Detailed Syllabus

For

M.Sc. I (MATHEMATICS)

Or

B.Sc. (Research) MATHEMATICS

COURSE-I : Abstract Algebra

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: 0720301	**Course Title: Abstract Algebra**	**Theory**

Course Objectives: Acquiring ability for defining algebraic structures, constructing substructures, analyzing a given structure, developing new structures based on given structures, and comparing structures.

Course Outcomes (CO's):

CO1. Ability to solve non-trivial problems based on various concepts in the course.

CO2. Determining the connection and transit amid formerly studied mathematics (discrete mathematics) and advanced mathematics (advanced abstract mathematics).

CO3. Ability to apply abstract algebra to solve problems in other branches of mathematics and also in other disciplines.

CO4. Describing relationship between Abstract Algebra and other courses in mathematics.

CO5. Understanding the dependency of results based on earlier results, and thereby developing a correct approach towards life realizing the deep connection among past, present and future. For example, in ring theory, the ring of polynomials over a field is a gift of the division algorithm.

CO6. Possessing pre-requisites for pursuing research in Cryptography

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4--0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definitions of a group, Subgroups, Cyclic group, Permutation group, Even and odd permutation; statement of Cayley's theorem, Lagrange's theorem; definitions of Normal subgroup, Quotient group, Ring, Subrings, Integral domain and field, Ideal and quotient ring, automorphism, inner automorphism, Polynomial ring over commutative ring, definition of division algorithm, principal ideal domain, Reducibility tests, Irreducibility tests, Eisenstein criterion. Unique factorization domains, Euclidean domain	15
II	Cauchy's theorem for finite abelian group, Cauchy's theorem for an arbitrary finite group, Fundamental theorem on homomorphism of groups, Second and third law of isomorphism of groups, Maximal subgroup, Composition series, Jordon Holder's theorem, Subnormal and normal series, Solvable groups, Characteristic property of solvable groups	15

III	Direct products, External Direct products, Internal Direct products, Sylow p-subgroups, Sylow's first theorem, Double cosets, Sylow's second and third theorem, Applications of Sylow's theorem.	**15**
IV	The fundamental theorem on finite abelian groups, Invariants of finite abelian groups, Isomorphic abelian groups of order p^n, non-isomorphic abelian groups of order p^n, Decomposable groups. Imbedding of rings, Field of quotients of an integral domain, Maximal Ideal,. Field extensions, Finite field extensions, Simple field extensions, Algebraic and transcendental extensions, Minimal polynomial, Remainder theorem, Factor theorem.	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **David S. Dummit & Richard M. Foote:** Abstract Algebra, Wiley, 3rd Edition, 2011
2. **Joseph A. Gallian:** Contemporary Abstract Algebra 9th Edition, 2019.
3. **Khanna, Vijay K & Bhambri, S K** A Course in Abstract Algebra, S Chand and Company Ltd; Fifth edition (2022)
4. **Herstein, I.N.: Topics in Algebra**, Wiley, 2nd Edition, 2006.
5. **Bhattacharya, P.B., Nagpaul, S.K.** Basic Abstract Algebra (2nd Edition) Cambridge University Press, Indian Edition, 1997.
6. **Lang, S.:** Algebra, Pearson Education 3rd Edition, 1992
7. **J. B. Fraleigh** : A first course in Abstract Algebra.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-II : Real Analysis

Programme/Class: M.Sc.	Year: P.G. Ist Year or UG in Research Fourth Year	Semester: First/Seventh
Course Code: 0720302	**Course Title: Real Analysis**	**Theory**

Course Objectives:
This course puts forward some basic concepts of real-valued functions and its applications. The purpose of this course is to provide a foundation for understanding the different branches of mathematics.

Course outcomes:

CO1. To provide a topological study of real-valued functions.
CO2. To study the concepts of convergence and uniform convergence of series and sequence of real-valued functions and their applications.
CO3. To provide the methods for finding the maxima and minima values of multivariate real-valued functions with their applications.
CO4. To study the concept of integrability of real-valued functions over the closed and bounded interval and their applications in different areas, such as quantum physics.
CO5. This course gives a wide study of different concepts of functions of serval variables, such as limit and continuity, differentiability, partial differentiability and integrability.
CO6. This course lays a foundation to study other important courses such as functional analysis, complex analysis and differential equations. This course plays a central role to get the employment for the students because it is available with a great importance in the syllabi of different competitive exams

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definition and existence of Riemann-Stieltjes integral. Properties of the integral, integration and differentiation, The fundamental theorem of calculus, and Integration of vector-valued functions.	15
II	Sequences and series of functions. Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Uniform convergence and continuity, Uniform convergence and Riemann-Stieltjes integration, Uniform convergence and differentiation, Weierstrass Approximation Theorem.	15
III	Power series, Algebra of power series, Uniqueness theorem for power series. Abel's and Tauber's theorems.	15
IV	Functions of several variables, Linear transformation, Derivatives in an open subset of R^n, Chain rule, Partial derivatives, Interchange of the order of differentiation.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Apostol, T. M.:** Mathematical Analysis, Narosa Publishing, New Delhi, 1985

2. **Brown. W., Churchill ,R.V.,** Fourier Series and Boundary Value Problems, 8th 3rd Edition, 2015, McGraw Hill Education, New Delhi
3. **Royden, H. L.:** Real Analysis, (4th Edition), Macmillan Publishing Co. Inc. New York, 1993.
4. **Rudin, W.:** Principles of Mathematical Analysis, (3rd edition) McGraw-Hill, Kogaku Sha, 1903, International student edition.
1. **White, J.:** Real Analysis, An Introduction, Addison-Wesley Publishing, Co. Inc., 1968.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-III : Advanced Differential Equation

Programme/Class: M.Sc.	Year: P.G. Ist Year or UG in Research Fourth Year	Semester: First/Seventh
Course Code: 0720303	**Course Title: Advanced Differential Equation**	**Theory**

Course Objectives:

1. To explore the basic ideas of Differential Equations combined with some real-life problems
2. Differential equations are very important in the mathematical modeling of physical systems.
3. Many fundamental laws of physics and chemistry can be formulated as differential equations.
4. In biology and economics, differential equations are used to model the behavior of complex systems.
5. Ordinary Differential Equations are used to calculate the movement or flow of electricity, motion of an object to and fro like a pendulum, to explain thermodynamics concepts.

Course outcomes:

CO1. The use of the differential equation theory is to solve various types of Mathematical modeling problems.
CO2. The use of the differential equation theory is to solve many problems presented in different sciences such as Biology, Chemical sciences and Physics.
CO3. The use of this theory is to solve many real-life based problems such as population problem, control problems and networking security problems etc.
CO4. This theory can solve many engineering problems such as the exact trajectory path of a rocket or a missile.
CO5. Students will be able to formulate and solve differential equations arising from changes in physical world.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4--0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Ordinary Differential Equations (ODEs), General theory of homogenous and non-homogeneous linear ODEs, System of first order ODEs, The method of variation of parameters, Wronskian, Sturm-liouville boundary value problem, Picard's method of successive approximation, Picard's Theorem.	15
II	Ordinary points, Singularities, Regular and Irregular singular points, Series solutions about ordinary points, Frobenius series solution Green function.	15
IV	Origin of first order Partial Differential Equations (PDEs), Lagrange method for solving first order PDEs, Integral surfaces passing through a given curve, Surface orthogonal to a given system of surface, Non-linear PDEs of the first order, Charpit's method for first order PDEs, Jacobi Mathod, Cauchy problem for first order PDEs, Origin of second order partial differential equation and their classification, linear PDEs with constant and variable coefficients.	15

V	General solution of higher order PDEs with constant coefficient, Diffusion, Wave and Laplace equations by the method of separation of variables, Reduction of second order partial differential equation into its canonical form, Non-linear partial differential equations of second order.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Coddington, Earl A. & Levinson, Norman:** Theory of Ordinary Differential equations, Tata McGraw-Hill Publication.
2. **Rai,B., Chaudhary ,D.P. and Freedman, H.I.:** A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi 2013.
3. **Simmons, G.F.:** Differential Equations with Applications and Historical Notes, Second Edition, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi (2017).
4. **Sneddon, Ian:** Elements of Partial Differential Equation, McGraw-Hill Book Company.
5. **Wirkus Stephen A, & Swift , Randall J.**: A Course in Ordinary Differential Equations 1st Edition, CRC Press, Taylor & Francis Group, 2015.
6. **Ross. S. L.:** Differential Equations, 3rd Edition, Wiley. (1980)

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

COURSE-IV : Metric Space

Programme/Class: M.Sc.	Year: P.G. Ist Year or UG in Research Fourth Year	Semester: First/Seven
Course Code: 0720304	**Course Title: Metric Space**	**Theory**

Course Objectives:

The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others; to introduce the theory of metric and topological spaces; to show how the theory and concepts grow naturally from idea of distance; to be able to give examples which show that metric spaces are more general than Euclidean spaces; to be able to work with continuous functions, and to recognize whether spaces are connected, compact or complete. Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

Course outcomes:

CO1: To show how the theory and concepts grow naturally from idea of distance

CO2: Differentiate between functions that define a metric on a set and those that do not.

CO3: Use the Banach fixed point theorem to demonstrate the existence and uniqueness of solutions to differential equations

CO4: Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty

CO5: Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

CO6: Understand sequentially compact spaces, Countable compactness, BWP and compactness and explain the relation between the three types of compactness in metric spaces.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4--0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Metric Space: Metric on a set, pseudo-metrics and metrics Distance between two sets. Equivalent metrics. Limit points and closure: closed sets, Derived set of a set. Adherent points and closure of a set, Dense subsets, Interior of a set and its properties, Subspaces, Product spaces, Structure of Open balls in a product space. Closures and interiors in a product space, Finite product of metric spaces.	15
II	Convergent sequences. Cauchy sequences. Characterization of adherent points and limit points in terms of convergent sequences. Convergence in products. Convergence in Euclidean spaces. Cluster points of a sequence. Subsequences. Cluster points and convergent subsequences. Algebra of convergent real sequences. Spaces of sequences.	15

III	Continuity at a point. Continuity over a space. Continuity of composite, graph and projection maps. Algebra of real valued continuous functions in a metric space. Homeomorphisms. Isometries. Relation between isometries and Homeomorphism. Uniform continuity. Complete metric spaces. Completeness and Continuous mappings. Completeness and subspaces. Cantor's Intersection Theorem. Contraction Mapping Principle. Connectedness: Connected metric spaces. Connected sets. Characterization of connected subsets of the real line. Properties of Connectedness	**15**
IV	Compact spaces and Compact subsets. Compact subsets of the real line. Sequential compactness and its characterization. Countable compactness, Bolzano-Weierstrass property. Sequential characterization of BWP. Equivalence of BWP and sequential compactness. Covering characterization of the BWP. Bolzano-Weierstrass Property and Total boundedness. BolzanoWeierstrass Property and compactness. Lebesgue covering lemma. Compactness and completeness, Compactness and uniform continuity. Boundedness of continuous real-valued functions on compact metric spaces	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. **Copson, E.T:** Metric Spaces, Cambridge tracts, 2010. 2. **Dieudonne ,J.:** Foundation of Modern Analysis, Academic Press, New York, 1960. 3. **Kasriel ,R. H.:** Metric Spaces, Dover Publications, New York, 2009. 1. **Kumaresan S.** Topology of Metric Spaces, 2nd Edition, Narosa (2011).		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:.....		

Core-Elective Course -V : Mathematical Statistics		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester: Second**/Eight
Course Code: 0820305	**Course Title: Mathematical Statistics**	**Theory**

Course Objectives: The aim of this course is to extend and master students' knowledge of probability and statistical methods and to provide theoretical background for studying advanced statistical methods, Upon successful completion of this course, students will be able to study, correctly apply and interpret different statistical methods.

Course outcomes:

CO1: Explore the basic ideas about measures of central tendency, dispersion and their applications in other statistical problems.

CO2: Explain the different types of discrete and continuous distributions and their utilization.

CO3: Tackle big data and draw inferences form it by applying appropriate statistical techniques.

CO4: Apply the knowledge of statistical techniques in various experimental and industrial requirements

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Probability: Set theoretic approach, Sample spaces, Events; Dependent and Independent events, The concept of Probability, Statistical or empirical definition, Conditional probability, Bay's theorem, Probability mass and density functions, Chebyshev's inequality.	15
II	Random variables, Distribution functions, Joint probability distribution function, Conditional distribution function, Probability density function, Expectation, Covariance, Variance of variables, standard discrete and continuous univariate distributions, standard errors, marginal and conditional distributions.	15
III	Basics concept of Moment generating function, Probability generating function and Universal generating function, Discrete distributions: Geometric, Bernoulli, Binomial, Poisson and uniform distributions, Continuous distributions: Normal, Exponential, Gamma, Chi-square, student's t and F, and Beta distributions.	15
IV	Curve Fitting, Correlation and regression: Curve fitting, The Method of Least Squares, fitting of a straight Line and second-degree Parabola, Correlation coefficients, Simple and multiple linear Regression, lines of regression, regression coefficient, Scatter diagram, test for slop and correlation	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Rohatgi, V.K., Saleh, A.K. Md. Ehsanes:** An Introduction to Probability and Statistics, Second Edition Wiley-Inderscience. (2008)
2. **Kennedy and Gentle:** Statistics Computing, Published by CRC Press. (2021)
3. **Mayer, P.L.**: Introductory Probability and Statistical Applications, IBH. 2nd Edition (1970)
4. **Mood, A.M. and Graybill, F.:** Introduction to the Theory of Statistics, McGraw Hill Education; 3rd edition (2017).
1. **Hogg, R.V., Craig, A. and McKean, Joseph W.:** Introduction to Mathematical Statistics, Pearson Education, .8th Edition New Delhi (2019)

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective Course – II: Advance Numerical Analysis

Programme/Class: M.Sc.	**Year:** UG Research Fourth Year or P.G. I Year	**Semester:** First/Seventh
Course Code: 0720306	**Course Title: Advance Numerical Analysis**	Theory

Course Objectives:

This course aims to provide students with the techniques for finding approximate numerical solutions to mathematical problems for which exact or analytical solutions are unavailable or inappropriate. Successful students will have an appreciation of the difficulties involved in finding reliable solutions and will gain practical knowledge of how to apply the techniques and methods to specific problems such as finding roots of equations, quadrature and numerical solution of differential equations.

Course outcomes:

CO1. Apply their knowledge of computer programming to develop and implement their own computer codes of numerical methods for solving different types of complex problems viz. nonlinear equations, a system of linear equations, interpolation and extrapolation, initial and boundary value problems of ordinary differential equations, etc.

CO2. Find the solution of linear and nonlinear equations and solution of differential equations.

CO3. Demonstrate understanding of common numerical methods and how they are used to obtain approximate.

CO4: 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.

CO5:Identify use of spline interpolation and difference equations in numerical analysis

Credits: **4**	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Modified Newton-Raphson method. Convergence of Newton Raphson Method, Bairstow method. Graffe's root squaring method for polynomial equations. Matrix Inversion: Gauss Jordan Method, Triangularization Method, Choleski's Method.	15
II	Algebraic Eigen values and Eigen vectors: Power methods, Jacobi's method, Given's method, Householder's method, Q-R method; Approximation: Least square polynomial approximation, polynomial approximation using orthogonal polynomials, Legendre's approximation, Approximation with trigonometric functions, Exponential functions, Rational functions. Approximation by Chebyshev polynomials, Max-min principle.	15
III	Numerical Solutions of initial value problems, Picard's method, Taylor's method, Single and multistep methods, Euler's and modified Euler's method, Runge-Kutta second order method and statement of fourth order Runge Kutta methods, Milne's method, Adams-Bash forth method.	15
IV	Spline approximation, construction of cubic spline, application to differential equation by spline method, introduction to difference equation and method of solution to find y^H and y^P	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: 1. **Froberg, C.E.:** Introduction to Numerical Analysis, Addison-Wesley Pub. Co., 2016. 2. **Gupta, Radhey S.:** Elements of Numerical Analysis, Macmillan India Ltd. New Delhi, 2015. 3. **Jain, M.K., Iyengar, S.R.K and Jain, R.K.:** Numerical Methods for Scientific and Engineering Computations, New Age International (P) Ltd. New Delhi, 2014. 4. **Sastry, S.S.:** Introductory Methods of Numerical Analysis, UBS Publishers, 2012.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.
FurtherSuggestions: .....

COMPULSORY COURSE- I : Topology		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester: Second**/Eight
Course Code: 0820301	**Course Title: Topology**	**Theory**

Course Objectives:

The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others; to introduce the theory of metric and topological spaces; to show how the theory and concepts grow naturally from idea of distance; to be able to give examples which show that metric spaces are more general than Euclidean spaces; to be able to work with continuous functions, and to recognize whether spaces are connected, compact or complete.Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

Course outcomes:

CO1: To show how the theory and concepts grow naturally from idea of distance

CO2: Differentiate between functions that define a metric on a set and those that do not.

CO3: Use the Banach fixed point theorem to demonstrate the existence and uniqueness of solutions to differential equations

CO4: Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty

CO5: Metric spaces are vital prerequisites for many mathematics courses including Analysis, Topology, Measure Theory, Complex Analysis etc.

CO6: Understand sequentially compact spaces, Countable compactness, BWP and compactness and explain the relation between the three types of compactness in metric spaces.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighborhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases. Subspaces, product spaces and relative topology.	15
II	Continuous functions, homeomorphisms, the pasting lemma, Connected and disconnected sets, connectedness on the real line, components, locally connected spaces.	15
III	Countability axioms – First and second countable spaces, Lindelof's theorems, Separable	15

	spaces, second countability and separability. Separation axioms – T0, T1, T2, T3, T3½, T4, their characterizations and basic properties. Urysohn's lemma and Tcitze extension theorem, Statement of Urysohn's metrization theorem.	
IV	Compactness – Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness and one point compactification. Statements of Tychonoff's Product theorem and Stone-cech compactification theorem.	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. **Simmons, G. F:** Introduction to Topology and Modern Analysis, Tata McGraw Hill, India,2016 2. **Dieudonne ,J.:** Foundation of Modern Analysis, Academic Press, New York, 1960. 3. **Munkres. James.:** Topology, 2nd Edition, Pearson Education, 2021. 2. **Kumaresan S.** Topology of Metric Spaces, 2nd Edition, Narosa (2011).		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:.....		

COMPULSORY COURSE-II : Advanced Complex Analysis

Programme/Class: M.Sc.	Year: P.G. Ist Year or UG in Research Fourth Year	Semester: Second/Eight
Course Code: 0820302	Course Title: Advanced Complex Analysis	Theory

Course Objectives:
This course aims to provide an understanding of the basic facts of complex analysis, in particular the nice properties enjoyed by the derivatives and integrals of functions of a complex variable, and to show how complex analysis can be used to evaluate complicated real integrals via residue calculus.

Course outcomes:

CO1. Know the fundamental concepts of complex analysis.

CO2. Prove the Cauchy-Riemann equations and apply them to complex functions in order to determine whether a given continuous function is complex differentiable.

CO3. Extend their knowledge to pursue research in this field.

CO4. Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Complex integration, Regular Arc, Contour, Cauchy-Goursat theorem, Simply connected domains, Multiply connected domains, Cauchy's integral formula, An extension of the Cauchy's integral formula, Significance of Cauchy's integral formula, Morera's Theorem, Cauchy's inequality, Liouville's theorem and its applications, The fundamental theorem of Algebra, Maximum modulus principle.	15
II	Properties and classifications of bilinear transformations, Bilinear transformation as conformal mappings, Riemann- Mapping Theorem, Examples of conformal mappings, Meromorphic functions, Entire functions, Taylor's theorem and its applications, Laurent's Theorem and its applications.	15
III	Singularities, Categorization of Singularities using Laurent's series, Isolated singularities, Residues, Cauchy's residue theorem, Evaluation of integrals, Many valued functions, branch points, branch cuts and branches of many valued functions, and with special reference to arg z, log z and z^a, The argument principle, Rouche's theorem. Analytic continuation, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation.	15
IV	Canonical products, Jensen's formula, Poisson-Jensen formula, Hadamard's three circles theorem, Order of an entire function, Exponent of convergence, Borel's theorem, Hadamard's factorization Theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc
Suggested Readings: 1. **Ahlfors, L.V.:** Complex Analysis, McGraw Hill Education; 3rd Edition, 2017. 2. **Brown, J., Churchill, R.V.:** Complex Variable and Applications, McGraw-Hill Education; 9th Edition, 2013. 3. **Conway, J. B.:** Functions of One Complex Variable, Springer-Verlag, International student Edition, 2nd Edition, 1996. 1. **Priestly, H. A.:** Introduction to Complex Analysis, Oxford University Press, 2008.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions:.....

Compulsory Course – III : Number Theory

Programme/Class: M.Sc.	Year: UG Research Fourth Year or P.G. I Year	Semester: Second/Eight
Course Code: 0820303	**Course Title: Number Theory**	Theory

Course Objectives:

The aim of the course is to acquaint students with almost all basic concepts of number theory and to demonstrate applications of number theory. It will help students to grasp rigorous and tricky proofs of many important results that have been used by them from quiet long time. The students will learn the use of Chinese remainder theorem, Fermat's Theorem, Wilson's theorem, Lagrange theorem, Quadratic reciprocity, etc. It will supply methods to solve linear Diophantine equations, linear congruences, system of linear congruences, quadratic congruences, etc. Students will be able to detect the primality of a large integer. It will show how various number theoretic concepts and theorems are applicable in cryptography.

Course outcomes:

CO1.Identify the challenging problems in modern mathematics and find their appropriate solutions.

CO2. Formulate and prove conjectures about numeric patterns, and produce rigorous arguments centered on the material of number theory, most notably in the use of Mathematical Induction and/or the Well Ordering Principal in the proof of theorems.

CO3. Apply the knowledge of Number theory and Cryptography to attain a good mathematical maturity and enables to build mathematical thinking and skill.

CO4. Design, analyse and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	The division algorithm, Definition and theory of the GCD, Euclid's Lemma, Definition and theory of the LCM, the extended Euclidean algorithm, Distribution of primes, the fundamental theorem of arithmetic, The Sieve of Eratosthenes, The Goldbach conjecture, Consequences of Dirichlet theorem, Statement of Prime Number theorem, Solutions of word problems using the theory of linear Diophantine equation, Solution of simultaneous system of linear congruences.	15
II	Number Theoretic Functions: The number (τ), sum (σ), and product of the divisors, Multiplicative function, Möbius function, Morten's Lemma, The Möbius inversion formula and its applications, The greatest integer function, Legendre formula and its application.	15
III	The order of an integer modulo n and order of higher powers of the integer modulo n , Primitive roots for primes, Finding all primitive roots of a prime, Composite numbers having primitive roots, The theory of indices, Properties of index, Solutions of non-linear congruences, Euler's criterion, Solutions of quadratic congruences with prime moduli	15
IV	Pseudoprimes and absolute pseudoprimes, Perfect numbers, even perfect numbers, The Fibonacci sequence and its properties, Continued fractions: representation of rational number as a finite simple continued fraction, Solution of linear Diophantine equation by means of simple continued fractions	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: **1. Burton, David M.: Elementary Number Theory** (7th Edition), McGraw Hill Education, 2017. **2. Dudley U.: Elementary Number Theory** (2nd edition) Dover Publications, 2008. **3. E. George. Andrews: Number Theory,** Dover Publications, 1994.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation. **Course prerequisites:** To study this course, a student must have had the subject Mathematics in UG degree
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.
FurtherSuggestions: .....

Core-Elective (Group - 1) COURSE-I : Mechanics		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester: Second**/Eight
Course Code: 0820304	**Course Title: Mechanics**	**Theory**

Course Objectives:

Mechanics is the oldest branch of the Physics discipline and is as well important in the discipline of Mathematics. It is actually an intermediate course in classical mechanics intended for mathematics majors. The core is the new formulation of mechanics and the substantial range of new techniques in the applications.

Course outcomes:

CO1. To distinguish between inertia frame of reference and non-inertial frame of reference.

CO2. To frame the mathematical constraints on the bases of physical restrictions imposed on a system, which simplifies the process of solution of a physical problem.

CO3. To understand the mechanics of a system of particles falling under classical mechanics.

CO4. To differentiate between Newtonian, Lagrangian, Hamiltonian and Routhian approach of solving a mechanical problem.

CO5. To determine the Lagrangian and Hamiltonian of mechanical systems and use these functions to obtain the solutions of even complicated mechanical systems with ease.

CO6. To identify the conserved quantities, if any, associated with the mechanical system.

CO7. To apply fundamental conservation principles to analyze mechanical systems.

CO8. To use advanced theoretical techniques to solve mechanical problems like use of canonical transformations, variational principles, Hamilton Jacobi theory.

CO9. To use Poisson's Brackets and Lagrange's Brackets to solve mechanical problems.

Credits: 4	**Core Elective**	**Max Marks** **(Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction to the system of particles, Conservation laws for the system of particles, generalized coordinates, Virtual displacements, Constraints and constrained motion, classification of constraints: Holonomic versus non-holonomic systems, Scleronomic versus rheonomic systems, Degree of Freedom, generalized velocity, generalized acceleration, generalized potential, generalized momentum (Conjugate momentum), Generalized force. Lagrangian Mechanics: Physics in configuration space with generalized coordinates as independent variable, Definition of the Lagrangian, Euler-Lagrange equations of motion, Derivation of Euler-Lagrange equations from differential principle i.e., by D' Alembert's principle, Simple applications of the Lagrangian formulation to systems with holonomic and non-holonomic constraints	15

II	Hamiltonian mechanics: physics in phase space with generalized coordinates and momenta treated as independent variables. Definition of the Hamiltonian (through Legendre's transformation) and its relation to the energy, Hamilton's canonical equations in cylindrical and spherical coordinates as well, Hamilton's principle, Derivation of Hamilton's equations by integral principle i.e. by Hamilton's principle, Derivation of Hamilton's principle by differential principle i. e. by D' Alembert's principle, Derivation of Lagrange's equations from integral principle i.e. Hamilton's principle, Simple applications of Hamilton's equations of motion. Cyclic (ignorable) coordinates and conservation laws. Routhian Mechanics: Definition of Routhian. Routh's equations of motion and energy function Principle of least action.	**15**
III	Variational Calculus and its Application to Mechanics: Euler's equation for functions of one dependent variable and its generalization to (i) "n" dependent variables (ii) higher order derivatives, Applications of calculus of variation: Shortest distance between two points on a plane, Minimum surface of revolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Lagrange's multiplier method.	**15**
IV	Hamilton Jacobi theory: Hamilton Jacobi equation. Jacobi theorem. Method of separation of variables in Hamilton Jacobi equation and its simple applications.	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. **Gelfand ,I.M., Fomin ,S.V. and Silverman ,R.A.:** Calculus of Variations, Prentice Hall,2000 2. **Goldstein, H.:** Classical Mechanics (3rd Edition), Pearson New International Edition, 2014. ISBN 13: 9780201657029/ ISBN 10: 0201657023 1. **Rana, N.C. and Joag, P.S.:** Classical Mechanics, Tata McGraw Hill, New Delhi. 1991. ISBN-10: 0074603159/ ISBN-13: 9780074603154		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:.....		

Core- Elective (Group - 1) COURSE- II : Financial Mathematics

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester: Second**/Eight
Course Code: 0820305	**Course Title: Financial Mathematics**	**Theory**

Course Objectives: The objectives are to introduce the basic mathematical concepts and techniques used in finance and business. This also highlights the inter-relationships of the mathematics and problem-solving skills with a particular emphasis on financial and business applications.

Course outcomes:

CO1: Demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.
CO2. Demonstrate understanding of concepts relating to functions and annuities.
CO3. Employ methods related to these concepts in a variety of financial applications
CO4. Apply logical thinking to problem solving in context.
CO5. Use appropriate technology to aid problem solving.
CO6. Demonstrate skills in writing mathematics

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 75 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Some Basic Definitions and Terminology, Basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model.	15
II	Brownian ad Geometric Brownian Motion, Theory of Martingales, Stochastic Calculus, Stochastic differential Equations.	15
III	Ito"s formula to solve SDE"s, FeymannKac theorem, Application of stochastic calculus in option pricing, Black Scholes partial differential equations and Black Scholes formula.	15
IV	Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM), Interest rates and interest rate derivatives:	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Parikh, J.C.**, Stochastic Process and Financial Markets, Alpha Science International, 2003.

1. **Roman,S**. An Introduction the Mathematics of Finance, Springer, 1st Edition, 2000
1. **Ross,S**. An Introduction to Mathematical Finance, Cambridge University press,3rd Edition, 2011.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective (Group-1) Course – III : FLUID DYNAMICS		
Programme/Class: M.Sc.	**Year:** U.G. Research Fourth Year of P.G. I Year	**Semester**: Second/Eight
Course Code: 0820306	**Course Title: FLUID DYNAMICS**	Theory

Course Objectives: Almost everything on this planet, either is a fluid or moves within or near a fluid. Fluid Mechanics is an important subject that is particularly open to cross fertilization with other sciences and disciplines of engineering. The main objective of the course is to develop fundamental knowledge and understanding of the mechanics of fluid at rest and in motion to develop the ability to demonstrate and formulate physical problems encountered in different branches of engineering in mathematical form and arrive at useful solutions

CO1. To know, understand and apply the basic concepts of Fluid Mechanics .
CO2. To describe the physical properties of a fluid.
CO3. To convert physical laws of conservation of mass, momentum, moment of momentum and energy into mathematical equations and apply them to describe the fluid motion.
CO4. To frame and describe the flow through potential function and stream function.
CO5. To describe the motion of ideal and real fluids with different techniques including complex variable technique.
CO6. To understand stress-strain relationship in Newtonian fluids.
CO7. To apply Bernoulli equations in their domain of validity for fluid flow rate measurement.
CO8. To understand the singularities of the flow field.
CO9. To make dimensional analysis and use it to derive the dimensionless numbers.
CO10. To link flow behavior with non-dimensional parameters
CO11. To apply the similitude concept and set up the relation between a model and a prototype.
CO12. To define, describe and apply the basic flow equations, such as the Navies-Stokes equations to evaluate velocity, pressure drop in simple geometries like laminar flows between parallel plates, axial and transverse flows in pipes and flows in annular region produced.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minim Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Introduction: fluid characteristics, continuum concept and basic properties of fluids, Newtonian law of viscosity, Kinematics of fluids: Eulerian vs. Lagrangian descriptions of fluid motion, Equivalence of Lagrangian and Eulerian methods, General motion of a fluid element: Translation (Acceleration of a fluid particle in a velocity field), Rotation (angular deformation) and Deformation (volumetric or extensional strain/ shear strain), Flow lines: Stream lines, Path lines, Streak lines, Boundary conditions and boundary surface.	15
II	General theory of stress in a real fluid: Normal stress, Shearing stress, Transformation of stress components from one coordinate system to another coordinate system, Symmetry of stress tensor, Plane stresses, Principal directions and Principal values of stress tensor, Constitutive equation for Newtonian fluid, Conservation laws by the Control Volume	15

	approach: Mass conservation equation in rectangular cartesian, cylindrical and spherical coordinate systems, Equivalence of the mass conservation equations derived by Lagrangian method and Eulerian method, Equation of conservation of momentum (NavierStokes Equation and Euler Equation), Equation of conservation of moment of momentum, Equation of conservation of energy, Simple and direct applications of conservation equations.	
III	Vorticity and circulation, Elementary properties of vortex motion, Stream function for two-dimensional incompressible Flow, Stream function and potential flow theory, Theorems about rotational and irrotational flows of inviscid and incompressible flows – Stokes' theorem, Kelvin's minimum energy theorem, Gauss theorem, Kelvin's circulation theorem, Uniqueness of irrotational flows. Bernoulli's equation for incompressible and inviscid flows: Integration of Euler's equation along a streamline for steady and unsteady flows, Applications of Bernoulli's equation for irrotational flows: Flow through an orifice, Motion of a jet through atmosphere, Pitot tube, Venturi meter.	**15**
IV	Two-dimensional irrotational incompressible flows (Complex variable technique and its applications): Blasius theorem, Milne's circle theorem, Flow field singularities: Sources, Sinks and Doublets in two dimensions, Images of a source/ sink/ doublet with respect to a line and with respect to a circle, Simple applications of source, sink and doublet. Dimensional analysis, Buckingham Pi theorem, Dimensionless numbers (Reynold number, Pressure coefficient, Mach number, Froude number, Prandtl number) and their properties Basic introduction to Newtonian and non-Newtonian rheologies	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Betchelor, G.K.** An Introduction of Fluid Mechanics, Oxford University Books, NewDelhi, 2000.
2. **Charlton, F.:** Text Book of Fluid Dynamics, CBS Publishers, Delhi, 2004.
3. **Raisinghania, M.D.:** Fluid Dynamics: with Complete Hydrodynamics and Boundary Layer Theory, S. Chand Publishing, 2014. ISBN 13: 9788121908696.
4. **Rathy, R.K.:** An Introduction of Fluid Dynamics, Oxford and IBH Publishing Co.,New Delhi, 1903.
5. **Yuan, S.W.:** Foundations of Fluid Mechanics, Prentice Hall of India Private Limited,New-Delhi, 1988., ISBN10: 0133298132/ ISBN-13: 978-0133298130.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG Level..

Suggested equivalent online courses: There are online courses on the channels such as Swayam, Swayam Prabha, and NPTEL. e -contents from different online libraires.

Further Suggestions:.....

Core-Elective (Group-2) COURSE-I : Linear Algebra

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester: Second**/Eight
Course Code: 0820307	**Course Title: Linear Algebra**	**Theory**

Course Objectives:
The main objective of this course is to develop theoretical as well as working knowledge of the central ideas of linear algebra like linear transformations, invertibility & isomorphisms, eigenvalues, eigenvectors, the minimal polynomial, diagonalization, canonical forms, rational & Jordan forms, bilinear forms and their classification.
Linear algebra finds applications in coding theory, cryptography, graph theory and linear programming. Thus, after completing this course, students shall bear a good insight to study general plus advanced contents of the above-mentioned courses.

Course outcomes:

CO1: Understand the notion of a vector space and linear transformation and to determine basis and dimension of a vector space.

CO2: Understand the concept of linear transformation and to find the range space and null space of the linear transformation

CO3: Find the eigenvectors and Eigen-value of a square matrix and to know diagonalization of the matrix

CO4: Compute an orthogonal basis using the Gram-Schmidt process.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Linear transformations, Isomorphism, Range and null space, The matrix representation of linear transformations, Linear functional, Double dual.	**15**
II	Invertibility and Isomorphisms, The change of coordinate matrix, The transpose of a linear transformations, Polynomial ideals, Prime factorization of polynomials, Inner product spaces, Bessel's inequality, Normal and unitary operators.	**15**
III	Elementary canonical forms: Annihilating polynomials, The minimal polynomial, Invariant subspaces,Simultaneous triangulation, Simultaneous diagonalization, Direct-sum decomposition, Invariant direct sums, The primary decomposition theorem.	**15**
IV	Orthogonal and unitary reduction of quadratic and Hermitian form, Positive definite quadratic forms, simultaneous reduction. Bilinear forms, Matrix of a bilinear form, Classification of bilinear forms: Symmetric bilinear forms, Skew-symmetric bilinear forms	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **David C.Lay, Steven R.Lay and Judi J.MC Donald**; Linear Algebra and Its Applications, 6th Edition Pearson Education 2021.
2. **Hoffman, K., Kunze R.:** Linear Algebra (2nd Edition), Pearson, 2017.
3. **Friedberg, S.H., Insel ,A.J., Spence, L.E.:** Linear Algebra Pearson Education India,2015.
4. **Strang, G.** Linear Algebra and its Applications (4th Edition), Cengage Learning, 2007.
5. **Sahai, V. and Bist, V.:** Linear Algebra (2nd Edition), Narosa Publishing House, 2013.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective (Group-2) COURSE-II : Data Structure with C

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester: Second**/Eight
Course Code: 0820308	**Course Title: Data Structure with C**	**Theory**

Course Objectives:

1. A prominent purpose of programming languages is to provide instructions to a computer.
2. Programming languages differ from most other forms of human expression in that they require a greater degree of precision and completeness.
3. Studying programming languages will help the students be better at their job, make more money, and be a happier, more fulfilled and more informed citizen, because they will learn to: Choose the most appropriate language for a given task.
1. A programming language lets the students to express computational tasks in certain ways.
2. Programming languages often produce more efficient code through optimization for specific system architecture.

Course outcomes:

CO1. Understanding a functional hierarchical code organization.
CO2. Ability to define and manage data structures based on problem subject domain.
CO3. Ability to work with textual information, characters and strings.
CO4. Students will be able to develop logics which will help them to create programs, applications in C.
CO5. Also, by learning the basic programming constructs they can easily switch over to any other Language in future.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	**Introduction to the C Language:** Writing a Simple C Program: Learning the format of a C program, declaring variables, designing program flow and control, defining and using functions, data types, using standard terminal I/O functions.	15
II	**Conditional Program Execution:** Applying if and switch statements, nesting if and else, restrictions on switch values, use of break and default with switch. Program Loops and Iteration: Uses of while, do and for loops, multiple loop variables, assignment operators, using break and continue. **Modular Programming, Arrays and Structures** Passing arguments by value, scope rules and global variables, separate compilation, and linkage, building your own modules. Array notation and representation, manipulating array elements, using multidimensional arrays, arrays of unknown or varying size.	15

III	**Structures:** Purpose and usage of structures, declaring structures, assigning of structures. Unions: Components in overlapping memory, declaring and using unions. .h vs. private .c files, hiding private variables and functions	**15**
IV	**Functions and Pointers to Objects:** Simple C-functions, passing arguments to functions, returning values from functions, reference arguments, overloaded functions, recursion, inline functions, default arguments, scope and storage class, returning by reference, Constant function arguments, runtime memory management. Pointer and address arithmetic, pointer operations and declarations, using pointers as function arguments, Dynamic memory allocation	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. **Budd,**"Object Oriented Programming ", Addison Wesley 2. **Balaguruswamy,** "Programming in ANSI C." TMH 3. **Kanetkar ,Yashwant** "Pointers in C" 4. **Schield, Herbert,** Complete Reference in C," TMH 1. **Yashwant Kanetkar,"** Let us C", BPB		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:		

Core-Elective (Group-2) Course – III: Dynamical System

Programme/Class: M.Sc.	**Year:** P.G. I Year or UG in Research Fourth Year	**Semester:** Second/Eight
Course Code: 0820309	**Course Title: Dynamical System**	**Theory**

Course Objectives: Dynamical systems describe the time evolution of systems which arise from mathematics, physics, biology, chemistry and other areas. As mathematical objects they are ordinary differential equations, usually nonlinear and therefore not usually able to explicitly solved. The aim of the course is to see how to make a qualitative analysis of a dynamical system using many different analytic tools. Course outcomes:

CO1. To introduce students to the basic mathematical skills for the qualitative solving of low dimensional systems of ordinary differential equations in continuous time, including dimensionless forms, phase portraits, and bifurcations.

CO2. To provide a brief introduction to the way ordinary differential equation can be used to model, explain and interpret real world problems.

CO3. To provide a brief introduction to the theory and concepts that under pin the field of dynamical systems.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	The orbit of a map, fixed point, equilibrium point, periodic point, circular map, configuration space and phase space.	15
II	Origin of bifurcation. Stability of a fixed point, equilibrium point. Concept of limit cycle and torus. Hyperbolicity. Quadratic map. Feigenbaum's universal constant.	15
III	Turning point, trans critical, pitch work. Hopf bifurcation. Period doubling phenomena. Nonlinear OscillatorsConservative system. Hamiltonian system. Various Type of oscillators in nonlinear system. Solutions of nonlinear differential equations.	15
IV	Phenomena of losing stability. Quasiperiodic motion. Topological study of nonlinear differential equations. Poincare map.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Arnold. V.I, Dynamical Systems, Cambridge University Press, 1993.
2. Arrowosmith. D.K., Introduction to Dynamical Systems, Cambridge University Press, 1990.

3. Robert L.Davaney. An Introduction to Chaotic Dynamical Systems, Addison-Wesley Publishing Co. 1989.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation. **Course prerequisites:** To study this course, a student must have had the subject Mathematics in UG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraires.
Further Suggestions:.....

Core-Elective (Group-1) COURSE-I : Research Methodology & Computer Applications		
Programme/Class: M.Sc.	**Year:** P.G. II Year or UG in Research Fifth Year	**Semester:** Third/Ninth
Course Code: 0920301	**Course Title: Research Methodology & Computer Applications**	**Theory**

Course Objectives: The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. The course develops the understanding of the basic framework of the research process. Also gives an understanding of various research designs and techniques.

Course outcomes:

CO1: Design a good quantitative purpose statement and good quantitative research questions and hypotheses.

CO2: Explain the epistemological assumptions of qualitative research methods, how to select the appropriate qualitative research method to address a research question, and the criteria for evaluating qualitative research methods

CO3: Design and conduct an in-depth interview study, an oral history interview study, a focus group study, ethnography, a qualitative content analysis study, a qualitative case study, and a mixed-method study.

CO4: Write a qualitative methods and findings section, as for a qualitative research article.

CO5. Design a good qualitative purpose statement and a good central question in qualitative research.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Meaning of Research, Purpose, Characteristics and Types of Research, Process of Research, Formulation of objectives, Formulation of Hypotheses, Types of Hypotheses, Methods of testing Hypotheses. Research plan and its components, Methods of Research (Survey, Observation, case study, experimental, historical and comparative methods).	15
II	Scientific research and literature survey, Role of a supervisor, a survey of a research topic, publishing a paper, reviewing a paper, research grant proposal writing, copyright issues, ethics and plagiarism.	15
IV	Computer Networking, Internet, Web Browsers, Search Engines. MS Word: Handling graphics tables and charts, Formatting in MS-Word. MS PowerPoint: Creating Slide Show, Screen Layout and Views, Applying Design Template. MS Excel: Features, Formulas and Functions, Data Analysis and Data Visualization in Excel.	15
VI	Scientific writing and presentation, writing a research paper, survey article, thesis writing, Equation Editors Software for Mathematics.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc
Suggested Readings: 1. **Donald E. Knuth,** Tracy L. Larrabee, and Paul M. Roberts, Mathematical Writing, Mathematical Association of America, Washington, D.C., 1989 2. **Kumar. R:** Research Methodology: A Step- b y - S t e p Guide for Beginners, (3rdEdition), SAGE, Inc., 2011. 3. **Nicholas J. Hingham,** Handbook of Writing for the Mathematical Sciences, Second Edition, SIAM, 1998. 4. **Norman E. Steenrod, Paul R. Halmos, Menahem M. Schiffer, Jean A.** How to Write Mathematics, American Mathematical Society, 1973. 5. **Lamport. L.,** LaTeX, a Document Preparation System, 2nd Ed., Addison-Wesley, 1994. 6. **Shortis. Tim:** The Language of ICT: Information and CommunicationTechnology, Taylor & Francis. 2016.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions:.....

Core-Elective (Group-1) COURSE-II : Linear Integral Equation

Programme/Class: M.Sc.	Year: U.G. Research Fifth Year of P.G. II Year	Semester: Third/Ninth
Course Code: 0920302	**Course Title: Linear Integral Equation**	**Theory**

Course Objectives:

1. To expose you to the basic ideas of Integral Equations combined with some real-life problems
2. Integral equations are very important in the mathematical modeling of physical systems.
3. Many fundamental laws of physics and chemistry can be formulated as Integral equations.
4. In biology and economics, Integral equations are used to model the behavior of complex systems.

Course outcomes:

CO1. The use of the differential equation theory is to solve various types of Mathematical modeling problems.
CO2. The use of the differential equation theory is to solve many problems presented in different sciences such as Biology, Chemical sciences and Physics.
CO3. The use of this theory is to solve many real-life based problems such as population problem, control problems and networking security problems etc.
CO4. This theory can solve many engineering problems such as the exact trajectory path of a rocket or a missile.
CO5. Students will be able to formulate and solve differential equations arising from changes in physical world.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Classification of Integral Equation, transformation of ordinary differential equation into Integral Equation, Boundary value problem, transforming initial value problem into Volterra Integral Equation, conversion of boundary value problem into Fredholm integral equation.	15
II	Different kind of Fredholm integral equation, orthogonality & orthonormality of eigen functions, degenerate kernel, symmetric kernel, fundamental properties of eigen values & eigen functions, Hilbert Schmidt Theorem, Schmidt's Solution of Non-homogeneous Fredholm Integral Equation of the Second Kind, resolvent kernel or reciprocal kernel, solution by successive substitution & successive approximation, Neumann Series, Iterated Kernel.	15
III	Solution of Volterra Integral Equation, Solution by successive substitution & Successive approximation, Neumann series, Classical Fredholm Theory, Fredholm's First, Second and Third Fundamental Theorem,	15

	Theorem, Resolvent Kernel, Resolvent kernel by using Fredholm's first theorem,	
IV	Ordinary Fourier series. Fourier series of functions with an arbitrary period, Change of Interval and half-range series, Bessel's inequality. Parseval's equation, Convergence of Fourier series, Dirichlet's kernel and its properties, Fourier theorem, Uniform convergence of Fourier series	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Kanwal,R. P.,** Linear Integral Equation, Theory and Technique, 2nd edition, 1996, Academic Press New York 1971.
2. **Gupta, A.S.,** Calculus of Variations with Applications, Ist edition. PHI, India.
3. **Hildebrand, F. B.,** Method of Applied Mathematics, 2nd edition, PHI, India
4. **Sharma D.C.,** Integral Equations. PHI, India

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:.....

Core-Elective (Group-1) COURSE-III : Information Theory

Programme/Class: M.Sc.	Year: U.G. Research Fifth Year of P.G. II Year	Semester: Third/Ninth
Course Code: 0920303	**Course Title: Information Theory**	**Theory**

Course Objectives: Information theory is concerned with the analysis of an entity called a communication system, It deals with the construction of a mathematical model for different blocks of information, It is oriented towards the fundamental limitations on the processing and communication of information, After the completion of the course, the students will be able to understand fundamentals of communication system.

Course outcomes:

CO1. Apply linear block codes for error detection and correction and design the channel performance using Information theory.

CO2. Decide an efficient data compression scheme for a given information source.

CO3. Compute entropy and mutual information of random variables.

CO4. Understand the relationship of information theoretical principles and Bayesian inference in data modeling and pattern recognition.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 . Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Measure of Information: Convexity, monotonicity and continuity properties. Extermination, saddle point, capacity as information radius, Entropy, Mutual information, The Shannon entropy and its properties, Entropy and Shannon's First Theorem, Join and condition entropies, Transformation and its properties.	15
II	Noiseless Coding: Ingredients and noiseless coding problem, uniquely decipherable codes, Necessary and sufficient condition for the existence of instantaneous codes, Construction of optimal codes.	15
III	Discrete Memory less Channel: The Channel and Mutual Information, Classification of channels, Channel Capacity, Calculation of Channel capacity, Decoding Schemes, The ideal observer, The Fundamental Theorem of Information Theory and its strong and weak converses.	15
IV	Continuous Channels: The time – discrete Gaussian channel, Uncertainty of absolutely continuous random variable, The converse to the coding theorem for time – discrete Gaussian channel, The time – continuous Gaussian channel, Band – limit channels,	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Aczel , J. M.and Daroczy: Z.** On Measures of Information and their Characterizations, Academic Press, New York, 1975.

2. Ash, R.: Information Theory, Inderscience, New York, 1995. **3. Reza, F.M.:** An Introduction to Information Theory, McGraw Hill Book Company Inc,1961.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.
Further Suggestions:.....

Core-Elective (Group-1) COURSE-IV : Mathematical Programming

Programme/Class: M.Sc.	**Year:** U.G. Research Fifth Year of P.G. II Year	**Semester: Third**/Ninth
Course Code: 0920304	**Course Title: Mathematical Programming**	**Theory**

Course Objectives:
This course presents the theory and applications of Mathematical Programming. It extends the theory of optimization methods to more realistic problems. After completing this course students will be able

Course outcomes:

CO1: The use of Mathematical Programming algorithms for problem solving but also the design of their variants for special problem cases.

CO2: The understanding of mathematical structure and properties of fundamental problem classes (e.g., linear, non-linear and integer programming, dynamic programming).

CO3: The formulation and solving of problems arising from practical, real-life settings.

CO4. To solve problems involving optimization models with integer constraints.

CO5. To have deep insight in solving optimization problems which are non-linear.

CO6. To distinguish between "single objective" and "multiple objective" functions.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Convex functions, pseudo-convex functions, quasi-convex, explicit quasi-convex, quasi-monotonic functions and their properties from the point of view of mathematical programming.	15
II	Generalized convex functions and their properties, Optimality conditions using generalized convex functions, Saddle point optimality condition, Nonlinear programming duality. Parametric linear programming, Integer Programming and linear goal programming, Dynamic Programming.	15
III	Lagrangian saddle points, Duality in nonlinear programming, Strong duality in convex-programming, Duality for linear and quadratic programming.	15
IV	Quadratic programming: (i) Wolfe's algorithm (ii) Beale's algorithm (iii) Theil and Vande Pannealgorithm. Duality theory of quadratic and convex programming, separable programming, sequential unconstrained minimization.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc
Suggested Readings: 1. **Hardy, G.:** Linear Programming (5th Edition), Narosa Publishing House, 2002 2. **Hardy, G.:** Nonlinear and Dynamic Programming (4th edition), Addison-Wesley,Reading Mass, 1974. 3. **Kambo, N.S.** Mathematical Programming Techniques, Affiliated East-West Press.2016. 4. **Mangasarian, O.L.:** Non-linear Programming (2nd Edition), McGraw Hill, New York,2006. 5. **Taha: H.A.** Operations Research An Introduction (10th Edition), PearsonPublication, 2019.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions:.....

Core-Elective (Group-1) COURSE-V: Difference Equations

Programme/Class: M.Sc.	Year: P.G. II Year	Semester: Third/Ninth
Course Code: 0920305	**Course Title: Difference Equations**	**Theory**

Course Objectives:
The objective of this course is to introduce the difference equations, solutions, Fundamental theorems for existence and uniqueness of difference equations.

Course outcomes: After completing this course, student is expected to learn the following:

CO1: Understand the occurring of difference equations and linear difference equations. Also will be able to solve these equations

CO2: Understand the non-linear difference equations and their linearization

CO3: Understand the System of difference equations.

CO4. Understand the nonlinear difference equations and their systems.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction, difference calculus, difference operators, Greens function, approximate summations, Linear difference equations of first order, existence and uniqueness of solutions, linear difference equations with constant coefficients,	15
II	Equations with variables coefficients, Non-linear equation that can be linearized, The z- transform, Properties of z-transform, Initial and final value theorem, General solution of Second order homogeneous difference equation, Matrix method for solving linear difference equations.	15
III	Systems of linear difference equations, qualitative behavior of solutions to linear difference equations, Generating function, Properties of generating function, Exponential Generating function, Recurrence relation.	15
IV	Nonlinear difference equations (Map): Steady states and their stability, the logistic difference equation, systems of nonlinear difference equations, stability criteria for second order equations,	

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Walter G. Kelly and Allen C. Peterson, Difference Equations: An Introduction with Applications, Academic Press, Harcourt Brace Joranovich Publishers, 1991.
2. Calvin Ahlbrandt and Allen C. Peterson, Discrete Hamiltonian System, Difference Equations, Continued fraction and Riccati equations, Kluwer, Bostan, 1996.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc.

Further Suggestions:.....

Core-Elective (Group-2) COURSE-I: Measure and Integration Theory

Programme/Class: M.Sc.	**Year:** P.G. II Year	**Semester: Third**/Ninth
Course Code: 0920306	**Course Title: Measure and Integration Theory**	**Theory**

Course Objectives: The objective of the course is to give an introduction to Lebesgue measure on the set of real numbers R and the concept of measure in general, indicating its role in the theory of integration. The later objective is to show how the concept of Lebesgue measure is used in developing the theory of (Lebesgue) integration which gives stronger (and better) results as compared to the theory of Riemann integration. The theory of measure and integration has numerous applications in other branches of pure and applied mathematics, for example in the theory of (partial) differential equations, functional analysis and fractal geometry.

Course outcomes:

CO1. Extend their knowledge of Lebesgue theory of integration by selecting and applying its tools for further research in this and other related areas.

CO2. Utilize the concepts of derivative. MVTS for vector-valued functions in applications different fields for example management, industry and economics etc.

CO3. Apply the knowledge of concepts of functions of several variables and measure theory in order to study theoretical development of different mathematical concepts and their applications.

CO4. Utilize the concepts of derivative, MVTS for vector-valued functions in applications different fields for example management, industry and economics etc

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Finite and Infinite Sets, Countable and uncountable sets, Cardinality of Sets, Arithmetic of cardinal numbers, Cantor's theorem, Cantor set and its properties, Cantor function and its properties, Continuum hypothesis.	15
II	Lebesgue outer measure and its properties, and sets, Lebesgue measure, Measurable sets and their properties, Algebra of sets, -Algebra of sets, Measure of open and closed sets, Borel sets and their measurability, Regularity, Non-measurable sets.	15
III	Measurable functions and their properties, Algebra of measurable functions, Step function, Characteristic function, Simple function, Sets of Measure zero, Convergence almost everywhere, Borel measurable function, Littlewood's three principles, Convergence in measure, Egoroff's theorem, Lusin theorem, Riesz theorem.	15
IV	The Lebesgue Integral: Riemann and Lebesgue integral, Lebesgue integral of a bounded function over a set of finite measure, Properties of Lebesgue integral for bounded measurable functions, Convergence Theorems, Fatou's Lemma, Integral of non-negative measurable functions, The general Lebesgue integral. Functions of bounded variation, Variation function, Jordan-Decomposition theorem, Differentiation of monotone functions, Vitali covering lemma, Lebesgue Differentiation Theorem, Differentiation of an integral, Absolute continuity. Lp-spaces.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings: 1. Barra, G de: Measure Theory and Integration, 2 nd Edition, New Age International (P) Ltd., 2011.

2. Goldberg, Richard R: Real analysis, Oxford and IBH, 2012.
3. Jain, P.K. & Gupta, V.P.: Lebesgue Measure and Integration, New Age International (P)Ltd., New Delhi.
4. Rana, Inder K., An Introduction to Measure and Integration, Narosa Publishing House, 2007.
5. Royden, H.L.: Real analysis, 4th Edition, Pearson, 2018.
6. Rudin, Walter, Real & Complex Analysis, McGraw Hill Education, 3rd Edition, 2017.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.

FurtherSuggestions: .....

Core-Elective (Group-II) COURSE-II : Advanced Operations Research

Programme/Class: M.Sc.	Year: P.G. II Year	Semester: Third/Ninth
Course Code: 0920307	**Course Title: Advanced Operations Research**	**Theory**

Course Objectives

Problems in optimization are the most common applications of mathematics. The main aim of this course is to present different methods of solving optimization problems in the areas of linear programming, inventory and queuing theory. In addition to theoretical treatments, there will be some introduction to numerical methods for optimization problems.

Course outcomes:

CO1: Apply the knowledge of basic optimization techniques in order to get the best possible results from a set of several possible solutions to different problems viz. linear programming problems, transportation problems, assignment problems, unconstrained and constrained problems, etc.

CO2: Understand the theoretical foundation and implementation of similar type optimization techniques available in the scientific literature.

CO3: Extend their knowledge of basic optimization techniques to do interesting research work on these types of optimization techniques.

CO4: Formulate an optimization problem from its physical consideration

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	**Sequencing:** Sequencing theory, Processing of n-jobs through two machines, three machines and m machines, Graphical Method. Trans-shipment Problems, Optimal solution, Stepping Stone Method, Crew Assignment problem, Travelling Salesperson's problem. **Simulation:** Introduction, Methodology of simulation, Basic concepts, Simulation procedure, Applications of simulation.	15
II	**Replacement:** Replacement of items that deteriorate, Problems of choosing between two machines, Problems in mortality and staffing. **Introduction to Inventory Systems:** Analytical structure of Production and Inventory problems. Objectives of Inventory management. Factors influencing inventories. Inventory related costs. Properties of Inventory systems. Selective Inventory control techniques and its applications. Concept of Lead time, VED and ABC analysis, Different types of demand pattern. Concept of deterioration and shortages.	15
III	Network analysis – Construction of the network diagram, Critical path – float and slack analysis,	15

	Total float, Free float, Independent float, Shortest-path problem, Minimum spanning tree problem, Maximum flow problem, Minimum cost flow problem, Project planning and control with PERT/CPM Programme Evaluation Review Technique (PERT), Project Time Crashing. Queuing theory: Steady state solution of queuing models, Service system, Single channel models, Multiple services channels M/M/1, M/M/C models.	
V	Non-Linear Programming, Kuhn-Tucker Optimality condition, Quadratic programming: Wolfe's method. Integer programming: Modeling using pure and mixed integer programming: Branch and Bound Techniques. Gomory's cutting plane algorithm, Sensitivity Analysis. Linear goal programming: Modeling using goal programming.	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. **Bazarra, M. S; Sherali ,H.D., and Shetty, C. M.,** Nonlinear Programming: Theory and Algorithms, 2nd Edn., John Wiley, 1993. (Available as WSE (2004) edition).
1. **Bertsekas, D.P.** Nonlinear Programming, 2nd Edition., Athena Scientific, 1999.
2. **Hadley, G.:** Linear Programming, Narosa Publishing House, 1995.
1. **Hillier, F.S. and Lieberman, G.J.:** Introduction to Operations Research (6th Edition),McGraw Hill International Edition, Industrial Engineering Series, 1995.
3. **Rao, S.S.:** Optimization Theory and Applications (2nd Edition), New Age Int., NewDelhi, 1995.
4. **Swarup, K., Gupta, P.K. and Mohan Man:** Operations Research (9th Edition), S.Chand and Sons, New Delhi, 2002.
2. **Taha, H.A.;** Operations Research: An Introduction (10th Edition), PearsonPublication, (2019)

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions: .....

Core-Elective (Group-II) COURSE-II : Theory of Vibrations

Programme/Class: M.Sc.	Year: P.G. II Year	Semester: Third/Ninth
Course Code: 0920308	**Course Title: Theory of Vibrations**	**Theory**

Course Objectives

1. Familiarize students with the mathematical modeling and analysis of mechanical vibration systems
2. Make students understand the importance of vibration analysis in the design of dynamical systems

Course outcomes:

CO1: Classify different types of vibrations and develop mathematical models of vibratory systems.

CO2: Analyze free and forced vibrations of single degree of freedom systems.

CO3: Estimate the natural frequencies and mode shapes of multi degree of freedom systems.

CO4: Analyze free vibrations of continuous systems

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Harmonic Motion, Periodic Motion, Vibration Terminology, Vibration Model, Equations of Motion: Natural Frequency, Energy Method, Rayleigh Method: Effective Mass, Principle of Virtual Work, Viscously Damped Free Vibration, Logarithmic Decrement, Coulomb Damping, Forced Harmonic Vibration, Rotating Unbalance, Rotor Unbalance, Whirling of Rotating Shafts, Support Motion, Vibration Isolation, Energy Dissipated by Damping, Equivalent Viscous Damping, Structural Damping, Sharpness of Resonance, Vibration-Measuring Instruments. Impulse Excitation, Arbitrary Excitation , Laplace Transform Formulation, Pulse Excitation and Rise Time, Shock Response Spectrum, Shock Isolation, Finite Difference Numerical Computation, Runge-Kutta Method (Method 2)	15
II	The Normal Mode Analysis, Initial Conditions, Coordinate Coupling, Forced Harmonic Vibration, Digital Computation Vibration Absorber, Centrifugal Pendulum Vibration Absorber, Vibration Damper, Flexibility Influence Coefficients, Reciprocity Theorem, Stiffness Influence Coefficients, Stiffness Matrix of Beam Elements, Static Condensation for Pinned Joints, Orthogonality of Eigenvectors, Modal Matrix P, Decoupling Forced Vibration Equations, Modal Damping in Forced Vibration, Normal Mode Summation, Equal Roots, Unrestrained (Degenerate) Systems	15

III	Generalized Coordinates, Virtual Work, Lagrange's Equation, Kinetic Energy, Potential Energy, and Generalized Force in Terms of Generalized Coordinates q, Root Solving, Gauss Elimination , Matrix Iteration, Convergence to Higher Modes, The Dynamic Matrix, Transformation of Coordinates (Standard Computer Form), Systems with Discrete Mass Matrix, Cholesky Decomposition, Jacobi Diagonalization	**15**
IV	Vibrating String , Longitudinal Vibration of Rods, Torsional Vibration of Rods, Vibration of Suspension Bridges, Euler Equation for Beams, Effect of Rotary Inertia and Shear Deformation, Element Stiffness and Mass, Stiffness and Mass for the Beam Element, Transformation of Coordinates (Global Coordinates), Element Stiffness and Element Mass in Global Coordinates, Vibrations Involving Beam Elements, Spring Constraints on Structure, Generalized Force for Distributed Load , Generalized Force Proportional to Displacement	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Theory of vibrations, W T Thomson, M D Dahleh and C Padmanabhan, Pearson Education,2018.
2. W.T.Thomson, Theory of vibration with Application(4th Ed.) Taylor & Francis New York.
3. Fundamentals of vibrations, Leonard Meirovitch, McGraw Hill International edition,2010

Reference(s)

1. Elements of vibration analysis, Leonard Meirovitch, Tata McGraw Hill, 2010.
2. Mechanical vibrations, S.S Rao.Pearson Education, 2018.
3. Engineering Vibrations, D.J Inman, Pearson International Education, 2011.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions: .....

Core-Elective (Group-2) Course – IV: Applied Statistics

Programme/Class: M.Sc.	**Year:** P.G. II Year	**Semester:** Third/Ninth
Course Code: 0920309	**Course Title: Applied Statistics**	Theory

Course Objectives: The aim of this course is to extend and master students in application of statistical methods and to provide theoretical background for studying advanced statistical methods. Upon successful completion of this course, students will be correctly applying and interpret different applications statistical methods.

Course Outcome:

CO1: Learn about various procedures of sampling and concept of sampling distribution that will help in statistical inference

CO2: Tackle big data and draw inferences form it by applying appropriate statistical techniques.

CO3: Will apply ANOVA used to test equality of three or more population means.

CO2: Apply the knowledge of statistical techniques in various experimental and industrial requirements.

CO4: Gain knowledge about time series forecasting techniques.

CO5: Explain the purpose of index numbers and their applications

CO6: Learn how control charts are constructed and how they are used to monitor quality standards.

CO7: Gain knowledge about computer fundamentals and learn about different statistical software's.

Credits: **4**	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Sampling techniques: What is Population , types of Population, sample and parameter, basic principle of sampling, sampling distribution, types of sampling methods , their Notations and terminology, theorems on sampling methods, numerical problems, advantages and disadvantages of different sampling methods.	15
II	Statistical quality control: Introduction to statistical quality control, advantages of Statistical quality control, control charts and types of control charts, numerical problems, comparison of different control charts Analysis of time series: Meaning and definition, components of time series, different Mathematical models in time series, numerical problems and importance of time series analysis.	15
III	Index number: Definition and classification of index number, construction of various index number and advantages of index number, numerical problems on index numbers.Computer Awareness: Different types of number system, computer basics and basics of statistical software's SPSS and its advantages.	15
IV	Analysis of variance: Definition, Basic assumptions, application of analysis of variance, one way and two-way analysis of variance, their computational work and examples limitations and precaution in ANOVA.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Rohatgi, V.K., Saleh, A.K. Md. Ehsanes:** An Introduction to Probability and Statistics, Second Edition Wiley-Inderscience. (2008)
2. **Kennedy and Gentle:** Statistics Computing, Published by CRC Press. (2021)
3. **Mayer, P.L.**: Introductory Probability and Statistical Applications, IBH. 2nd Edition (1970)
4. **Mood, A.M. and Graybill, F.:** Introduction to the Theory of Statistics, McGraw Hill Education; 3rd edition (2017).
5. **Hogg, R.V., Craig, A. and McKean, Joseph W.:** Introduction to Mathematical Statistics, Pearson Education, .8th Edition New Delhi (2019)
6. **Gupta,S.C and Kapoor V.K :**Fundamentals of Applied statistics ,Sultan Chand and sons New Delhi (2007)
7. **Mukhopadhyay**, P: Applied Statistics, Books and Allied Ltd. New Delhi.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.

FurtherSuggestions: .....

Core-Elective (Group-2) Course – V : Theory of Relativity

Programme/Class: M.Sc.	Year: PG II Year	Semester: Fourth/Tenth
Course Code: 0920310	**Course Title: Theory of Relativity**	**Theory**

Course Objectives: It will make the learner familiar with Relativity problem in real world.
Course outcomes:
CO1: Knowledge in Relativity - basic concepts, examples and applications
CO2. Knowledge in classical theory of relativity, Lorentz transformations, Relativistic Mechanics.
CO3. Knowledge in Special Relativity in classical Mechanics, Tensor Calculus.
CO4. Knowledge in The general theory of relativity, relativistic field equations, Schwarzschild solution, Cosmology, Electrodynamics etc.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	**Classical theory of relativity:** Speed of light: inertial frame (Galilean Frame), Galilean Transformation, Electrodynamics, Fizeau's experiment, Michelson and Morley experiment. **Lorentz transformations:** The new concept of space and time, postulates of special theory of relativity, Lorentz Transformation equation, Lorentz and Fitzgerald contraction, time dilation or apparent retardation of rest. Simultaneity, relativistic formulae for composition of velocities and accelerations, proper time, Lorentz Transformation form a group, problem related to time dilation, Lorentz contraction, composition of velocities, Lorentz invariance; Aberration (Relativistic treatment) Doppler's Effect, confirmation of doppler's affects and related problems.	15
II	**Relativistic mechanics:** Mass and Momentum, Newton's Law of Motion, measurement of different units, experimental verification of $m_o/(1-v_2/c_2)^{1/2}$, equivalence of mass and energy, transformation formula for mass, transformation formula for Momentum and energy, transformation formula for force, relativistic transformation formula for density, Minkowski space, geometrical interpretation of Lorentz Transformation, space and time like interval, world points and world line, light cone, proper time, energy Momentum four vector, relativistick equation of motion, Minkowski's equation of motion, solved problem related to $E=mc^2$, solved problem related to binding energy.	15
III	Special Relativity in classical mechanics, Tensor calculus : **Part 1:** Line element: Submission convention, Dummy suffix, Real suffix, Kronecker delta, Determinant, Four vectors (world vectors), Transformation of co-ordinates,	15

	Tensor, Symmetric tensor, Anti-symmetric tensor, Addition of tensors, Inner product of two vectors, Multiplication of tensors, Contraction, Quotient law of tensors, Reciprocal symmetric tensor, Relative tensor, Riemannian metric, Fundamental tensor, Magnitude of a vector, Associate tensor, Angle between two vectors. **Part 2:** Geodesic Curve. Covariant differentiation, Christoffel symbols, Geodesic, Differential equation of a geodesic, Tensor law of transformation for Christoffel symbols, Covariant differentiation of tensor, Gradient of a scalar, Curl of a vector, Divergence of a vector, Parallel displacement of a vector, Geodesic co-ordinates, Natural coordinates. **Part 3:** Curvature Tensor: Riemannian Christoffel's tensor, Properties of covariant curvature tensor, Contraction of R^{a}_{ijk} ,Bianchi Identity, Number of independent components R_{hijk} , Uniform vector field, Flat space time.	
IV	General theory of relativity: Introduction of general theory, Principle of covariance, Principle of equivalence. Relativistic Field Equations: Energy Momentum tensor, Field equation, Poisson's equation as an approximation of field equations, Derivation of field equations from Lagrangian density, Equality of inertial and gravitational mass. Schwarzschild Solution: Einstein's law of gravitation in empty space, Schwarzschild exterior solution. Birkhoff's theorem, Relation between M and m, Isotropic co-ordinates, Planetary orbits, Advance of perihelion, Gravitational shift of spectral lines, Schwarzschild's interior solution, Cosmology: Cosmological models, Einstein and De- Sitter line elements, Properties Einstein universe, Properties of De-Sitter universe, Comparison of Einstein model with actual universe, Comparison of De-Sitter model with actual universe.	15
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.		
Suggested Readings: **1-** Theory of Relativity: Dr. J.K. Goyal and Dr. K.P. Gupta; Krishna Prakashan Media (P) Ltd., Meerut, Delhi. **2-** Fundamentals of SPECIAL and GENERAL RELATIVITY: D.' Krori, I K. PHI LEARNING PVT. LTD.; Revised Edition (1 January 2010).		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.		
Further suggestions:		

Core-Elective (Group-1) Course – 1 : Fuzzy Set and Its Applications

Programme/Class: M.Sc.	**Year: PG II Year**	**Semester**: Fourth/Tenth
Course Code: 1020301	**Course Title:** Fuzzy Set and Its Applications	Theory

Course Objectives: The aim is to equip students with some state-of-the-art fuzzy-logic technology to prepare them in a better way for the rapidly evolving high-tech information-based modern industry and market. After completing this course, the students will be able to get employment if the electronics equipment's where computational artificial intelligence is used.

Course outcomes:

CO1. This theory helps to solve those problems which are described in linguistic terms.
CO2. This theory provides an excellent tool to handle the vagueness in modern science and technology problems such as computer science, economics and medical science.
CO3. This theory can be used to make modern systems based on Artificial Intelligence (A.I) and soft computing.
CO4. On the basis of this theory many real-life based problems can be solved such as robotics, management etc.
CO5. On the basis of the theory be able to apply fuzzy information in decision making.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25 + 75 Total=100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Introduction: Basics concepts on crisp sets, Fuzzy sets, α-cuts, Additional properties of α-cuts, Level sets, Cardinality of Fuzzy Sets, Types of fuzzy sets, L-Fuzzy Sets, Convex fuzzy sets, Decomposition Theorems, Extension principle for fuzzy sets.	15
II	Operations of Fuzzy Sets: Fuzzy complement, Fuzzy union, Fuzzy intersection, T-norms, T-conorms, combination of operations, General aggregation Operations. Fuzzy numbers: Concept of Fuzzy Number, Types of Fuzzy Numbers (Triangular and Trapezoidal), Arithmetic operations on Fuzzy Numbers.	15
III	Fuzzy Relations: Fuzzy relations, Projections and Cylindric extensions, Binary fuzzy relations, binary relations on single set, Fuzzy equivalence relations, Fuzzy partial order relations, Fuzzy ordering relations. Fuzzy ranking method.	15
IV	Fuzzy logic and Possibility theory: Fuzzy propositions, Fuzzy quantifiers, Linguistic hedges, Inference from conditional fuzzy propositions, Inference from conditional and qualified propositions, Fuzzy measures; description of axioms, properties of fuzzy measure, Possibility theory, Evidence theory; Belief measure, plausibility measure,	15

	properties of plausibility measure; necessity measure, properties of possibility and necessity measure, relation between belief measure and plausibility measure.	

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments etc.

Suggested Readings:

1. **Dubosis Didler and Prade, Henri,** Fuzzy Sets and systems Theory and Applications,
1. **Academioc Press, NewYork,** 1980
2. **Klir . Georage. J and Yuan Bo,** Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi. 2009
1. **Lee, Kwang H.,** First Course on Fuzzy Theory and Applications, **Springer International Edition, 2009.**
1. **Ross, Timothy J.**, Fuzzy Logic with Engineering Applications, McGraw Hills inc., 2004 New Delhi
1. **Roger, Jyh-Shing; Sun, Chuen-Tsai; Mizutani, Eiji,** Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, *MATLAB curriculum series*, illustrated, reprint, Prentice Hall, 1997
1. **Zimmermann,H.J.** Fuzzy Set Theory & its Applications, Allied Publishers Ltd. New Delhi, 2006.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses:
There are online courses on the channels such as Swayam Prabha, and NPTEL, Moocs. E-contents from different online libraires.

Further suggestions: .....

Core-Elective (Group-1) Course II : Functional Analysis

Programme/Class: M.A/M.Sc.	**Year: UG Fifth year of PG II Year**	**Semester**: Fourth/Tenth
Course Code: 1020302	**Course Title:** Functional Analysis	Theory

Course Objectives: The main goal of the course is to introduce students to Functional Analysis. Course outcomes:
CO1: Understand the basics of Functional Analysis.
CO2: Determine fundamental groups of some standard spaces like Euclidean spaces and Normed Linear space.
CO3: Understand proofs of some beautiful results such as fundamental theorem of Algebra and Hahn Banach , Riesz Fisher theorem.
CO4: Understand proofs of beautiful results of Hilbert spaces.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25 + 75 Total=100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Introduction to Linear Spaces, Normed Spaces, Banach spaces, Operators, Linear Functionals, Dual Spaces. Inner Product Spaces, Direct Sum, Orthonormalization, Adjoint Operators, self Adjoint, Unitary and Normal Operators.	15
II	Dual spaces, Open mapping and closed graph theorems, Hahn-Banach theorem for real and complex linear spaces, Uniform boundedness theorem, Reflexive Spaces.	15
III	Inner product spaces, Hilbert spaces – Orthonormal sets, Bessel's inequality, complete orthonormal sets and Perseval's identity	15
IV	Structure of Hilbert spaces, Projection theorem, Riesz representation theorem, Adjoint of an operator on Hilbert space, Self-adjoint operators, Normal and unitary operators, Projections.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. Jain, P.K. and Ahuja, O.P.: Functional Analysis, New Age (International P, Ltd,) NewDelhi, 2010.
2. Kreyszig, E.: Introductory Functional Analysis with Applications, John Wiley andSons, New York, 2007.
3. Simmons, G.F.: Introduction to Topology and Modern Analysis, McGraw Hill BookCo., New York, 2013.
4. Taylor, A.E. Introduction to Functional Analysis, John Wiley and Sons, New York,2013.
5. Berbarian, S.K.: Introduction to Hilbert Spaces, Oxford University Press, New York,1961

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation. **Course prerequisites:** To study this course, a student must have had the subject Mathematics in UG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.
Further Suggestions:-.....

Core-Elective (Group-1) COURSE – III : An Introduction to R-Programming

Programme/Class: M.Sc.	Year: P.G. II Year	Semester: Fourth/Tenth
Course Code: 1020303	**Course Title: An Introduction to R-Programming**	**Theory**

Course Objectives:

1. A prominent purpose of programming languages is to provide instructions to a computer.
2. Programming languages differ from most other forms of human expression in that they require a greater degree of precision and completeness.
3. Studying programming languages will help the students be better at their job, make more money, and be a happier, more fulfilled and more informed citizen, because they will learn to: Choose the most appropriate language for a given task.
1. A programming language lets the students to express computational tasks in certain ways.
2. Programming languages often produce more efficient code through optimization for specific system architecture.

Course outcomes:

CO1. Understanding a functional hierarchical code organization.
CO2. Ability to define and manage data structures based on problem subject domain.
CO3. Ability to work with textual information, characters and strings.
CO4. Students will be able to develop logics which will help them to create programs, applications in R.
CO5. Also, by learning the basic programming R constructs they can easily switch over to any other Language in future.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction to R-Software, Why R and Installation Procedure, Help Demo-Example packages and libraries, command line, editor and R-Studio. Basics in Calculation, Calculator and built in functions Assignments.	15
II	Use of R as a Calculator, functions and matrix operations, missing data and logical operator, truth table and conditional execution, Conditional Executions and loops, data management with sequence. Data management with repeats, sorting, ordering and lists, vector indexing, factors,	15
III	Data management with strings, print nad format functions, print and format with concatenate,	15

	paste function, splitting, replacements and evaluation of strings, display and formatting, importing CSV and Tabulator Data Files, Importing Data files from other softwares.	
IV	Data management with display paste, split, find and replacement, manipulations with alphabet, Data frames, import of external data in various file formats, statistical functions, compilation, frequency and partition values. Graphics and plots: Boxplots, statistical functions for central tendency, variation, skewness and Kutosis Bivariate three dimensional plot, correlation and examples of programming.	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content. Class activities/ assignments, etc		
Suggested Readings: 1. Salabh, "Introduction to r Software", Lecture notes on NPTEL. On www.nptel.ac.in ot www.swayam.gov.in 2. **Sharad Mehta, "Statistical Analysis using R Software" Excel Books.** 3. **Jared P Lander, "R for everyone", Addison Wesly Professional.** 4. **J D Long, "R Cookbook", O'Reilly.** 1. **Richard Cotton, "Learning R", O'Reilly.**		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:.....		

Core-Elective (Group-1) Course – IV : Differential Geometry

Programme/Class: M.A/M.Sc.	Year: UG Fifth year of PG II Year	Semester: Fourth/Tenth
Course Code: 1020304	**Course Title: Differential Geometry**	Theory

Course Objectives: In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developable and geodesics.

Course outcomes:

CO1: Learn about the concepts of curvature, torsion, involutes and evolutes.

CO2: : Familiarize with several concepts of tangent plane, Helicoids, metric and direction coefficients

CO3: : Understand the concepts of developable surfaces

CO4: Use the several notions of curvatures such as geodesic curvature and Gaussian curvatures

Credits:4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Tensor Algebra: Difference between tensor and vector, Contraction, Inner Product, Symmetric and skew-symmetric tensors, Reciprocal symmetric tensor, Relative tensor, Alternate tensor, Isotropic tensor, Christoffel Symbols and Covariant differentiation, Ricci tensor, Bianchi's identity.	15
II	Space Curves: Metric tensor of the Euclidean space of three dimensions, Tangent to a curve, Osculating plane, Serret Frenet formulae, Fundamental planes, Curvature of a curve, Torsion of a curve, Contact between curves and surfaces, Locus of centre of spherical curvature,Spherical Indicatrix, Tangent surface, involutes and evolutes, Helix.	**15**
III	Surfaces in Space: Parametric Transformation, Curves on a surface, Tangent plane and normal to the surface, First fundamental quadratic form of the surface, Angle between two parametric curves, Angle between a parametric curve and any general curve of the surface, Orthogonal Trajectories, Second fundamental tensor, Weingarten formulae	**15**
IV	The Normal Curvature of a surface: Normal curvature of a surface, Principal directions, Principal curvatures, Lines of curvature on a surface, Conjugate directions on a surface, Asymptotic direction at a point of a surface, Mean curvature, Gaussian curvature, Minimal surface, Gauss characteristic equation, Mainardi-Codazzi equations.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. Weatherburn, C. E. Differential Geometry of Three Dimensions, Cambridge University Press, 2016.

2. Graustein, W. C. Differential Geometry. Courier Corporation, 2012.
3. Wilmore T. J. An Introduction to Differential Geometry, Dover Publications Inc., 2012.
4. Pressley, A. Elementary Differential Geometry. Springer, 2002.

Suggested Continuous Evaluation Methods:
Continuous internal evaluation through internal tests quizzes and Presentation.

Further Suggestions:..... .....

Core-Elective (Group-1) Course – V : Algebraic Topology

Programme/Class: M.A/M.Sc.	**Year: PG II Year**	**Semester**: Fourth/Tenth
Course Code: 1020305	**Course Title:** Algebraic Topology	Theory

Course Objectives:
The main goal of the course is to introduce students to algebraic topology and standard topological invariants. We also intend to discuss different connections with differentiable topology, (co)homology theory and complex/real algebraic geometry.

Course outcomes:

CO1: Understand the basics of Algebraic Topology.

CO2: Determine fundamental groups of some standard spaces like Euclidean spaces and spheres.

CO3: Understand proofs of some beautiful results such as fundamental theorem of Algebra and Hurwitz-uniformization theorem.

CO4: Understand proofs of beautiful results of Borsuk's separation theorem.

Credits: 4	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Homotopy of paths, Fundamental group, Covering spaces, Fundamental group of the circle, Retractions and fixed points, Fundamental group of the punctured plane.	15
II	Deformation retract sandhotopy type, Fundamental group of S^n, Essential and inessential maps, Fundamental theorem of Algebra.	15
III	Topology of E^n, Borsuk's separation theorem, Deformation of subsets of E^{n-1}, Jordan curve theorem, Fiber spaces, Hurwicz Uniformization theorem.	15
IV	Classification of surfaces: Fundamental groups of surfaces, Homology of Surfaces, Cutting and pasting, Classification theorem.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Deo, S.:** Algebraic Topology, Springer Singapore, 2018

2. **Dugundj ,J.:** Topology, Allyn and Bacon, New York, 1975.
1. **Greenberg, Marwin J and Harper, J. R.** Algebraic Topology – A First Course (1st Edition), CRC Press, 2018
3. **Massey, W.S.:** Algebraic Topology- An Introduction, Springer India, 2010
4. **Munkres, James R.:** Topology – A First Course, Prentice Hall of India, Delhi 2018.
5. **Spanier, E.H.:** Algebraic Topology (3rd Edition), Springer, 1994.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.

Further Suggestions:.....

M.Sc. II

Core-Elective (Group-1) Course – VI: Mathematical Modeling

Programme/Class: M.A/ M.Sc.	**Year: PG II Year**	**Semester**: Fourth/Tenth
Course Code: 1020306	**Course Title:** Mathematical Modeling	Theory

Course Objectives:
Modeling and solving mathematical and engineering problems through the relationship between theoretical, mathematical, and computational aspects. It will make the learner familiar with mathematical modeling of real-world situations related to engineering systems development, prediction and evaluation of outcomes against design criteria.

Course outcomes:

CO1: Apply Simulation and Monte Carlo integration.

CO2. Apply different models to population dynamics

CO3. Apply inverse transform method and convolution method.

CO4. Know Markov Chain Monte-Carlo simulation and Metropolis-Hasting's algorithm.

Credits: 4	**Core Elective**	**Max Marks** **(Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Total No. of Lectures-Tutorial (04 hours per week): L-T: 4-0

Unit	Topics	No. of Lectures Total 60
I	**Introduction:** The technique on Mathematical Modelling, Mathematical Modelling through Calculus, Mathematical Modelling through ordinary differential equation of first order, Linear Growth and Decay model, Non-linear Growth and Decay model, Mathematical Modelling in dynamics through ordinary differential equation of first order.	15
II	**Mathematical Modelling through System of Differential Equations**: Modelling in population dynamics, Mathematical Modelling of Epidemics through system of differential equation of first order, Mathematical Modelling in Economics based on system of differential equation of first order, Mathematical Modelling in Medicine, Arms, Race Battles and International Trade in terms of ordinary differential equations.	15
III	**Mathematical Modelling through Difference Equations:** Need of Mathematical Modelling through Difference Equations, Mathematical Modelling through Difference Equations in Economics, Finance, Population dynamics and genetics.	15
IV	**Mathematical Modelling through Graphs:** Environment that can be modelled through Graphs, Mathematical Modelling in terms of Directed Graphs, Signed Graphs, weighted Diagraphs, Non-oriented Graphs.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings: 1. **Bender, E. A.** An introduction to mathematical modeling. Courier Corporation. (2012) 2. **Meerschaert, M. M**. (2013). Mathematical Modelling, Academic Press. (2013)	
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal Tests, quizzes and Presentation.	
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.	
Further suggestions:	

Core-Elective (Group-2) Course – I : Partial Differential Equation

Programme/Class: M.Sc.	Year: UG Fifth year of PG II Year	Semester: Fourth/Tenth
Course Code: 1020307	**Course Title:** Partial Differential Equation	Theory

Course Objectives:
Partial differential equations (PDEs) arise in every field of science and engineering, therefore the solutions of PDEs are of great interest in understanding various physical phenomena. Text of this paper is organized to study the four important fundamental linear partial differential equations: Transport equation, Laplace equation. Heat equation and Wave equation, and various explicit formulas for solutions along with their numerical solutions using finite difference method. Nonlinear first order PDEs which arise in fluid dynamics, continuum mechanics and optics are also included in this paper. Course outcomes:
CO1: Understand the partial differential equation problem and analyze linear and non-linear systems.
CO2: Classify second order PDE and solve boundary value problems by using separation of variable method
CO3: Determine integral surfaces passing through a curve, characteristic curves of second order PDE and compatible systems.
CO4: Understand the formation and solution of some significant PDEs like wave equation, heat equation and diffusion equation

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Examples of PDE, Classification, Transport equation: Initial value problem, non-homogeneous equation, Laplace's equation: Fundamental solution, Mean value formulas, Properties of harmonic functions, Energy methods.	15
II	Heat equation: Fundamental solution; Mean value formula, Properties of solutions, Energy methods, Wave equation: Solution by spherical means, non-homogeneous equations, Energy methods.	15
IV	Representation of Solutions-Separation of Variables, Similarity Solutions (Plane and Traveling Waves, Similarity Linder Scaling), Fourier and Laplace Transform, Hopf-Cole Transform, Hodograph and Legendre Transforms, Potential Functions	15
V	Applications of PDE: Vibration governed by one- and two-dimensional wave equations, vibrations of string and membranes, three dimensional problems, Diffusion equation, resolution of boundary value problems for diffusion equations and elementary solutions of diffusion equation.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. **Evans, L.C.:** Partial Differential Equations, Graduate Studies in Mathematics, Volume19, AMS, 1998.
2. **John, F.:** Partial Differential equations, Springer- Verlag, N.Y., 2013.

3. **Prasad, P. and Ravindran, R.:** Partial Differential Equations (2nd Edition), New AgeInternational Pub, New Delhi, 2011.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal Tests, quizzes and Presentation.
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.
Further Suggestions: .....

Core-Elective (Group-2) Course II : CRYPTOGRAPHY AND NETWORK SECURITY

Programme/Class: M.Sc.	Year: UG Fifth year of PG II Year	Semester: Fourth/Tenth
Course Code: 1020308	Course Title: CRYPTOGRAPHY AND NETWORK SECURITY	Theory

Course Objectives:

Cryptography is an information security tactic used to protect enterprise information and communication from cyber threats through the use of codes. This practice refers to secure information and communication techniques derived from mathematical concepts and a set of rule-based calculations, called algorithms, to transform messages in ways that are hard to decipher.

CO1: These algorithms are then used for cryptographic key generation, digital signing, verification to protect data privacy, web browsing on the internet, and confidential communication like credit card transactions and emails.

CO2: Cryptography achieves several information security-related objectives including confidentiality, integrity, and authentication, and non-repudiation. In this post, we explore what these reveal about cryptography.

CO3: Cryptography protects the confidentiality of information.

CO4: Confidentiality is a key priority when it comes to cryptography. It means that only people with the right permission can access the information transmitted and that this information is protected from unauthorised access at all stages of its lifecycle.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Introduction to Cryptology, Symmetric Cipher Model ,Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Permutation Cipher, Playfair Cipher, Mono-alphabetic and Poly-alphabetic Ciphers, Different types of attacks, Stream Ciphers, Linear feedback shift register , Data Encryption Standard.	15
II	Symmetric Key Distribution, Introduction to Public Key Cryptography, The RSA Algorithm, Diffie-Hellman Key Exchange Discrete Logarithm Problems, Diffie-Hellman Problems, Elgamal Cryptographic System,	15
III	Elliptic Curves and Their Arithmetic, Pairings on elliptic curves, ECDLP, ECDHP, Elliptic Curve Cryptography, Cryptographic Functions, Integrity, confidentiality, non repudiation , authentication.	15
IV	Digital Signatures, RSA Signature Scheme, ElGamal Digital Signature Scheme, Schnorr. Digital Signature Scheme, Elliptic digital Signature Scheme, Identity based Cryptosystem, Certificateless signature Scheme, IoT ,Cloud, Fog and edge computing.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. William Stallings, Cryptography and Network Security, Pearson.
2. Stinson, Douglas R. Cryptography: theory and practice. Chapman and Hall/CRC, 2018..
3. Stallings, William. Cryptography and network security (Principles and Practice) . Pearson Education India, 2023. 3.
4. Menezes, Alfred J., Paul C. Van Oorschot, and Scott A. Vanstone. Handbook of applied cryptography. CRC press.
5. Boneh, D., Franklin, M. (2001). Identity-Based Encryption from the Weil Pairing. In: Kilian, J. (eds) Advances in 2001. Lecture Notes in Computer Science, vol 2139. Springer, Berlin. Heidelberg. https://doi.org/10.1007/3-540-44647-5.
6. Al-Riyami, S.S., Paterson, K.G. (2003). Certificateless Public Key Cryptography. In: Laih, CS. (eds) Advances ASIACRYPT 2003. Lecture Notes in Computer Science, vol 2894. Springer, Berlin, Heidelberg. https://doi.org/10.1007
7. P. Garrett, An Introduction to Cryptology, Prentice Hall.
8. B. Schneier, Applied Cryptography, Wiley.
9. T. Beth, M. Frisch, G. Simmons, Public key Cryptography, Springer-Verlag.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal Tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs, and NPTEL. E-contents from different online libraires.

Further Suggestions: .....

Core-Elective (Group-2) Course – III : Mathematical Biology

Programme/Class: M.Sc.	Year: PG II Year	Semester: Fourth/Tenth
Course Code: 1020309	**Course Title:** Mathematical Biology	Theory

Course Objectives: To introduce certain mathematical tools like linear algebra, probability, Difference equations and Differential equations in modeling some aspects of Biological Systems Course outcomes:
CO1. Relate mathematical notions with biological phenomena.
CO2. Solve simple biological problems using discussed models.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	Dynamic modeling with difference equations; The Malthusian Model, Nonlinear Models, Analyzing Nonlinear Models, Variations on the Logistic Model, Comments on Discrete and Continuous Models. Linear Models of Structured Populations; Linear models and Matrix Algebra Projection Matrices for Structured Models. Reproduction and the drive for survival; The Darwinian Model of Evolution, Cells, replication of Living Systems, Population Growth and its Limitations, The Exponential Model for Growth and Decay. Age–Dependent Population Structures; Aging and Death, The Age –Structure of Populations, Predicting the Age –Structure of a Population.	15
II	Background on DNA, An Introduction to Probability, Conditional Probabilities, Matrix Models for base substitution, Phylogenetic Distances, Phylogenetic Trees.	15
IV	Infectious Disease Modeling; Elementary Epidemic Models, Threshold Values and Critical Parameters, Variations on a Theme, Multiple Population and Differentiated Infectivity.	15
V	A Mathematical Approach to HIV and AIDS; Viruses, The Immune System, HIV and AIDS, An HIV Infection Model, A Model for a Mutating AIDS, Predicting the Onset of AIDS.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. Barnes, B., Fulford, G. R. Mathematical Modelling with Case Studies, CRC Press. (2008)
2. Chou. C. S., Friedman, A. Introduction to Mathematical Biology. Springer. (2016)
3. Keshet, L.E., Mathematical Models in Biology, Random House New York. (1998)

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal Tests, quizzes and Presentation.
Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.
Further Suggestions: .....

Core-Elective (Group-2) Course – IV : File Structure and Data Base Management

Programme/Class: M.Sc.	Year: UG Fifth year of PG II Year	Semester: Fourth/Tenth
Course Code: 1020310	**Course Title:** File Structure and Data Base Management	Theory

Course Objectives:

The aims and objectives of this course are

1. To understand the basic concepts of file organization and Database,
2. To discuss the advantages of database system over conventional file system,
3. To make a logical and analytical comparison of different Data Models.
4. To provide strong dimensions, strengths and future prospects of Database Systems,
6. To design and implementation of Database Modeling.
1. To transform ERD (Entity Relationship Diagram) into relations,
2. To develop good skills in SQL (Structured Query Language).

Course outcomes:

CO1: Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL

CO2: Improve the database design by normalization and describe the fundamental elements of relational database management systems

CO3: Design ER-models to represent simple database application scenarios and convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.

CO4: Familiar with basic database storage structures and access techniques: file and page organizations, indexing methods including B tree, and hashing.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 4-0-0 (Five Hours in a week) or 60 Lecture Hours in a Semester

Unit	Topics	No. of Lectures Total 60
I	File Organization:The constitution of a file,Operations on files, Primary key Retrieval, Sequential files, Index sequential files:implicit index,L limit indexing multi-level,Indexing schemes, Structure of index sequential file, VSAM direct files, Hashing techniques, Extended hashing, Secondary Key Retrieval: Inverted and Multi list files, Indexing Using Tree Structures: Tree schemes, Operation, Capacity, B Tree, B+ trees.	15
II	Data base Management System: What is DBMS? Three - level architecture of DBMS, Relation Data Model: Relational Database: Attributes and domains, Tuples, Relations and their schemes, Relation representation, Keys, Relational operations, Integrity Rules, Relational Algebra: Basic Operations, Additional Relation algebraic operations, Some Relational Algebra Queries.	15

III	Structural Query Language (SQL): Data definition, Data manipulation, Condition Specification, Arithmetic and aggregate operators, SQL join, Set Manipulation, Categorization, Updates.	15
IV	Relational Database Design: Functional dependencies, First, second third and BCNF normal Forms, Data integrity and recovery. Database Security, Integrity and Control Security and Integrity threats, Defense mechanism, Integrity, Auditing and Control, Recent trends in DBMS- Distributed and Deductive Database.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.

Suggested Readings:

1. Date C.J.: Introduction to Database System, Addison Wesley, 2003.
2. Desai ,B.: An Introduction to Database System, Galgotia Publications, 2016.
3. Ullman ,J.D.: Principles of Database Systems (2 nd Edition), Galgotia Publications Pvt.Ltd., 1994/ W.H. Freeman & Co. Ltd., 1982.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal Tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.

Further Suggestions: .....

M.Sc. II
Core-Elective (Group-2) Course – V : An Introduction to Fuzzy Logic and Genetic Algorithm

Programme/Class: M.Sc.	**Year: PG II Year**	**Semester**: Fourth/Tenth
Course Code: 1020311	**Course Title:** An Introduction to Fuzzy Logic and Genetic Algorithm	Theory

Course Objectives: The aim is to equip students with some state-of-the-art fuzzy-logic, Genetic Algorithm Optimisation and Neural Network technology to prepare them in a better way for the rapidly evolving high-tech information-based modern industry and market. After completing this course, the students will be able to get employment if the electronics equipment's where computational artificial intelligence is used.

Course outcomes:

CO1. This theory helps to solve those problems which are described in linguistic terms.

CO2. This theory provides an excellent tool to handle the vagueness in modern science and technology problems such as computer science, economics and medical science by genetic algorithm, neural network.

CO3. This theory can be used to make modern systems based on Artificial Intelligence (A.I) and soft computing.

CO4. On the basis of this theory many real-life based problems can be solved such as robotics, management etc.

CO5. On the basis of the theory be able to apply fuzzy information in decision making,

Credits: 5	**Core Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Total No. of Lectures-Tutorial (05 hours per week): L-T: 5-1

Unit	Topics	No. of Lectures Total 60
I	Introduction: Basics concepts on crisp sets, Crisp relations, Fuzzy sets, α-cuts, Additional properties of α-cuts, Level sets, Cardinality of Fuzzy Sets, Types of fuzzy sets, L-Fuzzy Sets, Convex fuzzy sets, Fuzzy Cartesian products,	15
II	Operations of Fuzzy Sets: Fuzzy complement, Fuzzy union. Fuzzy intersection, T-norms, T-conorms, combination of operations, General aggregation Operations. Fuzzy numbers: Concept of Fuzzy Number, Types of Fuzzy Numbers (Triangular and Trapezoidal), Arithmetic operations on Fuzzy Numbers.Fuzzy Relations: Fuzzy relations, Projections and Cylindric extensions, Binary fuzzy relations, binary relations on single set, Fuzzy equivalence relations, Fuzzy partial order relations, Fuzzy ordering relations. Fuzzy ranking method.	15
III	Crisp Logic, Predicate Logic, Fuzzy logic and Possibility theory: Fuzzy propositions, Fuzzy quantifiers, Linguistic hedges, Inference from conditional fuzzy propositions, Inference from conditional and qualified propositions, Fuzzy Controller and Fuzzy Inference System: Fuzzification, Defuzzification (Center of area (COA), Center of maxima (COM), Min of max	15

	method (MOM), Center of sums, Weighed average method) Fuzzy rules, Fuzzy controller, Fuzzy inference systems (Mamdani, Sugeno's and Tsukamoto)	
IV	Genetic Algorithm(GA): History and basic concepts, search space, Encoding, Fitness function, Reproduction: Roulette-wheel selection, Boltzmann selection, rank selection, steady state selection, elitism, generation gap and steady state replacement. Crossover, Inversion and Deletion, Mutation operators, Bitwise operators, generation cycle, convergence in GA, optimisation under GA.	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments etc.

Suggested Readings:

1. **Dubosis Didler and Prade, Henri,** Fuzzy Sets and systems Theory and Applications,
2. **Academioc Press, NewYork,** 1980
3. **Klir . Georage. J and Yuan Bo,** Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi. 2009
4. **Lee, Kwang H.,** First Course on Fuzzy Theory and Applications, **Springer International Edition, 2009.**
5. **Ross, Timothy J.,** Fuzzy Logic with Engineering Applications, McGraw Hills inc.. 2004 New Delhi
6. **Roger, Jyh-Shing; Sun, Chuen-Tsai; Mizutani, Eiji,** Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, *MATLAB curriculum series,* illustrated, reprint, Prentice Hall, 1997
7. **Zimmermann,H.J.** Fuzzy Set Theory & its Applications, Allied Publishers Ltd. New Delhi, 2006.
8. **Rajasekaran S., Vijayalakshmi G.A.,** Neural Networks, Fuzzy Logic and Genetic Algorithm, (EEE) PHI, 2011.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in UG degree.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, and NPTEL, Moocs. E-contents from different online libraires.

Further suggestions: .....

Core-Elective (Group-2) Course – VI : Advanced Discrete Mathematics

Programme/Class: M.Sc.	Year: PG II Year	Semester: Fourth/Tenth
Course Code: 1020312	**Course Title: Advanced Discrete Mathematics**	Theory

Course Objectives: The main objective of the course is to introduce concepts of mathematical logic, Lattice and graph theory and to give a brief introduction of Boolean algebra, bipartite graphs and trees and studying for their applications in real life.

Course outcomes:

CO1: : Analyze logical propositions using truth tables.

CO2: : Understand the concept of lattice.

CO3: : Learn about the applications of Boolean algebra in switching theory.

CO4: Use the concept of planar graphs, trees and study for their properties.

Credits: 4	Core Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Total No. of Lectures-Tutorial (04 hours per week): L-T: 4-0

Unit	Topics	No. of Lectures Total 60
I	Formal Logic: Statements, proposition, symbolic representation and tautologies, quantifiers, proposition logic. Lattices: Lattices as partially ordered sets, their properties, lattices as algebraic systems, some special lattices, e.g., complete, complemented and distributive lattices, some special lattices e.g., bounded, complemented & distributive lattices.	15
II	Boolean Algebra: Boolean algebra as lattices, various Boolean identities, the switching algebra example, join - irreducible elements, atoms and minterms, Boolean Forms and their equivalence, minterm Boolean forms, sum of products canonical forms, minimization of Boolean functions, applications of Boolean algebra to switching theory (using AND, OR and NOT gates), Karnaugh maps.	15
III	Trees, Binary tree, Spanning tree, Euler's Formula for connected Planar Graphs. Complete& Complete Bibarate Graphs. Kuratowski's Theorem (statement only) and its use, Cut-sets, Fundamental Cut-sets, and Cycles. Minimal Spanning Trees and Kruskal's Algorithm.	15
IV	Matrix Representations of Graphs, Incidence Matrix, Circuit Matrix, Cut-Set Matrix, Adjacency Matrix, Euler's Theorem on the Existence of Eulerian Paths and Circuits. Directed Graphs. In degree and Out degree of a vertex. Weighted Graphs. Dijkstra's Algorithm	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: 1. Tremblay, J.P. and Manohar, R. Discrete Mathematical Structures with Applications to Computer Science. Ist edition McGraw Hill Book Co., 2017. 2. Lepschutz, S. and Lipson, M. Linear Algebra. 5th edition, Tata McGraw Hill 2012. 3. Ram, B. Discrete Mathematics. Pearson Education, 2012. 4. Kenneth H. R. Discrete Mathematics and Its Applications, 7th edition, Tata McGraw Hill, 2011. 5. 5. Liu, C. L. Elements of Discrete Mathematics. Tata McGraw Hill, 2000.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.
Further suggestions: .....

Pre-Ph.D. Course work Syllabus

Sem.	Paper Code	Title of the Paper	No. of Lectures(hrs.)/Duration	Credits
One	1120301	Research Methodology	60	04
	1120302	Vedic Mathematics	30	02
	1120303	Applied Mathematics-I	30	02
	1120304	Applied Mathematics-II	30	02
	1120305	Optimization	30	02
	1120365	Survey/Research Project	One Semester	04

Pre-Ph.D. COURSE WORK PAPER I, RESEARCH METHODOLOGY

Programme: Pre-Ph.D. Course work	**Duration**: Six Months	**Semester**: First
Course Code: 1120301	**Course Title:** Research Methodology	Theory

Course Objectives: The main objective of this paper is to

1. Identify and discuss the role and importance of research in the social sciences.
2. Identify and discuss the issues and concepts salient to the research process.
1. Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project.
3. Identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting.

Course Outcomes: At the end of this course, the students should be able to:

CO1. Understand some basic concepts of research and its methodologies.
CO2. Explain key research concepts and issues read, comprehend, and explain research articles in their academic discipline.
CO3. Select and define appropriate research problem and parameters.
CO4. Organize and conduct research (advanced project) in a more appropriate manner.
CO5. Write a research report and thesis.
CO6. Write a research proposal (grants).

Credits: 4	**Core Compulsory**

Total No. of Lectures-Tutorial (04 hours per week):
L-T: 4-0

Unit	Topics	No. of Lectures
I	Perception & Definition of Research, Objectives & Motivations of Research, Importance of Research, Types of Research, Research Methods versus Methodology, Process of Research, Review of Literature, Formulation of the Research Problem, Sources and Identification of a Research Problem, Status of the Research Problem, Formulation of Hypothesis, Research Design, Ethics in Research.	12
II	Synopsis, Funding Agencies in India for Research in Physical Sciences, Project Proposal, Project Report Writing, Research Paper Writing, Thesis Writing, Referencing, Formats of Writing References, Bibliography, Plagiarism, IPR, Technology Development and Transfer.	12
III	Types and Sources of Data, Data Collection Methods, Analysis of Data, Kertosis variance, Central Tendency, Dispersion, Skewness, Correlation, Regression, Probability (Elementary), Binomial, Poisson and Normal Distribution, Baye's rule and Independence of events, Chi-square test.	12
IV	Computer Networking, Internet, Web Browsers, Search Engines, MS Word: Handling graphics tables and charts, Formatting in MS-Word, MS Power point: Creating Slide Show, Screen Layout and Views, Applying Design Template, MS Excel: Features, Formulas and Functions, Number system, Computer codes, BCD Code, EBCDIC, ASCII, Computer Arithmetic.	12
V	Subject Classification Index, Citation, Citation Index, Impact Factor, h-index, i-10index, INFLIBNET, Introduction to Peer Reviewed and Open Access Journals, e-Journals, e-Library, Research Databases in Physical Sciences: Web of Science, Scopus, Science-Direct etc.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, Field visits., Internship, etc.

Suggested Readings:

1. **Creswell. W.**: Research Design, Qualitative, Quantitative and Mixed Methods Approaches (3rdEdition), SAGE, Inc., 2018.
2. **Gupta. S**: Research Methodology: Methods and Statistical Techniques, Deep & Deep Publications, 2010.
3. **Gupta. S.P.**: Statistical Methods, Sultan Chand &Sons, 2014.
4. **Kumar. R**: Research Methodology: A Step-by-Step Guide for Beginners (3rd Edition), SAGE, Inc., 2011.
5. **Melville. S. and Goddard. W.**: Research Methodology: An Introduction (2nd edition).Juta Academic, 2004.
6. **Shortis, T.**: The Language of ICT: Information and Communication Technology, Taylor & Francis, 2016.

Suggested Continuous Evaluation Methods: External evaluation

Course prerequisites: To study this course, a student must have had the subject Mathematics in PG degree

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.

Further Suggestions:.....

Pre-Ph.D. COURSE WORK PAPER II

Programme: Pre-Ph.D. Course work	**Duration**: Six Months	**Semester**: First
Course Code: **1120302**	**Course Title: Vedic Mathematics**	Theory

Course Objectives: The objective of this paper is

1. To introduce the basic concept of Vedic mathematics
2. To study the Derivative and Its Applications , Integrations and Its Applications by Vedic mathematics

Course Outcomes: At the end of this course, the students should be able to:

CO1. After complition the course student will be aware the ancient Indian Mathematics and contribution of our culture.

Credits: 2	**Core Compulsory**

Total No. of Lectures-Tutorial (02 hours per week): L-T: 2-0

Unit	Topics	No. of Lectures
Vedic Mathematics	16 Sutra And 13 Sub Sutras of Vedic Mathematics, Explanations of Ekadhiken Purvena, Eknueyena Purvena, Urdhwa Triyagbhyam Sutra, Contribution of Indian Mathematicians Madhvan, Parmeshvaran, Manjul Bhargav , Shakuntala Devi. Osculator, Recuuring Decimals, Quadratic Equations by Vedic Methods, Bi-quadratic Equations by Vedic Methods, Encryptions, Derivative and Its Applications , Integrations and Its Applications.	30

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, Field visits., Internship, etc.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in PG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.

Further Suggestions:.....

Suggested Readings:

1. **Chauthaiwale. Shriram.:** Enjoy Vedic Mathematics", Art of Living international Bangluru, India
2. **Arya, Vedaveer.:** Indian Contributions to Mathematics and Astronomy , Aryabhata Publications.
3. **Eminent Bharatiya** Mathematicians: Dr Shriram Chauthaiwale, Dr Deviprasad Verma Devendra Deshmukh published by Vidya Bharati, Kurukshetra.

Suggested Continuous Evaluation Methods: External Evaluation

Course prerequisites: To study this course, a student must have had the subject Mathematics in PG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.

Pre-Ph.D. COURSE WORK PAPER III

Programme: Pre-Ph.D. Course work	**Duration**: Six Months	**Semester**: First
Course Code: **1120303**	**Course Title: Applied Mathematics-I**	Theory

Course Objectives: The objective of this paper i

1. To learn the concept of Convergence of nets and filters Para compactness and Nagata-Smirnov Metrization theorem, Bing Metrization theorem
3. Learn the concept of automorphism on a finite field. Structure of multiplicative group of a finite field. Uniqueness of the splitting field, Solvability by radicals, Solvability of Galois group of a polynomial over a field.
4. To study the Inner product spaces, Hilbert spaces.

Course Outcomes: At the end of this course, the students should be able to:

CO1. Apply theoretical concepts in Algebra to understand real world applications.

CO2. Understand the notions of dot product and Hilbert space and apply the spectral theorem to the resolution of integral equations

Credits: 2	**Core Compulsory**

Total No. of Lectures-Tutorial (02 hours per week): L-T: 2-0

Unit	Topics	No. of Lectures
Applied Mathematics-I	"Introduction to the Mathematical Theory of Elasticity, Elasticity, stress, strain, Hooke's law, two- dimensional idealisations, plane stress and plane strain problems, equations of equilibrium, strain- displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions. Two dimensional problems in rectangular coordinates: Stress function, solution by polynomials, Saint Vénant's principle, bending of a cantilever, determination of displacements, Principal stresses, principal strains, three- dimensional Problem "	15
	Energy Theorems and Variational Principles of Elasticity: Strain energy and complementary energy, Clapeyron's theorem, virtual work and potential energy principles, principle of complementary potential energy, Betti's reciprocal theorem, principle of linear superposition, uniqueness of elasticity solution., Basic mathematical models on vibrational analysis for rectangular, circular, elliptic, infinite plates. Basics study of different parameters used in vibration analysis. Solution of mathematical models using different methods like Rayleigh Ritz method, Galerkin method, finite element method, Frobenious method	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, Field visits., Internship, etc.

Suggested Readings:

1. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, Mc Graw Hill, Singapore, 1982.
2. Srinath, L.S., Advanced Mechanics of Solids, Second Edition, Tata McGraw Hill, India, 2003.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation. **Course prerequisites:** To study this course, a student must have had the subject Mathematics in PG degree. **Suggested equivalent online courses:** There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires. **Further Suggestions:**.....
Suggested Readings: 1. **Balagurusamy. E:** Reliability Engineering, Tata McGraw Hill Publications, New Delhi, 2010. 2. **Barlowand. R.F, Proschan. F.:** Mathematical Theory of Reliability, John Wiley and Sons, 1996. 3. **Chandrasekhar. S.:** Hydro dynamic and Hydromagnetic Stability-Chapters!. II.VII,X. XI, Dover. NewYork. 1981.
Suggested Continuous Evaluation Methods: External Evaluation
Course prerequisites: To study this course, a student must have had the subject Mathematics in PG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.
Further Suggestions:.....

Pre-Ph.D. COURSE WORK PAPER - V

Programme: Pre-Ph.D. Course work	**Duration**: Six Months	**Semester**: First
Course Code: **1120305**	**Course Title: Optimization**	Theory

Course Objectives: The objective of this paper is

1. To introduce the basic concept of reliability theory, non-linear programming
8. To study the basic concept of inventory theory, demand, deterioration, shortages etc.

Course Outcomes: At the end of this course, the students should be able to:

CO1. Demonstrate knowledge and understanding of concepts of non-linear programming.

CO2. Understand the basic ideas of fuzzy sets, operations and properties of fuzzy sets and also about fuzzy relations.

CO3. Comprehend the dynamics of inventory management's principles, concepts, and techniques as they relate to the entire supply chain (customer demand, distribution, and product transformation processes).

Credits: 2	**Core Compulsory**

Total No. of Lectures-Tutorial (02 hours per week): L-T: 2-0

Unit	Topics	No. of Lectures
Optimization	**Inventory:** Analytical structure of inventory problems. Different types of demand pattern. Concept of deterioration and shortages. Concept of lead time, Deterministic inventory models, Trapezoidal type demand rate, Stock and price dependent consumption rate, deterioration, time-varying deterioration, imperfect production process, preservation technology, Two-warehouse inventory model, K-release rule, Bulk release rule, different type of holding costs. Concept of partial backlogging and lost sales, Inventory models under trade credit.	10
	Nonlinear programming: Kuhn-Tucker optimality condition, Quadratic programming: Wolfe's method. Integer programming: Modeling using pure and mixed integer programming. Branch and Bound technique. Gomory's cutting plane algorithm.	10
	Fuzzy Set Theory: Constructions of Fuzzy Sets and Operations on Fuzzy Sets, Fuzzy Optimization, Fuzzy control and fuzzy expert systems, Fuzzy Inference: Composition rule, Fuzzy rule and Implication, Inference Mechanism, Inference methods, Fuzzy Sets in Decision-Making: Fuzzy Rank Methods & ordering, Multi criteria Decision Making, decision-making under Fuzziness.	10

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, Field visits., Internship, etc.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests quizzes and Presentation.

Course prerequisites: To study this course, a student must have had the subject Mathematics in PG degree.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online

libraires. **Further Suggestions:**.....
Suggested Readings: **1. Dubosisand. D, Prade. H:** Fuzzy Sets and Systems Theory and Applications, Academic Press, New York, 1980. **2. Bazara. M. S., Sherali. H.D, Shetty .C.M:** Nonlinear Programming-Theory and Algorithms (3rd Edition), John Wiley& Sons, Inc., Hoboken, New Jersey, 2006. **3. Cai, Kai-Yuan**: Introduction to Fuzzy Reliability, Kluwer Academic Publishers, Boston/Dordrecht/London,1996. **4. George J. Klir and BoYuan:** Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi, 2009. 5. **Taha.H.A:** Operations Research-An Introduction (10thEdition), Pearson Publication, 2017.
Suggested Continuous Evaluation Methods: External Evaluation
Course prerequisites: To study this course, a student must have had the subject Mathematics in PG degree.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, and NPTEL. E-contents from different online libraires.
Further Suggestions:.....