SCHEME

M. Sc. (Hons.) Mathematics

(PG Programme as per NEP 2020)

Department of Physical Sciences

University Institute of Sciences (UIS)

Sant Baba Bhag Singh University

2023

ABOUT THE DEPARTMENT

The Physical Sciences expands our knowledge of the universe and underlines new technologies, which benefit our society. In keeping with the heritage of imparting quality education, teaching and research are the prime motive of the Department of Physical Sciences.

Department of Physical Sciences is dynamic and progressive in its development of new course initiatives and to contribute substantially to the goal of SBBSU and becoming a research oriented organization. The teaching is by way of interactive sessions between students and teachers. Our courses ensure a coherent degree structure while encouraging interdisciplinary approach.

Student centric, ICT enabled and interactive teaching, outcome based teaching model comprising of theoretical work, regular academic activities such as research projects, seminars, resource learning and hands-on laboratory work.

The Department wishes to focus on providing a comprehensive curriculum at undergraduate and postgraduate levels with teaching- learning adjunct to cater the need of industry, relevant research and career opportunities, meritorious careers in academia and proficient industries. Our research oriented teaching paves the way for entry into different careers since it equips students with advanced transferable skills in information gathering, analysis and presentation, which are vital tools in the field of science.

SALIENT FEATURES OF THE DEPARTMENT

- The department is blessed to have specialized faculty in various fields of Physical Sciences *viz.* Chemistry, Physics, Mathematics.
- The Department keeps its students abreast of latest advancements in technology through ultra-modern computer facilities, e-learning, virtual labs, SWAYAM Courses as per UGC guidelines.
- The department updates curricula on a regular basis to ensure that students keep up with the changing trends of education and research globally. The syllabi of courses are designed to equip students to qualify exams such as GATE, UGC- NET / SLET, TIFR etc.
- The Department has well equipped laboratories with a number of instruments and facilities like, UV-Visible Spectrophotometer, High Speed Centrifuge, Muffle furnance, Digital water bath, Polarimeter, Ultrasonic interferometer, Ballistic Galvanometer **,** Deflection and vibration Magnetometer **,** Electron spin resonance, Turbiditimeter, Abbs Refractrometer, Digital weighing balance/ Spring balance, Magnetic plate with stirrer, pH meter, Conductometer, Flame Photometer, colorimeter and a double distillation plant etc.
- Students and teachers participation in International, National, State and Regional seminars and conferences. Along with Industry aligned academia, expert interaction, is the key features of the department.
- Curricular and the co-curricular activities are well balanced in the Teaching Learning environment to provide holistic education to the students.
- The outcome based teaching model of faculty comprising of theoretical work, regular academic activities such as research projects, seminars, resource learning and hands-on laboratory work.
- Along with Industry aligned academia, expert interaction, is the key features of the department.

MSc. (Hons.) Mathematics

In this degree, candidates get a deeper knowledge of advanced mathematics through a vast preference of subjects such as geometry, calculus, algebra, number theory, dynamical systems, differential equations, etc. The students become more skilled and specialized in a particular subject after the master degree program. In this course, students learn to collect big data and analyse them with the help of different tools and methods.

Vision

To aspire, achieve and sustain for excellence in academics and research through scientific knowledge so as to provide solutions to global environmental issues and transform graduates into responsible citizens and competent professionals.

Mission:

- 1.Holistic development of learner through academic excellence, employability, acquisition of analytical skills and higher research.
- 2.To explore and advance new frontiers in physical sciences and integration with interdisciplinary sciences through visionary research for the benefit of society
- 3.To develop graduates for lifelong learning and professional growth.

ELIGIBILITY CRITERIA : **B**.**Sc**. (Pass) with **Mathematics** as one of the Core subjects /**B**.**Sc**. (Hons.) **Mathematics** with 50% marks (45% marks in case of **SC**/ST candidates) in aggregate or equivalent grade from any university recognized by **UGC**.

DURATION: 2 Years

CAREER PATHWAYS

Mathematics offers a huge variety of career opportunities. It is important to plan ahead and know about your options.

The following guide is designed to help you navigate through the maze of career options that exist for maths graduates. Each of the pages below offer an insight into relevant careers for maths graduates, including a description of career, the skills required, the pros and cons, as well as useful links.

Possible career choices:

- Accountancy & Professional Service
- The Actuarial Profession
- Banking - Investment Banking
- Banking - Retail Banking
- Computing & IT
- Engineering Sciences
- General Management
- Operational research
- Postgraduate Study - MSc & Taught Courses
- Postgraduate Study - PhD
- Statistical research
- Teaching

Programme Educational Objective (PEO) (The Course Objective is....)	
PEO1.	To provide high quality education in pure and applied mathematics.
PEO2.	To develop talented and committed human resource which act as catalyst to support interdisciplinary research and become fit for industry and entrepreneur.
PEO3.	To motivate for research in mathematical and statistical sciences.
PEO4.	To empower students to investigate new mathematical methodologies for future applications.
PEO5.	To develop employable skills and life time leaning skills to handly real world challenging problems.
PEO6	To develop employable skills and life time learning .

PROGRAMME OUTCOMES (POs)		
At the end of the program, the student will:		
PO1	**Disciplinary knowledge**	have in-depth knowledge of fundamental concepts and theoretical principles in different areas of Mathematics along with their applications.
PO2	**Critical thinking**	be able to identify, formulate and analyse a complex variety of problems in Mathematics.
PO3	**Problem solving**	be able to solve the complex problems of Mathematics related to Engineering, Sciences, Statistics, Management etc. that are best approached with critical thinking.
PO4	**Scientific /Analytical reasoning**	learn to investigate computational/ analytical methods, relate information and interpretation of data based on scientific reasoning. The student will be able to draw logical conclusions based on a group of observations, mathematical techniques and measurements.
PO5	**Modern tool usage**	have the knowledge of mathematical software and tools for treating the complex mathematical problems and scientific investigations.
PO6	**Environment & Sustainability**	understand the impact of the scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO7	**Research related Skills & Ethics**	be able to comprehend and write effective reports and design documentation related to mathematical research and literature, and make effective presentations.
PO8	**Self-directed learning**	become self-directed learners
PO9	**Individual and team work**	be able to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication skills**	be able to assimilate technical information about Mathematics from various sources and convey it to intended audience, both orally and in writing in an intelligible manner.
PO11	**Lifelong learning**	be able to relate, explore and analyse applications of mathematics in real life

PROGRAMME SPECIFIC OUTCOMES (PSOs)	
At the end of the program, the student will:	
PSO1.	be equipped with critical analysis and problem-solving skills with respect to all field of core mathematics required for science and engineering applications.
PSO2.	have mathematical knowledge of experimental/computational techniques and instrumentation required to work independently in research or industrial environments.
PSO3.	become a person with sharpen analytical thinking, logical deductions and rigor in reasoning.

PSO4.	be able to apply mathematical methodologies to open- ended real -world situations.
PSO5	be able to explain applications of Mathematics related to the real world in term of advanced computational/numerical methods, advanced software, and analytical tools.

1. Curriculum Structure: M.Sc (Hons.) Mathematics degree programme will have a curriculum with Syllabi consisting of following type of courses:

I. **Ability Enhancement Courses (AEC):** The Ability Enhancement Courses (AEC) may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC). AECC courses are the courses based upon the content that leads to Knowledge enhancement; these are mandatory for all disciplines.
SEC courses are value-based and/or skill-based and are aimed at providing hands-on- training, competencies, skills, etc.

A. Ability Enhancement Compulsory Courses (AECC): Human Values and Professional Ethics, Computer, Environmental Science /Natural Hazards and Disaster management, Communication.

B. Skill Enhancement Courses (SEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

II. **Major Courses :** A course, which should compulsorily by studied by a candidate as a core requirement is termed as a Major course. These courses are employability enhancement courses relevant to the chosen program of study. Program core comprises of Theory, Practical, Project, Seminar etc. Project work is considered as a special course involving application of knowledge in solving/ analyzing/exploring a real life situation/ difficult problem.

III. **Elective Courses:** Elective course is generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or with provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill. Accordingly, elective course may be categorizes as:

A. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective.
B. Project (I): An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

2. NOMENCLATURE USED:

A. Postgraduate Core Courses
i. Major Course
ii. Minor Course
iii. Practical

B. Ability Enhancement Courses (AEC):
i. Ability Enhancement Compulsory Courses (AECC)
ii. Skill Enhancement Courses (SEC).

C. Elective Courses (EL)
i. Discipline Specific Elective(DSE)

Course Scheme for M.Sc. (Hons.) Mathematics (As Per NEP)

Semester 1

Theory Subjects

S No.	Course Type	Sub Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credit Hours
1	Major	MAT551	Real Analysis – I	4:0:0	4:0:0	4	4
2	Major	MAT553	Complex Analysis	4:0:0	4:0:0	4	4
3	Major	MAT555	Abstract Algebra- I	4:0:0	4:0:0	4	4
4	DSE (Major)	MAT557 MAT559 MAT561	Ordinary Differential Equations Fluid Mechanics – I Linear Algebra	4:0:0	4:0:0	4	4
5	Minor	MAT563	Mechanics	3:1:0	3:1:0	4	4
6	Minor	MAT565	Operation Research-I	3:1:0	3:1:0	4	4
7	VAC	EVS003	Natural Hazard and Disaster Management	3:0:0	3:0:0	3	3

Total Contact Hours: 27

Total Credit Hours: 27

Major: Major Course
Minor: Minor Course
DSE-Discipline Specific Elective
VAC: Value Added Course

Course Scheme for M.Sc. (Hons.) Mathematics (As Per NEP)

Semester II

I. Theory Subjects

S No.	Course Type	Sub Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credit Hours
1	Major	MAT552	Real Analysis – II	4:0:0	4:0:0	4	4
2	Major	MAT554	Probability and Statistics	4:0:0	4:0:0	4	4
3	Major	MAT556	Abstract Algebra- II	4:0:0	4:0:0	4	4
4	DSE (Major)	MAT558 MAT560 MAT562	Partial Differential Equations Fluid Mechanics – II Discrete Mathematics	4:0:0	4:0:0	4	4
5	Minor	MAT564	Number Theory	3:1:0	3:1:0	4	4
6	Minor	MAT566	Operation Research- II	3:1:0	3:1:0	4	4
7	MDC	PHY580	Applications of Physics in Mathematics	3:0:0	3:0:0	3	3

Total Contact Hours: 27

Total Credit Hours: 27

Major: Major Course
Minor: Minor Course
DSE-Discipline Specific Elective
MDC: Multidisciplinary/Interdisciplinary

Course Scheme for M.Sc. (Hons.) Mathematics (As Per NEP)

Semester III

1. Theory Subjects

S No.	Course Type	Sub Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credit Hours
1	Major	RM653	Basics of Research Methodology in Physical and Mathematical Sciences	4:1:0	4:1:0	5	5
2	Major(DSE)	MAT651 MAT653 MAT655	Numerical Analysis Fuzzy Set Theory Field Extension and Galois Theory	4:0:0	4:0:0	4	4
3	Major(DSE)	MAT657 MAT659 MAT661	Topology Introduction to Special Functions Fundamental of Python	4:0:0	4:0:0	4	4
4	Minor	MAT663	Applications of ICT Tools in Research	2:0:0	2:0:0	2	2
5	Minor	RM655	Publication and Research Ethics	2:0:0	2:0:0	2	2

2. Practical Subjects

1	Major	MAT665	Statistical Lab	0:0:4	0:0:2	4	2
2	Major	MAT667	Dissertation – I	0:0:8	0:0:4	8	4
3	Minor (SEC)	MAT669	Seminar	0:0:4	0:0:2	4	2
					Total	**33**	**25**

- Evaluation of Dissertation-I will be based on submission of synopsis & approved research objectives through DRC.

Total Contact Hours: 33

Total Credit Hours: 25

Major: Major Course
Minor: Minor Course
SEC-Skill Enhancement Course
DSE- Discipline Specific Elective

Course Scheme for M.Sc. (Hons.) Mathematics (As Per NEP)

Semester IV

1. Theory Subjects

S No.	Course Type	Sub Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credit Hours
1	Major	RM654	Advances in Research Methodology in Physical and Mathematical Sciences	4:1:0	4:1:0	5	5
2	Major(DSE)	MAT652 MAT654 MAT656	Fourier Series and Integral Equations Functional Analysis Mathematical Methods	4:0:0	4:0:0	4	4
3	Major(DSE)	MAT658 MAT660 MAT662	Fractional Calculus Advanced Numerical Analysis Introduction to R- Programming	4:0:0	4:0:0	4	4

2. Practical Subjects

1	Major	MAT664	Numerical Analysis Lab	0:0:4	0:0:2	4	2
2	Major	MAT666	Dissertation – II	0:0:16	0:0:8	16	8
3	Minor	RM656	Scientific and Technical Writing	0:0:4	0:0:2	4	2
					Total	**37**	**25**

- Evaluation of Dissertation-II will be based on the submission and evaluation of completed dissertation through institutional RDC.

Total Contact Hours: 37

Total Credit Hours: 25

Major: Major Course
Minor: Minor Course
DSE- Discipline Specific Elective

Course Scheme Summary of M. Sc. (Hons.) Mathematics

Semester	Major	Minor	Major (DSE)	Value added	Multidisciplinary	SEC	Credits	Contact hr /week
1	12	8	4	3	-	-	27	27
2	12	8	4	--	3	-	27	27
3	11	4	8	--	--	2	25	33
4	15	2	8	--	--	--	25	37
Total	50	22	24	3	3	2	104	124

Semester - I

Course Code	**MAT551**
Course Title	**Real Analysis-I**
Type of course	Major
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	The aim of this course is to learn fundamental concepts of metric spaces, the Riemann-Stieltjes integral as a generalization of Riemann Integral, the calculus of several variables and basic theorem.
Course Outcomes (CO)	After the completion of the course, students will be able to: 1. describe fundamental properties of the real numbers that lead to the formal development of real analysis. 2. comprehend rigorous arguments developing the theory underpinning real analysis. 3. demonstrate an understanding of limits and how they are used in sequences, series, differentiation and integration.

UNIT-I

Finite, Countable and Uncountable sets, Metric spaces: definition, open sets, closed sets, interior and exterior point, adherent point, Compact sets, Heine-Borel Theorem, Perfect sets, The Cantor set, Separated sets, connected sets, Connected subsets of real line, Disconnected sets, Components.

UNIT-II

Limits of functions, Continuous functions, Compactness, Connectedness, monotonic functions, Infinite limits and Limits at infinity.

UNIT-III

Definition and existence of the Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, Fundamental Theorem of Calculus, Mean Value Theorems of Riemann Stieltje's integral.

UNIT-IV

Convergent sequences, Sub sequences, Cauchy sequences, Complete metric spaces, Cantor's Intersection Theorem, Baire's Category Theorem, Banach contraction principle, Functions of bounded variation.

Text & Reference Books:-

S. No.	**Name**	**Author(S)**	**Publisher**
1	Principles of Mathematical Analysis	Walter Rudin	McGraw-Hill Ltd
2	A course of Mathematical Analysis	Shanti Narayan	S. Chand
3	Mathematical Analysis	S. C. Malik	Wiley Eastern
4	Introduction to Real Analysis	R. G. Bartle	John Wiley and Sons
5	Elements of Real Analysis	H. S. Gaskill and P. P. Narayanaswami	Printice Hall,
6	Real Analysis	H.L. Royden	Macmillan *Company* Collier-*Macmillan* Limited

Course Code	**MAT553**
Course Title	**Complex Analysis**
Type of course	Major
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	The objective of this course is to introduce the fundamental ideas of the functions of complex variables and developing a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, complex integrals and a range of skills which will allow students to work effectively with the concepts.
Course Outcomes (CO)	At the end of this course, students will be able to : 1. analyze and evaluate the local properties of analytical functions and definite integral. 2. Describe the concept of definite integral and harmonic functions 3. Develop Taylor's and Laurent's series. 4. enhance and develop the ability of using the language of mathematics in analyzing the real-world problems of sciences and engineering.

UNIT-I

Complex plane, Stereographic projection, Riemann sphere, Function of complex variables, Continuity and Differentiability, Analytic functions, Conjugate function, Harmonic function, Cauchy Riemann equations (Cartesian and Polar form), Construction of analytic functions. Branch cut and Branch point.

UNIT-II

Complex line integral, Cauchy's theorem, Cauchy's integral formula and its generalized form. Cauchy's inequality, Poisson's integral formula, Morera's theorem,Liouville's theorem, conformal transformation, Bilinear transformation, critical points, fixed points, Cross ratio problems.

UNIT-III

Meromorphic and entire function, Power series, Taylor's theorem, Laurent's theorem, Maximum modulus theorem (Principle), Schwarz's Lemma, poles and zeroes of meromorphic functions, Argument principle, and Fundamental theorem of Algebra and Rouche's theorem.

UNIT-IV

Zeros, Singularities, Residue at a pole and at infinity, Cauchy's Residue theorem, Jordan's lemma, Integration round unit circle, Evaluation of Integrals of the type $\int f(z)dz$where $f(z)$is a rational function with degree of denominator polynomial greater than that of numerator polynomial by at least two and $C$is a circle, $\int_0^{2\pi} f(sin\theta, cos\theta)d\theta$ and$\int_{-\infty}^{\infty} f(x)dx$.

Text & Reference books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Complex Analysis	J.V Deshpande	Tata McGraw-Hill Publishing Company
2	Complex Analysis, third edition	D.V Ahlfors	McGraw-Hill International
3	Functions of Complex Variable and Application	James ward Brown, Ruel V. Churchill	McGraw Hill Higher Education
4	Complex Variables	M. R. Spiegel	McGraw Hill Book Company

Course Code	**MAT555**
Course Title	**Abstract Algebra-I**
Type of course	Major
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	This course covers some advanced topics of Group Theory and basic concept of ring theory, which are two most important branches of algebra.
Course Outcomes(CO)	After the completion of the course, students will be able to: 1. demonstrate insight into abstract algebra with focus on axiomatic theories. 2. demonstrate knowlegde and understanding of fundamental concepts including groups, subgroups, normal subgroups, homomorphisms and isomorphism. 3. demonstrate knowlegde and understanding of rings, fields and their properties.

UNIT-I

Review of basic property of Groups: Subgroups and cosets, cyclic groups, normal subgroups and quotient groups. Permutation groups, Even and odd permutations, Conjugacy classes of permutations, Alternating groups, Simplicity of An, n > 4. Cayley's Theorem, Direct products of groups.

UNIT-II

Fundamental Theorem for finite abelian groups, Sylow theorems and their applications, Finite Simple groups, Groups of order p^2, pq (p and q primes).

UNIT-III

Solvable groups, Normal and subnormal series, composition series, the theorems of Schreier and Jordan Holder.

UNIT-IV

Review of rings and homomorphism of rings, Ideals, Algebra of Ideals, Maximal and prime ideals, Ideal in Quotient rings, Field of Quotients of integral Domain, Matrix Rings and their ideals, Rings of Endomorphisms of Abelian Groups.

Text & Reference books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Basic Abstract Algebra	P.B. Bhattacharya, S.K. Jain& S.R. Nagpaul	Cambridge University Press
2	A Course in Abstract Algebra	Vijay K Khanna and S K Bhambri	Vikas Publishing house
3	Contemporary Abstract Algebra	J. A. Gallian	Narosa Publisihng House
	A First Course in Abstract Algebra	J. B. Fraleigh	Addison-WeseleyPublising

Course Code	**MAT557**
Course Title	**Ordinary Differential Equations**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	The objective of this course is to introduce ordinary differential equations and fundamental theorems for existence and uniqueness of their solutions. The course further aims to equip the students with fundamental knowledge and problems solving skills in power series solutions of ODE, and solution of systems of differential equations.
Course Outcomes (CO)	After the completion of the course, students will be able to: 1. understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence and uniqueness. 2. understand and solve differential equations of Strum Liouville type. 3. apply various power series methods to obtain series solutions of differential equations. 4. solve problems of ordinary differential equations arising in various fields.

UNIT-I

Review of fundamentals of Ordinary differential equations. The method of successive approximation. Initial value problem, Ascoli's Lemma, Gronwall's inequality, Cauchy Peano Existence Theorem, Picard's existence and uniqueness theorem, Lipschitz condition.

UNIT-II

Linear system of equations (homogeneous & non homogeneous). Superposition principle, Fundamental set of solutions, Fundamental Matrix, Wronskian, Abel Liouville formula, Reduction of order, Adjoint systems and Self Adjoint systems of second order. Linear 2nd order equations, preliminaries, Sturm's separation theorem, Sturm's fundamental comparison theorem.

UNIT-III

Orthogonal set of functions, Orthonormal set of functions, Gram-Schmidt process of orthonormalization, Sturm Liouville's boundary value problems, Orthogonality of Eigen functions. Adjoint forms, Lagrange identity, Green function to solve boundary value problems.

UNIT-IV

Power series solution of differential equation about an ordinary point, Solution about regular singular points: The method of Frobenius, Applications, Legendre's, Hermite's and Bessel's equation. Ordinary differential equations in more than two variables: Simultaneous Differential equations of the first order and the first degree in three variables, Methods of their solution and applications.

Text & Reference books:-

S. No.	**Name**	**Author(S)**	**Publisher**
1	Ordinary Differential Equations: Principles and Applications	K. Nandakumaran, P. S. Dhatti, Raju K. George	Cambridge University Press
2	Differential Equations	S.L. Ross	John Wiley and Sons
3	Introduction to Ordinary Differential Equations.	E.A. Coddington	Prentice-Hall of India Private Ltd
4	Elements of Partial Differential Equations.	N. Sneddon	Tata McGraw Hill
5	Ordinary Differential Equations: Theory and Applications	M. Rama Mohana Rao	East-West Press Pvt. Ltd
6	Advanced Differential Equations	M. D. Raisinghania	S. Chand &Company Ltd.

Course Code	**MAT559**
Course Title	**Fluid Mechanics-I**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	The objective of this course is to introduce the fundamentals of modern treatment of incompressible and compressible fluid flows.
Course Outcomes (CO)	After the completion of the course, students will be able to: 1. identify derivation of basic equations of fluid mechanics. 2. describe the motion of fluids. 3. formulate the problems on buoyancy and solve them.

UNIT-I

Real fluids and ideal fluids, velocity of fluid at a point, streamlines, path lines, streak lines, velocity potential, vorticity vector, local and particle rates of change, equation of continuity, incompressible fluid flow, acceleration of fluid, conditions at a rigid boundary.

UNIT-II

Euler's equation of motion, Bernoulli's equation, their applications, some potential theorems, flows involving axial symmetry- stationary sphere in a uniform stream, impulsive motion, Kelvin's theorem of circulation, equation of vorticity.

UNIT-III

Some three dimensional flows: sources, sinks and doublets, images in rigid planes, images in solid spheres, Stoke's stream function.

UNIT-IV

Two dimensional flows: complex velocity potential, Milne Thomson circle theorem and applications, theorem of Blasius, Vortex rows, Karman Vortex Street.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Text Book of Fluid Dynamics	F. Charlton	GK Publishers,
2	Fluid Mechanics, 2nd Edition	L.D. Landauand E. M. Lifhshitz	Pergamon Press Ltd
3	An Introduction to Fluid Mechanics	G. K. Batchelor	Cambridge University Press,
4	Fluid Mechanics	P. K. Kundu and I. M. Cohen.	Harcourt (India) Pvt. Ltd.

Course Code	**MAT561**
Course Title	**Linear Algebra**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.sc with Mathematics and B.A with Mathematics
Course Objective (CO)	The main objective is to introduce basic notions in linear algebra that are often used in mathematics and other sciences.
Course Outcomes (CO)	After the completion of the course, students will be able to: 1. understand the concept of basis and dimensions of vector space and solve the system of linear equations. 2. use the concept of the Eigen values and Eigenvectors, Characteristic and minimal polynomials, Canonical forms, Diagonal forms, triangular forms, Rational and Canonical Jordan Forms. 3. solve the numericals based on Inner Product Spaces, Norms and Distances, Orthonormal basis, The Gram-Schmidt orthogonalization, Normal and self-adjoint Operators 4. apply the concept of Unitary and Normal Operators, Spectral Theorem, Bilinear and Quadratic forms in the applied fileds of mathematics 5. Apply the knowledge of Linear Algebra to attain a good mathematical maturity and enables to build mathematical thinking and skill.

UNIT-I

Vector Spaces, Subspaces, Linear dependence, Basis and Dimensions, Algebra of Linear Transformation, Algebra of Matrices, Row rank, Column rank and their equality, System of Linear Equations.

UNIT-II

Eigen values and Eigenvectors, Characteristic and minimal polynomials, companion matrix, Cayley Hamilton Theorem, Matrix representation of Linear Transformation, Change of Basis, Canonical forms, Diagonal forms, triangular forms, Rational and Canonical Jordan Forms.

UNIT-III

Eigen spaces and similarity, Linear functional, Dual Spaces and dual basis, the double dual, Inner Product Spaces, Norms and Distances, Orthonormal basis, The Gram-Schmidt Orthogonalization, Orthogonal complements.

UNIT-IV

The adjoint of a Linear operator on an inner product space, Normal and self-adjoint Operators, Unitary and Normal Operators, Spectral Theorem, Bilinear and Quadratic forms.

Text & Reference books:-

S. No.	Name	Author(S)	Publisher
1	Linear Algebra, 3rd Edition	S. Lipschutz and M. Lipso	Tata McGraw Hill
2	Linear algebra, 2nd Edition	K. Hoffman and R. Kunze	Prentice Hall
3	Undergraduate Texts in Mathematics, 3rd Edition.	S. Lang	New York: SpringerVerlag
4	Linear Algebra Done Right, 2nd Edition.	S. Axler	Springer Verlag

Course Code	**MAT563**
Course Title	**Mechanics**
Type of course	Minor
L T P	3 1 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To introduce the concept of variation of functionals and variational techniques. Dynamics of rigid bodies, Lagrangian and Hamiltonian equations for dynamical systems are also introduced at large.
Course Outcomes (CO)	After the completion of the course the students will be able to: 1. solve isoperimetric problems of standard type. 2. solve simple initial and boundary value problems by using several variable calculus. 3. solve mechanics problems in one dimension that involve one or more of the forces of gravity, friction and air resistance

UNIT-I

The variation of a functional and its properties, Fundamental lemma of calculus of variations, Euler's equation for one dependent function and its different forms, Motivational problems of calculus of variation- Shortest distance in a plane, Minimum surface of revolution, Brachistochrone problem, Geodesics, Isoperimetric problems, Functionals involving several dependent variables, Functionals involving higher order derivatives.

UNIT-II

Variational problems with moving boundaries, Approximate solutions of Boundary Value Problems- Rayleigh-Ritz method, Galerkin's method, Generalised coordinates, Degree of freedom, Constraints, Holonomic and non-holonomic systems, Generalised velocity, Generalised potential, Generalised force, principle of virtual work, D'Alembert's principle, Lagrange's Equation, Simple applications of the Lagrangian formulation.

UNIT-III

Hamiltonian principle, principle of least action, derivation of Lagrange's equations from Hamilton's principle, Legendre transformations, Hamilton's canonical equation of motion, Solving problems using Hamilton's equations, Cyclic co-ordinates, Conservation theorems, Routhian.

UNIT-IV

Central force, Equivalent one-body problem, Motion in a central force field, Moments and product of inertia, Theorems of Parallel and Perpendicular axes, Angular momentum of a rigid body about a fixed point and about fixed principal axes, Euler's dynamical equations for motion of rigid body.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Text Book of Dynamics	F. Chorlton	CBS Publishers, New Delhi.
2	Dynamics of rigid body	S.L. Loney	New Age International Private Limited
3	Classical Mechanics	D.E Rutherford,	Oliver & Boyd Ltd.
4	An Introduction to the Calculus of Variation	C. Fox	York: Dover Publications, 1987

Course Code	**MAT565**
Course Title	**Operations Research-I**
Type of course	Minor
L T P	3 1 0
Credits	4
Course pre-requisite	B. Sc. with Mathematics and B.A with Mathematics
Course Objective (CO)	To inculcate the traits of rational decision making. To develop the research proposal and also find out the optimal solution.
Course Outcomes(CO)	At the end of this course, students will be able to: 1. formulate and solve problems as networks and graphs. 2. construct linear integer programming models and discuss the solution techniques. 3. set up decision models and use some solution methods for nonlinear optimization problems.

UNIT-I

Linear programming problem, properties of a solution to the linear programming problem, generating extreme point solution, simplex computational procedure, development of minimum feasible solution, the artificial basis techniques, a first feasible solution using slack variables, two phase and Big-M method with artificial variables.

UNIT-II

General transportation problem, transportation table, duality in transportation problem, loops in transportation tables, Linear Programming formulation, solution of transportation problem, test for optimality, degeneracy, transportation algorithm (MODI method), time-minimization transportation problem.

UNIT—III

Replacement of equipment/Asset that deteriorates gradually, replacement of equipment that fails suddenly, recruitment and promotion problem, equipment renewal problem Mathematical formulation of assignment problem, assignment method, typical assignment problem, the traveling salesman problem.

UNIT-IV

Two-person zero-sum games, maximum minimum principle, games without saddle points(Mixed strategies), graphical solution of$2\times n$ and $m\times 2$ games, dominance property, arithmetic method of $n\times n$ games, general solution of $m\times n$ rectangular games .Non Linear Programming Problem :-i.e one and multi variable unconstrained optimization Kuhn -Tucker conditions for constrained optimization .Quadratic , Convex, Non Convex Programming problem

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Linear Programming	S. L. Gass	McGraw Hill Book Company
2	Operations Research	K.K. Chawla	Kalyani Publication
3	Mathematical Programming	N.S. Kambo	East West Press
4	Operations Research	H. A. Taha	Taha, H.A
5	Operations Research	Kanti Sawrup	Sultan Chand & Sons

Course Code	**EVS003**
Course Title	**Natural Hazards and Disaster Management**
Type of course	VAC
L T P	3 0 0
Credits	3
Course prerequisite	Graduation
Course Objective	To learn about natural hazards, risk assessment and disaster management
Course Outcomes	After the completion of the course, students will be able to: 1. know the current overview of natural hazard materials 2. discuss the physical aspects of vulnerability and elements of risk mapping, assessment 3. know the development planning, sustainable development in the context of Climate Change

UNIT-I

Overview of natural hazards; Introduction to natural hazards, impact and mitigation in Global and Indian context; causes and consequences of geological hazards, flood, drought and climate change issues, forest hazard, tsunami and coastal hazards, cyclone hazards, snow avalanche, GLOF and glacier related hazards, extreme weather events, urban and industrial hazards.

UNIT-II

Introduction to vulnerability and risk assessment, socio-economic and physical aspects of vulnerability and elements of risk mapping, assessment, and reduction strategies.

UNIT-III

Earth observation: Data availability and key operational issues for DM: EO systems for natural hazards study: present (operational) and future systems; multi-temporal data sources, multi-temporal database organisation: Key operational issues, utilisation of geo-information products for disaster management (available through international cooperation e.g. International Charter etc.)

UNIT-IV

Disaster management framework of India and recent initiatives by Govt. of India with special emphasis on DRR HFA 2005-2015, MDG and SAARC comprehensive framework for DRR Disaster Management Support (DMS): Status in India for use of space inputs Mainstreaming DRR in Development Planning Sustainable development in the context of Climate Change Disaster Recovery-Strategy and case examples.

Text and Reference books:

S. No.	Name/Title	Author	Publisher
1	Environmental Hazards : Assessing Risk and Reducing Disaster	Keith Smith and Petley David, 2008.	Routledge
2	Geo-information for Disaster Management	van Oosterom Peter, Zlatanova Siyka and Fendel Elfriede, 2005	Springer-Verlag
3	Geospatial Techniques in Urban Hazards and Disaster Analysis	Showalter, Pamela S. and Lu, Yongmei, 2010.	John Wiley and Sons.
4	An International Perspective on Natural Disaster: Occurrence, Mitigation and Consequences	Stoltman JP, Lidstone J and Dechano LM., 2004.	Kluwer Academic Publishers

Semester -II

Course Code	**MAT552**
Course Title	**Real Analysis-II**
Type of course	Major
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	The objective of this course is to study the convergence of sequences and measure in an abstract setting after having studied Lebesgue measure on real line. The general $\mathbf{L^P}$spaces are also studied.
Course Outcomes(CO)	At the end of this course, students will be able to: 1. To relate the concept of convergence and weierstrass's approximation. 2. Illustrate how to communicating with: Peers, Lecturers and Community 3. Use the basics of Lebesgue integration to understand the theory leading to differentiation and other relevant topics.

UNIT-I

Cluster Point, Definition of point-wise and uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence, nowhere differentiable functions, Weierstrass's non-differentiable function, Weierstrass Approximation Theorem, Stone-Weierstrass's Theorem.

UNIT-II

Lebesgue and Outer Measure, Properties of Measurable Sets and Non Measurable Sets, σ-Algebra, Boral sets.

UNIT-III

Definition & Properties of Measurable functions, Characteristic functions, Step Functions and Simple Functions, Egoroff's Theorem, Lusin Theorem, Little wood's three Principles, Signed measures, The Lp-spaces, Riesz-Fischer Theorem; Riesz Representation theorem for Lp spaces, Radon-Nikodym theorem, Dual of Lp-spaces, The extension theorem.

UNIT-IV

Lebesgue Integral of bounded function, Comparison of Riemann and Lebesgue Integral, Integral of a non-negative function, Convergence in measure, Bounded Convergence Theorem, The general Lebesgue integral. Differentiation and Integration: Differentiation of monotone functions, Fatou's Lemma, Monotone Convergence Theorem and Differentiation of an integral, Absolute Continuity.

Text & Reference books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Principles of Mathematical Analysis	Walter Rudin	McGraw-Hill Ltd
2	Mathematical Analysis	S. C. Malik	Wiley Eastern
3	Introduction to Real Analysis	R. G. Bartle	John Wiley and Sons
4	Real Analysis	H.L. Royden,	Macmillan Co.
5	Mathematical Analysis,	T. Apostol	Narosa Publishers

Course Code	**MAT554**
Course Title	**Probability and Statistics**
Type of course	Major
L T P	4 0 0
Credits	4
Course prerequisite	B.sc with Mathematics and B.A with Mathematics
Course Objective (CO)	The course is designed to equip the students with various probability distributions and to develop greater skills and understanding of Sampling and Estimation.
Course Outcomes(CO)	After the completion of the course, students will be able to: 1. use the basic concept of random variable, probability density function, distribution functions and concept for the marginal/conditional distribution. 2. use discrete and continuous probability distribution. 3. apply the theory of sampling, estimators and sampling distributors. 4. handle the problems related to hypothesis for small samples and significance of t, Z and F distributions.

UNIT-I

Random Variables and Distribution Functions: Discrete and continuous random variables, Probability mass, Probability density and cumulative distribution functions, Joint, marginal and conditional distributions, Mathematical expectation, Variance and moments and Moment generating function.

UNIT-II

Discrete probability distributions: Bernoulli, Binomial, Poisson, Geometric and Negative Binomial distributions and their properties. Continuous probability distributions: Uniform, normal, beta distribution of first and second kind, gamma, exponential distributions and their properties.

UNIT-III

Sampling Theory: Types of Sampling- Simple, Stratified, Systematic, Errors in sampling, Parameter and Statistics. Estimation: Unbiasedness, Consistency, Invariant Estimator, Efficient Estimator, Minimum Variance Unbiased Estimators, Characteristics of Estimators, the Method of Maximum Likelihood Estimation, properties of estimators, confidence intervals. Exact Sampling Distributions: Chi-square distribution, Student's-t distribution, Snedecor's F-distribution, Fisher's – Z distribution.

UNIT-IV

Hypothesis Testing*:* Tests of significance for small samples, Null and Alternative hypothesis, Critical region and level of significance, Tests of hypotheses: most powerful and uniformly most powerful tests, likelihood ratio tests. Tests of significance based on t, Z and F distributions, Chi square test of goodness of fit. Large Sample tests, Sampling of attributes, Tests of significance for single Proportion and for difference of proportions, Sampling of variables, tests of significance for single mean and for difference of means and for difference of standard deviations.

Text & Reference Books:

S. No.	Name	Author(S)	Publisher
1	Introductory Probability and Statistical Applications	P. L. Meyer	Philippines: Addison-Wesley Publishing Company
2	Fundamentals of Mathematical Statistics	S. C. Guptaand V. K. Kapoor	Sultan Chand & Sons: New Delhi
3	Introduction to Probability and Statistics	J. S. Milton and J.C. Arnold,	Fourth Edition, McGraw Hill
4	An outline of statistical theory (Vol. 1 & 2).	A.M. Goon, M. K. Gupta, & B. Dasgupta	World Press Pvt Limited

Course Code	**MAT556**
Course Title	**Abstract Algebra-II**
Type of course	Major
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	The objective of this course is to introduce the advanced concepts of ring theory and modules.
Course Outcomes(CO)	After the completion of the course, the students will be: 1. able to appreciate quotient ring as a tool to solve algebraic problems 2. able to understand vector spaces algebraically as free modules and appreciate the differences between modules defined over different rings 3. exposed to different kinds of module- based problems.

UNIT-I

Rings:-Factorization Theory in Integral Domains, Divisibility, Unique Factorization Domain, Principal Ideal Domain, Euclidian Domain and their relationships, Polynomial rings over UFD's, Gauss's Lemma, Reducible and irreducible polynomials.

UNIT-II

Noetherian and Artinian Rings, Examples and Counter Examples, Artinian Rings without zero divisors, Nil Ideals in Artinian Rings, Hilbert Basis Theorem.

UNIT-III

Modules, submodules, free modules, quotient modules, Homomorphism theorems, direct sums, finitely generated modules, Simple modules, cyclic modules, differences between modules over rings and vector spaces.

UNIT-IV

Modules over PID's, structure theorem of modules over PID's, Torsion modules, Torsion free modules, Artinian and Noetherian Modules, Artinian And Noetherian rings, modules of finite length.

Text & Reference books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Topics in Algebra	I. N. Herstein,	Xerox Publishing Company Mass
2	Basic Abstract Algebra,	P.B. Bhattacharya, S.K. Jain, & S.R. Nagpaul	Cambridge University Press
3	A Course in Abstract Algebra	Vijay K Khanna and S. K. Bhambri	Vikas Publishing house
4	Contemporary Abstract Algebra,	J. A. Gallian	Narosa Publisihng

Course Code	**MAT558**
Course Title	**Partial Differential Equations**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with mathematics
Course Objective (CO)	The Objective of this course is to introduce first and higher order partial differential equations and their classification. Apart from explaining various analytic methods for computing the solutions of various partial differential equations, the course also explains various applications of partial differential equations in real physical phenomenon.
Course Outcomes(CO)	At the end of the course, the students will be able to: 1. understand partial differential equations of first order (linear and nonlinear), second and higher order. 2. Apply various analytic methods for computing solutions of various PDEs 3. understand the formation and solution of some significant PDEs like wave equation, heat equation and diffusion equation. 4. apply the knowledge of PDEs and their solutions in order to understand physical phenomena.

UNIT-I

First order linear and quasi partial differential equations, method of Lagrange's, Integral surface through a given curve, Surface orthogonal to given system of surfaces. Nonlinear Partial differential equations of first order, Charpit's Method and Jacobi's Method, Cauchy problem for first order PDEs.

UNIT-II

Partial Differential Equations of Second and Higher Order: Origin of second order partial differential equations. Higher order partial differential equations with constant coefficients. Equations with variable coefficients. Classification of second order partial differential equations. Canonical forms. Solution of non-linear second order partial differential equations by Monge's method.

UNIT-II

Method of Solution: Separation of variables in a PDE: Laplace, wave and diffusion equations, Elementary solutions of Laplace equations.

UNIT-IV

Applications of PDE: Wave equation, the occurrence of wave equations, elementary solutions of one-dimensional wave equation; vibrating membranes, three dimensional problems. Diffusion equation, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation.

Text & Reference books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Elements of Partial Differential Equations.	I.N. Sneddon, I. N.	Tata McGraw Hill
2	Differential Equations.	Piaggio	CBS Publisher
3	Differential Equations.	S.L. Ross	John wiley and Sons
4	Introduction to Ordinary Differential Equations.	E. A. Coddington	McGraw-Hil
5	Advanced Differential Equations	M.D. Raisinghania	S. Chand & Company

Course Code	**MAT560**
Course Title	**Fluid Mechanics- II**
Type of course	Discipline Specific Elective
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	This course is designed to make the students learn to develop mathematical models of fluid dynamical systems and use mathematical techniques to find solutions to these model
Course Outcomes(CO)	After the completion of the course, students will : 1. Acquire the knowledge of concepts of rotational and irrotational flow, stream functions, velocity potential, sink, source, vortex etc 2. be able to analyze simple fluid flow problems with Navier-Stoke's equation of motion. 3. understand the phenomenon of flow separation and boundary layer theory 4. have the knowledge of fundamental equations of the flow and energy

UNIT-I

Stress components in a real fluid, relation between Cartesian components of stress, rate of strain quadric and principal stresses, relations between stress and rate of strain, coefficient of viscosity and laminar flow.

UNIT-II

The Navier-Stokes equations of motion of a viscous fluid, steady motion of viscous fluid between parallel planes, steady flow through tube of uniform circular cross-section, flow through tubes of uniform cross section in the form of circle, ellipse and equilateral triangle.

UNIT-III

Diffusion of vorticity. Energy dissipation due to viscosity, steady flow past a fixed sphere, dimensional analysis, Reynolds numbers, Prandtl's boundary layer, Karman integral equation.

UNIT-IV

Elements of wave motion, waves in fluids, Surface gravity waves, standing waves, group velocity, energy of propagations, path of particles, waves at interface of two liquids.

Text & Reference Books:-

S.NO.	Name	Author(s)	Publisher
1	Text Book of Fluid Dynamics	F. Charlton	GK Publishers
2	Fluid Mechanics, 2nd Edition	L.D. Landau and E. M. Lifhshitz	Lifhshitz Pergamon Press Ltd
3	An Introduction to Fluid Mechanics	G. K. Batchelor	Cambridge University Press
4	Fluid Mechanics	P.K. Kunduand I. M. Cohen	Harcourt (India) Pvt. Ltd

Course Code	**MAT562**
Course Title	**Discrete Mathematics**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B. Sc. with Mathematics and B.A with Mathematics
Course Objective (CO)	The objective of this course is to acquaint the students with the concepts in Discrete Mathematics. It includes the topics like Logics, Graph Theory, Trees and Boolean algebra.
Course Outcomes(CO)	After the completion of the course, students will be able to: 1. understand the notion of mathematical thinking, mathematical proofs, and algorithmic thinking, and be able to apply them in problem solving. 2. understand some basic properties of graphs and related discrete structures, and be able to relate these to practical examples. 3. use effectively algebraic techniques to analyse basic discrete structures and algorithms.

UNIT-I

Basic logical operations, conditional and bi-conditional statements, tautologies, contradiction, Quantifiers, prepositional calculus, Recursively defined sequences, the characteristic polynomial. Solution of recurrence relations, generating function.Counting Techniques: The product rule, the sum rule, the inclusion–exclusion principle, The Pigeonhole Principle and examples.Simple arrangements and selections, Arrangements and selections with repetitions, Distributions, Binomial Coefficients.

UNIT-II

Language and Grammars: Computability and Formal Languages, Ordered sets, languages, Phrase structure grammars, Types of grammars and languages, Finite state machines-equivalent machines, Finite state machines as language recognizers, Analysis of algorithm-Time complexity.

UNIT-III

Introduction to Graph Theory: Basic Terminology, Special types of Graphs. The Handshaking Theorem, Paths and Circuits Shortest paths. Connectivity of Graphs. Isomorphism of Graphs. Homomorphism Graphs. Eulerian and Hamiltonian Graphs. Planar and Non-Planar Graphs. Euler'sformula. GraphColouring. Adjacency and Incidence Matrices. Travelling Salesman Problem.

UNIT-IV

Trees: Basic Terminology. Binary Trees. Tree Traversing: Pre-order, Post-order and In-order Traversals. Minimum Spanning Trees, Prim's and Kruskal's Algorithm. Boolean algebra, Boolean Function, Switching circuit and Logic Gates, K-map. Lattice Theory: Lattices and Algebraic Structures, Lattice as algebraic structures, complete lattices, Sub-lattices, Homomorphism on lattices, Modular lattices.

Text & Reference books:-

S. No.	**Name**	**Author(S)**	**Publisher**
1	Discrete Mathematics and its Applications	K.H. Rosen	McGraw Hill
2	Foundation of Discrete Mathematics	K. D. Joshi	J. Wiley & Sons,
3	Discrete Mathematics	P. K. Sharma	Modern Publication
4	Discrete Mathematical Structures with Applications to Computer Science	J. P. Trembley and R. P. Manohar	McGraw Hill

Course Code	**MAT564**
Course Title	**Number Theory**
Type of course	Minor
L T P	3 1 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To give a simple account of classical number theory, prepare students in number theory and algebra and to demonstrate applications of number theory
Course Outcomes(CO)	After the completion of the course, students will be able to: 1. apply the knowledge of Number theory to attain a good mathematical maturity and enables to build mathematical thinking and skill. 2. utilize the congruences, Chinese remainder theorem, indices, residue classes, Legendre symbols to solve different related problems. 3. identify and analyze different types of divisibility tests, Euler's theorem, Wilson theorem, Mobius inversion formula to formulate and solve various related problems. 4. design, analyze and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares. 5. identify the challenging problems in modern mathematics and find their appropriate solutions.

UNIT-I

Simultaneous Linear Congruence, Chinese Remainder theorem with applications, Wolsten-Holme's theorem, Lagrange's proof of Wilson theorem, Fermat numbers, The order of an integer modulo Primitive roots, Existence and number of primitive roots.

UNIT-II

Indices and their applications, Quadratic residues, Euler's criterion, Product of quadratic residues and quadratic non-residues, The Legendre symbol and its properties, Gauss's Lemma, Quadratic reciprocity law, Jacobian symbol and its properties.

UNIT-III

Criterion for an integer to be expressible as sum of two squares and sum of four squares, Farey series, Farey dissection of a circle and its applications to approximations of irrationals by rational.

UNIT-IV

Finite and Infinite simple continued fractions, periodic and purely periodic continued fractions, Lagrange's Theorem on periodic continued fractions. Applications to Pell's equation. The fundamental solution of Pell's equation.

Text & Reference Books

S. No	**Name**	**Author(S)**	**Publisher**
1	Theory of Numbers	Hardy and Wright	McGraw-Hill Ltd
2	An introduction to number theory	Niven and Zuckerman	S. Chand
3	Elementary Number Theory, McGraw Hill 2002.	Burton, M. David	McGraw Hill
4	Theory of Numbers	Randhir Singh	Sharma Publication

Course Code	**MAT566**
Course Title	**Operation Research- II**
Type of course	Minor
L T P	3 1 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To inculcate the traits of rational decision making. To develop the research proposal and also find out the optimal solution
Course Outcomes(CO)	At the end of the course, students will be able to: 1. appreciate the queuing models 2. understand how operational research is useful in management and administration 3. Devise the optimal solution to gain more profit.

UNIT-I

Queuing Theory:- Introduction, Queuing System, elements of queuing system, distributions of arrivals, inter arrivals, departure and service times. Classification of queuing models, single service queueing model with infinite capacity (M/M/1): (/FIFO).Queuing Models: (M/M/1): (N/FIFO), Generalized Model: Birth-Death Process, (M/M/C)(/FIFO), (M/M/C) (N/FIFO), (M/M/R) (KIGD), Power supply model.

UNIT-II

Inventory Control:- The inventory decisions, costs associated with inventories, factors affecting Inventory control, economic order quantity (EOQ), Deterministic inventory problems with no shortage and with shortages, EOQ problems with price breaks, Multi item deterministic Problems

UNIT-III

Simulation Models:-Need of simulation, methodology of simulation. Simulation models, event- type simulation, generation of random numbers, Monto-Carlo simulation, simulation of inventory problems. queuing systems, maintenance problem, job sequencing.

UNIT-IV

Integer Programming:-Gomory's all I.P.P. method, constructions of Gomory's constraints, Fractional cut method-all integer and mixed integer, Branch-and-Bound method, applications of integer programming.

Text & Reference Books:-

S. No.	Name/Title	Author	Publisher
1	Linear Programming	S.L. Gass	McGraw Hill Book Company
2	Operations Research	K. K. Chawla	Kalyani Publication
3	Mathematical Programming	N.S. Kambo	East West Press.
4	Operations Research	H.A. Taha	
	Operations Research	Kanti Sawrup	Sultan Chand & Sons

Course Code	**PHY580**
Course Title	**Applications of Physics in Mathematics**
Type of Course	Theory
L T P	3:0:0
Credits	3
Course Prerequisite	Graduation with Mathematics
Course Objectives	The objective of the course is to familiarize the students with basic concepts of errors and analysis of experimental data, thermal analysis, electrical method and theory of angular momentum.
Course Outcomes (CO)	At the end of this course, students will be able to: 1. understand the types of errors, sampling techniques and experimental stress analysis. 2. understand the basic concepts of thermos-gravimeter analysis, differential scanning calorimeter and determination of thermo-chemical parameters with basic principles. 3. understand the theory of electrical methods such as Hall effects, CV characteristics, Schottky barrier capacitance. 4. understand the relation rotation and angular momentum.

Unit-I (Errors and analysis of experimental data)

Types of errors - Mean, variance and standard deviation, standard deviation of standard deviation- sampling techniques- Chi square test. Experimental stress analysis: Stress Analysis by strain gauging, high temperature strain gauge techniques – photoelasticity and holography.

Unit-II (Thermal analysis)

Introduction- thermo gravimeter analysis- instrumentation of weight loss, decomposition products – differential scanning calorimeter- instrumentation specific heat capacity measurement – determination of thermo chemical parameters – differential thermal analysis- basic principles – melting point determination and analysis.

Unit-III (Electrical Methods)

Hall effect – carrier density – resistivity – two probe and four probe methods- scattering mechanism- Van Der Pauw method – CV characteristics – Schottky barrier capacitance – impurity concentration – electrochemical CV profiling – limitations.

Unit-IV (Theory of angular momentum)

Symmetry, invariance, conservation laws, relation between rotation and angular momentum, commutation rules, matrix representations.

Book Suggested

Sr. No.	Name	Authors	Publishers
1	Instrumental Methods of Analysis	Willard M, Steve D.	CBS Publishers, New Delhi.
2	Modern Physics	Tipler and Llewellen	W. H. Freeman and Company
3	Modern Physics	Gupta and Agarwal	Kedar Nath Ram Nath

Semester -III

Course Code	**RM653**
Course Title	**Basics of Research Methodology in Physical and Mathematical Sciences**
Type of course	Major
L T P	4 1 0
Credits	5
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To understand the philosophy of science and ethics, research integrity and publication ethics. To identify research misconduct and predatory publications. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.). To understand the usage of plagiarism tools
Course Outcomes (CO)	At the end of this course, the students should be able to: 1. understand some basic concepts of research and its methodologies. 2. Identify appropriate research topics. 3. Select and define appropriate research problem and parameters

UNIT-I

Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process.

UNIT-II

Problem Identification & Formulation – Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. Methods of Data Collection - Collection of Primary Data –secondary data – Drafting Questionnaire-Data Collection through Questionnaire - Data Collection through Schedules - Collection of Secondary Data.

UNIT-III

Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

UNIT-IV

Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches. Measurement: Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Research Methodology	C. R. Kothari	New Age International
2	Business Research Methods	Alan Bryman & Emma Bell	Oxford University Press
3	Research Methodology	Sinha, S.C. and Dhiman, A.K.	ESS ESS Publications
4	An introduction to Research Methodology	Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K.	RBSA Publishers

Course Code	**MAT651**
Course Title	**Numerical Analysis**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	This course is designed to introduce the basic concepts of Numerical Mathematics for solving the problems arising in various fields of application, those are difficult to deal with analytically. This course addresses development, analysis and application of different numerical methods to solve the problems, viz. system of linear & nonlinear equations, numerical initial and boundary value problems of ordinary differential equations etc.
Course Outcomes(CO)	After the completion of the course, the students will be able to: 1. identify and analyze different types of errors encountered in numerical computing. 2. apply the knowledge of Numerical Mathematics to solve problems efficiently arising in science, engineering and economics etc. 3. utilize the tools of the Numerical Mathematics in order to formulate the real-world problems from the view point of numerical mathematics. 4. Design, analyze and implement of numerical methods for solving different types of problems, viz. initial and boundary value problems of ordinary differential equations etc. 5. Create, select and apply appropriate numerical techniques with the understanding of their limitations so that any possible modification in these techniques could be carried out in further research.

UNIT-I

Errors, Error propagation, Order of approximation. Solution of non-linear equations: Bisection, Regula-falsi, Secant, Newton-Raphson, Generalized Newton's method, Chebyshev method, Halley's methods, General iteration method, Muller's method. Rate of convergence. Newton's method for complex roots and multiple roots, Simultaneous non-linear equations by Newton-Raphson method.

UNIT-II

Operators: Forward, Backward and Shift (Definitions and some relations among them). Interpolation: Finite differences, divided differences, Newton's formulae for interpolation, Lagrange and Hermite interpolation, Cubic Spline interpolation. Numerical integration-Trapezoidal, Simpson's 1/3rd rule, Simpson's 3/8th rule, Boole's rule, Weddle's rule, Errors in Integration formulae.

UNIT-III

Curve fitting: Linear and non-linear curve fitting, curve fitting by sum of exponentials, fitting of exponential Solution of Linear system of equations: Matrix inversion, Gauss-elimination and Gauss-Jordan method, LU decomposition method, Gauss Jacobi and Gauss Seidal method.

UNIT-IV

Solution of differential equations: Taylor series method, Euler's method, Modified Euler's method, Runge - Kutta methods of order two, three and four, Predictor –Corrector methods, Finite Difference Method for ODE and PDE (Boundary value problem).

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Introductory methods of Numerical Analysis	S. S. Sastry	PHI Learning Private Limited
2	Numerical Methods for Scientific and Engineering Computation	Iyenger Jain, and Mahinder Kumar	New Age International Publishers.
3	Numerical Mathematical Analysis	Scarborough	Prentice Hall of India.
4	Simulation and Monte Carlo method	R. Y. Rubinstein	John Wiley

Course Code	**MAT653**
Course Title	**Fuzzy Set theory**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B. Sc. with Mathematics and B.A with Mathematics
Course Objective (CO)	The objective of this course is to teach the students the need of fuzzy sets, arithmetic operations on fuzzy sets, fuzzy relations, possibility theory, fuzzy logic, and its applications
Course Outcomes(CO)	After the completion of the course, students will be able to : 1. Use the knowledge of fuzzy mathematics in real life situations based on credit & debit. 2. Use the knowledge of fuzzy mathematics in economics & Engg. 3. Enhance reasoning ability in students .

UNIT-I

Classical and Fuzzy Sets: Overview of classical sets, Membership function, A-cuts, Properties of a-cuts, Extension principle.

UNIT-II

Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of operations, Aggregation operations. Fuzzy Arithmetic: Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals and numbers, Fuzzy equations.

UNIT-III

Fuzzy Relations: Crisp and fuzzy relations, Projections and cylindric extensions, Binary fuzzy relations, Binary relations on single set, Equivalence, Compatibility and ordering Relations, Morphisms, Fuzzy relation equations.

UNIT-IV

Fuzzy Logic: Classical logic, Multi-valued logics, Fuzzy propositions, Fuzzy qualifiers, Linguistic hedges. Applications of Fuzzy Logic: Washing machines, Control systems engineering, Power engineering and Optimization.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Fuzzy Sets	G. J. Klirand T.A. Folger	Uncertainty and Information, PHI
2	Fuzzy Set Theory and its Applications	H.J. Zimmermann	Allied Publishers
3	Fuzzy Sets and Fuzzy logic	G.J. Klirand B. Yuan	Theory and Applications, PHI

Course Code	**MAT655**
Course Title	**Field Extensions and Galois Theory**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To draw an attention on various results of the different algebraic structures, in particular, extension fields, splitting fields, separable and inseparable extension, Galois extensions and cyclotomic extensions.
Course Outcomes (CO)	At the end of the course, students will be able to: 1. Compose clear and accurate proofs using the concept of Galois theory 2. Prove theorems applying algebraic ways of thinking 3. Demonstrate the knowledge and understanding of fundamental concepts of algebraic extension and finite fields

UNIT-I

Fields, Characteristic of a field, prime fields, finite field extensions, degree of a field extension, **a**lgebraic extensions, splitting fields: Existence & Uniqueness.

UNIT-II

Algebraic closure, Algebraically closed fields. Finite fields, Existence of GF(p_n), Construction of finite fields. Separable and purely inseparable extensions, Perfect fields,

UNIT-III

Simple extensions, Primitive elements, Lagrange's theorem on primitive elements, Normal extensions, Roots of unity. Galois extensions, The fundamental theorem of Galois theory,

UNIT-IV

Cyclotomic extensions, Abelian extensions, cyclic extensions, Frobenius mapping, Galois groups of finite fields, Quintic equations and solvability by radicals, Constructive polygons.

Text & Reference Books:

S. No	**Name**	**Author(S)**	**Publisher**
1	A first course in Abstract Algebra	J.B. Fraleigh	Narosa Publishing House, New Delhi.
2	Abstract Algebra	D.S. Dummit and R. M. Foote	John-Wiely and Sons StudentsEdition-1999
3	Basic Abstract Algebra	P.B. Bhattacharya, S. K. Jain and S. R. Nagpal	Cambridge University Press, 1997
4	Modren Algebra	S. Singh and Q. Zameeruddin	Vikas Publishing House, New Delhi

Course Code	**MAT657**
Course Title	**Topology**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B. Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics.
Course Outcomes(CO)	At the end of the course, students will be able to: 1. Demonstrate an understanding of the concepts of topological spaces and basic definitions of operators and neighborhood and their roles in mathematics 2. Prove basic results about completeness, compactness, connectedness and convergence within these structures. 3. Demonstrate an understanding of the concepts of Hausdroff spaces.

UNIT-I

Topological Spaces, Examples of topological spaces**:** the product topology, the metric topology, the quotient topology Topological Spaces, Basic concept, closure, interior, exterior and boundary of set, dense set, Closure operator and interior operator. Neighborhoods and neighborhood system.

UNIT-II

Bases for a topology, the subspace topology, Open sets, closed sets and limit points, closures, interiors, continuous functions, homeomorphisms.

UNIT-III

Separated sets, Connected sets, Connected and disconnected spaces, Connectedness on real line, locally connected space, Totally disconnected space, Compact space of the real line, limit point compactness, Heine-Borel Theorem, Local –compactness.

UNIT-IV

The Separation Axioms: The countability axiomsT_0, T_1, and T_2 spaces, examples and basic properties, Hausdorff spaces, Regularity, Complete Regularity, Normal Spaces, Normality, the Urysohn Lemma, the Urysohn Metrization Theorem, the Tietze Extension Theorem, the Tychonoff Theorem.

Text & Reference Books:

S. No	Name	Author(S)	Publisher
1	Elementary general Topology	T. O. Moore	Prentice-Hall
2	Topology	J. R. Munkres	Prentice-Hall
3	Introduction to Topology and Modern Analysis	G. F. Simmons	Tata McGraw-Hill Edition

Course Code	**MAT659**
Course Title	**Introduction to Special Functions**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.sc with Mathematics and B.A with Mathematics
Course Objective (CO)	To provide an introduction to the different Bessel's functions, Legendre's functions.
Course Outcomes(CO)	At the end of the course, students will be : 1. Familiar with various special functions 2. Able to use various methods to deal with the functions arisen in engineering and other sciences. 3. Able to use this knowledge to create various software.

UNIT-I

Bessel's functions of first and second kind, Recurrence relations, Generating functions, Trigonometric expansions, Asymptotic expansion, Neumann Expansion theory.

UNIT-II

Legendre's functions, Laplace integral for the Legendre Polynomials, Generating functions, Recurrence relations, Orthogonality, solution of Legendre's equations, Hermite Polynomials, Recurrence relations, Rodrigue formula.

UNIT-III

Hypergeometric function, solution of hypergeometric equation, Kummer function and it'sasymptotic expansion, Barnes Contour Integral,

UNIT-IV

Integral representation, Gauss Theorem, Kummer's theorem, Vandermonde's theorem.

Text & Reference Books:-

S. No.	**Name**	**Author(S)**	**Publisher**
1	The Special Functions and Their Approximation.	Y.P. Luke	Academic Press
2	Special Functions.	F. D. Rainville	Chelsea Pub Co
3	The Theory of Functions	E.C. Titchmarh	Oxford Science Publications

Course Code	**MAT661**
Course Title	**Fundamentals of Python**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	Basic knowledge of Programming
Course Objective (CO)	The objective of this course is to develop a basic understanding about the Python Concept
Course Outcomes(CO)	At the end of the course, students will be able to: 1. Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements. 2. Express proficiency in the handling of strings and functions. 3. Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets.

UNIT-I

Python Introduction, History of Python, Introduction to Python Interpreter and program execution, Python Installation Process in Windows and Linux, Python IDE, Introduction to anaconda, python variable declaration, Keywords, Indents in Python, Python input/output operations.

UNIT-II

Arithmetic Operators, Comparison Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Ternary Operator, Operator precedence.

UNIT-III

String, List, Tuple, Set, Dictionary (characteristics and methods), Conditional Statements (If, If-else, If-elif-else, Nested-if etc.) and loop control statements (for, while, Nested loops, Break, Continue, Pass statements)

Unit-IV

Introduction to functions, Function definition and calling, Function parameters, Default argument function, Variable argument function, in built functions in python, Scope of variable in python. Concept of Files, File opening in various modes and closing of a file, Reading from a file, Writing onto a file, some important File handling functions e.g open( ), close( ), read( ), readline ( ) etc.

Text & Reference Books

S. No.	Name	Author(s)	Publisher
1.	Fundamentals of Python:	Kenneth Lambert	Course Technology,
2.	Learning Python	O' Reilly	Mark Lutz
3.	Python Programming: An Introduction to Computer Science 2nd Edition	John Zelly	Mark Lutz

Course Code	**MAT663**
Course Title	**Applications of ICT Tools in Research**
Type of course	(Minor) SEC
L T P	2 0 0
Credits	2
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To understand the philosophy of science and ethics, research integrity and publication ethics. To identify research misconduct and predatory publications. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.). To understand the usage of plagiarism tools
Course Outcomes (CO)	At the end of the course the student will have awareness about the publication ethics and publication misconducts

UNIT I

Introduction of MOOC and Open Source LMS, LMS Activities and Resources. MOOC (NPTEL, Spoken Tutorials, e-PG Pathshala, Coursera, eDX, Udemy, Unacademy)

UNIT- II

Awareness of Academic Social Networking Sites (Academia.edu, Research Gate, Linkedin, Google Scholar, ORCID)

UNIT-III

Reference Management Software (Zotero, Mendeley, EndNote), Scholarly writing using Ms-Word.

UNIT-IV

ICT Tools for Academics : Google Slides, Google Meet, Google forms and Certify'em, Google Sites, Concept of OER and FOSS for education, Plagiarism Tools, Understanding Creative commons - Handling copyright for online resources / Courses.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Thesis and assignment writing,	Anderson B.H., Dursaton, and Poole M.:	Wiley Eastern 1997
2	Research Design and Methods	Bordens K.S. and Abbott, B	Mc Graw Hill, 2008
3	The Student's Guide to Research Ethics	Paul Oliver	Open University Press, 2003
4	Research Methods – A Process of Inquiry	Graziano, A., M., and Raulin, M. L.	Sixth Edition, Pearson, 2007

Course Code	**RM655**
Course Title	**Publication and Research Ethics**
Type of course	Minor (SEC)
L T P	2 0 0
Credits	2
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To understand the philosophy of science and ethics, research integrity and publication ethics. To identify research misconduct and predatory publications. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.). To understand the usage of plagiarism tools
Course Outcomes (CO)	At the end of the course the student will have awareness about the publication ethics and publication misconducts

UNIT I

Introduction to philosophy: definition, nature and scope, concept, branches - Ethics: definition, moral philosophy, nature of moral judgements and reactions.

UNIT II

Ethics with respect to science and research - Intellectual honesty and research integrity - Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP) - Redundant Publications: duplicate and overlapping publications, salami slicing - Selective reporting and misrepresentation of data.

UNIT III

Publication ethics: definition, introduction and importance - Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. - Conflicts of interest - Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types - Violation of publication ethics, authorship and contributor ship - Identification of publication misconduct, complaints and appeals - Predatory publisher and journals.

UNIT VI

Indexing databases, Citation databases: Web of Science, Scopus, etc. Research Metrics (3 Hrs.): Impact Factor of journal as per Journal Citations Report, SNIP, SJR, IPP, Cite Score - Metrics: h-index, g index, i10 Index, altmetrics.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Thesis and assignment writing,	Anderson B. H., Dursaton, and Poole M.:	Wiley Eastern 1997
2	Research Design and Methods	Bordens K. S. and Abbott, B	Mc Graw Hill, 2008
3	The Student's Guide to Research Ethics	Paul Oliver	Open University Press, 2003
4	Research Methods – A Process of Inquiry	Graziano, A., M., and Raulin, M. L.	Sixth Edition, Pearson, 2007

Course Code	**MAT665**
Course Title	**Statistical Lab**
Type of course	Major
L T P	0:0:4
Credits	2
Course prerequisite	B.sc with Mathematics and B.A with Mathematics
Course Objective	To provide an introduction to the different classical statistical tools and techniques
Course outcome	At the end of the course, students will be able to: 1. Tackle big data and draw inferences form it by applying appropriate statistical techniques. 2. Apply this knowledge in various experimental and industrial applications. 3. Apply the skill gained to perform experiments in higher studies/research

PRACTICAL/ LAB WORK

List of Practical

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Fitting of polynomials, exponential curves
7. Karl Pearson correlation coefficient
8. Partial and multiple correlations
9. Spearman rank correlation with and without ties.
10. Correlation coefficient for a bivariate frequency distribution
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

Text and Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Fundamentals of Statistics	Goon A.M., Gupta M.K. and Dasgupta B.	Vol. I & II, 8th Edn. The World Press, Kolkata.
2	Mathematical Statistics with Applications	Miller, Irwin and Miller, Marylees	Pearson Education, Asia.
3	Introduction to the Theory of Statistics	Mood, A.M. Graybill, F.A. and Boes, D.C.	Tata McGraw-Hill Pub. Co. Ltd.

Course Code	**MAT667**
Course Title	**Dissertation –I**
Type of course	Major
L T P	0: 0: 4
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective	The dissertation would develop scientific aptitude, reviewing of literature, critical thinking, hypothesis development, experiment planning, synopsis writing, problem presentation and way to solve the problem.
Course Outcomes	At the end of the course, students will be able to: 1. Explore research aptitude & practical ability of knowledge gained by student in understanding the basics of research 2. Develop critical thinking through the detailed review of literature comprehend expertise for writing the research reports in form of review article as well as research publications. 3. Analyze & generate experimental skills towards the industrial applications. 4. Equipped for the industrial outreach through the experimental knowledge gained through project work.

- The supervisor would be allocated at the start of the semester and research work would be undertaken in discussion with the supervisor.
- Evaluation of Dissertation-I will be based on the submission of synopsis and approved research objectives through DRC.

Course Code	**MAT669**
Course Title	**Seminar**
Type of course	Minor (SEC)
L T P	0: 0: 2
Credits	2
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective	The project would develop scientific aptitude, reviewing of literature, critical thinking, hypothesis development, experiment planning, synopsis writing, problem presentation and way to solve the problem.
Course Outcomes	At the end of the course, students will be able to: 1. Analyze current literature research for research topic of his/her area of expertise. 2. Design a research problem and prepare synopsis. 3. Plan future experiments in the laboratory.

- Supervisor would be allocated at the start of the semester and research work would be undertaken in discussion with the Supervisor.
- Conduct the literature survey of the topic/project allotted.
- Regular evaluation of dissertation progress will be done through regular seminars and presentations as per the schedules.
- At the end of the semester the student has to prepare a synopsis (including approved objectives of the research) as per the university guidelines.
- Upon submission of the synopsis, the synopsis would be evaluated based on a presentation before the departmental committee.

Semester-IV

Course Code	**RM654**
Course Title	**Advances in Research Methodology in Physical and Mathematical Sciences**
Type of course	Major
L T P	4 1 0
Credits	5
Course prerequisite	B. Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To understand the philosophy of science and ethics, research integrity and publication ethics. To identify research misconduct and predatory publications. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.). To understand the usage of plagiarism tools
Course Outcomes (CO)	At the end of this course, the students should be able to: 1. understand some basic concepts of research and its methodologies. 2. Identify appropriate research topics. 3. Select and define appropriate research problem and parameters

UNIT-I

Statistics in Research, Percentages, Frequency distribution, Averages, Measures of central tendency, Arithmetic means, Median, Mode, Geometric Mean, Harmonic Mean, Dispersion, Range, Mean Deviation, Standard Deviation, Root mean square deviation, variance, moments.

UNIT-II

Basic Statistical Distributions and their applications: Binomial, Poisson, Normal, Exponential, Weibull and Geometric Distributions.

UNIT-III

Sample size determination & sampling techniques: Random sampling, stratified sampling, systematic sampling and cluster sampling. Large Sample Tests and Small Sample Tests: Student t-test, F-test and $\chi 2$ test and their applications in research studies.

UNIT-IV

Correlation and Regression Analysis-Time series analysis: Forecasting methods. Principles of Experimentation, Sampling Design - Different Types of Sampling Design - Simple Random Sampling – Stratified Random Sampling - Systematic Sampling - Cluster Sampling - Area Sampling - Multistage Sampling.

Text & Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Research Methodology	C.R. Kothari	New Age International
2	Business Research Methods	Alan Bryman & Emma Bell	Oxford University Press
3	Research Methodology	Sinha, S.C. and Dhiman, A.K.	ESS ESS Publications
4	An introduction to Research Methodology	Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K.	RBSA Publishers
5	Intellectual property right	Deborah, E. Bouchoux	Cengage Learning

Course Code	**MAT652**
Course Title	**Fourier Series and Integral Equations**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To acquaint the students with the application of Laplace, Fourier transform and integral equations.
Course Outcomes(CO)	At the end of this course, students will be able to: 1. Solve problems using mathematics in unfamiliar settings. 2. engage in analyzing, solving, and computing real-world applications. 3. use mathematical concept while solving various problems of Engineering.

UNIT-I

Fourier Series, Half range Fourier sine series, half range Fourier cosine series, Euler's formula.

UNIT-II

Fourier Transform: Definition, existence and basic properties, Inversion formula of Fourier transform Convolution theorem, Parseval's relation. Fourier transform of derivatives and integrals, Fourier sine and cosine transform, Inverse Fourier transform, Solution of linear ordinary differential equations and partial differential equations.

UNIT-III

Linear integral equations, Special types of kernels, Singular integrals equations, Connection of integral equations with differential equations, Integral equations of the convolution type.

UNIT-IV

Solution of Fredholm Equations with iterated kernel, Fredholm Equations with general kernel: Solution by the method of successive approximations, adomian decomposition method, Volterraintegral equations: Solution by the method of successive approximations, adomian decomposition method.

Text & Reference Books:

S. No.	Name	Author(S)	Publisher
1	Integral Equations	B.L. Moiseiwitsch	Pitman press, Bath Ltd.
2	Fourier series and Integral Transform	A. Pinckusand S. Zafrany.	Cambridge University Press
3	The Classical Theory of Integral Equations: A Concise Treatment.	S. M. Zemyan	New York: Birkh*a*user
4	A First Course in Integral Equations.	A.M. Wazwaz	World Scientific

Course Code	**MAT654**
Course Title	**Functional Analysis**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B. Sc. with Mathematics and B.A with Mathematics
Course Objective (CO)	This course is an introduction to Banach Spaces and Hilbert Spaces along with various operators/functional so as to enable the students to study advanced topics in Functional Analysis
Course Outcomes(CO)	At the end of the course, students will be able to: 1. Understand the Banach spaces and transformation on Banach spaces 2. Prove Hahn Banach theorem and open mapping theorem 3. Describe operators and fundamental theorems 4. Able to apply of topological approach in the study of solutions of Difference Equations in different boundary value problems arising in Biological and Ecological systems and different engineering problems. 5. Use of topological concepts in Architecture Engineering.

UNIT-I

Normed Linear Spaces, L P -Spaces: Holder's And Minkowski's Inequalities, Banach Spaces, Subspaces, Quotient Spaces, Convergence And Completeness, Hahn Banach Theorem, Open Mapping Theorem, Closed Graph Theorem, Baire Category Theorem, Banach Steinhauns Theorem (Uniform Boundedness Principle), Boundedness and Continuity Of Linear Transformation, Riesz-Fischer Theorem

UNIT-II

Projections on a Hilbert space: Spectral Theorem for normal operators, Compact linear operators on normed spaces, properties of Compact linear operators.

UNIT-III

Natural Embedding N into N^{**} :Dual Spaces, embedding in second dual. The conjugate space N*.The Hahn-Banach theorem and its consequences. Natural imbedding of N into N**, reflexivity of normed spaces, Open mapping theorem.

UNIT-IV

Hilbert and Banach Spaces: Hilbert space, orthonormal basis, Bessel's inequality, Riesz Fischer theorem, Parseval's identity, bounded Linear functionals; projections, Riesz Representation theorem, adjoint operators, self adjoint, normal, unitary and isometric operators.

Text & Reference books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Functional analysis	P K Sharma	Sharma publications
2	Functional Analysis	P K Jain, O P Ahuja	New Age International (P) Khalil Ahmed Ltd
3	Functional analysis	V Balmohan	New Age International Limited

Course Code	**MAT656**
Course Title	**Mathematical Methods**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective (CO)	To acquaint the students with the application of Laplace, Fourier transform and integral equations.
Course Outcomes (CO)	At the end of this course, students will be able to: 1. Understand the theory and applications of integral transforms. 2. Explain how integral transforms can be used to solve a variety of differential equations. 3. Familiarized with the notion of mathematical modelling and some basic mathematical models.

UNIT-I

Laplace Transform: Definition, existence and basic properties of the Laplace transform, Inverse Laplace transform, Convolution theorem, Laplace Transform solution of linear differential equation and simultaneous linear differential equation with constant coefficients, Complex inversion formula.

UNIT-II

Fourier Transform: Definition, existence and basic properties, Inversion formula of Fourier transform Convolution theorem, Parseval's relation. Fourier transform of derivatives and integrals, Fourier sine and cosine transform, Inverse Fourier transform, Solution of linear ordinary differential equations and partial differential equations.

UNIT-III

Mathematical Modelling, Simple situations requiring mathematical modelling, Characteristic of mathematical modelling, Mathematical Modelling through differential equations.

UNIT-IV

Linear Growth and Decay Models, Non-linear Growth and Decay Models, Mathematical Modelling through system of ordinary differential equations of the first order, Prey Predator Models.

Text & Reference Books

S. No	**Name**	**Author(S)**	**Publisher**
1	Integral Equations	B.L. Moiseiwitsch	Pitman press, Bath Ltd.
2	Fourier series and Integral Transform	A. Pinckusand S. Zafrany.	Cambridge University Press
3	The Classical Theory of Integral Equations: A Concise Treatment.	S. M. Zemyan	New York: Birkh*a*user
4	A First Course in Integral Equations.	A. M. Wazwaz	World Scientific

Course Code	**MAT658**
Course Title	**Fractional Calculus**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	Differential Equations (Ordinary and Partial), Mathematical Methods
Course Objective (CO)	The objective of this course to cover the basics of the fractional calculus, or more aptly called the calculus of derivatives and integrals to an arbitrary order. Then introduce the concept of fractional differential equations and consider some of their applications. Also, study the numerical solution of fractional differential equations
Course Outcomes(CO)	At the end of the course, the students will be able to: 1. understand the Riemann-Liouville fractional integral and evaluate fractional integrals of some common functions 2. define the Riemann-Liouville and Caputo fractional derivatives and find the fractional derivatives of some common functions 3. state sufficient conditions under which the fractional integrals and derivatives exist 4. investigate some applications of the fractional calculus to the real world. 5. solve linear fractional differential equations using the Laplace transform and Fourier Transforms

UNIT-I

Special Functions of the Fractional Calculus. Gamma Function. Mittag-Leffler function, Fractional Derivatives and Integrals. Grunwald-Letnikov Fractional Derivatives. Riemann Liouville Fractional Derivatives. Some Other Approaches.

UNIT-II

Geometric and Physical Interpretation of Fractional Integration and Fractional Differentiation. Sequential Fractional Derivatives. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms of Fractional Derivatives. Mellin Transforms of Fractional Derivatives.

UNIT-III

Linear Fractional Differential Equations. Fractional Differential Equation of a General Form. Existence and Uniqueness Theorem as a Method of Solution. Dependence of a Solution on Initial Conditions. The Laplace Transform Method. Standard Fractional Differential Equations. Sequential Fractional Differential Equations.

UNIT-IV

Other Methods for the Solution of Fractional-order Equations. The Mellin Transform Method. Power Series Method. Babenko's Symbolic Calculus Method. Numerical Evaluation of Fractional Derivatives. Approximation of Fractional Derivatives.

Text & Reference books:-

S.No	**Name**	**Author(S)**	**Publisher**
1	Matrix approach to discrete fractional calculus	I. Podlubny	Fractional Calculus and Applied Analysis
2	Fractals and fractional calculus in continuum mechanics	A. Carpinteri, F. Mainardi	Springer-Verlag
3	An introduction to the fractional calculus	Miller K.S., Ross B	John Wiley
4	The fractional calculus	K. B. Oldham, J. Spanier	Academic Press

Course Code	**MAT660**
Course Title	**Advanced Numerical Analysis**
Type of course	Major (DSE)
L T P	4 0 0
Credits	4
Course prerequisite	B.sc with Mathematics and B.A with Mathematics
Course Objective (CO)	To provide an introduction to the different advanced classical numerical methods.
Course Outcomes(CO)	At the end of the course, the students will be able to: 1. Apply the knowledge of advanced numerical methods in order to solve different types of problems viz. linear systems, ordinary and partial differential equation arising in various field of applications for example in science, engineering and economics etc. 2. Select and implement an appropriate numerical method for solving a given problem keeping in mind nature of the problem. 3. Extend their knowledge to do research work on these methods and similar type of other methods.

UNIT-I

Finite difference approximation to partial derivatives, parabolic equations: An explicit method, crank Nicolson Implicit method, solution of implicit equations by Gauss Elimination, derivative boundary conditions, local truncation error, Convergence and stability.

UNIT-II

Hyperbolic equations: Implicit difference methods for wave equation solution of advection equation by finite difference method and Maccormack method, stability analysis, Lax, Wendroff explicit method on rectangular mesh for 1st order equations, Iterative methods for elliptic equations.

UNIT-III

Finite element methods: Rayleigh Ritz Method, the collocation and Galerkin's Method, finite element methods for ODE's.

UNIT-IV

Finite element methods for one dimensional and two dimensional problems, Introduction to F. E. M. for partial differential equations.

Text &Reference Books:-

S.No	**Name**	**Author(S)**	**Publisher**
1	Numerical Solution of Partial Differential Equations	G. D. Smith	Oxford University Press, U.S.A
2	Friendly Introduction to Numerical Analysis	B. Bradie	Pearson
3	An Introduction to Finite Element Methods	N. Reddy	McGraw Hill Education

Course Code	**MAT662**
Course Title	**Introduction to R Programming**
Type of Course	Major (DSE)
L T P	4 0 0
Credits	4
Course Prerequisites	Statistical analysis
Course Objective(s)	This subject gives an overview of Statistical analysis, graphics representation and reporting.
Course Outcomes (CO)	At the end of the course, the students will be able to: 1. Access online resources for R and import new function packages into the R workspace. 2. Import, review, manipulate and summarize data-sets in R. 3. Explore data-sets to create testable hypotheses and identify appropriate statistical tests.

UNIT-I

Overview of R Programming, Downloading and installing, Help of Function, Viewing documentation, General issues in R, Package Management, Data Types, Subsetting, Writing data, Reading from csv files, Creating a vector and vector operation, Initializing data frame, Control structure, Re-directing R Output.

UNIT-II

Creating bar chart and dot plot, Creating histogram and box plot, Plotting with base graphics, Plotting and coloring in R, Computing Basic Statistics, Comparing means of two samples, Testing a proportion, Data Munging Basics.

UNIT-III

Flow control: For loop, If condition, Debugging tools, List Management, Data Transformation, Merging Data Frames, Outlier Detection, Combining multiple vectors.

UNIT-IV

Performing queries, RODBC and DBI Package, Advanced Data handling, Combined and restructuring data frames, Logical Regression, Hierarchical Clustering PCA for Dimensionality Reduction.

Text & Reference Books:

S. No	Name	Author(S)	Publisher
1	The R Student Companion	Dennis, B. (2013)	Taylor & Francis Group
2	R for Everyone: Advanced Analytics and Graphics	William. Lander, J. P.	Addison- Wesley Data
3	The Art of R Programming	Matloff, N.	Statistical Software Design

Course Code	**MAT664**
Course Title	**Numerical Analysis LAB**
Type of course	Major (Practical)
L T P	0 0 2
Credits	2
Course prerequisite	B.sc with Mathematics and B.A with Mathematics
Course Objective (CO)	To provide an introduction to the different advanced classical numerical methods.
Course Outcomes(CO)	At the end of the course, students will be able to: 1. Identify the challenging problems in continuous mathematics (which are difficult to deal with analytically) and find their appropriate solutions accurately and efficiently using computer codes. 2. Develop, select and apply numerical methods as a computer code with the understanding of their limitations so that they can be implemented in order to get acceptable results. 3. Understand different implementation modes of a numerical method in order to solve a given problem efficiently.

The following programs of following methods are to be practiced:
1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Jacobi's method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. To evaluate definite integrals by using Gaussian Quadrature.
9. To evaluate double integrals by using Trapezoidal and Simpson method.
10. To compute the solution of ordinary differential equations with Taylor's series method.
11. To compute the solution of ordinary differential equations by using Euler's method.
12. To compute the solution of ordinary differential equations by using Runge -Kutta methods.

Text &Reference Books:-

S. No	**Name**	**Author(S)**	**Publisher**
1	Applied Numerical Analysis using MATLAB	Fausett, L.V.,	Pearson Prentice Hall
2	Numerical Methods using MATLAB	Mathews, J.H. and Fink, K.D.	Pearson Prentice Hall,
3	Numerical Analysis	Conte, S.D. and Boor, C.D.,	McGraw Hill

Course Code	**MAT666**
Course Title	**Dissertation –II**
Type of course	Major
L T P	0: 0: 8
Credits	8
Course prerequisite	B.Sc. with Mathematics or B.A with Mathematics
Course Objective	The dissertation would develop scientific aptitude, reviewing of literature, critical thinking, hypothesis development, experiment planning, synopsis writing, problem presentation and way to solve the problem.
Course Outcomes	At the end of the course, students will be able to: 1. Explore research aptitude & practical ability of knowledge gained by student in understanding the basics of research 2. Develop critical thinking through the detailed review of literature comprehend expertise for writing the research reports in form of review article as well as research publications. 3. Analyze & generate experimental skills towards the industrial applications. 4. Equipped for the industrial outreach through the experimental knowledge gained through project work.

- The supervisor would be allocated at the start of the semester and research work would be undertaken in discussion with the supervisor.
- At the end of the semester the student has to prepare a dissertation as per the university guidelines/ format.
- Upon submission of the dissertation, the dissertation would be evaluated based on a presentation through institutional RDC members.

Course Code	**RM656**
Course Title	**Scientific and Technical Writing**
Type of course	Minor
L T P	0 0 2
Credits	2
Course prerequisite	B.Sc. with Mathematics and B.A with Mathematics
Course Objective (CO)	This course will help you write well-researched, organized, and correctly documented research papers.
Course Outcomes(CO)	At the end of the course, students will be able to: 1. Find research resources, such as online resources (research databases, reference lists), and campus resources (writing centers, research librarian help) 2. Evaluate the credibility of research sources, especially the online resources 3. Find reference articles including scholarly articles from journals and news articles from foreign and domestic news sources 4. Learn strategies to avoid plagiarism and academic dishonesty such as using APA/MLA citation styles preparing a bibliography (references list), etc.

UNIT-I

Introduction to Technical Writing, what is research? , how do you structure a research paper? Basic Principles in Technical Writing: (Audience, Purpose, Organization, Flow, Style, Presentation)

UNIT-II

Introduction to text analysis tools: analyzing research paper biographies, Writing a research paper abstract: choosing between indicative and informative abstracts Writing a research paper title: keywords, noun phrases, and prepositions.

UNIT-III

Writing a research paper introduction: characteristic features and structure of introductions, explaining the situation, describing problems/limitations, describing the response,

UNIT-IV

Writing a research paper results section: deciding the type of visual aid, explaining figures and tables, Writing a research paper discussion/conclusion section: summarizing results, adjusting the strength of interpretations using hedging.

Text Books:

S. No	**Name**	**Author(S)**	**Publisher**
1	Thesis and assignment writing,	Anderson B.H., Dursaton, and Poole M.:	Wiley Eastern 1997
2	Research Design and Methods	Bordens K.S. and Abbott, B	Mc Graw Hill, 2008
3	The Student's Guide to Research Ethics	Paul Oliver	Open University Press, 2003
4	Research Methods – A Process of Inquiry	Graziano, A., M., and Raulin, M.,L	Sixth Edition, Pearson, 2007