, Equation of magneto hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance.
Wave Phenomenon in Magneto-Plasma: Electromagnetic waves perpendicular to B_0, phase velocity, Polarization, Cut-off and resonances, Electromagnetic waves parallel to B_0, Alfven waves.

References:
1. Introduction to Electrodynamics by D.J. Griffiths (Prentice - Hall, New Delhi)
2. The Classical theory of Fields by L.D. Landau and E.M. Lifshitz (Elsevier)
3. Classical Electrodynamics by J.D. Jackson (Wiley Eastern)
4. Introduction to Plasma Physics by F.F. Chen (Plenum Press, New York)
5. Plasma Physics by S.N. Sen (Pragati Prakashan)

PHY – 409F: Solid State Physics **Credit 4+0**

Course Objectives: Understanding the physics related to matter in solid state.

Course Outcomes:

CO1. The students will understand crystal structure and energy concepts.
CO2. Learn different properties of solids and their relation to crystal structure and defects.

Unit - I
Crystal Structure: Ionic, covalent, metallic and hydrogen bonding, space lattice and basis ; Types of lattice, Miller indices, crystal structures of NaCl, CsCl, ZnS, graphite and diamond; Reciprocal lattice and Brillouin Zones; Basic idea of crystal defects and dislocations.

Unit – II
Band Theory of Solids: Sommerfield model, Density of states, Fermi and mean energies at zero and finite temperatures; Origin of energy bands; Bloch Theorem; Kronig Penny model, Electron dynamics in crystalline lattice.

Unit - III
Thermal Properties: Lattice vibrations of mono and diatomic chains, Quantization of lattice vibration, Phonon; Infrared absorption; Einstein and Debye theories of specific heat; Thermal conductivity; Anharmonicity and Thermal expansion.

Unit - IV
Optical Properties: Optical reflectance, Kramers-Kronig relations; Conductivity and dielectric function of electron gas; Basic theory of luminescence, phosphorescence, thermoluminescence, electroluminescence and photo-conductivity; Excitons in ionic and molecular crystals, Electron-hole drops (EHD) and colour centres.

References:
1. Solid state Physics by A.J. Dekkar (McMillan Publishers)
2. Introduction to Solid State Physics by C. Kittel (Wiley Eastern)
3. Elementary Solid State Physics by M. Ali Omar (Pearson Education)
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, (Harcourt Asia Limited)
5. Principles of the Theory of Solids by J.M. Ziman (Cambridge University Press)
6. Solid State Physics by S.O. Pillai (New Age Publishers)

PHY – 410F: Group Theory and Molecular Spectra **Credit 4+0**

Course Objectives: Understanding radiations due to transitions in molecules and symmetry considerations for them.

Course Outcomes:

CO1. The students will understand various electromagnetic transitions in molecules.
CO2. Finding selection rules using symmetry and group considerations.
CO3. The students will be able to apply the concepts in various branches of Physics.

Unit – I

Rotation and Vibration Spectra: IR and Raman spectra of rigid rotator and harmonic oscillator, IR and Raman spectra of non-rigid rotator, anharmonic oscillator and vibrating rotator, Intensities in rotation - vibration spectra, Isotope effects in rotation and vibration spectra.

Unit – II

Electronic Spectra: Electronic energy and total energy, vibration structure of electronic transitions, progressions and sequences, rotational structure of electronic bands, band head formation and band origin. Intensity distribution in vibrational structure, Frank-Condon principle and its quantum mechanical formulation, intensity alternation in rotational lines.

Units – III

Group Theory: Symmetry elements and symmetry operations, Point group and their representation, Mathematical group, Matrix representation, Orthogonality theorem (statements and interpretation only), Reducible and irreducible representations, Direct product group.

Unit – IV

Vibrational and Raman Spectra: Normal modes, symmetry characterization of electronic states and vibrational modes of polyatomic molecules, character tables (C_{2v}, D_{3h} and D_{6h}) and their applications to selection rules of IR and Raman spectra, application to H_2O and CO_2 molecules.

References:

1. Molecular Spectra and Molecular Structure by G. Herzberg (Dover Publication).
2. Fundamentals of Spectroscopy by C.N. Banwell and E.M. McCash (Tata-McGraw-Hill)
3. Introduction to Molecular Spectroscopy by G.M. Barrow (McGraw-Hill)
4. Modern Spectroscopy by M.J. Hollas (Wiley Inter Science)
5. Elements of Group theory for Physicists by A.W. Joshi (Wiley Eastern)
6. Chemical Applications of Group Theory by F.A. Cotton (Wiley Eastern)

PHY – 411F: Major Research Project/Dissertation **Credit 12**

Course Objective: The primary goal of this course is to open the students to visualize and learn new techniques. The assigned project work could be related to the experiments available, theoretical concepts and development. The candidate shall submit a brief report and present seminar.

Course Outcomes: Student will learn presentation skills including making power point presentations etc.

DEEN DAYAL UPADHYAYA GORAKHPUR UNIVERSITY

GORAKHPUR

FOUR YEAR

B. Sc. CHEMISTRY Programme

(B.Sc. Chemistry- Honours and Research Programme)

Syllabus

(For the Academic Session-2024 onwards)

Appendix-A (Four Year UG Programme Framework)

Year	Semester	MAJOR-1 [Subject-1] From Same Faculty	MAJOR-2 [Subjec:-2] From Same Faculty	MINOR [Subject-3] From Same/ others Faculty	SEC Skill Enhancement Course/ vocational	AEC Ability Enhancement Courses/ CoCurricular	Research Project/ Dissertation/ Internship/ Field work/ survey	Total Credits	Degree and Credits	
1	I	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	S.E.C.-I (3 Credits)	AEC-1 (2 Credits)		23	Certificate in Faculty (46 Credits)	
	II	Th (6) OR Th (4)+ Prac (2)	Th (6)or Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	S.E.C.-2 (3 Credits)	AEC-2 (2 Credits)		23		Exit Option 1
2	III	Th (6) OR Th (4)+ Prac (2)	Th (6)or Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	S.E.C.-3 (3 Credits)	AEC-3 (2 Credits)		23	Diploma in Faculty (92 Credits)	
	IV	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)	Th (6) OR Th (4)+ Prac (2)		AEC-4 (2 Credits)	Any one (3 Credits)	23		Exit Option 2
3	V	Th (2x5) OR Th (2x4) + Prac (2)	Th (2x5) OR Th(2x4) + Frac (2)					20	UG Degree (132 Credits)	
	VI	Th (2x5) OR Th (2x4) + Prac (2)	Th (2x5) OR Th (2x4) + Prac (2)					20		
4	VII	Th (5x4) OR Th (4x4)+ Prac(4)						20	UG Honors (172 Credits)	
	VIII	Th (5x4) OR Th (4x4)+ Prac (4)						20		
OR		For Students who secured 75% Marks in First Six Semesters								
4	VII	Th (5x4) OR Th (4x4)+ Prac(4)						20	UG Honors with Research (172 Credits)	
	VIII	Th (2x4)					Research Project (12 Credits)	20		

B.Sc. Chemistry

B.Sc. I Semester

Paper No.	Paper Name	No. of Credits
CHE-101F	Fundamentals of Chemistry	4+0
CHE-102F	Qualitative Analysis	0+2
SECC-01F	Laboratory tools and techniques	3+0
AECC-01F	Academic writing	2+0

B.Sc. II Semester

Paper No.	Paper Name	No. of Credits
CHE-103F	Basic organic chemistry, solid state and chemistry of s and p-block elements	4+0
CHE-104F	Chemical Analysis	0+2
SECC-02F	Industrial Processes	3+0
AECC-02F	Personality Development and Leadership	2+0

B.Sc. III Semester

Paper No.	Paper Name	No. of Credits
CHE-201F	Chemical Dynamics, Organic & Coordination Chemistry	4+0
CHE-202F	Physical Analysis	0+2
SECC-03F	Environmental studies and Computer application	3+0
AECC-03F	Industrial Waste Management	2+0

B.Sc. IV Semester

Paper No.	Paper Name	No. of Credits
CHE-203F	Quantum Mechanics & Organic Synthesis-A	4+0
CHE-204F	Separation Technique and Volumetric Analysis	0+2
CHE-205F	Research Project	3+0
AECC-04F	Occupational Health Management	2+0

B.Sc. V Semester

Paper No.	Paper Name	No. of Credits
CHE-301F	Analytical Techniques and Organic Synthesis-B	4+0
CHE-302F	Polymer, Coordination and Inner Transition Metal Chemistry	4+0
CHE-303F	Qualitative and Quantitative Analysis	0+2

B.Sc. VI Semester (B.Sc. Chemistry)

Paper No.	Paper Name	No. of Credits
CHE-304F	Organic Synthesis-C	4+0
CHE-305F	Chemical Energetics & Bioinorganic Chemistry	4+0
CHE-306F	Physico-Chemical Analysis and Organic Synthesis	0+2

B.Sc. VII Semester
(B.Sc. Chemistry Honours) and (B.Sc. Chemistry Research)

Paper No.	Paper Name	No. of Credits
CHE-401F	Molecular Symmetry and Molecular Vibrations	4+0
CHE-402F	Quantum Chemistry-I	4+0
CHE-403F	Main Group Elements	4+0
CHE-404F	Organic Reaction Mechanism	4+0
CHE-405F	Surface Chemistry, purification and identification of materials	0+4

B.Sc. VIII Semester (B.Sc. Chemistry Honours)

Paper No.	Paper Name	No. of Credits
CHE-406F	Analytical Chemistry	4+0
CHE-407F	Thermodynamics and Electrochemistry	4+0
CHE-408F	Transition Elements	4+0
CHE-409F	Natural Products	4+0
CHE-410F	Chemical Kinetics, separation and identification of binary inorganic / organic materials	0+4

B.Sc. VIII Semester (B.Sc. Chemistry Research)

Paper No.	Paper Name	No. of Credits
CHE-406F	Analytical Chemistry	4+0
CHE-411F	Chemical Techniques	4+0
CHE-412F	Research Project	0+12

SUBJECT: CHEMISTRY

(Four Year Undergraduate Course Structure)

Purpose of the Program

The purpose of the undergraduate chemistry program is to provide the key knowledge based and laboratory resources to prepare students for career as professionals in various industries and research institutions.

Program Specific Outcomes

PS01. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in analytical, Inorganic, Organic and Physical Chemistries.

PS02. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

PS03. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PS04. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

PS05. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health, and medicine.

PS06. Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

PS07. Students will be able to function as a member of an interdisciplinary problem-solving team.

B.Sc. I Year (CHEMISTRY)

Semester-I

(Four Year Undergraduate Course Structure)

CHE 101F: Fundamentals of Chemistry	**Credit 4+0**

Course outcomes:

This course will provide a broad foundation in chemistry that stresses scientific reasoning and analytical problem solving with a molecular perspective. Students will gain an understanding of

- Molecular geometries, physical and chemical properties of the molecules.
- Current bonding models for simple inorganic and organic molecules to predict structures and important bonding parameters.
- The chapter Recapitulation of basics of organic chemistry gives the most primary and utmost important knowledge and concepts of organic Chemistry.
- This course gives a broader theoretical picture in multiple stages in an overall chemical reaction. It describes reactive intermediates, transition states and states of all the bonds broken and formed.
- The chapters Chemistry of alkanes and cycloalkanes gives the clear picture of singly bonded structure and geometry of the molecules.

Unit	**Topics**
I	**Atomic Structure:** Quantum numbers. shapes of s, p and d orbitals. Pauli's exclusion principle. Hund's rule of maximum multiplicity. Aufbau principle. Variation of orbital energies with atomic number and energy level diagram.
II	**Bonding theories of Molecules:** The valence bond theory (VBT) and it's limitations, Concept of hybridization, hybrid orbitals and molecular geometry, Bents rule, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions. Molecular orbital theory (MOT). Molecular orbital diagrams, bond orders of homonuclear and heteronuclear diatomic molecules and ions.
	Dipole Moment and Weak Chemical Forces- hydrogen bonding, Van der Waals forces

III	**Periodic properties of Atoms:** Brief discussion, factors affecting and variation trends of following properties in groups and periods. Effective nuclear charge, shielding or screening effect, Slater rules, Atomic and ionic radii, electronegativity, Pauling's/Allred Rochow's scales, Ionization enthalpy, electron gain enthalpy.
IV	**Kinetic theories of gases Gaseous State:** Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state. **Critical phenomena:** PV isotherms of real gases, continuity of states, the isotherms of Van der Waals equation, relationship between critical constants and Van der Waals constants, the law of corresponding states, reduced equation of state.
V	**Recapitulation of basics of Organic Chemistry:** Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, hyperconjugation; Electronic Displacements: Inductive, electromeric, resonance mesomeric effects and their applications
VI	**Mechanism of Organic Reactions:** Curved arrow notation, drawing electron movements with allows, half-headed and double-headed arrows, homolytic and heterolytic bond fission, Types of reagents electrophiles and nucleophiles, Types of organic reactions, Energy considerations. Reactive intermediates Carbocations, carbanions, free radicals, Assigning formal charges on intermediates and other ionic species.
VII	**Chemistry of Alkanes and Cycloalkanes** **A) Alkanes**: Classification of carbon atom in alkanes, General methods of preparation, physical and chemical properties of alkanes, Free radical substitutions: Halogenation -relative reactivity and selectivity **(B) Cycloalkanes:** Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Chair, Boat and Twist boat forms of cyclohexane with energy diagrams ring strain in small rings, theory of strain less rings. The case of cyclopropane ring, banana bonds.

Suggested Readings:

1. Lee, J.D. Concise Inorganic Chemistry, Pearson Education2010
2. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006.
3. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press,1994.
4. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
5. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
6. Clayden,J.,Greeves,N.&Warren,S.*OrganicChemistry,* 2nd edition,OxfordUniversityPress,2012.
7. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons,Inc.
8. Chaube D. K. *et al, A Textbook of fundamental chemistry*, The Krishna Publications.

B.Sc. I Year (CHEMISTRY)
Semester-I Practical
(Four Year Undergraduate Course Structure)

CHE 102F: Qualitative Analysis	**Credit 0+2**

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to understand the laboratory methods and tests related to estimation of metals ions and estimation of acids and alkali contents in commercial products.

- Potability tests of water samples
- Estimation of metal ions in samples
- Estimation of alkali and acid contents in samples
- Estimation of inorganic salts and hydrated water in samples

Unit	**Topics**
I	**Crystallisation and Determination of melting point** (i) Benzoic Acid (ii) Acetanilide
II	**Qualitative analysis of Inorganic mixture containing four radicals** NH_4^+, Na^+, K^+, Mg^{++}, Ca^{++}, Sr^{++}, Ba^{++}, Zn^{++}, Mn^{++}, Ni^{++}, Co^{++}, Al^{+++}, Fe^{+++}, Cr^{+++}, Cu^{++}, Bi^{++}, Cd^{++} As^{+++}, Sb^{+++}, Sn^{++}, Pb^{++}. CO_3^{2-},NO_2^-, S^{2-}, SO_3^{2-} ,SO_4^{2-}, F^-, Cl^-, Br^-, NO_3^-, CH_3COO^-.
III	**Calibration of thermometer, pipettes, burettes and other glasswares.**
IV	**Preparation of standards solutions by titration** Dilution 0.1M to 0.001M solutions, Mole concept and preparation of molar, formal, normal and molal solution.

Suggested Readings:

1. Mendham, J., Vogels Qauntitative Chemical Analysis, Pearson
2. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters3-5.
3. Harris, D.C.*Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
4. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.
5. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition
6. Chaube D. K. *et al, Practical Chemistry*, The Krishna Publications.

B.Sc. I Year (CHEMISTRY) Semester-II (Four Year Undergraduate Course Structure)	
CHE 103F: Basic Organic Chemistry, Solid State and Chemistry of s and p-Block Elements	**Credit 4+0**

Course outcomes: This course will provide a broad foundation of –

- Unsaturated hydrocarbons.
- Basic understanding of stereochemistry of organic compounds
- Chemistry of p-block elements and noble gases.

Unit	Topics
I	**Chemistry of Alkenes:** Methods of formation of alkenes, Elementary treatment of mechanism of (i) addition of hydrogen, halogens, halogen acids, water and sulphuric acid and (ii) Hydroboration, epoxidation, ozonolysis and hydroxylation.
II	**Chemistry of Alkynes:** Methods of formation of alkynes, Elementary treatment of mechanism of addition reactions of carbon-carbon triple bond- hydrogenation, halogenations, hydrohalogenation and hydration reactions.
III	**Stereochemistry:** Concept of isomerism, Types of isomerism. (i) Optical isomerism: (a) Concept of chirality, elements of symmetry (b) Optical isomerism of compounds containing one (lactic acid) and two asymmetric carbons (tartaric acid). (ii) Methods of racemization and resolution, relative and absolute configuration. (iii) Geometrical isomerism: Maleic and fumaric acid, and methods for their configurations. (iv) Sawhorse and Newman's projection formula; R-S, D-L and E-Z nomenclatures. (v) Conformations of ethane and n-butane
IV	**Liquid State:** Intermolecular forces, structure of liquids (a qualitative description). Structural differences between solids, liquids and gases. Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholesterol phases. Thermography and seven segment cell.
V	**General studies of s block elements :** Group wise discussion of s-block element with respect to electronic configuration, ionisation potential, electron affinity, electronegativity, atomic and ionic radii and their oxidation states. General trend of their compounds.
VI	**Solid State:** Definition of space lattice, unit cell. Laws of crystallography (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices and iii) Symmetry elements in crystals and law of symmetry .X-ray diffraction by crystals. Derivation of
	Bragg equation. Determination of crystal structure of NaCl and KCl.

VII	**p-Block Elements**: Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron-diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetra nitride, basic properties of halogens, interhalogens and polyhalides. **Chemistry of Noble Gasses**: Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Suggested Readings:

1. Davis,B.G.,Fairbanks,A.J.,*CarbohydrateChemistry*,OxfordChemistryPrimer,OxfordUniversityPress.
2. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd.(PearsonEducation).
3. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry7th Ed.*, W. H.Freeman.
4. Ball, D. W. Physical Chemistry Thomson Press, India(2007).
8. Castellan, G. W. Physical Chemistry 4th Ed. Narosa(2004).
9. R.B. Seymour & C.E. Carraher: *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
10. G.Odian:*PrinciplesofPolymerization*,4thEd.Wiley,2004.
11. F.W.Billmeyer:*TextbookofPolymerScience*,2ndEd.WileyInterscience,1971.
12. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education,1991

B.Sc. I Year (CHEMISTRY)
Semester-II Practical
(Four Year Undergraduate Course Structure)

CHE 104F: Chemical Analysis	**Credit 0+2**

Course outcomes:
This course will provide basic qualitative and quantitative experimental knowledge of biomolecules such as carbohydrates, proteins, amino acids, nucleic acids drug molecules. Upon successful completion of this course students may get job opportunities in food, beverage, and pharmaceutical industries.

Unit	**Topics**
I	Separation and identification of amino acids present in given mixture by paper chromatography, reporting the R_f value.
II	**Surface Tension and Viscosity** 1.Determination of surface tension of pure liquid or solution 2.Determination of viscosity of liquid pure liquid or solution
III	**Preparation of Organic Compounds** (i) Picrates (ii) Acetanilide (iii) 2,4,6 tribromoaniline
IV	**Identification of organic compounds** Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.

Suggested Readings:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* PearsonEducation.
3. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,*Universities Press
4. Cooper, T.G. Tool of Biochemistry. Wiley-Blackwell (1977).
5. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press(2009).
6. Varley, H., Gowenlock, A.H & Bell, M.: Practical Clinical Biochemistry,Heinemann,

B.Sc. II Year (CHEMISTRY) Semester-III (Four Year Undergraduate Course Structure)	
CHE 201F: Chemical Dynamics, Organic & Coordination Chemistry	**Credit 4+0**

Course Outcomes: Upon successful completion of this course students should be able to describe chemical kinetics, kinetic theories of gases, phase equilibirium, lementary knowledge of d-block elements and coordination chemistry.

Unit	Topics
I	**Chemical Kinetics:** Rate of a reaction, molecularity and order of reaction, concentration dependence of rates, mathematical characteristic of simple chemical reactions zero order, first order, second order, pseudo order, halflife and mean life. Determination of the order of reaction differential method, method of integration, half-life method and isolation method. Theories of chemical kinetics: Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects (no derivation).
II	**Phase Equilibrium:** Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system water, S, He and Diamond, graphite. Phase equilibria of two component systems Solid - liquid equilibria , simple eutectic. Pb-Ag systems.
III	**Aromaticity and Chemistry of Arenes:** Aromatic, Antiaromatic and non-Aromatic compounds, Nomenclature of benzene derivatives, MO picture of benzene, Character of arenes, cyclic carbocations/carbanions. Electrophilic aromatic substitution - halogenation, nitration, sulphonation and Friedel- Craft's Alkylation with their mechanism, Directing effects of the groups
IV	**Chemistry of Alcohols** Classification and nomenclature, Monohydric alcohols nomenclature, methods of formation by reduction of Aldehydes, Ketones, Carboxylic acids and Esters, Hydrogen bonding, Acidic nature, Differentiation among $1^{o,}$ 2^{o} and 3^{o} alcohols, Dihydric alcohols, Trihydric alcohols - nomenclature, methods of formation, chemical reactions of glycerol.

V	**Chemistry of Transition Elements** **Chemistry of Elements of First Transition Series** -Characteristic properties of d-block elements. Binary compounds (hydrides, carbides and oxides) of the elements of the first transition series and complexes with respect to relative stability of their oxidation states, coordination number and geometry. **Chemistry of Elements of Second and Third Transition Series-** General characteristics, comparative treatment of Zr/Hf, Nb/Ta, Mo/W in respect of ionic radii, oxidation states, magnetic behavior, spectral properties and stereochemistry.
VI	**Coordination Chemistry** Coordinate bonding, double complex salts, Werner's
	theory of coordination complexes classification of ligands, ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, geometrical and optical isomerism in square planar and octahedral complexes.
VII	**Theories of Coordination Chemistry** Metal- ligand bonding in transition metal complexes, limitations of valance bond theory, an elementary idea of crystal field theory, crystal field splitting 7 in octahedral, tetrahedral and square planner complexes, factors affecting the crystal-field parameters.

Suggested Readings:

1. Alberty,R A, Physical Chemistry,4 theditionWiley Eastern Ltd,2001.
2. Atkins,PW,the elements of physical chemistry,Oxford,1991
3. Barrow,G .M,International student Edition .McGraw Hill,McGraw-Hill,1973.
4. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley1995
5. Lee,J.D, Concise Inorganic Chemistry 4th EditionELBS,1977
6. Clayden,J.,Greeves,N.,Warren,S.,*OrganicChemistry*,Secondedition,OxfordUniversityPress2012.
7. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John Wiley and Sons, INC, Fifthedition.
8. Pavia, D. L. *et al*. *Introduction to Spectroscopy*, 5th Ed. Cengage Learning IndiaEd.
9. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
10. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
11. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
12. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

Suggestive digital platforms web links

1. https://www.coursera.org/courses?query=chemistry&languages=en
2. https://www.mooc-list.com/tags/physical-chemistry
3. https://www.coursera.org/learn/physical-chemistry
4. https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/
5. http://heecontent.upsdc.gov.in/Home.aspx

B.Sc. II Year (CHEMISTRY)
Semester-III Practical
(Four Year Undergraduate Course Structure)

CHE 202F: Physical Analysis .	**Credit 0+2**

Course Outcomes: Upon successful completion of this course students should be able to calibrate apparatus and prepare solutions of various concentrations, estimation of components through volumetric analysis; to perform dilatometric experiments: one and two component phase equilibrium experiments.

Unit	Topics
I	**Surface Tension and Viscosity** 1. Determination of surface tension of pure liquid or solution 2. Determination of viscosity of liquid pure liquid or solution
II	**Boiling point and Transition Temperature** 1. Boiling point of common organic liquid compounds **ANY FIVE:** *n* butylalcohol, cyclohexanol, ethyl methyl ketone, cyclohexanone, acetylacetone, isobutyl methyl ketone, isobutyl alcohol, acetonitrile, benzaldehyde and acetophenone. [Boiling points of the chosen organic compounds should preferably be within 180^0C]. 2.Transition Temperature, Determination of the transition temperature of the given substance by thermometric /dialometric method (e.g. $MnCl_2.4H_2O$/$SrBr_2.2H_2O$)
III	**Phase Equilibrium** 1. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol water system) and to determine the concentration of that solute in the given phenol-water system 2.To construct the phase diagram of two component (e.g. diphenylamine benzophenone) system by cooling by cooling curve method
IV	1. Kinetics of dissolution of Mg ribbon in HCl 2. Determination of Heat of neutralisation of (i) Strong Acid-Strong Base (ii) Strong Acid-Weak Base (iii) Weak Acid-Strong Base

Suggested Readings:

1. Skoog. D. A., West DM and Hollar
2. Analytical Chemistry, An Introduction 7th edition, Sauders College

Suggestive digital platforms web links

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

B.Sc. II Year (CHEMISTRY)
Semester-IV
(Four Year Undergraduate Course Structure)

CHE 203F: Quantum Mechanics and Organic Synthesis-A	**Credit 4+0**

Course Outcomes: Upon successful completion of this course students should be able to describe atomic structure, elementary quantum mechanics, wave function and its significance; Schrodinger wave equation and its applications; Molecular orbital theory, basic ideas Criteria for forming molecular orbital from atomic orbitals, Molecular Spectroscopy, Rotational Spectrum, vibrational Electronic Spectrum: photo chemistry and kinetics of photo chemical reaction

Analytical chemistry plays an enormous role in our society, such as in drug manufacturing, process control in industry, environmental monitoring, medical diagnostics, food production, and forensic surveys. It is also of great importance in different research areas. Analytical chemistry is a science that is directed towards creating new knowledge so that chemical analysis can be improved to respond to increasing or new demands.

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem-solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems
- Students will gain an understanding of how to determine the structure of organic molecules using IR spectroscopic technique
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography

Unit	Topics
I	**Elementary Quantum Mechanics**: Bohr's model of H atom. de-Broglie hypothesis. Heisenberg uncertainty principle, Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function and probability distribution curves, Radial and angular wave functions, Schrödinger wave equation for H-atom, separation into three equations (without derivation), bonding wave function, concept of σ, σ*, π, π*
II	**Molecular Spectroscopy**: Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom **Rotational Spectrum**: Diatomic molecules. Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell- Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect . **Vibrational Spectrum:** Infrared spectrum : Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of

	force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups. **Raman spectrum:** Concept of polarizability , pure rotational and pure vibrational, Raman spectra of diatomic molecules, selection rules.
III	**Chemistry of Phenols** : Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character, Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols electrophilic aromatic substitution, acylation and carboxylation.
IV	**Chemistry of Ethers and Epoxides**: Nomenclature of ethers and methods of their formation, physical properties, Chemical reactions cleavage and autoxidation, - Synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides,
V	**A. Volumetric Analysis** General principle of acid-base titrations, precipitation titrations, oxidation-reduction titrations, iodimetry and complexometric titrations, use of EDTA for the determination of Ca^{2+} and Mg^{2+} , Hardness of water, types of EDTA titrations and metal ion indicators. **B. Gravimetric Analysis** Precipitation from homogenous medium, purity of precipitates, coprecipitation, post-precipitation, washing and ignition of precipitates, contamination and their removal.
VI	**Errors and Evaluation** Definition of terms, mean and median, precision, standard deviation, relative standard deviation, accuracy- absolute error, types of error in experimental data determination (systematic), intermediate (or random) and gross, sources of errors and the effects upon the analytical results, methods for reporting analytical data, statistical evaluation and data -indeterminate errors, use of statistics
VII	**Separation Techniques: Solvent** extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media. Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution, and displacement methods.

Suggested Readings:

13. Alberty,R A, Physical Chemistry,4 theditionWiley Eastern Ltd,2001.
14. Atkins,PW,the elements of physical chemistry,Oxford,1991
15. Barrow,G .M,International student Edition .McGraw Hill,McGraw-Hill,1973.
16. Cotton,F.A, Wilkinson,G and Gaus,P. L ,Basic Inorganic Chemistry,3rd Edition ,Wiley1995
17. Lee,J.D, Concise Inorganic Chemistry 4th EditionELBS,1977
18. Clayden,J.,Greeves,N.,Warren,S.,*OrganicChemistry,*Secondedition,OxfordUniversityPress2012.
19. Silverstein, R. M., Bassler, G. C., Morrill, T. C. *Spectrometric Identification of Organic Compounds*, John Wiley and Sons, INC, Fifthedition.
20. Pavia, D. L. *et al. Introduction to Spectroscopy,* 5th Ed. Cengage Learning IndiaEd.
21. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
22. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
23. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
24. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

Suggestive digital platforms web links

6. https://www.coursera.org/courses?query=chemistry&languages=en
7. https://www.mooc-list.com/tags/physical-chemistry
8. https://www.coursera.org/learn/physical-chemistry
9. https://ocw.mit.edu/courses/chemistry/5-61-physical-chemistry-fall-2017/
10. http://heecontent.upsdc.gov.in/Home.aspx

B.Sc. II Year (CHEMISTRY)
Semester-IV Practical
(Four Year Undergraduate Course Structure)

CHE 204F: Separation Technique and Volumetric Analysis | **Credit 0+2**

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

- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to function as a member of an interdisciplinary problem-solving team.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems
- Students will gain an understanding of how to determine the structure of organic molecules using IR spectroscopic technique
- To develop basic skills required for purification, solvent extraction, TLC and column chromatography

Unit	Topics
I	**Chromatographic Separations** Paper chromatographic separation of following metal ions: i. Ni (II) and Co (II) ii. Cu(II) and Cd(II)
II	Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer Chromatography(TLC)
III	**Volumetric Exercises** I. Acid Base titrations II. Estimation of Oxalic acid by titrating with KMnO4 III. Estimation of Silver ions by Volhard's and Mohr's Method. IV. Redox titrations e.g. titration of ferrous ion with permanganate and dichromate using internal and external indicators. V. Estimation of hardness of water by EDTA.

Suggested Readings:

1. Mendham,J., Quantitative Chemical Analysis 6th Ed., Pearson,2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
3. Christian,G.D.AnalyticalChemistry,6thEd.JohnWiley&Sons,NewYork,2004.
4. Harris,D.C.ExploringChemicalAnalysis,9thEd.NewYork,W.H.Freeman,2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher,2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
7. Mikes, O. &Chalmes, R.A. Laboratory Handbook of Chromatographic &AlliedMethods, Elles Harwood Ltd.London.
8. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York,1974.

B.Sc. III Year (CHEMISTRY) Semester-V (Four Year Undergraduate Course Structure)	
CHE 301F: Analytical Techniques and Organic Synthesis-B	**Credit 4+0**

Course outcomes: Biomolecules are important for the functioning of living organisms. These molecules perform or trigger important biochemical reactions in living organisms. When studying biomolecules, one can understand the physiological function that regulates the proper growth and development of a human body. This course aims to introduce the students with basic of oxygen and halogen containing functional groups, experimental understanding of carbohydrates, amino acids, proteins, nucleic acids, and medicinal chemistry. Upon completion of this course students may get job opportunities in food, beverage, and pharmaceutical industries.Students will gain an understanding of which are used as solvents and raw material for synthesis of drug and other pharmaceutically important compounds and synthetic dyes.

Unit	Topics
I	**UV-Visible Spectroscopy :** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, types of electronic transitions, λmax, chromophore and auxochromes, nBathochromic and Hypsochromic shifts, Intensity of absorption, application of Woodward Rules for calculation of λmax for the conjugated dienes, alicyclic, homoannualar and heteroannular; extended conjugated systems, distinction between cis and trans isomers.
II	**Infrared Spectroscopy:** **IR Spectroscopy**: Fundamental and non-fundamental molecular vibrations; Hooke's law, selection rule, IR absorption positions of various functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance, application in functional group analysis and and interpretation of I.R. spectra of simple organic compounds.
III	**Chemistry of Organic Halides** Nomenclature and classes of alkyl halides, methods of formation, chemical reactions, Mechanisms of nucleophilic substitution reactions of alkyl halides, SN2 and SN1 reactions with energy profile diagrams; Polyhalogencompounds : Chloroform, carbon tetrachloride; Methods of formation of aryl halides, nuclear and side chain reactions; The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions; Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides,

IV	**Chemistry of Carbohydrates**: Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Mechanism of mutarotation Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Inter conversions of sugars (ascending and descending of sugar series, conversion of aldoses to ketoses).
V	**Chemistry of Proteins:** Classification of amino acids, zwitter ion structure and Isoelectric point. Overview of primary, secondary, tertiary, and quaternary structure of proteins.
	Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C terminal amino, Synthesis of simple peptides (upto dipeptides) by N-protection & C-activating groups and Merrifield solid phase synthesis.
VI	**Chemistry of Nucleic Acids:** Constituents of Nucleic acids: Adenine, guanine, thymine, and Cytosine (Structure only), Nucleosides and nucleotides (nomenclature), Synthesis of nucleic acids, Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation
VII	**Introductory Medicinal Chemistry:** Drug discovery, design, and development; Basic Retrosynthetic approach. Drug action-receptor theory. Structure activity relationships of drug molecules, binding role of OH group, -NH_2 group, double bond and aromatic ring.
VIII	**Synthetic Dyes:** Color and constitution (electronic Concept), Classification of dyes, Chemistry and synthesis of Methyl orange, Congo red, Malachite green

Suggested Readings:

1. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry,* Pearson Education,2003.
3. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press,2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry,* 2nd edition, OxfordUniversity Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry,* John Wiley & Sons,Inc.
7. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing CompanyLimited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition, Wiley.\

B.Sc. III Year (CHEMISTRY)

Semester-V

(Four Year Undergraduate Course Structure)

CHE 302F: Polymer, Coordination and Inner Transition Metal Chemistry	**Credit 4+0**

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

Unit	Topics
I	**Catalysis** General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation, or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts. Enzyme catalysis: Michaelis-Menten equation, Lineweaver-Burkplot, turn-over number.
II	**Chemistry of Lanthanides** Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, ceric ammonium sulphate and its analyticaluses.
III	**Chemistry of Actinides** Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U.
IV	**Thermodynamic and kinetic aspects of metal complexes** A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, stability constants of complexes and their determination, substitution reactions of square planar complexes.

V	**Inorganic Spectroscopy and Magnetism** **I.** Electronic spectra of Transition Metal Complexes, Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d1 and d9 states, discussion of the electronic spectrum of $[Ti(H2O)_6]$ 3+ and $[Cu(H_2O)_6]^{2+}$complex ion. **II.** Magnetic properties of transition metal complexes, types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ s and μ eff values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes. General description of magnetic properties : Paramagnetism, diamagnetism, ferromagnetism and magnetic susceptibility.
VI	**Metal Carbonyls and Nitrosyls** 18-electron rule, preparation, structure and nature of bonding in the mononuclear and dinuclear carbonyls and nitrosyls.
VII	**Introduction to Polymer** Monomers, Oligomers, Polymers and their characteristics, Classification of polymers: Natural synthetic, linear, cross linked and network; plastics, elastomers, fibers, Homopolymers and Co-polymers, Bonding in polymers : Primary and secondary bond forces in polymers ; cohesive energy, and decomposition of polymers. Silicones and Phosphazenes, Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.

Suggested Readings:

1. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education,2003.
3. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press,2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry*, 2nd edition, OxfordUniversity Press, 2012.
6. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing CompanyLimited.
7. March,J.*AdvancedOrganicChemistry*,Fourthedition,Wiley.
8. Lee,J.D.ConciseInorganicChemistry,PearsonEducation2010.

B.Sc. III Year (CHEMISTRY)
Semester-V Practical
(Four Year Undergraduate Course Structure)

CHE 303F: Qualitative and Quantitative Analysis | **Credit 0+2**

Course outcomes:

Upon completion of this course the students will have the knowledge and skills to understand the laboratory methods and tests related to inorganic mixtures and organic compounds.

- Separation of organic compounds from mixture
- Elemental analysis in organic compounds
- Identification of functional group in organic compounds
- Identification of organic compound

Unit	Topics
I	**Separation and Identification of Organic Mixture** Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives
II	1. To study the kinetics of reaction between acetone and iodine. 2. To determine the solubility of simple salt by evaporation method and to draw the solubility curve.
III	**Qualitative and quantitative analysis of carbohydrates:** 1. Separation of mixture of two sugars by ascending paper chromatography. 2. Differentiate between reducing and non reducing sugar. Synthesis of Osazones.
IV	**Determination and identification of Nucleic Acids** 1.Determination of nucleic acids 2.Extraction of DNA from onion/cauliflower

Suggested Readings:

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition,1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.
3. Harris,D.C.*ExploringChemicalAnalysis*,9th Ed.NewYork,W.H.Freeman,2016.
4. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher,2009.

B.Sc. III Year (CHEMISTRY)
Semester-VI
(Four Year Undergraduate Course Structure)

CHE 304F: Organic Synthesis C | **Credit 4+0**

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

The study of natural products and heterocyclic compounds offers an excellent strategy toward identifying novel biological probes for several diseases. Historically, natural products have played an important role in the development of pharmaceutical drugs for several diseases including cancer and infection.

- It relates and gives an analytical aptitude for synthesizing various industrially important compounds.
- Learn the different types of alkaloids, & terpenes etc and their chemistry and medicinal importance.
- Explain the importance of natural compounds as lead molecules for new drug discovery.

Unit	Topics
I	**Reagents in Organic Synthesis** A detailed study of the following reagents in organic transformations, Oxidation with SeO2, Jones Oxidation, PCC, PDC, NaBH4, LiAlH4, DIBAL-H
II	**Organometallic Compounds-** Organomagnesium compounds: the Grignard reagents, formation, structure and chemical reactions. Organolithium compounds: formation and chemical reactions.
III	**Chemistry of Aldehydes and ketones:** Nomenclature and structure of the carbonyl groups, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, Physical properties. Mechanism of nucleophillic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Wittig reaction Oxidation of aldehydes, Cannizzaro reaction, ~~MPV~~, Clemmensen, Wolff-Kishner, An introduction to a,b –unsaturated aldehyde and ketones.
IV	**Carboxylic acids and their Functional Derivatives** Nomenclature and classification of aliphatic and aromatic carboxylic acids. Preparation and reactions. Acidity (effect of substituents on acidity) and salt formation, Reactions: Mechanism of reduction, substitution in alkyl or aryl group, stereospecific addition to maleic and fumaric acids. Preparation and reactions of acid chlorides, acid anhydrides, amides and esters, acid and alkaline hydrolysis of esters, trans-esterification.
V	**Organic Compounds of Nitrogen-** Preparation of nitroalkanes and nitroarenes, Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in

	nitroarenes and their reductions in acidic, neutral and alkaline media, Picric acid, Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Gabriel- phthalimide reaction, Hofmann bromamide reaction. Reactions of amines, electrophilic aromatic substitution in arylamines,reactions of amines with nitrous acid.
VI	**Heterocyclic Chemistry** Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, Mechanism of nucleophilic substitution reaction in pyridine derivatives, Comparison of basicity of pyridine, piperidine and pyrrole. Mechanism of electrophilc substitution reactions of indole, quinoline and isoquinoline.
VII	**Rearrangements** A detailed study of the following rearrangements: Pinacol-pinacolone, Benzil Benzilic acid, and Fries rearrangement

Suggested Readings:

1. Morrison,R.N.&Boyd,R.N.*OrganicChemistry*,DorlingKindersley(India)Pvt.Ltd.(PearsonEducation).
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education,2003.
3. Carey, F. A., Guiliano, R. M.*Organic Chemistry*, Eighth edition, McGraw Hill Education,2012.
4. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press,2008.
5. Clayden, J., Greeves, N. &Warren, S. *Organic Chemistry*, 2nd edition, OxfordUniversity Press, 2012.
6. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry*, John Wiley & Sons,Inc.
7. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing CompanyLimited.
8. March, J. *Advanced Organic Chemistry*, Fourth edition,Wiley.
9. Acheson, R.M. Introduction to the Chemistry ofHeterocyclic compounds, John Welly& Sons (1976).
10. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
11. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry ofNatural
12. Products), Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
13. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan(2010).

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Suggested online links:

http://heecontent.upsdc.gov.in/Home.aspx

B.Sc. III Year (CHEMISTRY) Semester-VI (Four Year Undergraduate Course Structure)	
CHE 305F: Chemical Energetics and Bioinorganic Chemistry	**Credit 4+0**

Course outcomes: Upon successful completion of this course students should be able to describe laws of thermodynamics and its applications, phase equilibria of one and two component system, electro chemistry ,ionic equilibrium applications of conductivity and potentiometric measurements

Unit	Topics
I	**Thermodynamics-1 :** **First Law of Thermodynamics** : Statement , definition of internal energy and enthalpy. Heat capacity ,heat capacities at constant volume and pressure and their relationship. Joule's law Joule- Thomson coefficient and inversion temperature . **Thermochemistry:** Standard state, standard enthalpy of formation Hess's law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume . Enthalpy of neutralization . Bond dissociation energy and its calculation from thermo-chemical data , Kirchhoff's equation.
II	**Thermodynamics II** Second Law of Thermodynamics, Need for the law, different statements of the law, Carnot cycle and its efficiency. Carnot theorem. Thermodynamic scale of temperature. Concept of Entropy, Entropy as a state function, entropy as a function of V & T, entropy as a function of P&T, Entropy change in ideal gases and mixing of gases. Gibbs and Helmholtz Functions Gibbs function (G) and Helmhotz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change,
III	**Electrochemistry**: specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation ofmolar,equivalent and specific conductances with dilution. Migration of ions and Kohlrausch law, , Arrhenius theory of electrolyte dissociation and its limitations. Weak and strong electrolytes . Ostwald's dilution law, its uses and limitations .

IV	**Colligative Properties-**Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination, Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure, Elevation of boiling point and depression of freezing, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point.
V	**Bioinorganic Chemistry** Essential and trace elements in biological processes, metalloporphyrins with special reference to heamoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} and Mg^{2+}. Cu in plastocyanin and hemocyanin, Zn in carboxypeptidase and carbonic anhydrase.

Suggested Readings:

1. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B..I. Waverly Pvt. Ltd. NewDelhi.
2. Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press(2010).
3. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009). 4.
5. Ball,D.W.PhysicalChemistryThomsonPress,India(2007).
6. Castellan,G.W.PhysicalChemistry4thEdn.Narosa(2004).
7. Allen Bard ,JLarry . Faulkner R ,Fundamentals of Electrochemical methods fundamentals and applications,newYork John ,Wiley &sons ,2001
8. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th ed., New Age International, NewDelhi, 1995.

B.Sc. III Year (CHEMISTRY)
Semester-VI Practical
(Four Year Undergraduate Course Structure)

CHE 306F: Physico-Chemical Analysis and Organic Synthesis	**Credit 0+2**

Course Outcomes: Upon successful completion of this course students should be able to quantify the product obtained through gravimetric method; determination of R values and identification of organic compounds through paper and thin layer chromatography laboratory techniques: perform thermo chemical reactions

Unit	**Topics**
I	**Gravimetric Analysis** 1. Analysis of Cu as CuSCN, 2. Analysis of Ni as Ni(dimethylgloxime)
II	**Estimate the following metals gravimetrically:** 1. Barium as Barium sulphate 2. Zinc as Zinc Oxide 3. Iron as Iron Oxide 4. Chromium as Chromium Oxide 5. Lead as lead sulphate .
III	**Thermochemistry** 1. To determine the solubility of benzoic acid at different temperatures and to determine heat of the dissolution process. 2. To determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionization of the weak acid/weak base. 3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born-Habercycle.
IV	Preparation of organic compounds (Single Step Synthesis) (i) p-Bromoacetanilide (ii) p-Nitro acetanilide (iii) Soap from line seed oil or coconut oil (iv) Esterification of Benzoic Acid from Ethanol/Methanol

Suggested Readings:

1. Skkog DA, West DM Hollar, FJ, Analytical Chemistry: An Introduction 7th Edition, Sauders college publishing, Philadelphia (2010)
2. Larry Hargis, G Analytical Chemistry: Principles and Techniques

Suggestive digital platforms web links

4. https://www.labster.com/chemistry-virtual-labs/
5. https://www.vlab.co.in/broad-area-chemical-sciences
6. http://chemcollective.org/vlabs

B.Sc. Chemistry Honours and Research
Semester-VII

CHE 401F :Molecular Symmetry and Molecular Vibrations

(4+0 Credits)

Course Objectives: Symmetry strictly defines relations between molecular spectra and molecular structure. This paper focuses on the mathematical tools which are necessary to apply symmetry concepts to vibrational spectroscopy.

Unit-1

Symmetry elements and symmetry operations with special reference to water and ethane.

Classification of molecules/ ions based on their symmetry properties.

Unit-2

Derivation of matrices for rotation, reflection, rotation-reflection and inversion operations, Symmetry point groups applied to all type of molecules (C_{nh}, D_{nh}, C_{nv}, T_d, O_h and I_h).

Unit-3

Group multiplication basis, matrix representation, character of an operation, orthogonality, character tables, reducible and irreducible representations, groups, subgroups and classes.

Unit-4

Symmetry of normal vibrations, determination of normal modes by internal and Cartesian coordinates methods, mixing of internal coordinates in normal modes, selection rules for IR and Raman spectroscopy.

Unit-5

Normal coordinate analysis of water and ammonia molecules and their infrared and Raman spectral activity.

Books Recommended:

1. D.M. Bishop, "Group theory and Chemistry" Dover Publications.
2. F.A. Cotton, "Chemical Applications of Group Theory", John Wiley, 1971.
3. M. Hamaresh, "Group theory and its Applications to Physical Problems" Addison- Wisley
4. McWeeny, "Symmetry - An Introduction to Group Theory", Pergamon Press.
5. Lowell H. Hall "Group Theory and Symmetry in Chemistry", McGraw Hill Book Company, New York, 1969
6. K.VeeraReddy,"Symmetry and Spectroscopy of Molecules", New Age International Limited Publisher, New Delhi.

Course Outcomes:

CO 1: Symmetry elements and symmetry operations covers a wide area of research in theoretical chemistry.

CO 2: Understanding of symmetry of normal vibrations, determination of normal modes, mixing of internal coordinates and normal coordinate analysis of molecules develops the basis of experimental infra red and Raman spectroscopic analysis of molecules and their theoretical calculations via computational programmes.

CHE 402F : Quantum Chemistry I

(4+0 Credits)

Course Objectives: The objective of the course is to know the application of quantum mechanics in physical models and experiments of chemical systems. It is also called molecular quantum mechanics.

Unit-1

Fundamental Concepts:

- **a.** Operators and algebra of operators, commutators, Linear operators, Vector operators, Laplacian operators, Hermitian operators, Concept of normalization and orthogonality in wave function.
- **b.** Postulates of quantum mechanics.
- **c.** Schrodinger equation and particle in one dimensional and three-dimensional box and degeneracy of states.

Unit-2

Quantum mechanical treatment:

a. Quantum mechanical treatment of a harmonic oscillator, One dimensional Harmonic oscillator (Classical and quantum mechanical treatments), Energy levels of harmonic and an-harmonic oscillators.
b. Quantum mechanical treatment of a rigid rotor
c. Rigid rotor model of a diatomic molecule, Energy levels of a rigid rotor, Rigid rotor selection rule, A non rigid rotor.

Unit 3

Schrodinger equation for H atom:

Transformation of coordinates, Separation of Variables, φ,θ and R equations and theirsolutions, Spherical harmonics.

Unit 4

Many –Electron Atoms:

Antisymmetry and Slater determinant for the wave function of ground state of multielectron atom, Self consistent field approximation (Hartree's Theory).

Unit 5

Approximation methods:

The variation method, Perturbation method and First order Perturbation theory.

Reference Books:

1. Quantum Chemistry by Donald A. Macquarrie
2. Molecular Quantum Mechanics by P.W. Atkins and R.S. Friedman
3. Quantum Chemistry by R. K. Prasad
4. Introductory Quantum Chemistry by A. K. Chandra
5. Quantum Chemistry by Ira N. Levine
6. Physical Chemistry by T. Engel and P. Reid

Course Outcomes:

CO 1: Students will be able to grasp fundamental concepts of operators, algebra of operators and quantum mechanical and Schrodinger wave equations for single and multi electron systems.

CO 2: Real analysis covers a wide area of research in computational chemistry. This course is useful in various completive exams like CSIR-NET, IAS, PCS.

CHE 403F: Main Group Elements

(4+0 Credits)

Course Objectives: The paper of main group elements is introduced to M.Sc. classes for the study of s and p block elements of the periodic table. The core objective of this paper is to prepare the students to understand and correlate preparation, structure, bonding and properties of s and p block elements.

Unit-1

Stereochemistry of Bonding in Main Group Components:

dπ – pπ bonds, Bents rule, Energetics of hybridization

Unit-2

Preparation, Structure, Bonding and Technical Applications of,

a. Polyether complexes of alkali and alkaline earth metals
b. Polyphasphazenes
c. Thiazyl and its polymers, tetrasulfurdinitride.

Unit-3

a. Structure and bonding of Borane anions
b. Classification and structures of Silicates

Unit-4

Synthesis and structure of:

a. Carbides
b. Polyions of Ge, Sn, Pb, Sb, Bi and Hg

Unit-5

a. Definition and classification of organometallic compounds on the basis of hapticity and polarity of metal-carbon bond
b. Preparation, Properties, Structure and Applications of**a**lkyl and aryls of Lithium, Beryllium, Aluminum, Mercury and Tin.

Reference Books:

1. Advance Inorganic Chemistry, 6th Edition, Cotton and Wilkinson
2. Inorganic Chemistry, 4th Edition, Principles of Structure and Reactivity by J.F. Huheey, E.A. Keiter and R.L. Keiter, 1993

3. Chemistry of Elements by N.N. Greenwood and A. Ernshaw, Butterworths 1997
4. Organometallic Chemistry: A Unified Approach by R.C. Mehrotra and A.K. Singh
5. Comprehensive Coordination Chemistry Vol.3 by G. Wilkinson, R.D. Gillard, And J.A. McCleverty, Pergamon Press 1987.

Course Outcomes:

CO 1. Students will be able to demonstrate an intuitive understanding ofcorrelation between electronic configuration and bonding properties of elements.

CO 2. Chemistry of main group elements covers a wide area of research in inorganic chemistry.

CHE 404F:Organic Reaction Mechanism

(4+0 Credits)

Course Objectives:

1. Train students to graspbasics of organic reactions- step by step sequence of elementary reactions by which overall chemical change occurs.
2. To understand principles of organic reaction mechanism, substitution, elimination, homo- and hetero bond addition reactions.
3. To prepare the students for further research in organic chemistry.

Unit-1

Basic principle of organic reaction mechanism:

Potential energy diagram, methods of determination of organic reaction mechanism and their applications, kinetic isotopic effect and its importance in determination of reaction mechanism.

Unit-2

Substitution Reactions:

a. **Aromatic electrophilic substitution:** General view, energy profile diagram, arenium ion mechanism (ArSE) of different aromatic electrophilic substitution reactions, ipso-substitution and ortho/ para ratio.

b. **Aromatic nucleophilic substitution:** (ArSN) Addition- elimination and elimination- addition (benzyne) mechanisms,

c. **Aliphatic nucleophilic substitution:** Mechanism and stereochemistry of S_N1, S_N2, S_N' and S_N^i reactions, role of substrate's. Nuleophilic substitution at bridged head carbon atom.

d. **Neighouring group participation (NPG):** Evidence for NGP,participation of sigma., Pi- bonds, halogen, N-atoms and phenyl ring.

Unit-3

Elimination reaction:

E_1, E_2 and E_1cb mechanisms, orientation (Saytzef's and Hoffmann eliminations), pyrolytic (syn) elimination, stereochemistry of E_2 reaction, factors affecting E_1, E_2 and E_1cb reactions, Competition between substitution and elimination reactions.

Unit-4

C=C Bond Addition :

Mechanism and stereochemistry of addition of halogen and halogen acids to alkenes,1,2-hydroxylation, oxymercuration-demercuration, Corey epoxidation and cyclopropanation, Simmon-Smith cyclopropanation and Sharpless asymmetric epoxidation (SAE).

Unit-5

C-Hetero multiple Bond addition:

Mechanism of hydrolysis of ester and amide. Crame's rule. Condensationreaction involving Cannizzaro, Claisenand Knovenagel.

Reference Books:

1. Advanced Organic Chemistry Part. A &B By F. A. Carey and R. J. Sundberg, Plenum Publisher , New York, 2007.
2. Advanced Organic Chemistry By J. March, 2007.
3. Organic chemistry By J. Clayden, N. Greeves, S. Warren and P. Wothers, Oxford University Press , New York, 2001.

Course Outcomes: Organic reaction mechanism is the backbone of classical and applied organic chemistry.

Semester-VII (Practical)

CHE 405F: Surface Chemistry, purification and identification of materials

(0+4 Credits)

Physical Chemistry exercises:

1. Determination of the solubility of benzoic acid in water at different temperatures and calculate the heat of solution
2. Determinationof the distribution coefficient of benzoic acid between benzene and water
3. Determinationof the distribution coefficient of acetic acid between benzene and water
4. Determination of the distribution coefficient of iodine between carbon tetrachloride and water
5. Study the adsorption of acetic acid on charcoal and draw the Freundlich isotherm

Inorganic Chemistry exercises:

Qualitative analysis of an inorganic mixture of seven radicals including Tl, W, Se, Te, V, Be, U, Ti, Zr, Th, Ce and Li, in addition to the radicals prescribed for the B.Sc. course. Semi-micro analysis is to be done

Organic Chemistry exercises:

Preparation of organic compounds involving two stages. Emphasis should be given in the following processes:

Purification, distillation under reduced pressure, steam distillation and fractional crystallization.

B.Sc. Chemistry Honours

Semester-VIII

CHE 406F: Analytical Chemistry

(4+0 Credits)

Course Objectives:

1. To study concepts and theories behind basic methods and techniques used in analytical chemistry. This theory can be used to solve many rigorous problems of universe.
2. To prepare the students for further research in analytical methods of chemistry.

Unit-1

Electroanalytical Techniques:

a. **Conductometric:** Discussion of the nature of the curves of acid-base (including mixtures of acids), precipitation and complexometric titrations
b. **Potentiometric:** Different types of electrodes, discussion of the nature of the curves for oxidation-reduction and acid-base titrations, comparision with the conductometric method
c. **Voltammetry:** Cyclic voltammetry
d. **Polarography:** Dropping mercury electrode and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half wave potential, Ilkovic equation and factors affecting diffusion current

Unit-2

Thermoanalytical Methods:

a. **Thermogravimetry:** Apparatus, factors affecting TG, Interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$
b. **Differential Thermal Analysis and Differential Scanning Calorimetry:** Apparatus, factors affecting DTA and DSC curves with special reference to heating rate, particle size and packing, measurement of heat of transition, heat of reaction and heat of dehydration of salts and metal hydrates.

Unit-3

Radiochemical Methods

a. Isotope method

b. Inverse isotopic dilution

c. Neutron activation technique

Unit-4

Chromatographic Method:

a. **Gas Chromatography:** GLC and GSC

b. HPLC

Unit-5

Spectral Methods:

a. Nephelometry

b. Turbidimetry

c. Flame Photometry

Reference Books:

1. Fundamentals of Analytical Chemistry: D.A. Skoog, D.M. West and F.J. Holler, 1992, 6e
2. Quantitative Inorganic Analysis, A.I. Vogel, 2012, 7e
3. Instrumental Methods of Chemical Analysis: B.K. Sharma, 2011
4. Instrumental Methods of Chemical Analysis: H. Kaur, 2016, 12 e
5. Analytical Chemistry, Gary D. Christian, 2007, 6e
6. Instrumental Methods of Analysis: H.H. Willard, L.L. Merrit, Jr. J.A. Dean, 1974, 5e

Course Outcomes:

After studying this course the student will be able to,

CO 1. Understand the basic of this course and think & develop new ideas and concepts in analytical chemistry

CO 2. Know about electroanayltical, thermoanalytical, radiochemical, chromatographic and spectral techniques.

CHE 407F: Thermodynamics and Electrochemistry

(4+0 Credits)

Course Objectives: The main objective of the course is to provide fundamentalconcepts of thermodynamics effects and relationships. The course is to give knowledge of comprehensive and rigorous treatment of classical thermodynamics, thermodynamics relations. Explain the concept of partial molar properties fugacity and activity. The course is designed to give an insight of phenomena of electrolytic conductance, reactions in solutions, basic principles of electrical phenomena are important for interfaces and electrode processes.

Unit 1

a. **Some important thermodynamic effects and relationships :**

The Joule Thomson's effect, The Gibbs Helmoltz equation and its application, The ClausiusClapeyron equation, The Maxwell's relation.

b. **Partial molar Properties**

Partial molar quantities,(partial molar volume and partial molar Gibbs energy),Chemical potential and variation of chemical potential with temperature and pressure, The Gibbs Duhem equation

c. **Fugacity and Activity**

Fugacity, variation of fugacity with temperature and pressure, Activity and the activity coefficient.

Unit 2

The Third law Thermodynamics:

The third law, Nernst heat theorem, application of third law, The residual entropy.

Unit 3

Electrolytic Conductance of strong electrolytes:

Debye-Falkenhagen effects, Wein effects the ionic association, effect of ionic strength on rate of ionic reactions.

Unit 4

Electrical phenomena at interface:

The electrical double layer, electrokinetic phenomena, quantitative treatment of electro osmosis, Electrophoresis and streaming potential.

Unit 5

Electrode processes:

Dissolution and deposition potential, decomposition potential and its determination, Concentration Polarization and over voltage(hydrogen overvoltage and oxygen overvoltage), The Limiting current density.

Reference Books:

1. Thermodynamics for Chemists by S.Glasstone.
2. An Introduction of Chemical Thermodynamics by R.P.Rastogi and R.R.Mishra.
3. Thermodynamics by K.S.Pitzer
4. Electrochemistry by S.Glasstone
5. Electrochemistry by Potter
6. Modern Electrochemistry by Bockris Reddy VoL I&II
7. Comprehensive Physical Chemistry byN.B. Singh,S.S. Das and N.S. Gajbhiye, New Age International Publishers.

Course Outcomes:

CO 1. To understand various thermodynamic relationship, the concept of free energy and partial molar quantities, activity and activity coefficients and determination.

CO 2. To understand the phenomena of electrolytic conductance. Reactions in solutions.

CO 3. To understand electrical phenomena at interfaces and electrode processes.

CO 4. To understand application of electrochemistry in electrolytic processes.

CHE 408F: Transition Elements

(4+0 Credits)

Course Objectives:

1. Train students to grasp fundamental chemistry of transition metal elements- group of element whose atom has a partially filled *d* sub-shell.
2. To understand principles of structure, stereochemistry, kinetics and mechanism of transition metal elements.
3. To prepare the students for further research in transition metal chemistry.

Unit-1

Structures of 2 to 8 Coordinate Metal Complexes:

Cation-anion ratio in various polyhedral, Hybrid orbitals and preferred conditions of formation of the complexes of following geometries :

C.N.2 - Linear

C.N.3 - Trigonal planar, Trigonal pyramidal

C.N.4 - Tetrahedral, Square planar

C.N.5 - Trigonal bipyramidal, Square pyramidal, pentagonal.

C.N.6 - Octahedral, Trigonal prism

C.N.7 - Pentagonal bipyramidal, Capped octahedral, Capped trigonal prism.

C.N.8 - Cubic, Tetragonal antiprismatic, Dodecahedral, Hexagonal bipyramidal, and Bicapped trigonal prism,

Stereochemical non-rigidity in four to eight coordinate Complexes.

Unit-2

Stereoisomerism in six coordinate octahedral complexes (Ma3bcd, Ma2bcde, Mabcdef and complexes containing bi-and ter- dentate ligands, Intermolecular and intramolecular rearrangements (Bailar and Ray Dutta twist only), mechanism of racemisation in tris (chelate) octahedral complexes, Methods of resolution of optical isomers.

Unit-3

Kinetics and mechanism of substitution reactions in octahedral Co (III) and square planar Pt (II) complexes.

Unit-4

Mechanism of one electron transfer reactions (inner and outer sphere mechanisms), Factors affecting the rates of direct electron transfer reactions and the Marcus equation, Two electron transfer reactions.

Unit-5

Metal Ligand Equilibria in Solution:

Step wise and overall formation constants and their relations, Factors affecting the stability of metal complexes with reference to the nature of metal ions and ligands, determination of stability constants by pH-metric and spectroscopic methods.

Books Recommended:

1. Inorganic Chemistry, 4th Edition, Principles of Structure and Relativity by J.E. Huheey, E.A. Keiter and R.L. Keiter, 1993
2. Chemistry of Elements by N.N. Greenwood and A. Ernshaw, Butterworths, 1997
3. Mechanism of Inorganic Reactions; A Study Of Metal Complexes in Solution by F. Bosolo and R.G. Pearson
4. Ligand Field Theory And Its Application by B.N. Figgis and M.A. Hitchman, Wiley, NewYork, 2000.

Course Outcomes: After studying this course the student will be able to,

CO 1. Understand the basic of transition metal chemistry and think & develop new ideas in this field.

CO 2. Know geometries of 2 to 8 coordinate metal complexes, streoisomerism, kinetics and mechanism of substitution reactions in octahedral and square planar complexes.

CO 3. Understand mechanism of electron transfer reactions and stability of transition metal complexes.

CO 4. Develop new ideas for further research in the field of coordination chemistry.

CHE 409F: Natural Products

(4+0 Credits)

Course Objectives: Natural product chemistry is branch of chemistry that deals with chemicalcompounds or substances produced by a living organism-that is, found in nature. Natural products can also be prepared by chemicalsynthesis (both semi synthesis and total synthesis) and have played a central role in the development of the field of organic chemistry by providing challenging synthetic targets.

Basic concepts and knowledge of chemistry of natural products are necessary to develop understanding of core organic chemistry i.e. simple to complex organic

structures, organic structural determination, semi-synthetic to total synthetic pathways of organic structures etc.

Unit- 1

Acetogenins : Classification, general method of structure determination of,

- **a.** Flavones- Chrysin
- **b.** Flavonols–quercetin
- **c.** Anthocyanins- Cyanin
- **d.** Anthocyanidins- cyanidin chlorides

Unit-2

Terpenoids : Introduction, isolation and general methods of determining structure of,

- **a. Monoterpenoids**
- **i.** Acyclic monoterpenoids: Citral and geraniol
- **ii.** Monocyclic monoterpenoids : α-Terpineol

Unit-3

Alkaloids: Introduction and general methods of determining structure of,

- **i.** Hemlock alkaloid- Coniine
- **ii.** Pyrrolidine-Pyridine alkaloid- Nicotine
- **iii.** Chincona alkaloids -Quinine
- **iv.** Opium alkaloids : Papaverine and Morphine
- **v.** Rauwolfia alkaloids

Unit-4

Carbohydrates: Structure and functions of,

Disaccarides- Lactose, Sucrose

Unit-5

Biosynthesis of natural products:

i. The acetate hypothesis, Isoprene rule, mevalonic acid from acetylco-enzyme – A, biogenesis of terpenoids
ii. Shikimic acid pathway of biogenesis of aromatic ring
iii. General biogenesis of alkaloids

Reference Books:

1. Organic Chemistry, I.L. Finar Vol. I and II, 2000

2. Natural Products, S.M. Chawla, 2018
3. Biochemistry-Lehninger, 2000
4. Biochemistry by L. Stryer, 1995

Course Outcomes: After studying this course the student will be able to,

CO 1. Understand basics of different classes of natural products- Acetogenins, Terpenoids, Alkaloids and Carbohydrates and their general structural determination.

CO 2. Know about acetate hypothesis, isoprene rule, biogenesis of – Terpenoid, aromatic ring (Shikimic acid pathway) and alkaloid.

CO 3. develop ideas for further research total organic synthesis.

(Practical) CHE 410F: Chemical Kinetics, separation and identification of binary inorganic / organic materials

(0+4 Credits)

Physical Chemistry exercises:

1. Solubility curve for water-acetic acid-chloroform systems
2. Determination of the rate constant of the acid-catalysed hydrolysis of ethyl acetate at laboratory temperature
3. Determination of the rate constant of the hydrolysis of ethyl acetate by sodium hydroxide at laboratory temperature
4. Conductometric titration between strong acid and strong alkali
5. Determination of the dimerization constantof benzoic acid in benzene medium by partition method

Inorganic:

Either both gravimetric and one volumetric, one gravimetric estimation of two metal ions from following mixtures:

a. Cu^{+2} and Ni^{+2}
b. Cu^{+2} and Zn^{+2}
c. Ni^{+2} and Zn^{+2}
d. Cu^{+2} and Ba^{+2}
e. Cu^{+2} and Ag^{+}
f. Fe^{+2} and Ag^{+}
g. Ba^{+2} and Ag^{+}

Organic:

Analysis of binary organic mixture (Liquid-Liquid, Liquid-Solid, Solid-Solid)

B.Sc. Chemistry Research

Semester-VIII

CHE 406F: Analytical Chemistry
(4+0 Credits)

Course Objectives:

1. To study concepts and theories behind basic methods and techniques used in analytical chemistry. This theory can be used to solve many rigorous problems of universe.
2. To prepare the students for further research in analytical methods of chemistry.

Unit-1

Electroanalytical Techniques:

a. **Conductometric:** Discussion of the nature of the curves of acid-base (including mixtures of acids), precipitation and complexometric titrations
b. **Potentiometric:** Different types of electrodes, discussion of the nature of the curves for oxidation-reduction and acid-base titrations, comparision with the conductometric method
c. **Voltametry:** Cyclic voltametry
d. **Polarography:** Dropping mercury electrode and its advantages, polarographically active species, concept of residual, diffusion and limiting current of half wave potential, Ilkovic equation and factors affecting diffusion current

Unit-2

Thermoanalytical Methods:

a. **Thermogravimetry:** Apparatus, factors affecting TG, Interpretation of TG curves of $CaC_2O_4.H_2O$ and $MgC_2O_4.2H_2O$
b. **Differential Thermal Analysis and Differential Scanning Calorimetry:** Apparatus, factors affecting DTA and DSC curves with special reference to heating rate, particle size and packing, measurement of heat of transition, heat of reaction and heat of dehydration of salts and metal hydrates.

Unit-3

Radiochemical Methods

a. Isotope method
b. Inverse isotopic dilution

c. Neutron activation technique

Unit-4

Chromatographic Method:

a. **Gas Chromatography:** GLC and GSC

b. **HPLC**

Unit-5

Spectral Methods:

a. Nephelometry

b. Turbidimetry

c. Flame Photometry

Reference Books:

7. Fundamentals of Analytical Chemistry: D.A. Skoog, D.M. West and F.J. Holler, 1992, 6e
8. Quantitative Inorganic Analysis, A.I. Vogel, 2012, 7e
9. Instrumental Methods of Chemical Analysis: B.K. Sharma, 2011
10. Instrumental Methods of Chemical Analysis: H. Kaur, 2016, 12 e
11. Analytical Chemistry, Gary D. Christian, 2007, 6e
12. Instrumental Methods of Analysis: H.H. Willard, L.L. Merrit, Jr. J.A. Dean, 1974, 5e

Course Outcomes:

After studying this course the student will be able to,

CO 1. Understand the basic of this course and think & develop new ideas and concepts in analytical chemistry

CO 2. Know about electroanayltical, thermoanalytical, radiochemical, chromatographic and spectral techniques.

CHE 411F: Chemical Techniques

(4+0 Credits)

Unit I

Sampling methods and lab practices

Methods of sampling solids, liquids and gases, good lab practices, lab safety, waste disposal and managements, methods of storing chemicals, solvents and glassware.

Unit II

Introduction to basic non-instrumental laboratory techniques

Sample preparation, solution preparation, gravimetric analysis and volumetric techniques such as complexometric titration and types of EDTA titration.

Unit III

Introduction to basic instrumental laboratory techniques

Use and maintenance of analytical balance, potentiometer, pH meters, conductivity meters, mechanical stirrers, melting point apparatus, water heaters, water deionisers, magnetic stirrers and hot plates etc.

Unit IV

Fundamental aspects of various spectroscopy techniques

Introduction to UV-Visible, IR, NMR, EPR spectroscopies and Magnetic Measurements.

Unit V

Fundamental aspects of some analytical techniques

Basic principle, instrumentation and applications of Chromatographic methods, Atomic absorption spectroscopy and Flame photometry.

Reference Books:

1. Willard, H.H., Merritt, L.L., Dean, J.A., Instrumental methods of analysis, CBS Publishers and distributers, Shahdara, Delhi, 1986.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J., Smith, P.W.G. Vogel's practical organic chemistry, Pearson Education India, 1996.
3. Vogel, A.I., Elementary practical organic chemistry: Small scale preparations Part 1, Pearson Education India, 2010.
4. Silverstein, R. M., Webster, F.X., Spectrometric identification of organic compounds, John Wiley and Sons, 1997.

CHE-412F: Research Project

12 Credits

Under the research project, the student can conduct experiments, engage in review writing, perform lab work, or complete dissertation work related to the syllabus of a particular semester, all under the supervision of the assigned mentor.

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AECC 01F: ACADEMIC WRITING
(Semester I)

Unit 1
NTRODUCTION TO THE PROCESS OF WRITING

Significance of Vocabulary and language, Types and Tone of Writing - Descriptive,

Persuasive, analytical.

Purposes of writings - Academic communication, Review, Project Proposal

Unit 2

TOOLS OF WRITING

Understanding of the title, Gathering of materials - Summary,

Paraphrase and Notes - Paragraph formationand division - Structuring a write-up

Unit 3

WRITING ESSAYS

Forming essays - Addressing questions, addressing issues/topics, - using research
- other'swork, review, using quotes.

Unit 4

ETHICAL ASPECTS OF ACADEMIC WRITING

Style of writing Citation Style- types of citation styles - for books, book chapters andonline articles, Understanding of Plagiarism and how to avoid Plagiarism

Texbook(s):
1. L Lennie Irvin, What is Academic Writing,
2. John J Ruszkiewicz and Jay Dolmage, How to Write Anything,
3. Gordon Taylor, A Students' Writing Guide: How to Plan and Write Successful Essays,
4. John J Ruszkiewicz and Jay Dolmage, MLA & APA documentation and Format from How to Write Anything ,
5. F.M. Connel, A Textbook for the Study of Poetry, 2013

AECC 02F Personality Development and Leadership
(Semester II)

Unit I

Personality: Concept and Definition, Determinants of personality, Personality traits, Personality characteristics in organizations: Self-evaluation, Self-efficacy, Self-esteem, Self-monitoring: Positive and negative Impact. Organizational Context of Leadership and Personality.

Unit II

Leadership: Definition Importance of Leadership and Management, Leader vs Manager, Essential qualities of an effective leader

Unit III

Types of Leaders: Traditional, Transactional, Transformational, Inspirational and servant leadership, Issues in leadership: Emotional Intelligence and leadership, Trust as a factor, Gender and Leadership.

Unit IV

Theories of Leadership: Trait theory, Behavioral theories, Contingency theory .

Book Reference:

1. Organisational Behaviour ,M.Parikh and R.Gupta , TataMcGraw Hill Education Private Limited
2. Organisational Behavior, D. Nelson, J.C Quick and P. Khandelwal, Cengage Publication.

AECC 03F Industrial Waste Management
(Semester III)

Unit 1

Classification, sources and composition of solid, liquid and gaseous wastes, hazardous and non- hazardous wastes, special waste materials.

Unit 2

Storage and transport of and collection of industrial wastes.

Unit 3

Waste Minimization: Managements of waste, minimization, reuse and recycling, waste utilization and materials recovery.

Unit 4

Treatment of waste: Biological treatment, composting, anaerobic digestion, combustion, incineration and landfills, ultimate disposal.

Recommended Text Books

1. H. S. Peavy, D.R. Rowe and G. Techbanoglous, Environmental Engineering, Mcgraw Hill Books Co., 1985.
2. R. A. Corbitt, Started Handbook A Environmental Engineering; Mcgraw Hill New York, 1990.
3. A. M. Martin (ed), Bio-conservation of waste Materials to Industrial Products; Elsevier, Amsterdam, 1991.
4. O.P. Kharbanda and E. A. Stellworthy, Waste Management- towards a Sustainable Society, Gower, 1990.
5. E. Mortensen, Introduction to Solid Waste, Lecture Notes to Graduate Diploma in Environmental Engineering, University College, Ireland, 1990-1993.
6. K. L. Zirm, The Management of hazardous Substances in the environment, Applied Science, N.Y.
7. R. K. Somasekhar and Mariyengar(ED), Solid Waste Management- Current Status and Stratagies for Future, Allied Publishers, Mumbai2002.

AECC 04F Occupational Health Management
(Semester IV)

Unit I

Introduction, Classification of occupational health hazards, Storage and Handling of Hazardous Materials, First Aid & Emergency Procedure

Unit II Concept of personal protective equipments: types and uses, Threshold limit value, lethal dose and concentration,

Unit III

Approaches to prevent accident, Role of ILO: ILO Conventions & Recommendations.

Unit IV

Responsibilities of Government-Social organizations & Public Authorities, Risk Analysis & Risk Management

Recommended Text Books

1. Fundamentals of Industrial Hygiene by B.A. Plog & P. J. Quinlan
2. Handbook of Occupational Safety and Health by S. Z. Mansdorf.
3. Fundamentals of Occupational Safety and Health by J. Kohn & M. A. Friend

SECC 01F: Laboratory tools and techniques
Semester I

Unit: 1 Laboratory safety rules and Regulation

Addresses safety protocols, risk assessment, minimizing risks of hazards, chemical handling and storage, Equipment Safety and proper handling, Calibration of glasswares, hazard communication practices in chemical industries.

Unit: 2 Analytical techniques in Chemistry

Preparation of standard solutions in light of normality, molarity and molality, Theory and application of various analytical instruments commonly used in industry, such as chromatography and spectroscopy.

Unit: 3 Chemical Laboratory Management

Preparation of basic laboratory reagents such as Sodium hydroxide solution, neutral Ferric chloride solution, Ferrous sulphate solution, Iodine solution, Fehling solution, Nessler's reagent, Shiff's reagent etc. Principles of laboratory management including budgeting, equipment maintenance and personnel management, good laboratory practices.

Recommended books:

1. Vogels Text book of Quantitative Chemical Analysis, 5th edition
2. Vogels Text book of macro and semimicro qualitative inorganic analysis. G. Svela, 5th edition
3. Chemical reagent manual prepared by Chemistry department, SGTB Khalsa college under DBT's Star College Scheme, University of Delhi (Available online)

SECC 02F: Industrial Processes
Semester II

Unit: 1 Industrial Chemistry

Explore the application of chemistry in industrial processes including manufacturing and production. Visit of some industries and corporate offices situated near by Gorakhpur area.

Unit: 2 Process Chemistry/ Green Chemistry

Focus on optimisation and scale up of different chemical processes in industries, emphasizing on ideal process chemical route, its efficiency, greener way to synthesize compound with cost cutting processes.

Unit: 3 Quality control and Assurance

Principle and practices related to Quality control and Assurance in industries like pharmaceuticals, food and manufacturing. Food laws, food standardization and regulation agencies in India, national standards, international standards.

Recommended books:

1. E. Stocchi: Industrial Chemistry, Vol-1, Ellis Horwood Ltd. UK.
2. Sharma, B.K. & Gaur H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
3. Handbook of analysis and quality control for fruits and vegetable products, S. Ranhganna, Tata McGraw-Hill Education, 1986-Food.
4. Srilaxmi, Food Science, Edition: 3rd (2004). 7.Lillian Hoagland Meyer, Food Chemistry (2008).

SECC 03F: Environmental studies and Computer application
Semester III

Unit: 1 Environmental impact assessment

Examine the environmental impact of chemical processes, sources of industrial pollution, preventive actions of global warming and green house effects, radiation effects by the uses of cell phones and protection tips

Unit: 2 Instrumental analysis

Calibration, maintenance and troubleshooting of instruments used in industries, Qualitative and quantitative analysis of compounds, practical applications and advantages of various equipments used in chemistry practices and industries.

Unit: 3 Basic computational skill for chemist

Introduction and application of MS Word office, Chem draw, origin software, communication and internet basic of computer network, basic of electronic mail and document handling in E-mail.

Recommended books:

1. Environmental pollution, download. Nos.org/333courseE/10.pdf
2. Fundamental concepts of applied chemistry J.C. Ghosh, S. Chand and CO, LTD, New Delhi.

SYLLABUS

FOR THE

BACHELOR OF SCIENCE
(4 year)

IN

ZOOLOGY

FOUR YEAR FULL-TIME PROGRAMME

DEPARTMENT OF ZOOLOGY

FACULTY OF SCIENCE

DEEN DAYAL UPADHYAYA, GORAKHPUR UNIVERSITY,

GORAKHPUR-273009
2024

PROGRAME: B. Sc. 4 Year ZOOLOGY

Year	Semester	University Code	Paper Title	Theory/Practical	Course category	Credits	Semester Credit
1	I	ZOO-101F	Cytology, Genetics and Immunology	Theory	Compulsory	4+0	
		ZOO-102F	Cell Biology & Cytogenetics Lab	Practical	Compulsory	0+2	
	II	ZOO-103F	Biochemistry and Physiology	Theory	Compulsory	4+0	12
		ZOO-104F	Physiological, Biochemical & Hematology Lab	Practical	Compulsory	0+2	
2	**III**	ZOO-201F	Molecular Biology, Bioinstrumentation & Biotechniques	Theory	Compulsory	4+0	
		ZOO-202F	Bioinstrumentation & Molecular Biology Lab	Practical	Compulsory	0+2	
	IV	ZOO-203F	Gene Technology and Human Welfare	Theory	Compulsory	4+0	12
		ZOO-204F	Genetic Engineering Lab, Genetic Counselling& Telemedicine	Practical	Compulsory	0+2	
3	**V**	ZOO-301F	Diversity of Non-Chordates, Parasitological and Economic Zoology	Theory	Compulsory	4+0	
		ZOO-302F	Diversity of Chordates and Comparative Anatomy	Theory	Compulsory	4+0	
		ZOO-303F	Lab on Virtual Dissection, Anatomy, Economic Zoology and Parasitological	Practical	Compulsory	0+2	
	VI	ZOO-304F	Evolutionary Biology and Developmental Biology	Theory	Compulsory	4+0	20
		ZOO-305F	Ecology, Ethology, Environmental Science and Wildlife	Theory	Compulsory	4+0	
		ZOO-306F	Lab on Environmental Science, Behavioural Ecology, Developmental Biology, Wildlife, Ethology	Practical	Compulsory	0+2	
4	**VII**	ZOO-401F	Biology of invertebrates	Theory	Compulsory	4+0	
		ZOO-402F	Advances in modern scientific tools and techniques	Theory	Compulsory	4+0	
		ZOO-403F	Comparative Animal Physiology	Theory	Compulsory	4+0	20
		ZOO-404F	Biological Chemistry	Theory	Compulsory	4+0	
		ZOO-405 F	Practical based on ZOO-401F, ZOO-	Practical	Compulsory	0+4	

			402F, ZOO-403F & ZOO-404F				
	VIII	ZOO-406F	Biology of Chordates	Theory	Compulsory	4+0	20
		ZOO-407F	Systematics, Biodiversity and its conservation	Theory	Compulsory	4+0	
		ZOO-408F	Molecular genetics	Theory	Compulsory	4+0	
		ZOO-409F	Animal Development	Theory	Compulsory	4+0	
		ZOO-410F	Practical based on ZOO-406F**,**ZOO-407F, ZOO-408F & ZOO-409F	Practical	Compulsory	0+4	

CourseCode:ZOO-101F	**Semester: I**
CourseTitle:Cytology	
Credits:4+0	
Unit	**Topic**
I	**StructureandFunctionofCellOrganellesI** • Plasmamembrane:chemicalstructure—lipidsandproteins • Endomembrane system: protein targeting and sorting, endocytosis, exocytosis Introduction to all national Biologists (Zoologists) who have contributed/contributing to Zoological and Life Sciences as a mark of tributetoancientandmodernbiologywillbeincludedaspartofthe ContinuousInternalEvaluation(CIE)
II	**StructureandFunctionofCellOrganellesII** • Cytoskeleton:microtubules,microfilaments,intermediatefilaments • Mitochondria:Structure,oxidativephosphorylation • Peroxisomeandribosome:structureandfunction
III	**NucleusandChromatinStructure** • Structureandfunctionofnucleusin eukaryotes • ChemicalstructureandbasecompositionofDNAand RNA • DNAsupercoiling,chromatinorganization,structureofchromosomes • TypesofDNAandRNA
IV	**Cellcycle,CellDivisionandCell Signaling** • Celldivision:mitosisandmeiosis • Cellcycleanditsregulation,apoptosis,Signaltransduction:intracellular signalingandcellsurfacereceptorsviaG-proteinlinkedreceptors,JAK-STAT pathway
V	**MendelismandSex Determination** • Basicprinciplesofheredity:Mendel's laws,monohybridanddihybrid crosses • CompleteandIncompleteDominance, • Penetranceandexpressivity, • GenicSex-DeterminingSystems,EnvironmentalSexDetermination,SexDetermination in *Drosophila,* Sex Determination in Humans, • Sex-linkedcharacteristicsandDosagecompensation
VI	**ExtensionsofMendelism,GenesandEnvironment** • ExtensionsofMendelism:MultipleAlleles,Gene Interaction, • CytoplasmicInheritance,GeneticMaternal Effects, • GenomicImprinting,Anticipation, • Interaction Between Genes and Environment: Environmental Effects on Gene Expression, Inheritance of Continuous Characteristics
VII	**HumanChromosomesandPatternsof Inheritance** • Humankaryotype,Chromosomalanomalies:Structuralandnumerical aberrations with examples, • Pedigreeanalysis

VIII	**ImmuneSystemandits Components** • Historical perspective of Immunology, Innate and Adaptive Immunity, Structure and functions of different classes of immunoglobulins, Hypersensitivity, • Immune system: innate and adaptive immunity, clonal selection, complement system, • Humoralimmunityandcellmediatedimmunity, • Immunoglobulin and T-cell receptor genes: organization of Ig gene loci, molecular mechanism of generation of antibody diversity • HLAcomplex:organization,classIandIIHLAmolecules,expressionofHLA genes

CourseCode:**ZOO-102F**	**Semester: I**
CourseTitle:CellBiology&CytogeneticsLab	
Credits:0+2	

Unit	**Topic**
I	1. Tostudydifferentcelltypessuchasbuccalepithelialcells,neurons,striated muscle cells using Methylene blue. 2. TostudythedifferentstagesofMitosisinroottipof onion. 3. TostudythedifferentstagesofMeiosisingrasshoppertestis. 4. To prepare molecular models of nucleotides, amino acids, dipeptides using bead and stick method. 5. Tocheckthepermeabilityofcellsusingsaltsolutionofdifferent concentrations.
II	1. TostudydifferentmammalianbloodcelltypesusingLeishmanstain. 2. DeterminationofABOBloodgroup 3. Cellcountingandviabilitytestfromsplenocytesoffarmbredanimals/celllines. 4. Enumerationofredbloodcellsandwhitebloodcellsusinghaemocytometer
III	1. Studyofmutantphenotypesof*Drosophila.* 2. Preparationofpolytenechromosomes. 3. Studyofsexchromatin(Barrbodies)inbuccal smearandhairbudcells (Human). 4. Preparationofhumankaryotypeandstudythechromosomalaberrationswith respect to number, translocation, deletion etc. from the pictures provided. 5. Topreparefamilypedigrees.
IV	**VirtualLabs** 1. https://www.vlab.co.in 2. https://zoologysan.blogspot.com 3. www.vlab.iitb.ac.in/vlab 4. www.onlinelabs.in 5. www.powershow.com, 6. https://vlab.amrita.edu 7. https://sites.dartmouth.edu

Course Code:**ZOO-103F**	**Semester: II**
CourseTitle: Biochemistry and Physiology	
Credits:4+0	
Unit	**Topic**
I	**StructureandFunctionofBiomolecules** • StructureandBiologicalimportanceofcarbohydrates(Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates) • Lipids(saturated andunsaturated fatty acids,Tri-acylglycerols,Phospholipids, Glycolipids, Steroids) • Structure, Classification and General properties of α-amino acids; Essential and non-essential α-amino acids, • Levels of organization in proteins;Simple and conjugate proteins
II	**EnzymeActionand Regulation** • Nomenclature and classification of enzymes; Cofactors; Specificity of enzyme action; • Isozymes;Mechanismofenzyme action; • Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of Km and Vmax, Lineweaver-Burk plot; Enzyme inhibition; • Allostericenzymesandtheirkinetics;Regulationofenzyme action
III	**MetabolismofCarbohydratesandLipids** • Metabolism of Carbohydrates:glycolysis,citricacidcycle, gluconeogenesis, phosphate pentose pathway Glycogenolysis and Glycogenesis Lipids---Biosynthesisofpalmiticacid;Ketogenesis,β-oxidationandomega-oxidation of saturated fatty acids with even and odd number of carbon atoms
IV	**MetabolismofProteinsandNucleotides** • Catabolismofaminoacids:Transamination,Deamination,Ureacycle • Nucleotidesandvitamins • Reviewof mitochondrialrespiratorychain,Oxidativephosphorylation,and its regulation
V	**DigestionandRespiration** • Structuralorganizationandfunctionsofgastrointestinaltractandassociated glands • Mechanicalandchemicaldigestionoffood;Absorptionsofcarbohydrates, lipids,proteins,water,mineralsandvitamins; • Histologyoftracheaandlung, • Mechanism of respiration, Pulmonary ventilation;Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood,Respiratory pigments,Dissociationcurvesandthefactorsinfluencingit;Controlof respiration
VI	**Circulationand Excretion** • Componentsofbloodandtheirfunctions • Haemostasis:Bloodclottingsystem, • Bloodgroups: Rhfactor,ABOandMN • Structure of mammalian heart, Cardiac cycle; Cardiac output and its regulation, Electrocardiogram, Blood pressure and its regulation Structureofkidneyanditsfunctionalunit;Mechanismofurineformation
VII	**NervousSystemandEndocrinology** • Structureofneuron,restingmembrane potential • Originofactionpotentialanditspropagationacrossthemyelinatedand unmyelinated nerve fibers • Typesof synapse • Endocrineglands-pineal,pituitary,thyroid,parathyroid,pancreas,adrenal; hormones secreted by them

	• Classificationofhormones;MechanismofHormoneaction
VIII	**Muscular System** • Histologyofdifferenttypesof muscle, • Ultrastructureofskeletalmuscle; • Molecularandchemicalbasisofmusclecontraction; • Characteristicsofmuscletwitch;Motorunit,summationandtetanus

CourseCode:**ZOO-104F**	**Semester: II**
CourseTitle:Physiological,Biochemical&HematologyLab	
Credits:2+0	
Unit	**Topic**
I	1. EstimationofhaemoglobinusingSahli's haemoglobinometer 2. Preparationofhaeminandhaemochromogencrystals 3. Recordingofbloodpressureusingasphygmomanometer 4. Recordingofbloodglucoselevel byusing glucometer 5. Preparationofmolecularmodelsofaminoacids,dipeptidesetc.
II	1. StudyofpermanentslidesofMammalianskin,Cartilage,Bone, 2. Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid 3. Recordingofsimplemuscletwitchwithelectricalstimulation(or Virtual) 4. Demonstrationoftheunconditionedreflexaction(Deeptendonreflexsuchas knee jerk reflex)
III	1. Ninhydrintestfor-aminoacids. 2. Benedict'stestforreducingsugarandiodinetestfor starch. 3. Testforsugarandacetonein urine. 4. Qualitativetestsoffunctionalgroupsincarbohydrates,proteinsandlipids. 5. Paperchromatographyofaminoacids. 6. Actionofsalivaryamylaseunderoptimum conditions
IV	**VirtualLabs** 1. https://www.vlab.co.in 2. https://zoologysan.blogspot.com 3. www.vlab.iitb.ac.in/vlab 4. www.onlinelabs.in 5. www.powershow.com 6. https://vlab.amrita.edu 7. https://sites.dartmouth.edu

CourseCode:ZOO-201F	**Semester: III**
CourseTitle:MolecularBiologyandBioinstrumentation&Biotechniques	
Credits:4+0	
Unit	**Topic**
I	**Processof Transcription** • Finestructureof gene • RNApolymerases • Transcriptionfactorsandmachinery • Formationofinitiationcomplex • Initiation,elongationandterminationoftranscriptioninprokaryotesandeukaryotes
II	**Processof Translation** • TheGeneticcode • Ribosome • Factorsinvolvedintranslation • AminoacylationoftRNA,tRNA-identity,aminoacylTrnasynthetase • Initiation,elongationandterminationoftranslationinprokaryotesandeukaryotes
III	**RegulationofGeneExpressionI** • Regulationofgeneexpressioninprokaryotes:*lac*and*trp*operonsin*E.coli* • Regulationofgeneexpressionineukaryotes:Roleofchromatiningene expression • Regulationattranscriptionallevel,Post-transcriptionalmodifications:Capping, Splicing, Polyadenylation, RNA editing.
IV	**RegulationofGeneExpressionII** • Regulationofgeneexpressionineukaryotes: • Regulationattranslationallevel,Post-translationalmodifications:proteinfolding etc. • Intracellularproteindegradation • Genesilencing,RNAinterference(RNAi)
V	**PrincipleandTypesofMicroscopes** • PrincipleofMicroscopyandApplications • TypesofMicroscopes:lightmicroscopy,darkfieldmicroscopy,phase-contrast microscopy, • Fluorescencemicroscopy,confocalmicroscopy,electronmicroscopy
VI	**CentrifugationandChromatography** • Principleof Centrifugation: • TypesofCentrifuges: highspeedand ultracentrifuge • Typesofrotors:Vertical,Swing-out,Fixed-angle etc. • PrincipleandTypesofChromatography:paper,thinlayer,column---ion-exchange, gel filtration, HPLC, affinity
VII	**SpectrophotometryandBiochemicalTechniques** • Colorimetryandspectrophotometry:Beer-lambertlaw,absorptionspectrum • Biochemicaltechniques:MeasurementofpH, • Preparationofbuffersandsolutions • Measurement,applicationsandsafetymeasuresofradio-tracertechniques
VIII	**MolecularTechniques** • Nucleic acid fractionation, detection by electrophoresis, DNA sequencing, Polymerase Chain Reaction (PCR), primer designing, DNA fingerprinting, site directed mutagenesis, RFLP • Molecular cloning, genomic libraries, Gene transfer techniques: electroporation, microinjection • Detectionofproteins,PAGE,ELISA,Western blotting, • Hybridomatechnology

CourseCode:ZOO -202F	Semester: III
CourseTitle:Bioinstrumentation&MolecularBiologyLab	
Credits:0+2	

Unit	Topic
I	1. To study the working principle and Simple, Compound and Binocular microscopes. 2. To study the working principle of various lab equipments such as pH Meter, Electronic balance, vortex mixer, use of glass and micropipettes, Laminar flow, Incubator shaker, Waterbath, Centrifuge, Chromatography apparatus, etc.
II	1. Topreparesolutionsand buffers. 2. TolearntheworkingofColorimeterand Spectrophotometer. 3. Demonstration of differential centrifugation to fractionate different components in a mixture
III	1. Topreparedilutionsof Riboflavinandverifytheprincipleof spectrophotometer. 2. Toidentifydifferentaminoacidsinamixtureusingpaperchromatography. 3. DemonstrationofDNAextractionfrombloodortissuesamples. 4. To estimate amount ofDNAusingspectrophotometer.
IV	**VirtualLabs** 1. www.labinapp.com 2. www.uwlax.edu 3. www.labster.com 4. www.onlinelabs.in 5. www.powershow.in 6. https://vlab.amrita.edu 7. info@premiereducationaltechnologyies.com 8. https://li.wsu.edu

CourseCode:ZOO-203F	Semester: IV
CourseTitle:GeneTechnologyandHuman Welfare	
Credits:4+0	

Unit	Topic
I	**PrinciplesofGeneManipulation** • RecombinantDNATechnology • RestrictionEnzymes,DNAmodifyingenzymes,CloningVectors,Ligation • Genetransfertechniques,Genetherapy • Selectionandidentificationofrecombinantcells
II	**ApplicationsofGeneticEngineering** • Singlecell proteins, • Biosensors,Biochips, • Cropandlivestock,Improvement,Developmentoftransgenic organisms, • DevelopmentofDNAdrugsand, vaccines.
III	**Enzyme Technology** • Microbialculture, • Methodsofenzyme production, • Immobilizationofenzymes, • Applications
IV	**DNADiagnostics** • Geneticanalysisofhumandiseases,detectionofknownandunknownmutations • DNAfingerprinting • Conceptofpharmacogenomicsandpharmacogenetics • Personalizedmedicine—optimizingdrugtherapy
V	**BiostatisticsI** • Calculationsofmean,median,mode,variance,standard • Deviation, • Conceptsofcoefficientofvariation,Skewness,Kurtosis • Elementaryideaofprobabilityandapplication
VI	**BiostatisticsII** • Datasummarizing:frequencydistribution,graphical,presentation—bar,pie diagram, histogram, • Testsofsignificance:oneandtwosampletests,t-testandChi-squaretest
VII	**BasicsofComputers** • Basics(CPU,I/Ounits)andoperatingsystems, • ConceptofhomepagesandwebsitesWorldWideWeb,URLs,usingsearch engines
VIII	**Bioinformatics** • Databases:nucleicacids,genomes,proteinsequences,andstructures, Bibliography, • Sequenceanalysis(homology):pairwiseandmultiple,sequence alignments-BLAST,CLUSTALW, • Phylogeneticanalysis

CourseCode:ZOO-204F	**Semester: IV**
CourseTitle: GeneticEngineeringLab,GeneticCounseling& Telemedicine	
Credits:0+2	

Unit	**Topic**
I	1. Measurethepreandpostclitellarlengthsofearthwormsandcalculatemean, median, mode, standard deviation etc. 2. Measuretheheightandweightofallstudentsintheclassandapplystatistical measures.
II	1. Toperformbacterialcultureandcalculategenerationtimeof bacteria. 2. TostudyRestrictionenzymedigestionusingteaching kits. 3. TostudyPolymeraseChainReaction(PCR)usingteaching kits. 4. DemonstrationofagarosegelelectrophoresisfordetectionofDNA. 5. DemonstrationofPolyacrylamideGelElectrophoresis(PAGE)fordetectionof proteins. 6. Tocalculatemolecularweightofunknown DNAandproteinfragmentsfromgel pictures.
III	1. Tolearnthebasicsofcomputerapplications 2. TolearnsequenceanalysisusingBLAST 3. TolearnMultiplesequencealignmentusingCLUSTALW 4. TolearnaboutPhylogeneticanalysisusingtheprogrammePHYLIP. 5. TolearnhowtoperformPrimerdesigningforPCRusingavailablesoftwares etc.
IV	1. GelDocumentationSystemhttps://youtu.be/WPpt3-FanNE 2. Colorimeter-https://youtu.be/v4aK6G0bGuU 3. PCRPart1-https://youtu.be/CpGX1UFSl4A 4. PCRPart2-https://youtu.be/6IcHAYPTAEw 5. DNAisolationPart1-https://youtu.be/QE7Ul0JnY9A 6. DNAisolationpart2-https://youtu.be/-efr_HFeHxM 7. DNAcurve-https://youtu.be/ubL8QxTeuG4 8. Spectrophotometer-https://youtu.be/ubL8QxTeuG4 9. AgarosePart1-https://youtu.be/7gvHPFww--g 10. Agarosepart2-https://youtu.be/j_bOZCHNsSg

CourseCode:ZOO-301F	Semester: V
CourseTitle:DiversityofNon-Chordates,ParasitologyandEconomicZoology	
Credits:4+0	

Unit	Topic
I	**ProtozoatoCoelenterate** • Protozoa-*Euglena*,*Monocystis*and*Paramecium* • Porifera–*Sycon* • Coelenterata-*Obelia*and*Aurelia*
II	**Ctenophorato Nemathelminthes** • Ctenophora-Salientfeatures • Platyhelminthes - *Fasciola* (Liver fluke) and *Taenia* (Tape worm) Nemathelminthes - *Ancylostoma*(Hook worm)
III	**AnnelidatoArthropoda** • Annelida-*Nereis*and*Hirudinaria*(Leech) • Arthropoda-*Palaemon*(Prawn)and*Schistocerca*(Locust)
IV	**MolluscatoHemichordata** • Mollusca-*Lamellidens*(Freshwatermussel)and*Pila* • Echinodermata-*Pentaceros*(excludingdevelopment)
V	**Parasitology** • Structure, life cycle, pathogenicity, including diseases, causes symptoms and control of thefollowingparasitesofdomesticanimalsandhumans:*Trypanosoma*,*Giardiaand Wuchereria*
VI	**Vectorsandpests** • Lifecycleandtheircontroloffollowingpests:Gundhibug,Sugarcaneleafhopper, Rodents. Termites and Mosquitoes and their control.
VII	**EconomicZoology-1** • Animalbreedingandculture:Aquaculture,Pisciculture,Poultry
VIII	**EconomicZoology-2** • Sericulture,Apiculture,Lac-culture,Vermiculture

CourseCode:ZOO-302F	**Semester: V**
CourseTitle:DiversityofChordatesandComparativeAnatomy	
Credits:4+0	
Unit	**Topic**
I	**OriginofChordates&Hemichordata** • Origin of Chordates. • ClassificationofPhylumChordatauptotheOrder. • Hemichordata: General characteristics, classification and detailed study of *Balanoglossus* (Habit and Habitat, Morphology, Anatomy, Physiology and Development).
II	**CephalochordataandUrochordata** • Cephalochordata:Generalcharacteristics,classificationanddetailedstudyof *Branchiostoma*(*Amphioxus*) (Habit and Habitat, Morphology, Anatomy, Physiology). • Urochordata:Generalcharacteristics,classificationanddetailedstudyof *Herdmania*(HabitandHabitat,MorphologyAnatomy,PhysiologyandPost Embryonic Development).
III	**ClassificationandGeneralCharacteristicsofVertebrates** • GeneralcharactersandClassificationofdifferentclassesofPiscesandAmphibia up to the order with examples. • NeotenyandPaedogenesis
IV	**ClassificationandGeneralCharacteristicsofVertebrates** • GeneralcharactersandClassificationofdifferentclassesofReptilia,Avesand Mammalia up to the order with examples. • PoisonousandNonPoisonousSnakes,Bitingmechanismof snakes. • FlightAdaptationsinBirds • AdaptiveRadiationsin Eutheria
V	**IntegumentarySystem** • Structure,functionsandderivativesofintegument **SkeletalSystem** • Overviewofaxialandappendicularskeleton, JawsuspensoriumVisceral arches
VI	**DigestiveSystem** • Alimentarycanalandassociated glands **RespiratorySystem** • Skin,gills,lungsandairsacs;Accessoryrespiratoryorgans
VII	**CirculatorySystem** • Generalplanofcirculation,evolutionofheartandaortic arches **UrinogenitalSystem** • Successionofkidney,Evolutionofurinogenitalducts,Typesofmammalianuteri
VIII	**Nervous System** • ComparativeaccountofbrainAutonomicnervoussystem,Spinalcord,Cranial nerves in mammals **SenseOrgans** • ClassificationofreceptorsBriefaccountofvisualandauditoryreceptorsinman

CourseCode::ZOO-303F	**Semester: V**
CourseTitle: LabonVirtualDissection,Anatomy,EconomicZoologyandParasitology	
Credits:0+2	
Unit	**Topic**
I	1. Studyofanimalspecimensofvariousanimalphyla. 2. Topreparepermanentstainedslideofseptalnephridiaof earthworm. 3. Totakeoutthenerveringofearthworm Totakeouthastateplatefrom*Palaemon*
II	1. Studyofanimalspecimensofvariousanimal phyla 2. Studyonuseandethicalhandlingofmodelorganisms(Mice,rats,rabbit andpig). 3. Topreparestained/unstainedslideofplacoid scales 4. Comparativestudyofbonesofdifferentvertebrates 5. Comparativestudyofhistologicalslidesofdifferenttissuesofvertebrates.
III	1. PermanentPreparationof:*Euglena*,*Paramecium* 2. Study of prepared slides/ specimens of *Entamoeba Giardia, Leishmania, Trypanosoma,PlasmodiumFasciola,Cotugnia,Taenia,Rallietina,Polystoma Schistosoma, Echinococcus, Enterobius, Ascaris and Ancylostoma*; 3. Permanent Preparation of *Cimex* (bed bug)/ *Pediculus*(Louse), *Haematopinus*(cattlelouse),freshwaterannelids,arthropods;andsoilarthropods,Larvalstages of helminths and arthropods 4. Permanentmountofwings,mouthpartsanddevelopmentalstagesofmosquito and house fly 5. Permanentpreparationofticks/mites,abdominalgillsofaquatidinsectsviz. Chironomus larva, dragonfly and mayfly nymphs, preparation of antenna of housefly Identification of pests. 6. Lifehistoryofsilkworm,honeybeeandlacinsect 7. DifferenttypesofimportantediblefishesofIndia 8. Slidesofplantnematodes 9. Studyofanaquaticecosystem,itsbioticcomponentsandfoodchain 10. ProjectReport/modelchartmaking 11. **Dissections**:throughmultimedia/ models *12.* **Cockroach**:Centralnervous system *13.* ***Wallago***:AfferentandefferentbranchialvesselsCranialnerves,Weberian ossicles
IV	**VirtualLabs** 1. https://www.vlab.co.in 2. https://zoologysan.blogspot.com 3. www.vlab.iitb.ac.in/vlab 4. https://www.vlab.co.in 5. https://zoologysan.blogspot.com 6. www.vlab.iitb.ac.in/vlabwww.onlinelabs.in 7. www.powershow.comhttps://vlab.amrita.edu 8. https://sites.dartmouth.edu

CourseCode:ZOO-304F	Semester: VI
CourseTitle:EvolutionaryandDevelopmentalBiology	
Credits:4+0	

Unit	Topic
I	**Theoriesof Evolution** • Originof Life • Historicalreviewofevolutionaryconcept:Lamarckism,Darwinism(Natural, Sexual and Artifical selection) • Modernsynthetictheoryofevolution • Patternsofevolution(Divergence,ConvergenceParallel, Coevolution)
II	**PopulationGenetics** • MicroevolutionandMacroevolution:allelefrequencies,genotypefrequencies, • HardyWeinbergequilibriumandconditionsforitsmaintenance • Forcesofevolution:mutation,selection,geneticdrift
III	**DirectEvidencesof Evolution** • Typesoffossils,Incompletenessoffossilrecord, • Datingoffossils,Phylogenyofhorse
IV	**SpeciesConceptand Extinction** • Biologicalspeciesconcept(AdvantagesandLimitations); • Modesofspeciation(Allopatric,Sympatric) • Massextinction(Causes,Namesoffivemajorextinctions)
V	**GameteFertilizationandEarlyDevelopment** • Gametogenesis,Fertilization • Cleavagepattern • Gastrulation,fatemaps • Developmentalmechanicsofcellspecification • Morphogenesisandcelladhesion
VI	**DevelopmentalGenes** • Genesanddevelopment • Molecularbasisofdevelopment • Differentialgeneexpression
VII	**EarlyVertebrate Development** • Earlydevelopmentofvertebrates(fish,birds&mammals) • Metamorphosis,regenerationandstem cells • Environmentalregulationofdevelopment
VIII	**LateDevelopmentalProcesses** • Thedynamicsoforgandevelopment • Developmentofeye,kidney,limb • Metamorphosis:thehormonalreactivationofdevelopmentinamphibians,insects • Regeneration:salamanderlimbs,mammalianliver,Hydras • Aging:thebiologyof senescence

CourseCode:ZOO-305F	Semester: VI
CourseTitle:Ecology,Ethology,EnvironmentalBiologyandWildlife	
Credits:4+0	

Unit	Topic
I	**IntroductiontoEcology** • Historyofecology,AutecologyandsynecologyLevelsoforganization,Lawsoflimiting factors Study of physical factors
II	**Organizationof Ecosystem** • Levelsoforganization,LawsoflimitingfactorsStudyofphysicalfactors, • Population:Density,natality,mortality,lifetables,fecunditytables,survivorship curves, age ratio, sex ratio, dispersal and dispersion, Exponential and logistic growth, • Typesofecosystemswithoneexampleindetail,Foodchain:Detritusandgrazing food chains, , Food web, Energy flow through the ecosystem • EcologicalpyramidsandEcologicalefficiencies,Nutrientandbiogeochemical cycle with one example of Carbon cycle
III	**CommunityEcology** • Communitycharacteristics:speciesrichness,dominancediversity,abundance, Ecologicalsuccessionwithone example
IV	**EnvironmentalHazards** • SourcesofEnvironmentalhazards • Climate changes • Greenhousegasesandglobal warming • Acidrain,Ozonelayerdestruction
V	**EffectsofClimateChange** • Effectofclimatechangeonpublichealth • Sourcesofwaste,typesandcharacteristics Sewagedisposalandits management,Solidwastedisposal,Biomedicalwastehandlinganddisposal, • Nuclearwastehandlinganddisposal,Wastefromthermalpowerplants, • CasehistoriesonBhopalgastragedy,Chernobyldisaster,Sevesodisasterand Three Mile Island accident and their aftermath.
VI	**BehaviouralEcologyandChronobiology** • Originandhistoryof Ethology • Instinctvs.LearntBehaviour • Associativelearning,classicalandoperantconditioning,Habituation,Imprinting • Circadianrhythms;TidalrhythmsandLunarrhythms • Chronomedicine
VII	**IntroductiontoWildLife** • Valuesofwildlife-positive and negative; • Conservationethics; • Importanceofconservation; • Causesof depletion; • Worldconservationstrategies.
VIII	**Protectedareas** • Nationalparks&sanctuaries, • Communityreserve; • Importantfeaturesofprotectedareasin India; • Tigerconservation-TigerreservesinIndia; • ManagementchallengesinTigerreserve

CourseCode:ZOO-306F	Semester: VI
CourseTitle:LabonEcology,EnvironmentalScience,BehavioralEcology&wildlife	
Credits:0+2	

Unit	Topic
I	1. Studyoflifetablesandplottingofsurvivorshipcurvesofdifferenttypesfromthe hypothetical/real data provided. 2. Studyofpopulationdynamicsthroughnumericalproblems. 3. Studyofcircadianfunctionsinhumans(dailyeating,sleepandtemperature patterns).
II	1. ReportonavisittoNationalPark/BiodiversityPark/Wildlifesanctuary
III	1. Demonstrationof basicequipmentneededinwildlifestudiesuse,care and maintenance(Compass,Binoculars,Spottingscope,RangeFinders,Global Positioning System, Various types of Cameras and lenses) 2. Familiarization and study of animal evidences in the field; Identification of animalsthroughpugmarks,hoofmarks,scats,pelletgroups,nestantlersetc. 3. Demonstrationofdifferentfieldtechniquesforfloraand fauna
IV	**VirtualLabs** 1. https://www.vlab.co.in 2. https://zoologysan.blogspot.com 3. www.vlab.iitb.ac.in/vlab

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CourseCode:ZOO-401F	Semester: VII
CourseTitle:Biology of Invertebrates	
Credits: 4+0	

Unit	Topics
I	• Nutrition and reproduction in protozoa; • Origin of Metazoa; • Organization and Affinities of Porifera; • Polymorphism and Colony formation in Cnidaria; • Coral reefs.
II	• Life cycle patterns in Helminth parasites; • Ecology of soil Nematodes; • Segmental organs in Annelida; • Adaptive Radiation in Annelida.
III	• Organization and Affinities of Onychophora; • Larval forms in Crustacea; • Parasitism in molluscs, • Torsion its effect and significance in Gastropods.
IV	• Larval forms in Echinodermata; • Affinities of Echinodermata and Hemichordata; • Brief outlines of the structure and affinities of minor phyla with special reference to Ctenophore, Rotifera, Acanthocephala, Sipunculoidea and Echiuroidea

CourseCode:**ZOO-402F**	**Semester: VII**
CourseTitle:Advances in Modern Tools and Techniques	
Credits: 4+0	
Unit	**Topics**
I	Principles and uses of analytical Instruments: • Balances, • Flame Photometer, • Spectrophotometer, • Spectrofluro-photometer, • Atomic Absorption Spectrophotometer
II	Microbial technique: • Media preparation and Sterilization, • Inoculation and Growth Monitoring, • Use of microbes in Fermentation, • Microbial Assays.
III	Separation and Identification of Bio-molecules by Chromatography: • Paper and thin layer Chromatography, • Gel exclusion Chromatography, • High performance Liquid Chromatography (HPLC), • Affinity Chromatography.
IV	Electrophoresis techniques: • General principles, • Support media; • Electrophoresis of proteins and nucleic acid; • Capillary Electrophoresis, • Principles of Differential and Density centrifugation.

CourseCode:**ZOO-403F**	**Semester: VII**
CourseTitle:Comparative Animal Physiology	
Credits:4+0	
Unit	**Topics**
I	• Modes of nutrition, • Types of digestion and absorption of food; • Neurons, Neuroglial cells, irritability, axonal and synaptic transmission • Mechanism of conduction and transmission of nerve impulses; • Sodium-Potassium ATPase pump, ion channels; • Nernst equation, ionic basis of resting and spike potential, electrical potential • Types of synapse and neurotransmitters.
II	• Osmotic conformity and role of membranes in ionic regulation • Stenohaline, Euryhaline animals • Hypo and Hyper environment and terrestrial life • General characteristics of stimulus and response reaction • Chemoreceptors, • photoreceptors, • phonoreceptors, • mechanoreceptors, • equilibrium reception; • Respiration: Oxygen and Carbon dioxide transport, • factors affecting oxygen dissociation • Respiratory adaptation to low oxygen tension, • regulatory process in respiration.
III	• Thermoregulation in animals: • Temperature relationship in poikilotherms, homeotherms, endotherms and heterotherms, • Thermal acclimatization; • Circulation: Types of circulation, • Physiological categories of heart, conduction system, • Cardiac cycle, • Electrocardiogram; • Body fluids, blood coagulation; • Hematological abnormalities, • Effectors organs; • Types of muscles, its composition, mechanism of muscle contraction.
IV	• Pattern of nitrogen excretion in different animals • Types of excretory products, • Pattern of excretion, • Excretory devices in invertebrates and vertebrates; • Biosynthesis of urea and uric acids; • Comparative study of endocrines organs and their hormonal secretion in non-chordates and chordates

Semester: VII	**Semester: VII**
CourseTitle:Biological Chemistry	
Credits: 2+0	
Unit	**Topics**
I	• Chemical equilibrium, • Law of Mass action; • Elementary thermodynamic system; • Calculation of free energy change during biological Redox Reactions, • Acid base Reactions • Amphoteric, Zwitter ions.
II	• **Kinetics of enzyme of reaction**: 1. Kinetic of Enzyme– Catalyzed reactions, 2. Order of enzyme reaction, 3. Rate equations, 4. Two substrate reactions; 5. Temperature Coefficient, 6. Activation Energy; • Enzyme Inhibition, • Competitive and Noncompetitive inhibitors; • Applications of Enzyme Inhibition Techniques in pest control, • Allosteric Enzyme
III	• **Structure and function of**: 1. Vitamins 2. Coenzymes; • **Aerobic and anaerobic energy production from**: 1. Carbohydrates, (Glycolysis, HMP Shunt) 2. Energy production from lipids (Beta oxidation of fatty acids) 3. Catabolic breakdown of amino acids, (Deamination, and transamination of amino acids (Phenyl alanine, Tryptophan, Aspartate, Proline and Threonine)
IV	• **Biosynthesis of**: 1. Amino Acids (Phenylalanine, Tryptophan, Aspartate, Proline and Threonine), 2. Nucleotides, 3. Glycogen 4. Urea • Immobilized enzymes and their applications.

CourseCode:**ZOO-405F**	**Semester: VII**
CourseTitle:Practicals Based on ZOO-401F, ZOO-402F, ZOO-403F & ZOO-404F	
Credits:0+4	
Unit	**Topics**
I	• General characters and classification of the non- chordates phyla (Protozoa to Echinodermata) with the help of museum specimens and slides. • **Protozoa:** Vital staining and staining preparation of *Paramecium;* Study of cyclosis and trichocysts in *Paramecium;* Permanent preparation of *Ceratium, Noctiluca,Paramecium, Vorticella,* Study of prepared slides: *Balantidium, Nyctotherus, Opalina. Paramecium* conjugation/binary fission, *Entamoeba histolytica, Giardia, Trypanosoma, Leishmania, Trichomona.* • **Porifera:** Permanent preparation of gemmules, sponging fibres and different kinds of spicules, Study of museum specimen's specimens/models; *Lecuosolania, Sycon,Grantia, Euplectella, Hyalonema, Oscarella, Chondrilla, Chliona, Chalina, Spongilla, Spongia, Hippospongia.* • **Cnidaria and Ctenophora:** Study of nematocycsts of *Hydra,* Permanent preparation of*Hydra; Obelia and* other hydrozoan colonies and *Obelia* Medusa; Study of museum specimens/ models:*Tubularia, Bougainvillia, Pennaria, Hydractinia, Sertularia, Campanularia, Millepora, Stylaster, Physalia, Porpita, Valella, Aurelia, Rhizostoma, Tubipora, Alcyonium, Gorgonia, Corallium, Pennatula, Zoanthus, Metridium, Adamsia, Cerianthus, Fungia, Madrepora, Cestum.* • **Helminths:** Permanent preparation of selected soil and plant nematodes , cestode and trematode parasites of cattle and poultry , and different larval stages of liver fluke, Study of museum specimens/ whole mounts: *Convoluta, Dugesia, Bipalium, Fasciola , Paramphistomum, Schistosoma, Taenia, Moniezia , Echinococcus, Trichuris, Trichinella, Heterodera, Enterobius, Ascaris, Ancylostoma, Dracunculus, Wuchereria; study of prepared slides: Scolex of tape worm ,mature and gravid proglottid of tape worm; Study of cysticercus larva, hydatid cyst, larval stage of Fasciola .* • **Annelida:** Study of museum specimens*/models: Aphrodite, Tomopteris, Glycera, Chaetopterus, Arenicola, Sabella, Amphitrite, Serpula, Tubifex, Branchiobdella, Eisenia, Metaphire, Placobdella, Pontobdella, Branchellion, Polygordius,* Study of prepared slides*:* T.S. of body of leech passing through various places. • **Arthropoda:** Study of museum specimen: *Limulus, Palamnaeus, Lycosa, Apus, Argulus,Balanus, Sacculina, Mysis, Gmmarus, Squilla*, Prawn, Lobster, true crab, hermit crab, *Julus, Scolopendra, Scutigerella, Lepisma, Mantis,* stick insect, grass hopper, *termites ,Forficula, Pediculus, Ranatra, Dysdercus, Musca* ,Lady bird beetle, butterfly, wasp, *Xenopsylla,* life history of honey bee, lac insect and silk moth; Study of prepared slides: Mouth parts of mosquitoes, house fly, honey bee, butterfly , *Sarcoptes, Ixodes, Cimex, Daphnia, Cypris, Cyclops, Pediculus, Pthirus.* • **Mollusca:** Study of museum specimen/models:*Chiton, Dentaliun, Pila, Aplysia, Baccinum, Doris, Lymnaea, Mytilus, Patella, Pecten, Limax,* pearl oyster, *Teredo, Nautilus, Loligo, Sepia, Octopus.* Study of prepared slide: Radula, T.S of shell of *Unio,* T.S of gill lamina *of Unio,* T.S of body of *Unio* passing through middle region; Larvae of molluscs.

	• **Echinodermata:** Study of museums specimen/ models: *Astropecten, Asterias, Ophio*thrix, *Opiura, Echinus, Clypeaster, Echinocardium, Thyone, Holothuria, Antedon*; Study of prepared slides: Larvae of echinoderms: Aristotle's lantern. • **Hemichordate:** Study of museum specimens: *Balanoglossus, Cephalodiscus: Tornaria*larva, • **Minor phyla:** Representative specimens of Onychophora (*Peripatus*), Sipunculida*(Sipunculus*), Echiurida (*Bonelia)*
II	• Basic principles and Application of: 1. Microtome, 2. Spectro-photometer, 3. Flame photometer, 4. Atomic absorption, 5. Spectrofluorometer-photometer, 6. Paper and thin layer chromatography, 7. Centrifuge.
III	• Comparative study of total count of erythrocyte and leukocytes of fish bird, and rat. • Comparative study of different leukocyte count (DLC) of fish, bird and rat, • Colorimetric estimation of hemoglobin content of the blood, Color index and mean corpuscular hemoglobin in fish, bird and rat, • Determination of hematocrit in fish, bird and rat, • Determination of respiratory rate of rat in relations to size and sex; • Determination of respiration rate in fish at different temperatures.
IV	• Isolation and colorimetric determination of glycogen content of rat liver; • Demonstration of effect of epinephrine on the glycogen yield from the liver; • Estimation of nucleic acids in testis of rat. • Comparative estimation of the protein content and total lipid in fat body of cockroach, liver of fish and rat. • Quantitative estimation of total free amino acid in tissues of cockroach and paper chromatographic separation of these amino acids; • Kinetic essay of salivary amylase and to study the effects of time, temperature and pH on its activity; • Study of effect of substrate concentration on the activity of urease enzyme; • Inhibition of cholinesterase activity in the brain of rat organophosphate.

CourseCode:**ZOO-406F**	**Semester: VIII**
CourseTitle:Biology of Chordates	
Credits:4+0	
Unit	**Topics**
I	• Origin of chordates: • Characteristic of Ostractoderms (Cephalaspida, Anaspida, Pteraspida, Coelolepida) • Placodermi (Rhenanida, Acanthothoraci, Petalichthyida ,Arthrodira , Ptyctodontida, Phyllolepida, Antiarchi , Brindabellaspida); • Inter-relationship among Ostracoderms and Placodermis.
II	• General organization (external characters, endoskeleton alimentary canal, respiratory organ, blood vascular system, sense organs, urinogenital system) of Holocephali; • Affinities of Holocephali, Dipnoi and Crosspterygii; • Origin of paired fins in teleosts; • Origin of tetrapoda from Lung fishes, Bichirs and Crosspterygians.
III	• Rhynchocephalia, • Origin and Evolution of Reptiles (Seymouria, Cotylosaurs, Captorhinomorphs, *Diadetomorphs plesiosaurs* and Ichthyosaurs, Archosaurs, Saurischia, Bronotosaurs and Diplodocus, Ornithischia) • Origin and evolution of Birds (Jurassic birds, Cretaceous birds, Cenozoic birds); • Aerodynamics in Birds (modification in skeleton and musculature aspects ratio, take off, gliding and soaring flapping flight, slow and fast flight, perching mechanism, hovering; landing); • Origin and evolution of mammals; • Diagnostic characters of mammals and reptiles with mammalian features (Seymouriamorph, Captorhynomrph, Theromorphs) Cynognathus, • Conversion stage of reptiles in mammals; firstmammals, • Adaptive radiation in Eutheria.
IV	• Comparative study of heart in different classes of vertebrates, e.g. fish, amphibians' reptiles, birds and mammals; • Arterial and venous channel in different vertebrate group; • Comparative study of urinogenital system in different groups, e.g Amphibians, Reptiles, Birds and Mammals.

CourseCode:**ZOO-407F**	**Semester: VIII**
CourseTitle:Systematics, Biodiversity & its Conservation	
Credits:4+0	
Unit	**Topics**
I	• Definition and basics concept of biosystematics & Taxonomy: Historical resume of systematic and its importance and application in biology; • Trends in biosystematics: Concepts of different conventional and newer aspects– 1. Chemotaxonomy, 2. Cytotaxonomy, 3. Ethotaxonomy, 4. Molecular taxonomy, 5. DNA fingerprinting & Molecular markers for detection and evaluation of polymorphism, 6. RFLP, 7. RAPD, 8. Numerical taxonomy.
II	• Dimensions of Speciation and Taxonomic Characters: Types of lineage changes, • Production of additional lineage, • Species concepts and its categories, • Subspecies and infra-specific categories, • Theories of biological classification, • Hierarchy of categories, • Taxonomic and non- taxonomic characters.
III	• Procedure in taxonomy: 1. Collection, 2. Preservation, 3. Identification, 4. Different kinds of taxonomic keys, their merits and demerits, 5. Different kinds of Systematic publications, • Type of concept – different zoological types, • Zoological Nomenclature, • Formation of scientific names of various taxa, • International Code of Zoological Nomenclature (ICZN) –its operative principles, • Interpretation and Application of important rules
IV	• Lamarckian theories, Neo- Lamarkism, • Darwin's theory of natural selection: merits and demerits, • Darwinian and pre-darwinian concepts of evolution: Birth of concept of organic evolution; • Post–Darwinain concepts of evolution: Neo-darwinian concepts and sources of variation. • Gradualistic vs. non-gradualistic theories, • Mayr's Founder Principle, • Gould's punctuated equilibrium theory, • Kimura's neutral theory, • Neo–Darwinism'ssynthetic theory of evolution. • Isolation and speciation;

	• Genes in population; • Hardy-Weinberg Law, • Sewall Wright Effect, • Micro evolution, Macro evolution and Mega evolution, • Evolution in action

CourseCode:**ZOO-408F**	**Semester: VIII**
CourseTitle:Molecular Genetics	
Credits:4+0	
Unit	**Topics**
I	• Mendel's Law and their chromosomal basis; • Extension of Mendel's principles; • Allelic variations and gene function, • Incomplete dominance and co- dominance, • Gene mutation for allelism, • Gene action– from genotype to phenotype • Penetrance and Expressivity, • Gene interaction, • Epistasis Pleiotropy, • Interaction of gene.
II	• Chromosomes and gene, • Cytoplasmic inheritance, • Environment and Heredity, • Lethal genes; • sex–linked inheritance; • Pedigree Analysis, • Chromosomal Mapping, • Elements of Eugenics, • Imprinting of genes, • Gene Therapy
III	• Sex chromosome, • Sex determination, • Multiple allelism, • Numerical and Structural chromosome aberrations and their significance; • DNA replication, • Transposable elements in Prokaryotes and Eukaryotes, • Role of transposable elements in genetic regulation
IV	• Microbial Genetics: Bacterial transformation, transduction, conjugation, • Bacterial chromosome, • Bacteriophages, • Molecular CytogeneticTechniques (FISH, GISH, DNA Fingerprinting, Flow cytometry and Chromosome painting)

CourseCode:**ZOO-409F**	**Semester: VIII**
CourseTitle:Animal Embryology	
Credits:4+0	
Unit	**Topics**
I	• Basic concepts of Development Biology • Cellular Differentiation, • Signaling, • Role of genes in Embryonic Development of *Drosophila*, • Mutant screening in *Drosphila*, • Pattern Regulation in Insect- Imaginal Discs; • Development Pattern in Zebra fish; chicken and rat, • Determination of polarity and symmetry.
II	• Early Embryonic Development of Vertebrates and Invertebrates; • Gametogensis, • Structure of the gametes – the sperm and eggs, its types; • Function of Vitellogenins, Yolk and Egg membranes; • Hormonal control of ovulation; • Fertilization, mechanism and types, capacitation, acrosome formation, fertilizin and anti-fertilizin reactions, • Amphimixis, • Patterns and planes of cleavages in different types of animal eggs, • Role Yolk in egg organization, • Morulation and blastulation, • Types of blastulas.
III	• Fate maps and cell lineages; • Gastrulation; • Axis and germs layers; • Morphogenesis, morphogenetic movement; cell adhesion, • Neural tube formation, cell migration, tubulation, exogastrulation delamination, • Fate of germinal layers, • Notogenesis and mesogenesis; • Axis specification in Drosophila; • Anterior –Posterior and Dorsal –Ventral patterning • Role of maternal genes; • Growth and Differentiation its regulation at the level of chromosome;
IV	• Introduction and organizer concept; • Stem cell types and its biomedical application, • Tetraogensis, neoplasia, tumerogenesis, allometric growth, nucleocytoplasmic interaction, • Regulation of tissue regeneration and gradients in development system in Hydra and an amphibian, transplantation, • Ageing, theories and age-related changes at molecular level, biological ageing effect of various nutrients and hormones on ageing,cell death, • Transgenic animals: methods of formation, gene targeting, • Production and biomedical application of transgenic animals, mosaics, chimeras and knock out animals, • Metamorphosis in Insect and Amphibians.

CourseCode:**ZOO-410F**	**Semester: VIII**
CourseTitle:Practical based on ZOO-406F, ZOO-407F, ZOO-408F & ZOO-409F	
Credits:0+4	
Unit	**Topics**
I	• General character and Classification of chordate phyla. • **Urochordata:** Study of museum specimens/ whole*: Oikopleura, Herdmania, Ascidia, Pyrosoma, Doliolum, Salpa.* • **Cephalochordata:** Study of museum specimens/ models: Branchiostoma. • **Cyclostomata:** Study of museum specimens /models: *Petromyzon, Myxine; Ammocoete*larva. • **Pisces:** Study of museum specimens/ models: *Sphyrna (hammer – headed shark), Trygon, (string –rays), Pristis, Raja (skate), Torpedo (electric–rays), Chimaera, Polypterus, Acipener, Polydon, Amia, Lepidosteus, Hilsa, Harppodon, Notopterus, Labeo, Catla, Cyprinus, Cirrhina, Heteropneustes, Clarias, Wallago, Mystus, Anguilla, Exocoteus, Hippocampus, Channa, Amphipinous, Anabas, Synaptura, Echeneis, Neoceratodus, Protopterus, Lepidosiren;* Study of disarticulated bones of carp. • **Amphibia:** Study of museum specimen/models*: Ichthyophis, Uraeotyphlus, Cryptobrunchus, Ambystoma, Axolotl larva, Salamandra, Amphiuma, Triturus, Proteus, Necturus, Siren, Alytes, Bufo, Hyla, Rhacophorus,* Study of disarticulated bones of Frog.
II	• **Reptilia*:*** Study of museum specimen/models Chelone, *Kachua, Sphenodon, Hemidactylus, Calotes, Draco, Phrynosoma, Iguana, Heloderma, Varanus, Ophiosarus, Typhlops, Python, Natrix, Ptyas, Dendrophis, Bungarus, Naja, Russlle's viper, Pit viper, Hydrophis, Cerotalus, Crocodilus, Alligator, Gavialis, Ichthyosarus, Dimentron, Brontosarus, Tyranosarus, Stegosarus,* • Study of disarticulated bones of varanus • **Aves:** Study of museum specimens/*models: Arhaeopterys*, *Milvus* (Kite), *Gyps (*Vulture*), Pavo* (Peacock*), Columba* (Pigeon*), Eudynamys*(Koel*), Psittacula*(Parrot*), Bubo* (Owl), *Coracias* (Nilkanth*), Dinopium*(Woodpecker*), House sparrow, Corvus* (Crow). • Study of disarticulated bones of fowl. • **Mammals:** Study of museum specimens models: *Echidna, Ornithorhynchus, , Erinaceus, Shrew, Pteropus, Bat, Loris, Manis, Hystrix, Funambulus, Rattus, Oryctologus* or *Lepus, Herpestes, Lutra*, (otter), Civet cat, *Macaca*. • Study of disarticulated bones of rabbit, Skull of dog.
III	• Study of different stages of mitosis in onion root tip • Study of different stages of meiosis in testis of grasshopper or any other insect with the acetocarmine squash method, • Study of the salivary gland chromosomes of *Drosophila* and C*hironomus.*

IV	• Experiments on artificial ovulation, insemination • Study of the post embryonic stages of frog and insects, • Mounting of egg and embryos of snail, • Study of hormonal control of amphibian metamorphosis, • Incubation and mounting of chick embryos, • Study of prepared slides of the embryology of frog, chick and mammals & mammalian placenta, • Application of window techniques for in –situ study of chick embryo with special reference to morphogenetic movements, • Determination of the effect of temperature on the embryonic development of chick, • Study of the development of selected organs through preserved specimen and prepared slides, • Experiments on regeneration in Hydra, Earthworm and Lizard.

SKILL ENHANCEMENT COURSES (SEC)

Four years Zoology B Sc. honors course

List of Skill Enhancement Course (SEC) Course Credits: 3+0

S.No.	Course name	Semester	Course code	Credits	Lectures	Max marks
1	Vermiculture	I	SEC Z-1	3	3 lectures/week	100
2	Apiculture	II	SECZ -2	3	3 lectures/week	100
3	Sericulture	III	SEC Z-3	3	3 lectures/week	100

Objective of the AEC Courses

1. To provide basic conceptual understanding of skill enhancement.
2. To understand approaches of skill development.
3. Use skills and knowledge for self employability.

Course Code: SEC Z-1	**Semester: I**
CourseTitle:Vermiculture	**Total teachings hrs: 45**
Credits: 3+0	**Max Marks 100**

Unit	Topics
I	• Vermiculture: definition, meaning, history, biology of earthworms, and biology of earthworms' key to identify the species of earthworms. • Economic importance, values in maintenance of soil structure, role of four 'r's in recycling (reduce, reuse, recycle and restore). • Vermicomposting and vermiculture methods.
II	• Useful species of earthworms for vermicomposting, • Local and exotic species of earthworms, • Complementary activities of auto-evaluation; • Application and significance of vermicompost in agro-ecosystem, • Use of vermiwash as liquid bio-fertilizer.
III	• Role of earthworm in bio-transformation of the human waste, residues and bio-organic matter. • Use of humus and organic matter for production of fertilizer (product, qualities), ground population of earthworm.
IV	• Effect of combination of vermiwash with biopesticides on crop productivity, • Role of earthworms in improvement of soil fertility, • Benefits of Vermiculture,

	• Role of vermicomposting in generation of self-employment.

CourseCode: SECZ -2	**Semester: II**
CourseTitle:Apiculture	**Total teachings hrs: 45**
Credits: 3+0	**Max Marks 100**

Unit	**Topics**
I	• Introduction to Apiculture - scope, importance, history of beekeeping: Beekeeping in India, South East Asia and world. • Origin, systematics and distribution of honey bees, • honey bee morphology, anatomy and life cycle, • species of honey bee - indigenous, exotic. • Study of social behavior of honey bee: attack, bee dance, annual biological cycle of the bee colony • Identification of swarming tendency in a colony.
II	• Tools and equipment, • Basic requirements for beekeeping start up, • Honey bee keeping methods; Traditional and Modern bee keeping, urban or backyard beekeeping, migration and swarming of bees. • Role of Central Honey Bee Research & Training Institute BIS standard Tools used in apiculture,
III	• Honey - its composition, properties and medicinal use, • Honey extraction & handling - Quality control standards, • Processing of honey, packaging, storage, marketing • Role of apiculture in self-employment
IV	• Honeybee Enemies and Diseases [with the help of Photographs], • enemies: Mites, Wax Moths, Ants, Bee Eaters, Garden Lizards, and Bears. • Microbial diseases with special reference to Nosema, Sac brood Virus, Thai sac brood virus, American foul brood, and European foul brood diseases, • Prevention and control measures of the diseases.

Course Code: SECZ-3	**Semester: III**
CourseTitle:Sericulture	**Total teachings hrs: 45**
Credits: 3+0	**Max Marks 100**

Unit	Topics
I	• Origin and history of Sericulture, • Introduction of silk and silk worm, • Habitat, and life cycle of *Bombyx mori*, egg, larva, pupa and adult, host plants. • Morphology of mulberry plant, egg production, development biology of silkworm, rearing of larva and cocoon, equipment; disinfection and hygiene. • Biochemistry of silk, types of silk produced in India, fibroin structure, and; Importance of mulberry silk.
II	• Components of Sericulture, • Physical and commercial characteristics of cocoons; cocoon sorting, • Rearing operations: brushing, young and late-age silkworm rearing, molting, mounting, spinning, cocoon harvesting and marketing. • Cocoon Production and Silk Reeling Technology, • Sericulture Economics and Extension, • Diseases and pests of Mulberry plant, their preventive and control measures.
III	• Cocoon stifling Mulberry Physiology and Mulberry breeding and Genetics, • Cocoon Production and Silk Reeling Technology, • Post Cocoon Technology • Sericulture Organization & Management, • Role of state departments of Sericulture, Central Silk Board, Universities and NGOs in Sericulture development.
IV	• Mulberry and Silkworm Physiology, • Non - Mulberry Sericulture, • Sericulture Technology and Entrepreneurial Development, • Sericulture marketing. • Role of women in sericulture and employment generation.

Syllabus for

ABILITY ENHANCEMENT COURSES (AEC)

Four years Zoology B Sc. honors course

Objective of the AEC Courses

1. To provide basic conceptual understanding of ability enhancement. 2. To understand approaches of ability development 3. To build ability to prepare students for self employability

List of ability Enhancement Course (AEC) 2+0

S.No.	Course name	Semester	Course code	Credits	Lectures	Max marks
1	Biostatistics, bioinformatics and Computer applications	I	AECZ- 1	2	2 lectures/week	100
2	Disaster risk reduction and management	II	AECZ- 2	2	2 lectures/week	100
3	Animal ethics & model organisms	III	AECZ- 3	2	2 lectures/week	100
4	Aquaculture skills	IV	AECZ- 4	2	2 lectures/week	100

AECZ- 1: Ability enhancement course

Title: Biostatistics, Computer applications and Bioinformatics Credits 2 total teachings hrs 30 Max marks 100

Unit-I

Concepts of population and sample, need for sampling, census and sample surveys, mean, median, mode, standard error and standard deviation, kurtosis, graphical presentation of data, probability, sample size determination, Multinomial and binomial sampling distributions, confidence intervals, Poisson's, distribution, Chi-squared test, sample t-tests, variance and covariance, correlation and regression analysis

Unit-II

Introduction of Computers, classification of Computers, organization of Computer, Key boards, memory hierarchy, Primary Memory - memory unit, SRAM, DRAM, SDRAM, RDRAM, Flash memory. Secondary storage devices Magnetic Disk, Floppy Disk, Optical Disk, Magnetic Drum , Input Devices, Output Devices, applications of MS-office (MS-Word, MS-excel and Power point).

Unit III Introduction to bioinformatics and its relation with molecular biology. Examples of related tools (FASTA, BLAST, BLAT), databases (GENBANK, Pubmed, PDB) and software (RASMOL, Ligand Explorer), applications of bioinformatics.

Unit IV Biological Database and its Types, Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (primary, composite, and secondary). Specialized Genome databases: (SGD,

TIGR, and ACeDB). Structure databases (CATH, SCOP, and PDBsum), File Format (Genbank, DDBJ, FASTA, PDB, SwissProt), methods of sequence alignments

AECZ- 2**: Ability enhancement course**

Disaster risk reduction and management Credits 2 total teachings hrs 30 Max marks 100

Course Outcomes-

1. To build basic conceptual understanding of disasters.
2. To build ability to integrate knowledge and analyze, evaluate and manage the different aspects of disasters at local and global levels within limited available information.
3. To describe, analyze and evaluate the environmental, social, cultural, economic, legal and organizational aspects influencing vulnerabilities and capacities to face disasters.
4. To work theoretically and practically in the processes of disaster management (disaster risk reduction, response, and recovery) and relate their interconnections.

UNIT I
Fundamentals of Disaster Management
Concept of Disaster, Hazard, Vulnerability, Exposure, Capacity, Disaster Management Cycle: Preparedness, Response, Recovery and Mitigation, Disaster Risk Reduction (DRR), Institutional Framework in India.

UNIT II
Types of Disaster
Natural Disasters: Earthquake, Flood, Drought, Landslide, Land Subsidence, Cyclones, Volcanoes, Tsunami, Avalanches, Global Climate Extremes.
Anthropogenic Disasters: Nuclear Weapons and Spills, Chemical Weapons and Spills, War and Terrorism, Oil Spills, Forest Fires and Accidents (Transportation, Infrastructure Collapse).

UNIT III
Disaster Preparedness of Disasters
Dos and Do not's at individual or household levels (before, during and after a disaster) Communication, Coordination, Cooperation during the Emergencies, Community Based First Aid (CBFA), Community Based Disaster Management (CBDM), Importance of Mock Drills.

UNIT IV
Disaster Risk Assessment Techniques
Risk Identification, Application of Remote Sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS) in Disaster Management and Risk Assessment.

AECZ- 3: Ability enhancement course

Animal ethics and model organisms Credits 2 total teachings hrs 30 Max marks 100

Unit: I,

Animal ethics; experimental health and welfare issues, captivity and animal behavior, rights of animals, physiological and environmental stress.Feeding and breeding Strategies, use of animals in biomedical research according to CPCSEA/IAEC Regulatory Guidelines, animal ethics in laboratory experimental animals, Use of genetically modified animals in experimental research.

Unit II

Animal handling techniques, tools and techniques, physical and chemical restraint with special reference to euthanasia abiding ethics, basic principles of anesthesia, surgery and post surgical care.

Unit III

Use of animal models i.e. Zebra Fish, Drosophila, mice and rat models in biomedical research and drug development, safety evaluations, regulatory protocols (before clinical trials), Animal age profile, experimental age, dosage, toxicity, survival and death, Animal welfare Board of India– its role, functions and current status

Unit IV

Use of invertebrate models i.e. fruit fly and eukaryotic nematodes as alternate of vertebrate animals to study various diseases such as cancer. The use of computers in predicting the various biological and toxic effects of a chemical, to reduce the usage of animals, computer-aided drug designs, simulations for identifying the receptor binding site for the potential drug

AECZ- 4**: Ability enhancement course**

AECZ- 4**: Aquaculture skills Credits 2 total teachings hrs 30 Max marks 100**

Unit I

Commercially important finfish, freshwater fishes, exotic carps, ornamental fishes, of commercially important shellfish – crabs, prawns and shrimps. Identification of eggs and larval forms of cultivable finfish and shellfish, fish food organisms: collection and identification.

Unit II

Nutritional requirements of finfish and shellfish viz. carps, cat fishes, shrimp and prawn; major nutrients – carbohydrates, proteins and lipids and their importance, Natural food and live feed culture: methods of collection of live feed organisms; identification, isolation and maintenance of phytoplankton and zooplankton; mass culture of spirulina and azolla, culture of rotifers (Brachionus and Moina) and artemia.

Unit III

Hatchery design and Management: Criteria for site selection of hatchery and nursery. Design and operation of different types of hatchery systems- hatchery protocols, larval rearing stages, packaging and transport of seed. Breeding and culture of ornamental fish, aquarium design and fabrication.

Unit IV

Soil and water quality monitoring and management; Hatchery technology for Indian major carps and exotic carps and Catfishes, Induced breeding: Methods of natural and artificial fertilization

PROPOSED STRUCTURE OF SYLLABUS

Deen Dayal Upadhyaya Gorakhpur University

दीनदयाल उपाध्याय गोरखपुर विश्वविद्यालय

UG PROGRAMME -BOTANY

(FACULTY OF SCIENCE)

National Education Policy-2020

THREE PLUS ONE FRAMEWORK 2024

UG Syllabus Specimen Structure Table

FRAMEWORK OF THREE PLUS ONE UG PROGRAMME IN BOTANY MAJOR 2024

Year/ Semester	Subject 1 Major 1	Subject 2 Major 2	Subject 3 Minor	SEC Skill enhancement course/ vocational	AEC Ability Enhancement Courses/ CoCurricular	Research project /Dissertation/ /internship/Field work/ Survey	Total credits	Degree and credits
1st year/ I SEM	Botany 6 credits(4+2)	6	6	SEC – 1 (3 CREDITS)	AEC -1 (2 CREDITS)		23	Certificate in Faculty (46 Credits)
1st year/ II SEM	Botany 6 credits(4+2)	6	6	SEC – 2 (3 CREDITS)	AEC -2 (2 CREDITS)		23	
2nd year/ III SEM	Botany 6 credits(4+2)	6	6	SEC – 3 (3 CREDITS)	AEC -3 (2 CREDITS)		23	Diploma in Faculty (96 Credits)
2nd year/ IV SEM	Botany 6 credits(4+2)	6	6		AEC -4 (2 CREDITS)	Any one (3 credits)	23	
3rd year/ V SEM	Botany 10 c,2X4+2	10					20	UG Degree (132 Credits)
3rd year/ VI SEM	Botany 10 c,2X4+2	10					20	
4th year/ VII SEM	Botany 20 c,4X4+4						20	UG Honors (172 credits)
4th year/ VIII SEM	Botany 20 c,4X4+4						20	
OR	For Students who secured 75% Marks in First Six Semesters							
4th year/ VII SEM	Botany 20 c,4X4+4						20	UG Honors with Research (172 credits)
4th year/ VIII SEM	Botany 20c,2X4					Research Project (12 Credits)	20	

PROPOSED COURSE STRUCTURE FOR BOTANY (MAJOR)

SEMESTER-WISE TITLES OF THE PAPERS IN B.SC. (BOTANY)			
YEAR	**COURSE CODE**	**PAPER TITLE**	**CREDITS**
		CERTIFICATE COURSE	
FIRST YEAR		**Semester-I**	
	BOT 101F	Paper: Plant Biodiversity-I	4+0
	BOT 102F	Practical Sem I	0+2
		Semester-II	
	BOT 103F	Plant Biodiversity-II	4+0
	BOT 104F	Practical Sem II	0+2
		DIPLOMA COURSE	
SECOND YEAR		**Semester-III**	
	BOT 201F	Microbiology and Plant Pathology	4+0
	BOT 202F	Practical Sem III	0+2
		Semester-IV	
	BOT 203F	Plant Biochemistry	4+0
	BOT 204F	Practical Sem IV	0+2
		BACHELOR OF SCIENCE	
THIRD YEAR		**Semester-V**	
	BOT 301F	Cell Biology, Genetics and Molecular Biology	4+0
	BOT 302F	Plant Physiology	4+0
	BOT 303F	Practical Sem V	0+2
		Semester-VI	
	BOT 304F	Cytogenetics, Biostatistics, Plant Breeding	4+0
	BOT 305F	Ecology & Environment	4+0
	BOT 306F	Practical Sem VI	0+2
FOURTH YEAR		***BOTANY HONOURS COURSE***	
		Semester- VII	
	BOT 401F	Phytogeography and Plant Resorce Utilization	4+0
	BOT 402F	Ethnobotany and Pharmacognosy	4+0
	BOT 403F	Environment Management and Climate Change	4+0
	BOT 404F	Utilization and Management of Aquatic Algal Resources	4+0
	BOT 405F	Practical Sem VII	0+4
		Semester -VIII	
	BOT 406F	Biofertilizers and Biopesticides	4+0
	BOT 407F	Nursery and Gardening	4+0
	BOT 408F	Mushroom Cultivation	4+0
	BOT 409F	Landscaping Floriculture	4+0
	BOT 410F	Practical Sem VIII	0+4
	OR	***BOTANY HONOURS COURSE WITH RESEARCH*** **(For Students who secured 75% Marks in First Six Semesters)**	
		Semester- VII	
	BOT 401F	Phytogeography and Plant Resource Utilization	4+0
	BOT 402F	Ethnobotany and Pharmacognosy	4+0
	BOT 403F	Environment Management and Climate Change	4+0
	BOT 404F	Utilization and Management of Aquatic Algal Resources	4+0
	BOT 405F	Practical Sem VII	4+0
		Semester –VIII	
	BOT 411F	Bioinformatics and Computer Application	4+0
	BOT 412F	Genetic Engineering and Tissue Culture	4+0
	BOT 413F	Research Project	12

SUBJECT: BOTANY

Subject prerequisites:

1. To study Botany, a student must have had the subject Biology/Biotechnology learnt at 10+2 level.
2. Keen interest in plants and plant-related research, Potential in mathematics, biology and chemistry
3. Skills and aptitude for scientific study and research
4. Creativity and good comprehension while working on scientific procedures and research
5. Computer aptitude.

COURSE INTRODUCTION

The new curriculum of B.Sc. in Science (Botany) offers essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core, elective and vocational papers with significant inter-disciplinary components.

Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

B.Sc. Botany Programme covers academic activities within the classroom sessions along with practical concepts at laboratory sessions. Infield, outstation activities and projects are also required to be organized for real-life experience and learning.

Candidates who have curiosity in plants kingdom, ecosystem, love exploring exotic places and wish to work as researchers or professions like Botanist, Conservationist, Ecologist, etc. can choose B.Sc. Botany course.

Programme outcomes (POs):

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

PO 1	CBCS syllabus with a combination of general and specialized education shall introduce the concepts of breadth and depth in learning
PO2	Shall produce competent plant biologists who can employ and implement their gained knowledge in basic and applied aspects that will profoundly influence the prevailing paradigm of agriculture, industry, healthcare and environment to provide sustainable development.
PO 3	Will increase the ability of critical thinking, development of scientific attitude, handling of problems and generating solutions, improve practical skills, enhance communication skill, social interaction, increase awareness in judicious use of plant resources by recognizing the ethical value system.
PO 4	The training provided to the students will make them competent enough for doing jobs in Govt. and private sectors of academia, research and industry along with graduate preparation for national as well as international competitive examinations, especially UGC-CSIR NET, UPSC Civil Services Examination, IFS, NSC, FCI, BSI, FRI etc.
PO 5	Certificate and diploma courses are framed to generate self- entrepreneurship and self-employability, if multiexit option is opted.
PO 6	Lifelong learning be achieved by drawing attention to the vast world of knowledge of plants and their domestication.

Programme specific outcomes (PSOs):

B.Sc. I Year

This Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. It shall maintain a balance between the traditional botany and modern science for shifting it towards the frontier areas of plant sciences with applied approach. This syllabus has been drafted to enable the learners to prepare them for self-entrepreneurship and employment in various fields including academics as well as competitive exams. Students would gain wide knowledge in following aspects:

1. Diversity of lower plants and microbes, their habitat, morphology, architecture and reproduction.
2. Diversity of thallophytes, pteridophytes and Gymnosperm
3. Economic value of plants and their use in Human Welfare.

This course provides a broad understanding of identifying, growing and using plants.This course is primarily aimed to introduce people to the richness of plant diversity found in surrounding areas. Lecture sessions are designed to cover fundamental topics concerning classification of plants and their utilization required for understanding the flora and vegetation. Practical sessions are organized following theory for easy understanding of the various parts of the plants, structural organization of floral parts and diversity therein. Participants are taken to different locations covering a variety of habitats and forest types to acquaint them with the native flora. in the long run, will contribute towards building momentum for people's participation in environmental conservation without compromising on academic rigor and our rich wealth of knowledge inherited over generations.

1. The course will cover conventional topics in Field Botany like Evolutionary History & Diversity ofplants, Complete

Morphology, Nomenclature of plants, Systems of Classification, Keys toimportant Families of Flowering Plants, Field Data Collection & Herbarium Techniques.

2. The course is designed to become a commercial crop grower, florist, protected cultivator, greenbelt plant advisor to industries, pharmacologist & taxonomist.

Programme specific outcomes (PSOs):
B.Sc. II Year

This Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. It shall maintain a balance between the traditional botany and modern science for shifting it towards the frontier areas of plant sciences with applied approach. This syllabus has been drafted to enable the learners to prepare them for self-entrepreneurship and employment in various fields including academics as well as competitive exams. Students would gain wide knowledge in following aspects:

1. Diversity of plants and microbes, their habitat, morphology, architecture and reproduction.
2. Plant disease causing microbes, symptoms & control.
3. Different aspects of plants Biochemistry and diagnostic techniques

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

The learning outcomes of a three years graduation course are aligned with programme learning outcomes but these are specific to-specific courses offered in a program. The core courses shall be the backbone of this framework whereas discipline electives, generic electives and skill enhancement courses would add academic excellence in the subject together with a multi-dimensional and multidisciplinary approach.

1. Understanding of plant classification systematics, evolution, ecology, developmentalbiology, physiology, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms.
2. This course is suitable to produce expertise in conservation biology like ex-situ conservation, response to habitat change, genotype characterization and reproductive biology.
3.Understanding of various analytical techniques of plant sciences, use of plants asindustrial resources or as a human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.
4. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data**.**
5. Entrepreneurship Skill Development, Understand the issues of environmental contexts and sustainable development, Inculcation of human values,
6. Strengthen mathematical and computational skills. Enable students to use ICT&AI effectively.
7. Develop good skills in the laboratory such as observation and evaluation by the use of modern tools and technology.

Programme specific outcomes (PSOs):
B.Sc. IV Year / Botany Hons.

The learning outcomes of afour years graduation course are aligned with programme learning outcomes but these are specific to-specific courses offered in a program. The core courses shall be the backbone of this framework whereas applied courses of relevant thrust areas will enable the students to venture into new vocational areas. The core papers are applied in nature based on basic knowledge gained in earlier semesters. These include use of plants in medicines, in industries, as food, feed, drugs, nutraceuticals. It wil strengthen computational skills of the students as well as introduce them to bioinformatics with better understanding of data analysis in biological sciences. this course enables them to understand environment sustainable goals , environmental ethics and its role in various fields. The course will add additional knowledge towards lake management and a entrepreneurial green house management course.

Year: I	Semester: I	Code:**BOT10F**
Paper: Plant Biodiversity-I		
Theory : Core	Total Credit: 4+0	

Course outcomes:
After the completion of the course the students will be able to:
1. Develop understanding about the classification and diversity of different microbes including viruses, Algae, Fungi & Lichens & their economic importance.
2. Develop conceptual skill about identifying microbes,pathogens,biofertilizers & lichens
Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms

Unit	Topic	No. of Lectures
I	Algae: General characteristics, life cycle and classification, Range of thallus organization in algae, pigment diversity, reserve food materials. Economic importance of algae: role of algae in soil fertility, commercial products from algae–biofuel, phycocolloids and cosmetics.	
II	Reproduction, classification and life cycle of *Nostoc, Chlorella*, *Volvox, Oedogonium, Chara, Sargassum, Ectocarpus, Navicula* and *Polysiphonia.*	
III	Fungi: General characteristics, nutrition, life cycle, economic importance and classification of fungi upto class. Heterothallism, Physiological specialization, heterokaryosis and Parasexuality. Lichens.	
IV	Distinguishing characters of Myxomycota: General characters of Mastigomycotina, Zygomycota: *Rhizopus,* Ascomycota:*Saccharomyces, Penicillium, Peziza.*Basidiomycotina:*Puccinia, Agaricus;* Deuteromycotina:*Fusarium, Alternaria*.	
V	Bryophytes: General characteristics, adaptations to land habit, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of *Riccia*, *Marchantia*,*Anthoceros and Sphagnum*. (Developmental details not to be included). Economic importance of bryophytes.	
VI	Pteridophytes : General characteristics, Early land plants (*Rhynia*). Classification (up to family) with examples, Heterospory and seed habit, stelar evolution, economic importance of Pteridophytes.	
VII	Gymnosperms: Classification and distribution, Salient features of Cycadales, Ginkgoales, Coniferales and Gnetales, their examples, structure and reproduction; economic importance	
VIII	Palaeobotany: General account of Cycadofilicales, Bennettitales and Cordaitales; Geological time scale; Brief account of process of fossilization & types of fossils and study techniques; Contribution of Birbal Sahni.	

Year: I	Semester: I	Code:**BOT 102F**
Practicals	Credits; 0+2	

		No. of Lectures
	Algae: Type study of algae: Cyanophyceae –*Spirullina, Gloeotrichia, Nostoc. Oscillatoria.* Chlorophyceae - *Chlorella*, *Volvox, Oedogonium, Cladophora,*and *Chara.* Xanthophyceae – *Vaucheria.* Bacillariophyceae – *Navicula*, *Pinnularia.* Phaeophyceae – *Sargassum,* Rhodophyceae – *Polysiphonia.*	
	Fungi and Lichens: 1. Isolation of different fungi: Saprophytic, Coprophilous, Keratinophilic. 2. Identification of fungi by lactophenol cotton blue method. *Rhizopus, Saccharomyces, Penicillium, Peziza, Ustilago, Puccinia; Fusarium,Curvularia, Alternaria.* 3. *Agaricus*: Specimens of button stage and fullgrown mushroom; Sectioning of gills of *Agaricus*.. Lichens: crustose, foliose and fruticose specimens.	
	Bryophytes:*Marchantia*- morphology of thallus, W.M. rhizoids and scales, V.S. thallus through Gemma cup, W.M. gemmae (all temporary slides), V.S. antheridiophore, archegoniophore, L.S. sporophyte (all permanent slides). *Sphagnum*- morphology, W.M. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S. capsule and protonema.	
	Pteridophytes:*Lycopodium*: Habit, stem T. S. stobilus V. S.,*Selaginella*: Habit, rhizophore T. S, stem T . S, axis with strobilus, V.S. of strobilus, Megasporophyll and microsporophyll.*Equisetum* - Habit, rhizome and stem T.S. and V. S. of strobilus. *Marsilea* and *Azolla* – Habitat & its structure	
	Gymnosperms : 1. *Cycas* – seedling, coralloid root and coralloid root T. S., T. S. of leaflet and Rachis, micro and megasporophyll, male cone V. S., microsporophyll T. S. entire and V. S. of ovule.*Pinus* - Branch of indefinite growth, spur shoot, T. S of old stem and needle R.L.S and T. L. S. of stem, male and female cone, V.S. of male and female cone. 2. *Ephedra, Gnetum and Ginkgo* &*Thuja*: Habit, stem T. S (young and mature), leaf T. S, male and female strobilus, V. S. of male and female cone, ovule V. S. and seed.	
	Palaeobotany & Palynology 1. Morphology of *Rhynia* and fossils gymnosperms & other groups. 2. Visit Birbal Sahni Institute of Palaeosciences or virtual conference with their scientists to learn fossilization. 3. Mark and know about Indian geographical sites rich in plant fossils.	
	Commercial Uses and Production technology 1. *Azolla* production 2. Production technology of Resins 3. Production and propagation of Ornamental *Pteris*, Cycadales, Coniferales for landscaping. 4. Lab method for qualitative testing/ extraction of Ephedrine ,Taxol and *Thuj*a oil.	

Year: I	Semester: II	Code:**BOT103F**
Paper: Plant Biodiversity-II		
Theory Core		Credits: 4+0

Course outcomes:
After the completion of the course the students will be able to:

- Understand morphology, anatomy, reproduction and developmental changes therein through typological study and
- create a knowledge base in understanding the basis of plant diversity, economic values & taxonomy of plants Understand the details of external and internal structures of flowering plant
- To gain an understanding of the history and concepts underlying various approaches to plant taxonomy and classification.
- To learn the major patterns of diversity among plants, and the characters and types of data used to classify plants. To compare the different approaches to classification with regard to the analysis of data.
- To become familiar with major taxa and their identifying characteristics, and to develop in depth knowledge of the current taxonomy of a major plant family.
- To discover and use diverse taxonomic resources, reference materials, herbarium collections, publications.

Unit	Topic	No. of Lectures
I	Angiosperm Morphology(Stem, Roots, Leaves & Flowers, Inflorescence) Morphology and modifications of roots; stem, leaf and bud. Types of inflorescences; flowers, flower parts, fruits and types of placentation; Definition and types of seeds.	
II	Plant Anatomy: Meristematic and permanent tissues, Organs (root, stem and leaf). Apical meristems & theories on apical organization - Apical cell theory, Histogen theory, Tunica -Corpus theory. Secondary growth - Root and stem- cambium (structure and function) annular rings, Anomalous secondary growth - *Bignonia, Boerhaavia, Dracaena,Nyctanthes*	
III	Reproductive Botany: Plant Embryology, Structure of microsporangium, microsporogenesis, Structure of megasporangium and its types, megasporogenesis, Structure and types of female gametophyte, types of pollination, Methods of pollination, Germination of pollen grain, structure of male gametophyte, Fertilization, structure of dicot and monocot embryo, Endosperm, Double fertilization, Apomixis and polyembryony.	
IV	Palynology: Pollen structure, pollen morphology, pollen allergy, Applied Palynology: Basic concepts, Palaeopalynology, Aeropalynology, Forensic palynology, Role in taxonomic evidences.	
V	Taxonomic Resources & Nomenclature Components of taxonomy (identification, nomenclature, classification) ; Taxonomic resources: Herbarium- functions & important herbaria, Botanical gardens, Flora, Keys- single access and multi-access. Principles and rules of Botanical Nomenclature according to ICN (ranks and names; principle of priority, binomial system; type method, author citation, valid-publication).Types of classification:	

	Artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series) angiosperm phylogeny group (APG IV) classification.	
VI	Identification of Angiospermic families -I: A study of the following families with emphasis on the morphological peculiarities and economic importance of its members (based on Bentham & Hooker's system) Ranunculaceae, Papaveraceae, Malvaceae, Rutaceae, Fabaceae, Myrtaceae, Cucurbitaceae, Rubiaceae, Asteraceae, Apocynaceae, Acanthaceae, Asclepiadaceae, Solanaceae.	
VII	Identification of Angiospermic families -II: A study of the following families with emphasis on the morphological peculiarities and economic importance of its members (based on Bentham & Hooker's system)-Amaranthaceae, Euphorbiaceae, Apiaceae, Lamiaceae, Orchidaceae, Liliaceae, Musaceae, Poaceae.	
VIII	Modern trends in Plant taxonomy: Brief idea on Phenetics, Biometrics, Cladistics (Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy). TOOLS & SOFTWARES IN PLANT IDENTIFICATION: GIS (i) Patterns(ii) Features (iii) Quantities Digital Taxonomy (e-flora), Description Language for taxonomy – DELTA,internet directory for botany.	

Year: I	Semester: II	Code:**BOT104F**
Practicals	Credits: 0+2	

		No. of Lectures

Angiosperm Morphology

1. To study diversity in leaf shape, size and other foliar features.
2. To study monopodial and sympodial branching.
3. Morphology of Fruits
4. Inflorescence types- study from fresh/ preserved specimens
5. Flowers- study of different types from fresh/ preserved specimens
6. Fruits- study from different types from fresh/preserved specimens
7. Study of ovules (permanent slides/ specimens/photographs)- types (anatropous, orthotropous, amphitropous and campylotropous)
8. Modifications in Roots,stems, leaves and inflorescences

Plant Anatomy:

Normal & Anomalous secondary thickening - *Bignonia, Dracaena, Boerhaavia diffusa, Nyctanthes*

Study of primary and secondary growth in the root and stem of monocots and dicots by section cutting and permanent slides. Study of internal structure of dicot and monocot leaves. Study of structure of stomata.

Reproductive Botany

1. Structure of anther, microsporogenesis and pollen grains
2. Structure of ovule and embryo sac development (through slides).
3. Study of embryo development in monocots and dicots.
4. Vegetative propagation by means of cutting, budding and grafting exercises.
5. Study of seed germination.
6. Study of pollen morphology of the following plants –*Hibiscus, Vinca, Balsam, Ixora, Crotalaria, Bougainvillea* by microscopic observation.
   Calculation of pollen viability percentage using in vitro pollen germination techn

Herbarium: Plant collecting, Preservation and Documentation: Stepwise Practicing Herbarium techniques: (a) FIELD EQUIPMENTS, Global Positioning System (GPS) instrument & Collection of any wild 25 plant specimens(b)Learn to handle Herbarium making tools (c) Pressing and

Drying of collected plant specimens (d) Special treatments for all varied groups of plants (e) Mount on standard herbarium sheets (f) Label them using Standard method (g) Organize them and give Index Register Number
Taxonomic Identification using plant structure Classify 25 plants on the basis of Taxonomic description (Plant Morphology, Anatomy, Reproductive parts, Habit, adaptation anomalies) according to Bentham and Hooker natural system of classification in the following families: Malvaceae, Fabaceae (Papilionaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.
Identification during excursions: (a) Conducting Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus (list to be provided) and making FIELD NOTE BOOK and filling Sample of a page of field-book, used in Botanical Survey of India.
Botanical Nomenclature & reporting Method: (a) Give nomenclature to collected plants as per ICN rules and prepare labels as per BSI (b) Author Citation, Effective Publication and Principle of Priority: To show a specimen paper on Basic structure of a taxonomic Research published on a new species in taxonomic journal

Year: II	Semester: III	**Code: BOT 20F**
Paper: Microbiology and Plant Pathology		
Theory Core	Credits 4+0	

Course outcomes:
After the completion of the course the students will be able to:
1. Develop understanding about the classification and diversity of bacteria their economic importance.
2. Develop conceptual skill about identifying microbes,pathogens,
3. Gain knowledge about developing commercial enterprise of microbial products.
4. Learn host –pathogen relationship and disease management.
5. use of microbes in industries

Unit	Topic	No. of Lectures
I	Viruses: general characteristics, viral culture, Structure of viruses, Bacteriophages, Structure of T4 &, λ-phage; Lytic and Lysogenic cycles, viroid, Prions & mycoplasma& phytoplasma, Actinomycetes & plasmids and their economic uses.	
II	Bacteria: Cell structure of Eukaryotic and prokaryotic cells, Gram positive and Gram-negative bacteria, Structure of a bacteria; Bacterial Chemotaxis, Bacterial Growth curve, factors affecting growth of microbes; measurement of growth; Batch culture, Synchronous growth of microbes; Sporulation and recombination in bacteria.	
III	Food Microbiology: Food spoilage, food preservation, fermented foods, food borne pathogens, single cell protein (SCP)	
IV	Agricultural Microbiology: biofertilizers, biopesticides, biological nitrogen fixation by algae and bacteria and Plant Growth Promoting Rhizobacteria (PGPR), Mass production of bacterial biofertilizers, blue green algae, *Azolla* and *mycorrhiza*.	
V	Industrial Microbiology: Production of antibiotics, enzymes, alcoholic beverages and organic acids.	
VI	Water Microbiology: Microbiology of water, water born diseases, water purification, waste water and sewage disposal, bioremediation	
VII	Plant Pathology Disease concept, Symptoms, Etiology & causal complex, Primary and secondary inoculums, Infection, Pathogenicity and pathogenesis, Koch's Postulates. Mechanism of infection, Disease cycle (monocyclic, polycyclic and polyetic). Phytoimmunology (plant defense mechanism)	
VIII	Diseases and Control Symptoms, Causal organism, Disease cycle and Control measures of –Late Blight of Potato, False Smut of Rice/ Brown spot of rice and	

	'White rust of Crucifers, Red Rot of Sugarcane, Wilting of Arhar, Mosaic diseases on tobacco and cucumber, yellow vein mosaic of bhindi; Citrus Canker, Little leaf of brinjal; Damping off of seedlings, Disease management: Quarantine, Chemical, Biological, Integrated pest disease management, fungicides- Bordeaux mixture, Lime Sulphur, Tobacco decoction, Neem cake & oil.	

Year: II	Semester: III	Code:**BOT202F**
Practicals	Credits 0+2	

		No. of Lectures
	Microbiology • Isolation of bacteria. • Identification of bacteria. • Staining techniques: Gram's, Negative, Endospore, Capsule and Cell Wall. • Cultural characteristics of bacteria on NA. • Pure culture techniques (Types of streaking). • Biochemical characterization:IMViC, Carbohydrate fermentation test, Mannitol motility test, Gelatin liquefaction test, Urease test, Nitrate reduction test, Catalase test, Oxidase test. • Isolation of nitrogen fixing bacteria from root nodules of legumes. • Enumeration of rhizosphere to non rhizosphere population of bacteria. • Isolation of antagonistic Pseudomonas from soil. • Microscopic observations of root colonization by VAM fungi. • Isolation of Azospirillum sp. from the roots of grasses. • Isolation of phyllosphere microflora. • Isolation of P solubilizing microorganisms. • Wine production. • Isolation of lactic acid bacteria from curd. • Isolation of lipolytic organisms from butter or cheese. • Immobilized bacterial cells for production of hydrolytic enzymes. • Enzyme production and assay – cellulase, protease and amylase. • Immobilization of yeast. • Isolation of cellulolytic and anaerobic sulphate reducing bacteria. • Isolation and characterization of acidophilic, alkalophilic and halophilic bacteria. • Cultivation of Spirulina, & Chlorella in lab for biofuel. • Visit to NBAIM, Mau, Varanasi(Kashi)/ IMTECH (Institute of Microbial Technology),Chandigarh for viewing Culture Repository. • Visit to biofertilizers and biopesticides unit to understand about the Unit operation procedures. • Alcohol production. from Sugarcane Juice.	
	Plant Pathology • Preparation of fungal media (PDA) &Sterilization process. • Isolation of pathogen from diseased leaf.	

	Identification: Pathological specimens of Brown spot of rice, Bacterial blight of rice, Loose smut of wheat, Stem rot of mustard, Late blight of potato; Slides of uredial, telial, pycnial& aecial stages of *Puccinia*,Few viral and bacterial plant diseases.

Year: II	Semester: IV	**Code: BOT 203F**
Paper: Plant Biochemistry		
Theory core	Credits: 4+0	

Course outcomes:
After the completion of the course the students will be able to:
1. different aspects of Biochemistry
2. Learn basic biomolecules, structure, physiological functions
3. Assimilate Knowledge about Biochemical constitution of plant diversity.
4.learn about secondary metabolites and various biochemical techniques

Unit	Topic	No. of Lectures
I	Carbohydrates: Nomenclature and classification; Role of monosaccharides (glucose, fructose, sugar alcohols – mannitol); Disaccharides (sucrose, lactose), Oligosaccharides and polysaccharides (structural-cellulose, hemicelluloses, pectin,; storage – starch, inulin).	
II	Lipids: Storage lipids, fatty acids- structure and functions, Structural lipids (Membrane lipids): Phosphoglycerides, Shingolipids, sterols.	
III	Proteins: Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quaternary; Isoelectric point; Protein denaturation and biological roles of proteins.	
IV	Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleic acids,Nucleic acid denaturation and re-naturation.	
V	Enzymes: Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; mechanism of action (activation energy, lock and key hypothesis, induced- fit theory),	
VI	Enzyme inhibition- irreversible and reversible inhibition (competitive, non-competitive, and uncompetitive inhibition), factors affecting enzyme activity, Allosteric enzymes, and cooperativity effect in allosteric proteins.	
VII	Secondary Metabolites: Structure and functions of terpenes, phenolics and alkaloids. Industrial utilization of secondary metabolites.	
VIII	Biochemical techniques: different types of chromatographic techniques, based on ion exchange and affinity, electrophoresis, isoelectric focusing, MALDI-TOF, Western blot, SDS-PAGE,centrifugation, spectrophotometry and protein sequencing.	

Year: II	Semester: IV	**Code: BOT 204F**
Practicals	Credits :0+2	

		No. of Lectures
	Techniques for biochemical analysis 1. Weighing and Preparation of solutions -percentage, molar & normal solutions, dilution from stock solution etc. 2. Separation of amino acids by paper chromatography. 3. Detection of organic acids: citric, tartaric, oxalic and malic from laboratory samples., 4. Qualitative Analysis of carbohydrates, 5. Estimation of reducing sugar by anthrone method, 6. Qualitative Analysis of Lipids 7. Qualitative analysis of Amino acids and Proteins 8. Quantitative Analysis of Nucleic Acids, 9. Analysis of dietary supplements, nutraceuticals & antioxidants, Testing of adulterants in food items. • A basic idea of chromatography: Principle, paper chromatography and column chromatography; demonstration of column chromatography.	

Year: III	Semester: V	**Code: BOT 301F**
Paper-I: Cell Biology, Genetics and Molecular Biology		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:
1. various aspects of cell and cellular organization, chromosomes
2. concepts of mendel principles of genetics and inheritance
2. Understand nucleic acids, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
3. Know about Processing and modification of RNA and translation process, function and regulation of expression.

Unit	Topic	No. of Lectures
I	Cell biology Structure and function of cell wall, plasma membrane, ribosomes, Endoplasmic reticulum, golgi apparatus, mitochondria, chloroplast, lysosomes, peroxisomes and cell inclusions - Organization of nucleus: nuclear envelope, nucleoplasm and nucleolus.	
II	Chromosomal nomenclature- chromatids, centromere, telomere, satellite, secondary constriction.Organization of chromosomes- Nucleic acid and histones- types and classification.	
III	Lampbrush chromosomes and polytene chromosomes- Karyotype and idiogram.Cell cycle: G0, G1, S and G2 phases – mitosis, amitosis and meiosis. Cyclin-dependent protein kinases (only brief introduction)	
IV	Genetics Mendel's principles of genetics, chromosome theory of inheritance, crossing over and linkage; Incomplete dominance and codominance; Interaction of genes; Extra-nuclear Inheritance, Sex chromosomes and Sex determination in plants.	
V	Molecular Biology Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase, bacteriophage experiment, DNA structure, types of DNA, types of genetic material.	
VI	DNA replication in prokaryotes and eukaryotes, Ø (theta) mode of replication, replication of linear, dsDNA, replicating the 5´end of linear chromosome including replication enzymes.	
VII	Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation, (Prokaryotes and eukaryotes), genetic code. Regulation of gene expression in Prokaryotes: *lac* operon; and in eukaryotes.	

VIII	Blotting techniques: Northern and Southern blotting, DNA fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR.	

Year: III	Semester: V	**Code: BOT 302F**
Paper-II: Plant Physiology		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:

1. various plant physiological processes
2. Plant nutrition and deficiency, translocation
3. Respiration and photosynthesis in plants
4. Plant hormones and and sensory phobiology

Unit	Topic	No. of Lectures
I	Plant water relation: Structure and properties of water, diffusion and osmosis, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.	
II	Mineral Nutrition: Criteria of essentiality of elements; Role of essential elements; Symptoms of mineral deficiency in major crops, Transport of ions across cell membrane, active and passive transport. Nitrogen assimilation.	
III	Translocation in phloem:, Composition of phloem sap, girdling experiment; Pressure flow model, apoplastic and symplastic phloem loading and unloading.	
IV	Photosynthesis: Pigments involved in photosynthesis, action spectra and enhancement effect, Photosystems, Electron transport chain in chloroplast and Photophosphorylation, C3 & C4 photosynthesis, CAM- Plants.	
V	Respiration: Glycolysis, Krebs cycle, fate of pyruvate- aerobic and anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of Krebs cycle, mitochondrial electron transport system, oxidative phosphorylation, ATP-Synthetase, chemiosmotic mechanism, P/O ratio, cyanide-resistant respiration, factors affecting respiration.	
VI	Lipid Metabolism: Synthesis and breakdown of triglycerides, oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilization of lipids during seed germination, β-oxidation.	
VII	Phytohormones and Seed Physiology: Developmental roles of phytohormones- (auxins, gibberellins, cytokinins, ABA, ethylene.), Seed physiology & Dormancy, Vernalization.	

VIII	Sensory Photobiology: Photoperiodism (SDP, LDP, day neutral plants); Phytochrome (discovery and structure), red and far red-light responses on photomorphogenesis.	

Year: III	Semester: V	**Code: BOT 303F**
Practicals	Credits: 0+2	
		No. of Lectures

Cell biology

1. Study of plant cell structure with the help of epidermal peal mount of Onion/Rhoeo/Crinum.
2. Measurement of cell size by the technique of micrometry.
3. Counting cells per unit volume with the help of haemocytometer (Yeast/pollen grains).

Determination of mitotic index and frequency of different mitotic stages in pre-fixed root tips of Allium cepa.

Genetics

1. Monohybrid cross (Dominance and incomplete dominance)
2. Dihybrid cross (Dominance and incomplete dominance)
3. Gene interactions (All types of gene interactions mentioned in the syllabus)
    a. Recessive epistasis 9: 3: 1.
    b. Dominant epistasis 12: 3: I
    c. Complementary genes 9: 7
    d. Duplicate genes with cumulative effect 9: 6: 1
    e. Inhibitory genes 13: 3

- Observe the genetic variations among inter and intra specific plants.

Demonstration of Breeding techniques-Hybridization, case studies of mutation, polyploidy, emasculation experiment.

Genetic material

1. Instruments and equipments used in molecular biology.
2. Preparation of LB medium and cultivating E.coli on it.
3. Isolation of Genomic DNA
4. Isolation of DNA from plants
5. Examination of the purity of DNA by agarose gel electrophoresis.
6. Quantification of DNA by UV-spectrophotometer
7. Estimation of DNA by diphenylamine method.

Plant water relation, Mineral Nutrition and translocation in phloem

1. Determination of osmotic potential of plant cell sap by plasmolytic method using leaves of Rhoeo / Tradescantia.
2. Osmosis – by potato osmoscope experiment
3. Effect of temperature on absorption of water by storage tissue and determination of Q10.
4. Experiment to demonstrate the transpiration phenomenon with the bell jar method
5. Experiment for demonstration of Transpiration by Four-Leaf Experiment:
6. Structure of stomata (dicot & monocot)
7. Determination of rate of transpiration using cobalt chloride method.
8. Experiment to measure the rate of transpiration by using Farmer's Potometer
9. Experiment to measure the rate of transpiration by using Ganong's potometer
10. Effect of Temperature on membrane permeability by colorimetric method.

Study of mineral deficiency symptoms using plant material/photographs.

Photo Synthesis & Respiration

- Separation of plastidial pigments by solvent and paper chromatography.

- Estimation of total chlorophyll content from different chronologically aged leaves (young, mature and senescence) by Arnon method.
- Effect of HCO_3 concentration on oxygen evolution during photosynthesis in an aquatic plant and to find out the optimum and toxic concentration (either by volume measurement or bubble counting).
- Measurement of oxygen uptake by respiring tissue (per g/hr.)
- Determination of the RQ of germinating seeds.

Effect of light intensity on oxygen evolution in photosynthesis using Wilmott' bubble

Plant Development, Movements, Dormancy & Responses

1. Geotropism and phototropism — Klinostàt
2. Hydrotropism
    a. Measurement of growth — Arc and Liver Auxonometer
3. To study the phenomenon of seed germination (effect of light).
4. To study the induction of amylase activity in germinating grains.
5. Test of seed viability by TTC method.

Year: III	Semester: VI	**Code: BOT304F**

Paper-I: Cytogenetics, Biostatistics, Plant Breeding

Theory core	Credits:4+0

Course Outcome:

After the completion of the course the students will be able to:

1. Cytogenetics in Plant sciences,
2. Plant breeding and its role in crop improvement
3. Basics of Biostatistics and its use data analysis

Unit	Topic	No. of Lectures
I	Cytogenetics Variation in Chromosome number (Numerical aberrations)- anueploidy and Euploidy-haploidy, polyploidy- significance (Structural aberrations) - deletion, duplication, inversion and translocation.	
II	Methods of creating various ploidy levels, ways to use euploid and aneuploids. Examples of polyploid crops.	
III	Plant Breeding Incompatibility, male sterility, hybridization- inter generic, inter specific, and inter varietal hybridization with examples, emasculation, bagging, pollination.	
IV	Selection - mass selection, pure line selection and clonal selection. Genetic basis of selection methods, Introductory concepts of -Breeding for pest, pathogenic diseases and stress resistance.	
V	Composite and synthetic varieties, Heterosis and its exploitation in plant breeding, types of heterosis, basis of heterosis.	
VI	Mutation breeding, physical and chemical mutagens, mutagenic treatment, procedure of mutation breeding. Realeased mutant varieties.	
VII	Biostatistics: Definition, statistical methods, basic principles, variables-measurements, functions, limitations and uses of statistics. Biometry: Data, Sample, Population,random sampling.	
VIII	Frequency distribution- definition only, Central tendency– Arithmetic Mean, Mode and Median; Measurement of	

	dispersion–Coefficient of variation, Standard Deviation, Standard error of Mean; Test of significance: chi- square test for goodness of fit.	

Year: III	Semester: VI	**Code: BOT 305F**
Paper-II: Ecology and Environment		
Theory core	Credits: 4+0	

Course outcomes:

1. acquaint the students with complex interrelationship between organisms and environment;
2. make them understand methods for studying vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.
3. This knowledge is critical in evolving strategies for sustainable natural resource management and biodiversity conservation

Unit	Topic	No. of Lectures
I	Ecology and Ecosystems Definition of Ecology, Ecological Factors, Positive and negative interactions. Ecosystem-Concept of an ecosystem-structure and function of an ecosystem. Abiotic and biotic components,	
II	Types of ecosystems: terrestrial and aquatic acosystems- forest ecosystem, grasslands, deserts,freshwater and marine ecosystems, agroecosystems. Population and community ecology (brief introduction).	
III	Food chains and food webs, ecological pyramids, productivity of different ecosystems, primary productivity (gross and net primary productivity), secondary productivity, flow of energy in an ecosystem.	
IV	Ecological Adaptations– Hydrophytes, Xerophytes, Halophytes, Epiphytes. Ecological Succession-definition and types. Processes (autogenic,allogenic,autotrophic,heterotrophic,primary & secondary), Hydrosere and Xerosere.	
V	Soil Formation, Properties & Conservation Soil: Origin, Formation, composition, Soil types, Soil Profile, Soil Microorganisms, soil processes, Soil Erosion, Biogeochemical cycles of carbon, water, Soil Conservation: Biological– Contour farming, Mulching, Strip cropping, Terracing and Soil reclamation.	

VI	Biodiversity and its Conservation: Definition -genetic, species and ecosystem diversity.Value of biodiversity:hotspots of biodiversity threats to biodiversity. Endemic and endangered species of plants in India.	
VII	Species extinction: local extinction, ecological extinction, biological extinction (natural extinction, mass extinction, major extinction, man-made or sixth extinction), extinction vortex.	
VIII	*Ex-situ* and *in-situ* conservation, IUCN status categories of species, Red data book, Role of Seed Bank and Gene Bank, valuing plant resources,ecotourism, Role of BSI.	

Year: III	Semester: VI	**Code: BOT 306F**
Practicals	Credits: 0+2	
		No. of Lectures
	Biostatistics: • Univariate analysis of statistical data: Statistical tables, mean, mode, median, standard deviation and standard error (using seedling population / leaflet size). • Calculation of correlation coefficient values and finding out the probability. 3.Determination of goodness of fit in Mendellian and modified mono-and dihybrid ratios (3:1, 1:1, 9:3:3:1, 1:1:1:1, 9:7, 13:3, 15:1) by Chi-square analysis and comment on the nature of inheritance. • Computer application in biostatistics - MS Excel and SPSS	
	Ecology &Environment 1. Ecological Adaptations: Hydrophytes, Xerophytes, Halophytes, Epiphytes and Parasites 2. Study of morphological adaptations of hydrophytes and xerophytes (four each). 3. Study of biotic interactions of: Stem parasite (Cuscuta), Root parasite (Orobanche) Epiphytes, Predation (Insectivorous plants). 4. Observation and study of different ecosystems mentioned in the syllabus. Field visit to familiarize students with ecology of different sites	
	Soil Formation, Properties & Conservation 1. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper) 2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.	

	3. Determination of organic matter of different soil samples by Walkley & Black rapid titration method. 4. Soil Profile study 5. Soil types of India-Map	
	Biodiversity • Study of community structure by quadrat method and determination of (i) Minimal size of the quadrat, (ii) Frequency, density and abundance of components (to be done during excursion/field visit).	

Year: IV	Semester: VII	**Code: BOT 401F**
Paper-I: Phytogeography and Plant Resorce Utilization		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:
- Basic concepts of plant distribution, phytogeopgraphy
- Use of plants as food, medicine, commercial products

Unit	Topic	No. of Lectures
I	Introductory concepts of biogeographic regions of India and world, Agroecological and floristic zones of India. Natural vegetation of India, static and dynamic plant geography,	
II	Basic principles governing geographical distribution of plants, Vegetational types in Uttar Pradesh. Centers of diversity of plants, origin of crop plants.Concept of sustainable development.	
III	Study of the plants with Botanical names, Family, part used, and economic uses yielding Edible & essential oils; Sugar, Starch; Fibers; Paper, Fumitories & Masticatories, Rubber,Dyes, Timber,biofuel crops.	
IV	Major cereal crops, millets, major vegetable crops, plantation crops, spices	

Year: IV	Semester: VII	**Code:BOT 402F**
Paper-II: Ethnobotany and Pharmacognosy		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:

1. Ethnobotany and its use in human welfare
2. Ethnobotanical aspect of conservation and management of plant resources
3. Preparation of drugs and commercialization

Unit	Topic	No. of Lectures
I	Methodologies of ethnobotanical research: field work, literature, herbaria and musea and other aspects of ethnobotany. Importance of ethnobotany in Indian systems of medicine (Siddha, Ayurveda and Unani).	
II	Study of common plants used by tribes. Ethnobotanical aspect of conservation and management of plant resources, Preservation of primeval forests in the form of sacred groves of individual species and Botanical uses depicted in our epics. Plants in primary health care*:* common medicinal plants.	
III	Preparation of drugs for commercial market - Organoleptic evaluation of drugs, Microscopic evaluation of drugs-, Physical evaluation of drugs. Sources of crude drugs– roots, rhizome, bulb, corm, leaves, stems, flowers, fruits and seeds.	
IV	Collection of wild herbs, Hydrotherapy or Herbal bath - Herbal oils - Liquid extracts or Tincture - Poultices - Salves - Slippery elm slurry and gruel - Suppositories - Teas. Glycosides and Flavonoids and therapeutic applications. Anthocyanins and Coumarins and therapeutic applications, Volatile oils and and Alkaloids and pharmacological activities.	

Year: III	Semester: VII	**Code: BOT 403F**

Paper-III: Environment Management and Climate Change

Theory core	Credits: 4+0

Course Outcome:
After the completion of the course the students will be able to:

- Sustainable development of natural resources
- Environmental audit & Sustainability
- Pollution,Waste management, environmental ethics

Unit	Topic	No. of Lectures
I	Natural resources & Sustainable utilization: Land Utilization, Soil degradation and management strategies; Restoration of degraded lands. Wetlands; Threats and management strategies, Ramsar sites, Forests: Major and minor forest products; Biological Invasion, Energy: Renewable and non-renewable sources of energy, contemporary practices in resource management.	
II	Environmental audit & Sustainability Introductory concepts of environmental audit; Guidelines of environmental audit; Concept of energy and green audit, Concept of Sustainable Agriculture; India's environment action programme: issues, approaches and initiatives towards Sustainability; Sustainable development in practice.	
III	Pollution,Waste management & Circular Economy Environmental pollution, Environmental protection laws, Bioremediation, Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor, digesters, fixed film reactors, bioscrubbers, biotrickling filters; case study: Ganga Action Plan; implementation of CNG;Waste- Types,	

	collection and disposal, Recycling of solid wastes (hazardous & non-hazardous) - classification, collection and segregation, Incineration, Pyrolysis and gasification, Sanitary landfilling ; composting, Biogas production.	
IV	Environmental ethics, Carbon Credits & Role of GIS Introduction to Carbon credit: concept, exchange of carbon credits. Carbon sequestration, importance, meaning and ways. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Applications and case studies of remote sensing and GIS in land use planning, forest resources & agriculture studies.	

Year: IV	Semester: VII	**Code: BOT 404F**
Paper-IV: Utilization and Management of Algal Resources		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:

- Students would be able to utilize and management of aquatic algal resources.
- Bioprospection of algal resources.
- UnderstandAlgal culturing process.

Unit	Topic	No. of Lectures
I	An overview of algal resources, ecological services by algae, role of algae in fisheries, aquaculture of algae-batch and mass cultivation, selection of culture medium, isolation and maintenance of algal cultures, water quality for algal culture.	
II	Bio-prospecting of algal resources for value added compounds/products, single cell protein, pharmaceuticals and nutraceuticals, biofuels, food and feed, algal compounds in cosmetics, bioremediation through algae, algae as bioi-indicator of pollution.	
III	Value addition through food chain, utilization of algae in aquaculture, impact of habitat degradation on algal resources, wastewater utilization for algal cultivation.	
IV	Application of algal density in identifying potential fishing zones, role of algae in global warming mitigation. Exotic algal species, algal blooms, algal toxins and fisheries. Control of algal bloom.	

Year: IV	Semester: VII	**Code: BOT 405F**
Practicals	Credits: 0+4	

	Phytogeography: • Marking of vegetation types of India, World & Uttar Pradesh on maps • Phytogeographical areas of India
	Economic Botany &Microtechnique: • Cereals: Wheat (habit sketch, L.S./T.S. of grain, starch grains, micro-

	chemical tests); rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests) • Legume: Pea or ground nut (habit, fruit, seed structure, micro-chemical tests) • Source of sugars and starches: Sugarcane (habit sketch; cane juice- micro-chemical tests); potato (habit sketch, tuber morphology, T.S. of tuber to show localization of starch grains, W.M. of starch) grains, micro-chemical tests. • Tea- tea leaves, tests for tannin • Mustard- plant specimen, seeds, tests for fat in crushed seeds • Timbers: section of young stem. • Jute- specimen, transverse section of stem, tests for lignin on T.S. of stem and study of fiber following maceration technique. Study of specimens of economic importance mentioned in Unit I-& II
	Cultivating Medicinal and aromatic plants & Essential oil extraction Lemon grass/ Neem/ Zinger /Rose/Mint
	Ethnobotany • Study of common plants used by tribes. *Aegle marmelos, Ficus religiosa, Cynodon dactylon.* • Visit a tribal area and collect information on their traditional method of treatment using crude drugs. • Familiarize with at least 5 folk medicines and study the cultivation, extraction and its medicinal application. • Observe the plants of ethnobotanical importance in your area. Visit to an Ayurveda college or Ayurvedic Research Institute / Hospital
	Instrumentation and herbal Preparations • Develop Capsules of herbs/ Develop Herbal oils/ Develop Poultice/cream Analyse some active ingredients using chromatography /Spectrophotometry
	Phytochemistry: • Determination of the percentage of foreign leaf in a drug composed of a mixture of leaves. • Dimensions of Calcium oxalate crystals in powdered crude drug. • Preliminary phytochemical tests for alkaloids, terpenoids, glycosides, volatile oils, tannins & resins. Any 5 herbal preparations.
	Pollution &Waste management • Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter • Estimation of chloride and dissolved oxygen content in water sample • Comparative anatomical studies of leaves form polluted and less polluted areas. • Measurement of dissolved O2 by azide modification of Winkler's method. • Determination of dissolved oxygen of water samples from polluted and unpolluted sources. • Microbiological assessment of drinking water using MPN technique- water from well, river, water supply department and packaged drinking water • Making kitchen waste from compost/vermicompost by Enzymes/Bio decomposer/ Whey with dung. Climate Change, Carbon Credits & Role of GIS • Conducting Waste Audit of your Institution -Demo • 2. Green auditing of the College/University –Demo

	• Water testing in green house • Types of substrates used in greenhouse • Study of local fresh water body for hydrophytic biodiversity Water analysis of local fresh water bodies
	Algal Resources: Identification and documentation of algae from freshwater habitats (local), techniques for algal cultivation and maintenance of pure cultures, Spirulina and Chlorella Cultivation, extraction of pigments from algae (carotenoids and phycocyanin), heavy metal removal by algae.

Year: IV	Semester: VIII	**Code: BOT 406F**
Paper-I: Biofertilizer and Biopesticides		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:

- Know about biofertilizers and thei application in crop fields.
- Know about practical application of PGPR (plant growth promoting rhizobacteria).

Unit	Topic	No. of Lectures
I	General account of microbes used as biofertilizers-PGPR, nitrogen fixing bacteria, algae and mycorrhizae.	
II	Isolation of PGPR and mass multiplication, *Azospirillum Azotobacter*-classification and characteristics, crop response to *Azotobacter* inoculums etc. Cyanobacteria, Azolla and *Anabaena azollae* association, biological nitrogen fixation, Azolla in rice cultivation.	
III	Mycorrhizal association, types of mycorrhizal association, phosphorus nutrition, Biocompost making methods from agricultural and industrial wates, types and methods of vermicomposting.	
IV	Biopesticides: basic concepts, bacterial and fungal biopesticides, botanical pesticides and their application.	

Year: IV	Semester: VIII	**Code: BOT 407F**
Paper-II: Nursery and Gardening		
Theory core	Credits: 4+0	
Course Outcome:		

After the completion of the course the students will be able to:

- Understand scope of Nursery and gardening
- Know about vegetative propagation

Unit	Topic	No. of Lectures
I	Scope and objectives of nursery, infrastructure for nursery. Planning and seasonal activities. Planting-direct seeding and transplants.	
II	Structure and types of seeds, seed dormancy-causes and methods of breaking dormancy, seed storage.	
III	Vegetative propagation-cutting, selection of cutting, treatment of cutting. Rooting medium and planting of cuttings. Hardening of plants-green house, mist chamber, shade house and glass house.	
IV	Gardening-objectives and scope, different types of gardening-landscape and home gardening, parks and its components-plant materials and design. Gardening operations-soil laying, manuring, watering, management of pests and diseases and harvesting.	

Year: IV	Semester: VIII	**Code: BOT 408F**
Paper-III: Mushroom Cultivation		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:

- Basics of mushroom cultivation.
- Cultivation of Button, Oyster and Straw Mushrooms.

Unit	Topic	No. of Lectures
I	Cultivation system, farm design, Compost and composting-fundamentals of cultivation system, principles of mushroom farm layout-location of building plot, design of farm, bulk chamber, composting platform, equipments and facilities.	
II	Machinery required for compost making, materials for compost preparation. Methods of composting-long method of composting and short method of composting.	
III	Spawn and Spawning-Facilities required for spawn preparation, preparation of spawn substrate, preparation of pure culture, media used in raising pure culture, storage of spawn.	
IV	Cultivation of Button, Oyster and Straw Mushrooms-collection of raw materials, compost and composting, spawn and spawning, cropping and crop management, picking and packing. Nutrient Profile of Mushroom-protein, amino acids, calorific values, carbohydrates, fats, vitamins and minerals.	

Year: IV	Semester: VIII	**Code: BOT 409F**
Paper-IV: Landscaping Floriculture		
Theory core	Credits: 4+0	

Course Outcome:
After the completion of the course the students will be able to:

- Understand basic concept of floriculture.
- Initiate commercial floriculture- a start-up.

Unit	Topic	No. of Lectures
I	Ornamental plants-flowering annuals, herbaceous perennials, divine vines, shade and ornamental trees, ornamental bulbous and foliage plants, cacti and succulents, palms and cycads, ferns and selaginellas. Cultivation of plants in pots, indoor gardening and bonsai.	
II	Principles of garden design-English, Italian, French, Persian, Mughal and Japanese gardens, features of garden (garden wall, fencing, steps, hedge, edging, lawn, flower, beds, shrubbery, borders, water garden), some famous gardens of India.	
III	Landscaping places of public importance-landscaping highways and educational institutions.	
IV	Commercial floriculture- factors affecting flower production, production and packaging of cut flowers(Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold, Rose, Lilium and Orchids). Diseases and pests of ornamental plants.	

Year: IV	Semester: VIII	**Code: BOT 410F**
Practicals	CREDIT 0+4	
	• Collection of biofertilizers, field application of biofertilizers. • Isolation and inoculums productionof VAM. • Cultivation of different vegetables. • Field visit of green houses, parks and glass houses. • Visit to relevant Labs and field visit (involved in mushroom cultivation). • Visit to Nurseries and cultivation of different plants in pots.	No. of Lectures

Year: IV	Semester: VII	**Code: BOT 411F**
Paper-IV: Bioinformatics and Computer Application		
Theory core	Credits: 4+0	

Course Outcome:

After the completion of the course the students will be able to:

- Learn fundamentals of computer application and Bioinformatics
- Learn about biological databases and their use
- Learn about phylogentic analysis and its importance

Unit	Topic:	No. of Lectures
I	Computer fundamentals: MS Office: PPT, Microsoft Excel, data entry, graphs, aggregate functions, formulas and functions, number systems, conversion devices, secondary storage media. GPS tagging, Plant Identification Apps, programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, and computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	
II	Biological databases : Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem,)	
III	Data Generation and Data Retrieval : Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez).	

IV	Phylogenetic analysis : Introductory concepts of -Similarity, identity and homology, Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Phylogenetic analysis: Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees.	

Year: IV	Semester: VII	**Code: BOT 412F**

Paper-III: Genetic Engineering and Plant Tissue Culture

Theory core	Credits: 4+0

Course Outcome:
After the completion of the course the students will be able to:

- Process of gene cloning
- Use of recombinant technology in crop improvement
- Plant morphogenesis
- Basics of plant tissue culture

Unit	Topic	No. of Lectures
I	Gene cloning- cutting and joining of DNA molecules- restriction endonucleases, DNA ligase, cloning vectors (plasmids, cosmids, bacteriophage, YAC and BAC), , gene libraries	
II	Gene transfer methods, marker genes-reporter genes, selectable markers, Transgenic in crop improvement-pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice)	
III	Cytodifferentiation, organogenic differentiation, types of culture-seed culture, embryo culture, organ culture, callus culture Cell culture, cell suspension cultures,,Micropropagation, *in vitro* production of haploids.	
IV	Protoplast isolation, somatic hybridization, somaclonal variation-basis of somaclonal variation, plant secondary metabolites production, cryopreservation.	

Year: IV	Semester: VIII	**Code: BOT 413F**

Research Project	CREDIT 12

	According to relevant needs.	No. of Lectures