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).