चौधरी चरण सिंह विश्वविद्यालय, मेरठ

CHAUDHARY CHARAN SINGH UNIVERSITY, MEERUT

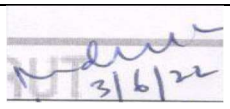
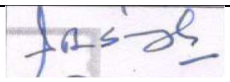
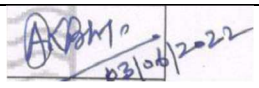
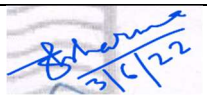
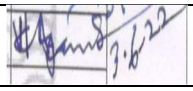
U.G. Research, P.G. (Mathematics) &

Pre. Ph.D. Course- Work PROGRAMME CURRICULUM & SYLLABUS

DEPARTMENT OF MATHEMATICS

(For both University Campus and Colleges)

Members from the Board of Studies

S. No.	Name	Designation	College/ University	Signature
1	Prof. M. K. Gupta	Dean Faculty of Science	Chaudhary Charan Singh University, Meerut.	
2	Prof. Shiv Raj Singh	Convener I	Chaudhary Charan Singh University, Meerut.	
3	Dr. Narottam Kumar	Convener II	Meerut College Meerut.	
4	Prof. Jaimala	Member	Chaudhary Charan Singh University, Meerut.	
5	Dr. Anirudh Kumar Bhargava	Member	MMH College, Ghaziabad	
6	Dr. Madan Pal Singh	Member	Janta Vedic College, Baraut	
7.	Prof. R. C. Dimri	External Subject Expert	HNB Garahwal Central University, Srinagar	
8.	Prof. Shri Prakash Sharma ®	External Subject Expert	IIT Roorkee	
9.	Prof. D. Pandey ®	External Subject Expert	Chaudhary Charan Singh University, Meerut.	
10.	Dr. V. K. Agarwal (R)	Principal	D.N. College, Meerut	
11.	Dr. Satya Deo Tripathi	Scientist	Harish Chandra Research Institute, Prayag Raj	

DEPARTMENT OF MATHEMATICS
CHAUDHARY CHARAN SINGH UNIVERSITY MEERUT

VISION OF THE UNIVERSITY

To produce such professionals who have global competence, vision, and skills as are necessary to meet the challenges of emerging global knowledge economy, by the power of innovation, creativity and efficient learning ability.

MISSION OF THE UNIVERSITY

To emerge among the top ten universities in India within next ten years through defining, implementing and operating dynamic-academic, administrative and functional process, for optimal use of available resources.

ABOUT THE DEPARTMENT

The department of Mathematics was established with the objective of promoting post-graduate studies and research in Mathematics. Mathematics is the queen of all sciences therefore the importance of mathematics in any curriculum is self-evident. This is the single science that is being used by all other disciplines, that is why its growth over the years has been phenomenal. In view of this, Mathematics was one of the earliest subjects, which was introduced in the University in 1969. Only the M.Phil. program was introduced in the beginning but later, the idea being to produce system analysts, designers, and researchers rather than mere programmers, M.Sc./M.A. were also started. From the academic session 2021-22 under graduation program (B.Sc./ B.A.) under NEP has also been started.

VISION OF THE DEPARTMENT

- Vision of the Mathematics Department of University Campus and affiliated Colleges is to create a community of mathematical learning in which we promote outstanding teaching, Indian knowledge system, deep understanding and, global centre of excellence in research for the growth of the Nation.
- To achieve high standards of excellence in generating and propagating knowledge in Mathematics.
- To provide an environment where students can learn, become competent users of mathematics and understand the use of mathematics in other disciplines.

MISSION OF THE DEPARTMENT

- To provide an effective teaching-learning process.
- To impart world-class education in an environment of fundamental and applied research in Mathematics.
- To emerge as a global center of learning, academic excellence and innovative research.
- To include innovative skills, teamwork and ethical practices among students so as to meet societal expectations.
- To provide quality education for higher studies and competitive like CSIR-UGC JRF/NET, GATE, SLET, Civil Services, Scientist, and research programme.

M.Sc. Mathematics
Programme prerequisites

To study this programme a student must have/ had the subject Mathematics at UG level.

Programme Outcomes

PO1: Apply knowledge of Mathematics, in all the fields of learning including higher research and its extensions.

PO2: Innovate, invent and solve complex mathematical problems using the knowledge of pure and applied mathematics.

PO3: Provide opportunities in higher education and development on the professional front. It also gives the opportunity for career advancement in teaching, research, and industries.

PO4: Integration of Interdisciplinary thinking and practice.

PO5: Analyze a problem, identify and define the computing requirements with respect to organizational factors appropriate to its solution, and plan strategies for their solution.

PO6: Design, implement and evaluate information systems, processes, components, or programs and source cost-benefit efficient alternatives to meet desired needs, goals, and constraints.

PO7: Deploy and use effective skills, tools, and techniques necessary for information systems practice.

PO8: Most importantly, the program inculcates among the students the higher values which enable them to withstand the challenges of life.

PO9: Deploy and use effective skills, tools, and techniques necessary for information systems practice.

PO10. Effectively communicate about their field of expertise on their activities, with their peer and society at large, such as, being able to comprehend and write effective reports and design documentation.

Programme Specific Outcomes

PSO1. After successful completion of this program, the students would be able to apply knowledge of Mathematics, in all the fields of learning, including higher research and its extensions.

PSO2. To provide students with knowledge and capability in formulating and analysis of mathematical models of real-life applications.

PSO3. To provide comprehensive curriculum to groom the students into qualitative scientific manpower.

PSO3. Carry out development work as well as take up challenges in the emerging areas of the industry.

PSO4. Demonstrate competence in using mathematical and computational skills to model, formulate and solve real life applications.

PSO5. To provide students with a knowledge, abilities and insight in Mathematics and computational techniques so that they are able to work as mathematical professional.

PSO6. Crack lectureship and fellowship exams approved by UGC like CSIR – NET and SET/ ISRO/DRDO.

PSO7. Victorious in getting employment in different areas, such as industries, laboratories, Banks, Insurance Companies, Educational/Research institutions, Administrative positions, since the impact of the subject concerned is very wide.

PSO8. Encourage personality development skills like time management, crisis management, stress interviews and working as a team.

PSO9. To develop problem-solving skills and apply them independently to problems in pure and applied mathematics.

PSO10. To assimilate complex mathematical ideas and arguments.

PSO 11: To improve your own learning and performance.

PSO 12: To develop abstract mathematical thinking

Semester-wise Titles of the Papers in M.Sc. (Mathematics)

Year	Semester	**Course Code**	Core Compulsory/ Elective/ Value added	Paper Title	Theory/ Practical	Credits
I	I		Core Compulsory	Abstract Algebra	Theory	05
			Core Compulsory	Real Analysis	Theory	05
			Core Compulsory	Advanced Differential Equations	Theory	05
			Core Compulsory	Topology	Theory	05
			Core Compulsory	Research Project	Project	04
			Minor Elective & Value added **(for other Faculty)**	Vedic Mathematics#	Theory	04
	II		Core Elective & Value added	**Any one of the following** (a) Advanced Complex Analysis (b) Research Methodology & Computer Applications (c) Dynamical System	Theory	05
			Core Elective	**Any one of the Following** (a) Mechanics (b) Linear Algebra (c) Mathematical Statistics	Theory	05
			Core Elective	**Any One of the following** (a) Advanced Operations Research (b) Programming Language (c) Financial Mathematics	Theory	05
			Core Elective	**Any One of the following** (a) Advanced Discrete Mathematics (b) Data Structure (c) Differential Geometry	Theory	05
			Core Compulsory	Research Project	Project	04
			Minor Elective &Value added **(for other Faculty)**	Quantitative Aptitude#	Theory	04
Note: **#Students (other faculty) can opt at least one minor elective of four credits from Semester I or II #Students of PG Mathematics need to opt one minor elective of at least four credits from other faculty from Semester I or II.**						
				Any Two of the following	Theory	05+05

II	III		Core Elective & Value added	(a) Fluid Dyanamics (b) Functional Analysis (c) Introduction to Soft Computing (d) Mathematical Robotics (e) Information Theory		
			Core Elective & Value added	**Any Two of the following** (a) Advanced Numerical Analysis (b) Measure and Integration (c) Algebraic Coding Theory (d) Object Oriented Programming in C++ (e) Partial Differential Equation	Theory	05+05
			Core Compulsory	Research Project	Project	04
			Value Added (for other Faculty)	Vedic Mathematics	Theory	02
	IV		Core Elective	**Any Two of the following** (a) Mathematical Method (b) Number Theory (c) Mathematical Cryptography (d) Mathematical Biology (e) Mathematical Programming	Theory	05+05
			Core Elective	**Any Two of the Following** (a) Advanced Topology (b) Fuzzy Sets and its Applications (c) Mathematical Modeling and Simulation. (d) File Structure and Database Management System (e) Algebraic Topology	Theory	05+05
			Core Compulsory	Research Project	Project	04

List of all Papers in four Semester

Programme	Year	Semester	Course Title	Core Compulsory/ Elective/Value added	Credit	Teaching Hours
M.Sc.	I	FIRST	Abstract Algebra	Core Compulsory	05	60
			Real Analysis	Core- Compulsory	05	60
			Differential Equations	Core Compulsory	05	60
			Topology	Core Compulsory	05	60
			Research Project	Core Compulsory	04	
			Vedic Mathematics#	Minor Elective (for other faculty)	04	30
		SECOND	Any one of the following (a)Advanced Complex Analysis (b) Research Methodology & Computer Application (c) Dynamical System	Core Compulsory	05	60
			Any one of the following (a) Mechanics (b) Linear Algebra (c) Mathematical Statistics	Core Compulsory	05	60
			Any one of the Following (a) Advanced Operations Research (b) Programming Language (c) Financial Mathematics	Core Elective	05	60
			Any one of the Following (a) Advanced Discrete Mathematics (b) Data Structure (c) Differential Geometry	Core Elective	05	60

			Research Project	**Core Compulsory**	**04**	**60**
			Quantitative Aptitude#	**Minor Elective (for other Faculty)**	**04**	
	Note: Students (Other Faculty) can opt for only one minor elective from either Semester I Or II. Students of PG mathematics need to opt one minor elective of at least four credits from other faculty either in semester I or II.					
	II	**THIRD**	**Any Two of the following** **(a) Fluid Dynamics** **(b) Functional Analysis** **(c) Introduction to Soft Computing** **(d) Mathematical Robotics** **(e) Information Theory**	**Core Elective**	**05+05**	**60+60**
			Any Two of the following **(a) Advanced Numerical Analysis** **(b) Measure and Integration** **(c) Algebraic Coding Theory** **(d) Object Oriented Programming in C++** **(e) Partial Differential Equation.**	**Core Elective**	**05+05**	**60+60**
			Research Project	**Core Compulsory**	**04**	
			Vedic Mathematics	**Value Added**	**02**	**30**
		FOURTH	**Any Two of the following** **(a) Mathematical Method** **(b) Number Theory** **(c) Mathematical Cryptography** **(d) Mathematical Biology** **(e) Mathematical Programming**	**Core Elective**	**05+05**	**60+60**

			Any Two of the following **(a) Advanced Topology** **(b) Fuzzy Sets and Its Applications** **(c) Mathematical Modeling and Simulation.** **(d) File Structure and Database Management System** **(e) Algebraic Topology**	**Core Elective**	**05+05**	**60+60**
			Research Project	**Core Compulsory**	**04**	

Pre-Ph.D. Course Work Mathematics (Effective from 2022)
Structure

Sem.	Paper Code	Title of the Paper	No. of Lectures(hrs.)/Duration	Credits
One		Research Methodology	60	04
		Advanced Mathematics I	60	06
		Advanced Mathematics II	60	06
		Survey/Research Project	One semester	Qualifying

Detailed Syllabus

For

M.A. /M.Sc. I (MATHEMATICS)

or

B.A. /B.Sc. (Research)
MATHEMATICS

M.A./M.Sc. I (SEMESTER-I) PAPER-I

Abstract Algebra

Programme/Class: M.A./M.Sc.	**Year:** UG Research Fourth Year or P.G. Ist Year	**Semester:** First
Subject: Mathematics		
Course Code:	**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 Outcome:

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 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: **5**	**Core Compulsory**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	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.	12
II	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.	12
III	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, Zorn's lemma, Krull's theorem, Gauss lemma.	12
IV	Field extensions, Finite field extensions, Simple field extensions, Algebraic and transcendental extensions, Minimal polynomial, Remainder theorem, Factor theorem, Primitive n^{th} root of unity, Existence of a primitive n^{th} root of unity, Cyclotomic polynomials.	12
V	Splitting field, Separable extension, Perfect field, Automorphisms of a field, Group of automorphisms of a field, Fixed field, Normal extensions, Fundamental theorem of Galois theory, Construction by ruler and compass, Finite fields, Structure of finite fields, Subfields of finite fields.	12

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

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:
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M.A./M.Sc. I (SEMESTER-I) PAPER-II
Real Analysis

Programme/Class: M.A./M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester:** First
Subject: Mathematics		
Course Code:	**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: **5**	**Core Compulsory**

Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
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.	12
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.	12
III	Power series, Algebra of power series, Uniqueness theorem for power series. Abel's and Tauber's theorems.	12
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.	12
V	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.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, 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, 1976, International student edition.
5. **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.

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:
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M.A./M.Sc. I (SEMESTER-I) PAPER-III
Advanced Differential Equation

Programme/Class: M.A/ M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester:** First
Subject: Mathematics		
Course Code:	**Course Title:** Advanced Differential Equation	Theory

Course Objectives:

1. To expose you to 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: 5	**Core Compulsory**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
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.	12
II	Ordinary points, Singularities, Regular and Irregular singular points, Series solutions about ordinary points, Frobenius series solution Green function.	12
III	Gauss Hypergeometric equation, Derivative and Integral formula for Hypergeometric functions, the point at infinity, Beta and Gamma functions, Hermite polynomial and its different properties.	12
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, Cauchy problem for first order PDEs, Origin of second order partial differential equation and their classification, linear PDEs with constant and variable coefficients.	12
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.	12

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

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:
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M.A./M.Sc. I (SEMESTER-I) PAPER-IV
Topology

Programme/Class: M.A/M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester:** First
Subject: Mathematics		
Course Code:	**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 topologicalspaces; 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: 5	Core Compulsory
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Product spaces, Structure of open balls in a product space, Closures and interiors in a product space, Finite product of metric spaces. Contraction Mapping Principle, Baire's Category Theorem, Connectedness: Connected metric spaces, Connected sets, Characterization of connected subsets of the real line, Properties of connectedness.	12
II	Convergent sequences, Cauchy sequences, Characterization of adherent points and limit points interms of convergent sequences, Convergence in products, Convergence in Euclidean spaces, Cluster points of a sequence, Subsequence, Cluster points and convergent subsequences, Algebra of convergent real sequences, Spaces of sequences.	12
III	Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighborhoods, Interior, Exterior, Boundary and accumulation points, Derived sets, Bases and subbases, Subspaces, Product spaces and relative topology.	12
IV	Continuous functions, Homeomorphisms, The Pasting lemma, Connected and disconnected sets, Connectedness on the real line, Components, Locally connected spaces. Countability axioms – First and second countable spaces, Lindelof's Theorems, Separablespaces,Second countability and Separability.	12
V	Compact spaces and compact subsets, Compact subsets of the real line, Sequential compactness and its characterization, Countable compactness, Bolzano-Weierstrass Property (BWP), Sequential characterization of BWP, Equivalence of BWP and sequential compactness, Covering characterization of the BWP, BWP and total boundedness, BWP and compactness, Lebesgue covering lemma, Compactness and completeness, Compactness and uniform continuity, Boundedness of continuous real-valued functions on compact metric spaces.	12

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

Suggested Readings:

1. **Simmons, G. F:** Introduction to Topology and Modern Analysis, Tata McGraw Hill, India,2016
2. **Copson, E.T:** Metric Spaces**,** Cambridge tracts, 2010.
3. **Dieudonne ,J.:** Foundation of Modern Analysis**,** Academic Press, New York, 1960.
4. **Kasriel ,R. H.:** Metric Spaces**,** Dover Publications, New York, 2009.
5. **Munkres. James.:** Topology, 2nd Edition, Pearson Education, 2021.
6. **Kumaresan S.** Topology of Metric Spaces, 2nd Edition, Narosa (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:
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M.A./M.Sc. I (SEMESTER-I) Minor Elective
Vedic Mathematics

Programme /Class: M. A/M. Sc	**Year:** I	**Semester:** First
Subject: Vedic Mathematics		
Course Code:	**Course Title:** Vedic Mathematics	**Theory**

Course objectives: The objective of this course to enhance the problem-solving skills.
To improve the basic mathematical skills and to help students who are preparing for competitive exams

Course Outcomes:

CO1. It enables faster calculation as compared to the usual method.

CO2. Students will be able to utilize Vedic sutras to enhance their skills for competitive exams and able to solve examinations more efficiently.

CO3. It provides an easy and convenient solution to difficult mathematics problems and calculations.

CO4. It helps to increase mental concentration.

Credits: 4	**Minor Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 4- 1

Unit	Topics	No. of Lectures Total 48
I	Introduction of Vedic Mathematics, Sankalan, Vyavkalan , Friend and Fast Friend , Complements, Beejank , Deviation Methods.	12
II	Vinculum Number, Conversion and its Applications, Formations of Tables , Duplex Method and Its Applications , Square and Square Roots (Perfect), Cube and Cube Roots (Perfect)	12
III	Multiplication by Vedic Sutras, Division by Vedic Sutras , Flag Method , Test of Divisibility, Mixed Operations.	12
IV	Indian Mathematicians (Aryabhatt , Bharti Krishna Trith ji , Nina Gupta, Varahmihir)	12

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

Suggested Readings:

1. **Chauthaiwale, Shriram**" "Enjoy Vedic Mathematics" Art of Living international Bangluru, India
2. **Chauthaiwale, Shriram, Verma, Deviprasadand and Deshmukh, Devendra,** "Eminent Bharatiya Mathematicians".
3. **Singh Shivraj, Kumar Anil, Gupta Soniya, Yadav Rashmi** "Vedic Ganit", Pragati Prakashan, Meerut, India,2022, First Edition.
4. **Vishvkarma, Kailash,** "Vaidik Ganit Vihangam Drishti Part 1" Shiksha Sanskriti Uthan Nyas New Delhi.
5. **Chauthaiwale, Shriram,** "Vedic Ganit Praneta Shankaracharya Pujay shri Bharti Krishan Trithji" Shiksha Sanskriti Uthan Nyas New Delhi.
6. **Upadhyay B.L.** "Prachin Bharatiya Ganit" Vigyan Bharti, New Delhi, India.
7. **Mohan Braj** "History of Mathematics" Hindi Samiti Information Department U.P.,India.
8. **Handa Nidhi** "Ancient Hindu Mathematics an Introduction" Oshina Publications, Indore (MP), India, 2018, First Edition.
9. "Vedic Ganit Nirdeshika" Vidya Bharti Sanskriti Shiksha Sansthan, Haryana, India, 2017, Seventh Edition.
10. **Arya, Vedveer**, "Indian Contributions to Mathematics and Astronomy" Aryabhata Publications.

This course can be opted as a minor elective course by the students of following subjects: Arts and Commerce
Suggested Continuous Evaluation Methods: **Continuous Internal Evaluations through tests, quizzes and presentations.**
Suggested equivalent online courses: www.vedicganita.org by Dr. S.K.Kapoor, **vedic-ganit-certificate-course-in-hansraj college**
Further Suggestions: ……..

M.A./M.Sc. I (SEMESTER-II) PAPER-I
Advanced Complex Analysis

Programme/Class: M.A./M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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: 5	**Core Compulsory**
Max. Marks: 100	Min. Passing Marks:
Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1	

Unit	Topics	No. of Lectures Total 60
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.	12
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,	12
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	12
IV	Weierstrass' factorization theorem, Gamma function and its properties, Riemann zeta function, Riemann's functional equation, Mittag-Leffler's expansion theorem and its applications, Analytic continuation, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation.	12
V	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.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, 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.
4. **Priestly, H. A.:** Introduction to Complex Analysis, Oxford University Press, 2008.

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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-I
Research Methodology & Computer Applications

Programme/Class: M.A./ M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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: 5	**Core Compulsory**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T- 5-01

Unit	Topics	No. of Lectures Total 60
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).	12
II	Scientific research and literature survey, History of mathematics, finding and solving research problems, 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.	12
III	Research tools: Searching google (query modifiers), MathSciNet, ZMATH, Scopus, ISI Web of Science, Impact factor, h-index, Google Scholar, ORCID, JStor, Online and open access journals, Virtual library of various countries.	12
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, DataAnalysis and Data Visualization in Excel.	12
V	Scientific writing and presentation, writing a research paper, survey article, thesis writing; LaTex, PS Tricks etc., Software for Mathematics: Mathematica /MATLAB /Scilab/GAP.	12

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

Course prerequisites: To study this course, a student must have had 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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-I
Dynamical System

Programme/Class: M.A./M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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 underpin the field of dynamical systems.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	The orbit of a map, fixed point, equilibrium point, periodic point, circular map, configuration space and phase space.	12
II	Origin of bifurcation. Stability of a fixed point, equilibrium point. Concept of limit cycle and torus. Hyperbolicity. Quadratic map. Feigenbaum's universal constant.	12
III	Turning point, trans critical, pitch work. Hopf bifurcation. Period doubling phenomena. Nonlinear Oscillators-Conservative system. Hamiltonian system. Various Type of oscillators in nonlinear system. Solutions of nonlinear differential equations.	12
IV	Phenomena of losing stability. Quasiperiodic motion. Topological study of nonlinear differential equations. Poincare map.	12
V	Randomness of orbits of a dynamical system. Chaos. Strange attractors. Various roots to chaos. Onset mechanism of turbulence.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, 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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-II, Mechanics

Programme/Class: M.A. M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
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.	12
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.	12
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.	12
IV	Theoretical Mechanics: Canonical transformation of the Hamiltonian formulation of mechanics in phase space. Four types of generating functions, Poisson Brackets: their definition and their elementary properties. Equations of motion in Poisson Brackets form, Poisson theorem, Jacobi-Poisson theorem, Lagrange Brackets, Invariance of Poisson and Lagrange Brackets with respect to canonical transformations, Relation between Poisson and Lagrange Brackets.	12
V	Hamilton Jacobi theory: Hamilton Jacobi equation, Jacobi theorem, Method of separation of variables in Hamilton Jacobi equation and its simple applications	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, 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
3. **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.

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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-II
Linear Algebra

Programme/Class: M.A/ M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:
Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1.	

Unit	Topics	No. of Lectures Total 60
I	Linear transformations, Isomorphism, Range and null space, The matrix representation of a linear transformations, Linear functionals, Double dual.	12
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.	12
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.	12
IV	The Rational and Jordan forms: Cyclic subspaces and annihilators, Cyclic decomposition and the rational form, The Jordan form.	12
V	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	12

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

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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-II
Mathematical Statistics

Programme/Class: M.A/M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
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.	12
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.	12
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.	12
IV	Sampling Methods: Random Sampling Methods, Simple Random sampling, Stratified Sampling, Systematic Sampling, Probability Proportional to size sampling, Test of Hypothesis and significance: Statistical Hypothesis (Simple and composite), Null and alternative hypotheses, N-P Lemma, Examples of MP and UMP tests, p-value, Tests for Significance, Testing the significance for population mean and variance for t-distribution and chi-square distribution.	12
V	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.	12

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)

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:

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M.A./M.Sc. I (SEMESTER-II) PAPER-III
Advanced Operations Research

Programme/Class: M.A/ M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Sequencing theory, Processing of n-jobs through two machines, three machines and m machines, Graphical Method. Transshipment 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.	12
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.	12
III	Network analysis – Construction of the network diagram, Critical path – float and slack analysis, 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, Multipleservice channels M/M/1, M/M/C models.	12
IV	Introduction to Game Theory, Principles of decision making, Two person Zero – sum game, Pure strategy, Saddle point, Dominance Rule, Mixed strategy, Reduction of m * n game and solution of 2*2, 2*s and 2*2 cases by Graphical and Algebraic methods and formulation to Linear Programming Problem (LPP). Sub-game method, Graphical solutions, Iterative method, Solutions by linear programming,	12
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.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, 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).
2. **Bertsekas, D.P.** Nonlinear Programming, 2nd Edition., Athena Scientific, 1999.
3. **Hadley, G.:** Linear Programming**,** Narosa Publishing House, 1995.
4. **Hillier, F.S. and Lieberman, G.J.:** Introduction to Operations Research (6th Edition),McGraw Hill International Edition, Industrial Engineering Series, 1995.
5. **Rao, S.S.:** Optimization Theory and Applications (2nd Edition), New Age Int., NewDelhi, 1995.
6. **Swarup, K., Gupta, P.K. and Mohan Man:** Operations Research (9th Edition), S.Chand and Sons, New Delhi, 2002.
7. **Taha, H.A.;** Operations Research: An Introduction (10th Edition), PearsonPublication, (2019)

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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-II
Programming Language

Programme/Class: M.Sc.	**Year:** UG Research Fourth Year or PG. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**Course Title:** Programming Language	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.
4. A programming language lets the students to express computational tasks in certain ways.
5. 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorials (in hours per week): L-T: 5-1		
Unit	**Topics**	**No. of Lectures Total 60**
I	**Introduction to the C Language** Writing a Simple C Program: Learning the format of a C program, declaring variables, designingprogram flow and control, defining and using functions, datatypes, using standard terminal I/O functions. Conditional Program Execution: Applying if and switch statements, nesting if andelse, 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.	12
II	**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. Structures: Purpose and usageof 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	12
III	**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, const function arguments, runtime memory management. Pointer and address arithmetic, pointer operations and declarations, using pointers as function arguments, Dynamic memory allocation.	12
IV	**Object oriented paradigm & C++ at a glance** Introduction, Classes and objects: A simple class, C++ objects as physical objects, C++ objectsas data types, structures and classes, classes, objects and memory, static class data, constant member functions and constant objects, friend function and class, class design steps, classrevisited, constructors, parameterized constructors, destructor, order of construction and destruction, constructors with default arguments, nameless objects, dynamic initialization through constructors, constructors with dynamic operations, copy constructor, constructors for two-dimensional arrays, constant objects and constructor, static data members with constructors and destructors, nested classes.	12
V	**Inheritance and Polymorphism** Introduction, class revised, derived class declaration, forms of inheritance, inheritance and member accessibility, constructors and destructors in derived classes, constructors invocationand data members initialization, overloaded member functions, abstract classes, types of inheritance, virtual functions and base class, pointer to derived class objects, array of pointers to base class objects, pure virtual functions, abstract classes, virtual destructors, kinds of polymorphism, inclusion polymorphism, virtual methods, polymorphic objects.	12
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.		

Suggested Readings:

1. **Budd,"**Object Oriented Programming ", Addison Wesley
2. **Balaguruswamy,** "Programming in ANSI C," TMH
3. **Balaguruswami,** "Object oriented with C++", TMH .
4. **C++ Primer** , "Lip man and Lajole", Addison Wesley.
5. **Kanetkar ,Yashwant** "Pointers in C"
6. **Litvin, Maria , litvin , Gary**,"Programming in C++",Vikas.
7. **Mastering** C++ K.R Venugopal Rajkumar, TMH.
8. **Schield, Herbert,** Complete Reference in C," TMH
9. **Samantha, D,** "Object oriented Programming in C++ and Java ", PHI
10. **Yashwant Kanetkar,"** Let us C", BPB

Suggested Continuous Evaluation Methods: Continuous internal evaluation through quizzes and Presentation.
Course prerequisites: To study this course, a student must have had the subject Mathematics/Computer 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: ……..

M.A./M.Sc. II (SEMESTER-II) PAPER-III
Financial Mathematics

Programme/Class: M.A./M.Sc.	**Year:** U.G Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**Course Title:** Financial Mathematics	Theory

Course Objectives: The objectives are to provide an introduction to 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorials (in hours per week): L-T-P: 5-1

Unit	Topics	No. of Lectures Total 60
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.	12
II	Brownian ad Geometric Brownian Motion, Theory of Martingales, Stochastic Calculus, Stochastic differential Equations.	12
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.	12
IV	Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM), Interest rates and interest rate derivatives:	12
V	Binomial lattice model, Vasicek, Hull and White and Cox Ingersoll Ross (CIR) Model for bond p	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: 1. **Parikh, J.C.**, Stochastic Process and Financial Markets, Alpha Science International, 2003. 2. **Roman,S**. An Introduction the Mathematics of Finance, Springer, 1st Edition, 2000 3. **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.
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: ……..

M.A./M.Sc. I (SEMESTER-II) PAPER-IV
Advanced Discrete Mathematics

Programme/Class: M.A/M.Sc.	**Year:** UG Research Fourth Year or PG Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**Course Title:** Advanced Discrete Mathematics	Theory

Course Objectives:

The objective of this course is to provide an overview of discrete mathematics. Through this course, students and researchers can learn basic knowledge of mathematical logic, lattice theory, Boolean algebra and graph theory.

Course outcomes:

CO1. To utilize the mathematical concepts in development of many engineering branches, such as computer science, electronic and communication, electrical and space science.
CO2. To study finite deterministic and non-deterministic machine.
CO3. To use this theory in the development of many computer languages.
CO4. To solve many research problems and real-world problems by using graph theory.
CO5. To study Boolean algebra for solving the problems of coding theory, system reliability and others.
CO6. This course has high rate of employability due to its great applicability in engineering.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures- (in hours per week): L-T: 5-1		
Unit	**Topics**	**No. of Lectures Total 60**
I	Finite state machine (FSM): transition table and state diagrams, Input and output stings for FSM Pattern recognition machines, Delay machines, Equivalence of states, The minimization process, Phrase-structure grammar and its types, Backus-Naur form (BNF), Finite state automata (FSA), Pushdown automata, Turing machine	12
II	Lattices: Lattices as partially ordered sets, Properties of lattices, Duality, Lattices as algebraic systems, Sublattices, Direct products, Bounded lattices, Complete lattices, Complemented lattices, Distributive lattices, Cover of an element, Atoms, Join and meet irreducible elements.	12
III	Boolean algebras, De Morgan formulae, Complete Boolean algebras, Boolean algebras and Boolean rings, The algebra of relations, The lattice of propositions, Valuations of Boolean algebras.	12
IV	Basic concepts of graph, Operation in graph, Monoid, Group, Groups of subgraphs, Vector space, Vector space associated with a graph, Basic vectors of a graph, Circuit and cut-set subspaces, Bases of circuit and cut-set subspaces, Orthogonal vectors and spaces, Intersection and join of circuit and cut-set subspaces, Rank and nullity of a graph, Incidence matrix and its rank, Sub matrices of incidence matrix, Circuit matrix, Cut-set matrix, Fundamental circuit matrix and its rank, Path matrix, Adjacency matrix.	12
V	Directed graph and its types, Digraphs and binary relations, directed paths and connectedness, Euler digraphs, Trees with directed edges, Fundamental circuits in digraphs, Paired comparisons and tournaments, A cyclic digraphs and decyclization, Enumeration of graphs and its types, counting labeled trees, Counting unlabeled trees, Graph enumeration with Polya's Theorem	12

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

Suggested Readings:

1. **Deo, N.**: Graph Theory with Applications to Engineering and Computer Sciences,PHI, New Delhi, 2012.
2. **Gersting, J. L.**: Mathematical Structure for Computer Science (3rd Edition)**,** ComputerScience Press, New York, 1993.
3. **Hopcroft, J. E. and Ullman J.D.**: Introduction to Automata Theory Languages &Computation, Narosa Publishing House, Delhi, 2002.
4. **Lepschutz, Seymour**: Finite Mathematics, McGraw-Hill, New York, 1966.
5. **Liu, C. L.**: Elements of Discrete Mathematics (2nd Edition), McGraw-Hill, New York,1985.
6. **Lipschutz, Seymour & Lipson, M.**L **Shoum's** Outline of Discrete Mathematics, (4th Edition)2021. Mc Graw Hill.
7. **Trembley J.P. and Manohar, R**: Discrete Mathematical Structures withApplications to Computer Science (1st Edition), McGraw Hill, 2001.

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:
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M.A./M.Sc. I (SEMESTER-II) PAPER-IV
Data Structure

Programme/Class: M.A/M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**Course Title:** Data Structure	Theory

Course Objectives:

1. The course is designed to develop skills to design and analyze simple linear and nonlinear data structures.
2. It strengthens the ability to the students to identify and apply the suitable data structure for the given real-world problem.
3. It enables them to gain knowledge in practical applications of data structures.
4. To provide the knowledge of basic data structures and their implementations.

Course outcomes:

CO1. Ability to program data structures and use them in implementations of abstract data types.
CO2. Ability to devise novel solutions to small scale programming challenges involving data structures and recursion.
CO3. Understanding of basic algorithmic complexity.
CO4. Data Structures & Algorithms helps in cracking product-based company interviews. ...
CO5. Learning Data Structures helps in writing optimized code.
CO6. Designing Algorithms.
CO7. Learning Advanced Skills.
CO8. Strong Foundation in Data Structures helps you crack interviews.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	**Introduction to data structure and Array:** Introduction: Basic Terminology: Elementary Data Organization, Data Structure Operations, Algorithms Complexity, Time-Space Trade off. Array Definition and Analysis, Representation of Linear Arrays in Memory, Traversing of Linear Arrays, Insertion and Deletion, Single Dimensional Arrays, Two Dimensional Arrays, Bubble Sorting, Selection Sorting, Linear Search, Binary Search, Multidimensional Arrays, Function Associated with Arrays, Character String in C, Character String Operations, Arrays as parameters, Implementing One Dimensional Array.	12
II	**Stacks, Queues and Sorting:** Introduction to Operations Associated with Stacks Push & Pop, Array representation of stacks, Operation associated with stacks: Create, Add, Delete, Application of stacks recursion polish expression and their compilation conversion of infix expression to prefix and postfix expression, Tower of Hanoi problem, Representation of Queues, Operations of queues: Create, Add, Delete, Front, Empty, Priority of Queues, Sorting: Insertion Sort, Quick sort, two-way Merge sort, Heap sort	12
III	**Linked Lists and Trees:** Singly linked lists: Representation of linked lists in memory, Traversing, Searching, and Insertion into, Deletion from linked list, Polynomial Addition, More on linked list, Header nodes, Doubly linked list, Generalized list.Trees: Basic Terminology, Binary Trees and their representation, expression evaluation, Complete Binary trees, Extended binary trees, traversing binary trees, Searching, Insertion and Deletion in binary search trees, Complexity of searching algorithm, Path length, Huffman's algorithm, General trees, AVL trees, Threaded trees, B trees.	12
IV	**Graphs:** Terminology and Representations, Graphs & Multigraphs, Directed Graphs, Sequential representation of graphs, Adjacency matrices, Transversal Connected Component and Spanning trees, shortest path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.	12
V	**File Structure:** The standard C Library: Input/Output: fopen, fread, etc. String handling functions, Math functions: log, sin etc. Other Standard C functions. Physical storage media, File organization, Organization records into blocks, Sequential blocks, Indexing & Hashing, Primary Indices. Secondary Indices, B+ tree index files, Static, Hash functions, Indexing & hashing comparisons.	12

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

Suggested Readings:

1. **Horowitz and Sahani**, "Fundamentals of Data structures", Galgotia publications
2. **Kruse, R.L., Leary, B.P., Tondo, CL**., "Data structure and program design in C" , PHI
3. **Tannenbaum**, "Data Structures", PHI
4. **Tremblay, Jean Paul & Sorenson, Pal G.**An introduction to data structures and application by (McGraw Hill)

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:
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M.A./M.Sc. II (SEMESTER-II) PAPER-IV
Differential Geometry

Programme/Class: M.A/ M.Sc.	**Year:** U.G. Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**Course Title:** Differential Geometry	Theory

Course Objectives: The objectives of this course are

1. This course introduces the fundamentals of differential Geometry primarily by focusing on the theory of curves and surfaces in three spaces.
2. Introducing the concepts: Regular curves, arc length, and natural parametrization.

Course outcomes:

CO1: Explain the geometry of different types of curves and spaces.

CO2: Understand the basic concepts and results related to space curves, tangents, normal and surfaces.

CO3: Understand principal directions and curvatures, asymptotic lines and then apply their important theorems and results to study various properties of curves and surfaces.

CO4: Explain the physical properties of different curves and spaces.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:
Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1	

Unit	Topics	No. of Lectures Total 60
I	Theory of space curves, arc length, Ttangent and normals, Curvature and torsion of curve given as the intersection of two surfaces, Involute and evolute.	12
II	Metric: The first and second fundamental form, Weingarton equation, Orthogonal trajectories, Mensuier theorem, Gaussian curvature, Euler's theorem, Dupin's theorem, Rodrigue's theorem, Dupin'sindicatrix.	12
III	Spherical Indicatrix, Bertrand Curve, Surfaces, Envelopes, Edge of Regression, Developable Surfaces, Two Fundamental Form.	12
IV	Asymptotic lines, Fundamental equations of surface theory, Gauss'sformulae,Gausscharacteristics equations, Mainardi Codazzi equations, Weingarton equations, Bonnet's theorem on parallel surface.	12
V	Geodesics, Clairaut's theorem,Gauss Bonnet theorem,Conformal mapping and Geodesic mappings,Tissot's theorem, Dini's theorem.	12

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

Suggested Readings:

1. **Carmo ,M. Do:** Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
2. **Laugwitz, D. :** Differential and Riemannian Geometry, Academic Press, 1965.
3. **Millman ,R.S. and Parker, G.D.** Elements of Differential Geometry**,** Prentice Hall,1977
4. **Neill ,B.O.:** Elementary Differential Geometry, Academic Press, 1966.
5. **Singer** ,I**.M. and J.A.** Thorpe: Lecture notes on Elementary Topology and Geometry, Springer-Verlag, 1967.
6. **Thorpe, J.A.:** Elementry Topics in Differential Geometry**,** Springer-verlag, 1979.
7. **Willmore ,T.J.:** An Introduction to Differential Geometry and RiemannianGeometry, Oxford University Press, 1965.

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:
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M.A./M.Sc. II (SEMESTER-II) Minor Elective
Quantitative Aptitude

Programme/Class: M.A./ M.Sc.	**Year:** U.G Research Fourth Year or P.G. Ist Year	**Semester**: Second
Subject: Mathematics		
Course Code:	**Course Title:** Quantitative Aptitude	Theory
Course Objectives: The aim of this course is to develop fast mathematical thinking and computational.		

Course outcomes:

CO1.For Encourage the interest in Mathematics for other student rather than Science students.

CO2. For Cracking the Ist Part of NET Exam.

Credits: 4	**Minor Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T-P: 4-1

Unit	Topics	No. of Lectures Total 48
I	Simplifications, Percentage, Profit & Loss, Simple Interest, Compound Interest, H.C.F.& L.C.M., Mixed Problems	12
II	Introduction of Equations, Simple Equation, Problems on S.E., Linear Equations, Problems on L.E., Quadratic Equations, Problems on Q.E.	12
III	Problems On Number, Problem on Ages, Number System, Applications of Number System.	12
IV	Height &Distance, Progressions, Arithmetic Progression, Geometric Progression, Harmonic Progression, Applications of Progressions	12

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

Suggested Readings:

1. **Aggarwal, R.S**., Quantitative Aptitude for Competitive Exam, (S. Chand)
2. **Guha, Abhijit**., Quantitative Aptitude for Competitive Exam, (Mc, Graw. Hill Education)

This course can be opted as an elective by the students of following subjects: Open for al

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Course prerequisites: Nil

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:

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Detailed Syllabus

For

M.A. /M.Sc. II (MATHEMATICS)
or

Master Degree

IN

MATHEMATICS

M.A./M.Sc. II (SEMESTER-III) PAPER-I or II
Fluid Dynamics

Programme/Class: M.A/ M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**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 othersciences 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.

Course outcomes:

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 behaviour 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 Navier-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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:
Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1	

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.	12
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 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 (Navier-Stokes Equation and Euler Equation), Equation of conservation of moment of momentum, Equation of conservation of energy, Simple and direct applications of conservation equations.	12
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.	12
IV	Two-dimensional irrotational incompressible flows (Complex variable technique and its applications): Flow over a corner, Flow over a circular cylinder, Flow over a moving circular cylinder, Flow over a moving circular cylinder with circulation, 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.	12
V	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. Exact solutions for Navier-Stokes equations: Flow between two parallel rigid porous and non-porous plates - Plane couette flow, Pressure driven (Poiseuille) flow, Generalized plane couette flow, Flow of two immiscible fluids between two rigid non-porous parallel plates, Pressure driven (Hagen-Poiseuille) flow through a tube of uniform circular cross section , Flow through an annulus (created by two concentric circular cylinders) under constant pressure gradient, Flow through a rotating annulus.	12

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, 1976.
5. **Yuan, S.W.:** Foundations of Fluid Mechanics, Prentice Hall of India Private Limited,New-Delhi, 1988., ISBN-10: 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 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.A./M.Sc. I (SEMESTER-III) PAPER-I or II
Functional Analysis

Programme/Class: M.A/M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Functional Analysis	Theory

Course Objectives:
The objective of this course is to introduce the concepts of normed linear space, Banach space and Hilbert space. This course lays a foundation for solving many research problems in different areas such as quantum physics, dynamical system theory and operator theory.

Course outcomes:

CO1. This course has lots of applications in many research areas, such as differential equations, dynamical system theory.

CO2. To study the different concepts of normed linear space with numerical examples.

CO3. To provide a study of the relationship among the different spaces, such as normed linear space, metric space and inner product space.

CO4. To provide a comprehensive study of linear operators and linear functionals on Banach and Hilbert spaces with their properties.

CO5. This course can be applied as a basic tool to solve the problems of integral equations, dynamics of fluids and optimization theory.

CO6. It is highly recommended course to get the employment in research as well as teaching profession.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Normed linear spaces, Banach spaces, Examples and counter examples, Equivalent norms, Reisz Lemma, Basic properties of finite dimensional normed linear spaces, Bounded linear operators and functionals.	12
II	Dual spaces, Open mapping and closed graph theorems, Hahn-Banach theorem for real and complex linear spaces, Uniform boundedness theorem.	12
III	Inner product spaces, Hilbert spaces – Orthonormal sets, Bessel's inequality, complete orthonormal sets and Perseval's identity.	12
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.	12
V	Spectral theory in finite dimensional normed spaces, Resolvent operator, Spectral properties of bounded linear operators, Spectral radius, More results on resolvent and spectrum, Spectral properties of bounded self-adjoint linear operators, Spectral family of a bounded self—adjoint linear operator, Spectra representation of bounded self-adjoint operators.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: 1. **Goffan, C. and Pedrick , G.:** A First course in Functional Analysis, AMS ChelseaPublishing: An Imprint of the American Mathematical Society, New York, 1983. 2. **Jain, P.K. and Ahuja, O.P.:** Functional Analysis**,** New Age (International P, Ltd,) NewDelhi, 2010. 3. **Kreyszig, E.:** Introductory Functional Analysis with Applications**,** John Wiley andSons, New York, 2007. 4. **Simmons, G.F.:** Introduction to Topology and Modern Analysis, McGraw Hill BookCo., New York, 2013. 5. **Taylor, A.E.** Introduction to Functional Analysis, John Wiley and Sons, New York,2013. 6. **Bollobas, B.:** Linear Analysis, An Introductory Course, Cambridge University Press,Cambridge, 1999. 7. **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: ……..

M.A./M.Sc. II (SEMESTER-III) PAPER-I or II
Introduction to Soft Computing

Programme/Class: M.A./M.Sc.	**Year:** PG. 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Introduction to Soft Computing	Theory

Course Objectives:

1. To introduce the concepts in Soft Computing such as Artificial Neural Networks,
2. Fuzzy logic-based systems, genetic algorithm-based systems and their hybrids.

Course outcomes:

CO1. Learn soft computing techniques and their applications.

CO2. Analyze various neural network architectures.

CO3. Define the fuzzy systems.

CO4. Understand the genetic algorithm concepts and their applications.

CO5. Identify and select a suitable Soft Computing technology to solve the problem; construct a solution and implement a Soft Computing solution.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1		
Unit	**Topics**	**No. of Lectures Total 60**
I	Introduction to Soft Computing Artificial neural networks - biological neurons, Basic models of artificial neural networks – Connections, Learning, Activation Functions, McCulloch and Pitts Neuron, Hebb network.	12
II	Perceptron networks – Learning rule – Training and testing algorithm, Adaptive Linear Neuron, Back propagation Network – Architecture, Training algorithm	12
III	Adaptive networks, Supervised learning neural networks, learning from reinforcement, unsupervised learning neural networks.	12
IV	Fuzzy logic - fuzzy sets - properties - operations on fuzzy sets Fuzzy membership functions, fuzzification, Methods of membership value assignments –, Lambda – cuts for fuzzy sets.	12
V	Introduction to genetic algorithm, operators in genetic algorithm - coding - selection - cross over – mutation, stopping condition for genetic algorithm flow, Genetic-neuro hybrid systems, Genetic Fuzzy rule-based system.	12

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

Suggested Readings:

Text Book

1. **Ross, Timothy J.** Fuzzy Logic with engineering applications, John Wiley & Sons, 2016.
2. **Sivanandam, S. N. and Deepa, S. N.,** Principles of soft computing – John Wiley & Sons, 2007.

References

1. **Bart Kosko,** Neural Network and Fuzzy Systems- Prentice Hall, Inc., Englewood Cliffs, 1992.
2. **Driankov D., Hellendoorn H. and Reinfrank M.,** An Introduction to Fuzzy Control, Narosa Pub., 2001.
3. **Eberhart, R. and Shi, Y.** Computational Intelligence: Concepts to Implementation, Morgan Kaufman/Elsevier, 2007.
4. **Goldberg D.E.,** Genetic Algorithms in Search, Optimization, and Machine Learning, Addison Wesley, 1989.
5. **Shing, Jyh., Jang Roger, Mizutani Eiji., Sun, Chuen-Tsai,** Neuro-fuzzy and Soft Computing: A Computational, Prentice Hall, Inc., 2007
6. **Simon Haykin,** Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc.1998
7. **Sinha N. K. and Gupta, M. M**., Soft Computing & Intelligent Systems: Theory & Applications-Academic Press /Elsevier. 2009.

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

Course Prerequisites: Nil

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:
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M.A./M.Sc. II (SEMESTER-III) PAPER-I Or II
Mathematical Robotics

Programme/Class: M.A./M.Sc.	**Year:** PG. 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Mathematical Robotics	Theory

Course Objectives:

1. To introduce the concepts of Robotic system, its components and instrumentation and control related to robotics.
2. To provide knowledge on the various robotic systems with the help of mathematical models.
3. To introduce the control aspects of non-linear systems.
4. To learn the concepts of non-linear observer design.

Course outcomes:

CO1. explain the fundamentals of robotics and its components
CO2. Illustrate the Kinematics and Dynamics of robotics
CO3. Elucidate the need and implementation of related Instrumentation & control in robotics
CO4. Illustrate the movement of robotic joints with computers/microcontrollers.
CO5. Explain sensors and instrumentation in robotic.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Introduction to Robotics: Brief History, Types of Robots, Laws of Robotics, Advantages and Disadvantages of Robot, Basic Principles in Robotics,	12
II	Mathematical Representation of Robots: Coordinate Frames, Position and Orientation of Rigid Body, Transformations Between Coordinate Systems, Rotary Joint, Prismatic Joint, Screw Joint, Cylindrical Joint, Spherical Joint, Representation of Links Using Denavit – Hartenberg Parameters, Links Transform Matrices.	12
III	Direct Kinematic Model and Inverse Kinematic Model: Degree of Freedom of a Manipulator, Kinematic Modeling of The Manipulator, Kinematic Relationship Between Adjacent Links, Manipulator Transformation Matrix, Manipulator Workspace, Solvability of Inverse Kinematic Model, Solution Techniques.	12
IV	Velocity Analysis and Statics Manipulators: Linear and Angular Velocity of a Rigid Body, Relationship Between Transformation Matrix and Angular Velocity, Mapping Velocity Vector, Velocity Propagation Along Links, Manipulator Jacobian, Jacobian Inverse Jacobian Singularities, Static Analysis.	12
V	Dynamic Modeling and Trajectory Planning: Langragian Mechanics, Dynamic Model of Two and Three Degree of Freedom Manipulator, Dynamic Equation in Cartesian Space, Inverse Dynamic Manipulator, Langrange–Euler Formulation, Newton–Euler Formulation, Comparison Of Langrange–Euler and Newton–Euler Formulations, Steps in Trajectory Planning, Joint Space Techniques, Cartesian Space Techniques, Trajectory Planning for Orientation, Stability Analysis of Dynamic System.	12

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

Suggested Readings:

1. **Ghosal**, **Ashitva** Robotics (Fundamental Concepts and Analysis), Oxford University Press.
2. **Mittal ,R K and Nagrath, I J** Robotics and Control, Tata Megraw-Hill Publishing Company Limited, New Delhi.
2. **Niku, Saeed B.,** Introduction to Robotics, Prentice Hall of India Private Limited, New Delhi
3. **Schilling**, **Robert J.** Fundamentals of Robotics (Analysis and Control), Prentice Hall of India Private Limited, 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.

Further Suggestions:
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M.A./M.Sc. II (SEMESTER-III) PAPER-I Or II
Information Theory

Programme/Class: M.A/ M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**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 modelling and pattern recognition.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
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.	12
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.	12
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.	12
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,	12
V	Some intuitive properties, Maximality, Stability, Additivity, Subadditivity, Nonnegativity, Continuity, Branching etc. and interconnection among them, Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.	12

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.

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:
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M.A./M.Sc. II (SEMESTER-III) PAPER-III Or IV
Advanced Numerical Analysis

Programme/Class: M.A. M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Advanced 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 findingreliable 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, numerical differentiation and integration, numerical initial and boundary value problems of ordinary differential equations, etc.

CO2: Analyze and modify computer codes available in the scientific literature.

CO3. Find the solution of linear and nonlinear equations and solution of differential equations.

CO4. Demonstrate understanding of common numerical methods and how they are used to obtain approximate.

CO5: 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.

CO6: Utilize the symbolic tools of Computer Algebra System (CAS) for example MATLAB, MATHEMATICA and MAPLE independently and in their computer codes for solving a given problem

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Numerical Solution of Partial Differential Equation, Classification of second order partial differential Equations, Finite-difference approximations to partial derivatives, Notation for functions of several variables, Solution of Laplace equation, One dimension heat equation, One dimensional wave equation, Solution of wave equation.	12
II	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.	12
III	Computer Programming: Binary system; Arithmetic and logical operations on numbers; Octal and Hexadecimal systems; Conversion to and from decimal systems; Algebra of binary numbers. Elements of computer systems and concept of memory; Basic logic gates and truth tables, Boolean algebra, normal forms. Representation of unsigned integers, signed integers and reals, double precision reals and long integers. Algorithms and flow charts for solving numerical analysis problems.	12
IV	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.	12
V	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-Bashforth method.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: **Froberg, C.E.:** Introduction to Numerical Analysis**,** Addison-Wesley Pub. Co.,2016. **Gupta, Radhey S.:** Elements of Numerical Analysis, Macmillan India Ltd. NewDelhi, 2015. **Jain, M.K., Iyengar, S.R.K and Jain, R.K.:** Numerical Methods for Scientific andEngineering Computations, New Age International (P) Ltd. New Delhi, 2014. **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.
Further Suggestions: ……..

M.A./M.Sc. II (SEMESTER-III) PAPER-III or IV, Measure and Integration

Programme/Class: M.A./ M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Measure and Integration	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: 5	**Core Elective**

Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorials (in hours per week): L-T-P: 5-1

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.	12
II	Lebesgue outer measure and its properties, $\mathcal{F}_\sigma$ and $\mathcal{G}_\delta$ sets, Lebesgue measure, Measurable sets and their properties, Algebra of sets, σ-Algebra of sets, Measure of open and closed sets, Borel sets and their measurability, Regularity, Non-measurable sets.	12
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.	12
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.	12
V	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.	12

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

Suggested Readings:

1. **Barra, G de**: Measure Theory and Integration, 2nd 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.

Further Suggestions:
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M.A./M.Sc. II (SEMESTER-III) PAPER-II Or IV
Coding Theory

Programme/Class: M.A/ M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Coding Theory	Theory

Course Objectives:
The objective of the course is to teach the students how to produce algebraic codes based on the methods of groups and finite fields and to make the students familiar with some of the most widely used codes and their applications. After studying the course, the students will be able to understand and implement the most widely used algebraic codes, write programs coding and decoding messages.

Course outcomes:
CO1: understand cyclic codes and to study the concept of Bose-Chaudhuri-Hocquenghem (B.C.H.) Codes and Weight Distributions
CO2: learn about basic techniques of algebraic coding theory like matrix encoding, polynomial encoding, and decoding by coset leaders etc.
CO3: understand the concept of Maximum-Likelihood Decoding and Syndrome Decoding and to analyze Double Error-Correcting B.C.H. code and finite fields polynomials.
CO4: learn how algebraic coding theory is applicable in real world problems.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	The Communication channel**,** The coding problem, Types of codes, Error-Detecting and Error- Correcting Codes, Linear codes, The Hemming metric, Description of linear block codes by matrices. Covering Radius Problem.	12
II	Dual codes, Standard Array Syndrome, Step by step decoding modular representation, Error- correction capabilities of linear codes, bounds of minimum distance for block codes, Plot kin Bound, Hamming sphere packing bound, bounds for burst error detecting and correcting codes.	12
III	Important linear block – codes, hamming codes, Golay codes, Perfect codes, Quasi-perfect codes, Reed – Muller codes, Codes derived by Hadamard matrices, Product codes, Concatenated codes, Convolutional Codes.	12
IV	A double-error correcting decimal Code and an introduction to BCH codes, BCH bounds, Cycliccodes, Structure of Cyclic Code, Matrix representation of cyclic codes.	12
V	Hamming and Golay codes as cyclic codes, Error detection with cyclic codes, MDS codes. Self-Dual Code.	12

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

Suggested Readings:

1. **Hill, R.:** A first course in Coding Theory**,** Oxford University Press, 1986.
2. **Lint, J.H. Van**: Introduction to Coding Theory, Springer Verlag, Heidelberg, 2013.
3. **Pless ,V.:** Introduction to the Theory of Error-Correcting Codes **(**3rd Edition), WileyInterscience, New York, 1998.
4. **Pless, V. and Huffman, W.C.:** Fundamentals of Error-Correcting Codes**,** CambridgeUniversity Press, 2003.
5. **Rhee, M. Y.:** Error Correcting Coding Theory, McGraw Hill Inc., 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:
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M.A./M.Sc. II (SEMESTER-III) PAPER-III Or IV
Object Oriented programming in C++

Programme/Class: M.A/M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Object Oriented Programming in C++	Theory

Course Objectives:
This course aims to provide a conceptual understanding of computer system and languages. The objective is to equip students with the knowledge and skills required to implement solutions to problems using the C^{++} programming language.

Course outcomes:

CO1: Strengthen the knowledge on Files and I/O Streams of C++ programming.

CO2: Acquire basic knowledge about Programming in C++

CO3: Gather extensive knowledge in C ++ programming and developing programming skills.

CO4: Understand the Real-Time System design, Hypertext and Hypermedia and AI Expert System

Credits: 5	Core Elective
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Computer system introduction, Characteristics and classification of computers, CPU,ALU,Control unit, data & instruction flow, primary, secondary and cache memories, RAM, ROM, PROM, EPROM, Programming language classifications.	12
II	Introduction to Object Oriented Concepts: Features of OOP's: Class, Objects, Inheritance, Reusability, Data Abstraction, Data Encapsulation, Constructor & Destructor, Polymorphism, Overloading and Virtual functions.	12
III	C^{++}Programming: Data types: Basic data types, User defined data types, new data types Control statement: Looping, Nested loops, Arrays and Strings: Arrays fundamentals, arrays assistance data, arrays of objects, strings, string library functions, arrays of strings, functions, Structures & unions, Pointers.	12
IV	Simple Data Structures: Stacks, Queues, Single and double linked lists, Circular lists, Trees, Binary search tree, C^{++} implementation of stacks, Queues and linked lists.	12
V	Algorithms for searching, Sorting and merging e, g, sequential search, Binary search, Insertion sort, Bubble sort, Selection sort, Merge sort, Quick sort, Heap sort.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, etc.
Suggested Readings: 1. **Balaguruswami:** Programming in C^{++} (3^{rd} Edition), McGraw Hill, 2010. 2. **Kanetkar, Y.P.: Let us C^{++}** (2^{nd} Edition), BPB India, 2015. 3. **Stroustrup, Bjarne:** The C^{++} programming Language, Addison-Wesley Professional,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.
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: ……..

M.A./M.Sc. II (SEMESTER-III) PAPER-III Or IV, Partial Differential Equation

Programme/Class: M.A./M.Sc.	**Year:** PG 2^{nd} Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**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 thispaper 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1		
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.	12
II	Heat equation: Fundamental solution; Mean value formula, Properties of solutions, Energy methods, Wave equation: Solution by spherical means, non-homogeneous equations, Energy methods.	12
III	Nonlinear first order PDE complete integrals, Envelopes, Characteristics; Hamilton Jacobi equations (Calculus of variations, Hamilton's ODE, Legendre transform, Hopf-Lax formula,Weaksolutions,Uniqueness),Conservationlaws(Rankine-Hugoniotcondition,Lax-Oleinik formula, Weak solutions, Uniqueness).	12
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	12
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.	12

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 (2^{nd} 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:
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M.A./M.Sc. II (SEMESTER-III) Value added Course, Vedic Mathematics

Programme/Class: M.A./M.Sc.	**Year:** PG 2nd Year	**Semester**: Third
Subject: Mathematics		
Course Code:	**Course Title:** Vedic Arithmetic	Theory

Course Objectives: The aim of this course is to develop fast mathematical thinking and enhance computational abilities.

Course outcomes:

CO1. Codes are developed using Vedic mathematics as well as implementations of encryption using VLSI circuits.

CO2. In order to speed up calculations in internet security and cryptographic algorithms, Vedic mathematics division, exponentiation, and multiplication are being used.

CO3. The arithmetic and logic unit (ALU) in a computer handles all aspects of logical and mathematical calculations. Various sutras including udharvtriyakbhyam and nikhilam are used for multiplication methods.

Credits: 2	Minor Elective
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 2-1

Unit	Topics	No. of Lectures Total 30
I	History of Vedic Mathematics, Introduction of Vedic Mathematics, History of Indian Mathematics. Basic Operations Covering Addition, Subtractions, Multiplications, Complement, Vinculum Numbers, Digital Roots. Applications of Vinculum Numbers, Uses of Digital Roots.	10
II	Multiplications Techniques (Special Case), Comparison of Standard Methods with Vedic Methods, Multiplications by Urdhwa Triyagbhyam Sutra, Multiplications by Deviation Methods, Different Methods of Squares, Square roots, Cubes, Cube roots.	10
III	Quadratic Equations, Some basic problems with Vedic Methods, Use of Various Vedic Techniques for Competitive Exams, Mathematical Contribution in Indian Mathematics (Bhaskaracharya , Mahaviracharya, Varahmihir etc) .	10

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

Suggested Readings:

1. Bharti Krishna Trith Ji "Vedic Ganit" Moti Lal Banarasi Das , Delhi, India, 1991,First Edition.
2. Uppadhya B.L. "Prachin Bharatiya Ganit" Vigyan Bharti, New Delhi, India.
3. Mohan Braj "History of Mathematics" Hindi Samiti Information Department U.P.,India.
4. Handa Nidhi "Ancient Hindu Mathematics an Introduction" Oshina Publications, Indore (MP), India, 2018, First Edition.
5. "Vedic Ganit Nirdeshika" Vidya Bharti Sanskriti Shiksha Sansthan, Haryana, India, 2017, Seventh Edition.
6. Singh Shivraj , Kumar Anil ,Gupta Soniya ,Yadav Rashmi "Vedic Ganit", Pragati Prakashan, Meerut,India,2022 ,First Edition.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests quizzes and Presentation.

Course prerequisites: open for all

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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-I Or II, Mathematical Methods

Programme/Class: M.Sc.	**Year:** PG 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**Course Title:** Mathematical Methods	Theory

Course Objectives:
The course covers three important areas with the objectives to acquaint students with newtechniques namely Fourier series methods, Integral equations methods and methods of Calculus of Variations. After completing the course, the students will be able to apply the Fourier analysis, integral equations and calculus of variations to many physical problems in science and engineering.

Course outcomes:
CO1. To study the Fourier series and its applications in boundary value problems.
CO2. To study the calculus of variations for solving many engineering problems.
CO3. To provide a study of eigenvalues and eigenfunctions of linear integral equations.
CO4. This course can be utilized to solve many physical problems.
CO5. To show an application of generalized Fourier series in solving of symmetric integral equations.
CO6. 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorials (in hours per week): LT: 5-1

Unit	Topics	No. of Lectures Total 60
I	Basic elements of the calculus of variations. Necessary condition for an extremum. Euler's equation with the cases of one variable and several variables. Variational problems for functional involving several dependent variables, Invariance of Euler's equations. Variational problems in parametric form. Functionals depending on higher order derivatives. Functional dependent on the functions of several independent variables, Variational problems with subsidiary conditions.	12
II	Derivation of the basic formula. Variational problems with moving boundaries, Variational problem with a moving boundary for a functional dependent on two functions, Jacobi condition, Weierstrass function, Legendre condition, Weak minimum and weak maximum.	12
III	Definitions of integral equations and their classification, Relation between integral and differential equations, Fredholm integral equations of second kind with separable kernels, Reduction to a system of algebraic equations.	12
IV	Eigen values and eigen functions, iterated kernels, iterative scheme for solving Fredholm integral equation of second kind (Neumann series), Resolvent kernel, Application of iterative scheme to Volterra's integral equation of second kind.	12
V	Hilbert Schmidt theory, symmetric kernels, Orthonormal systems of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations by using Hilbert Schmidt theory.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, Class activities/ assignments, Field visits., Internship, 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
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.A./M.Sc. II (SEMESTER-IV) PAPER-I or II
Number Theory

Programme/Class: M.A./M.Sc.	**Year:** PG 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code	**Course Title:** Number Theory	Theory

Course Objectives:
The aim of the course is to acquaint students with almost all basic concepts of number theory andto 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 conceptsand 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, analyze and implement the concepts of Diophantine equations for solving different types of problems, for example, sum of two and four squares

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:
Total No. of Lectures-Tutorials (in hours per week): L-T: 5-1	

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.	12
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.	12
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	12
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.	12
V	Application to cryptography: Cryptology, Cryptography, Cryptanalysis, Symmetric Key Cryptography, Public Key Cryptography, Pohlig-Hellman cryptosystem, RSA cryptosystem, Knapsack cryptosystem, ElGamal cryptosystem.	12

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.

Further Suggestions:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-I or II

MATHEMATICAL CRYPTOGRAPHY

Programme/Class: M.A./M.Sc.	**Year:** PG 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code	**Course Title:** MATHEMATICAL CRYPTOGRAPHY	Theory

Course Objectives:

- Learn fundamentals of classical and modern cryptography
- Understand concept and techniques of key exchange mechanisms
- Gain knowledge of digital signatures, services, and attacks
- Learn computational complexity theory and emerging cryptographic techniques

Course outcomes:

CO1. Learn classical cryptographic techniques, Feistel structure, DES, Triple DES, and various block cipher modes of operation.
CO2. Understand the properties of symmetric and asymmetric key cryptosystems and differences between them.
CO3. Learn digital signature process and its security services.
CO4. Understand classification of problems into P, NP, and NP-complete classes, and understand the significance of the P versus NP problem in cryptography.
CO5. Understand the concepts of signcryption, certificateless public key cryptography, and identity-based public key cryptography, and their role in secure communication systems.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Classical cryptography: The XOR operation, Feistel cryptosystem, Data encryption standard (DES), Triple DES, Modes of operation for block cryptosystem: Electronic codebook (ECB) mode, Cipherblock chaining (CBC) mode, Cipher feedback (CFB) mode, Output feedback (OFB) mode.	12
II	Asymmetric key cryptography: Difference between symmetric key and asymmetric key cryptosystems, Diffie-Hellman key exchange, RSA cryptosystem, Rabin cryptosystems, ElGamal cryptosystems.	12
III	Digital signature: Digital signature process, Digital signature services, Attacks on digital signature, Digital signature schemes, Variations and applications for digital signatures	12
IV	Complexity theory: Time complexity, Big-O and small- o notation. The class P, Polynomial time. The class NP. The P versus NP. NP-completeness, Polynomial time reducibility.	12
V	Introduction to signcryption, certificate less public key cryptography, and ID based public key cryptography.	12

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

Suggested Readings:

1. **W. Stallings: Cryptography and Network Security:Principles and Practices**, Pearson; 6th Edition, 2013.
2. **Michael Sipser: Introduction to the Theory of Computation,** Cengage; 3rd edition, 1 October 2014.

3. **Y. Zheng**:**Digital signcryption or How to achieve cost (signature + encryption) << cost(signature) + cost (encryption)**, Available at http://www,signcryption,org/publications/pdffiles/yz-c97-fnl-rvs.pdf.
4. **D. Boneh and M. Franklin**: **Identity based encryption from Weil pairing,** Available at http://eprint,iacr,org/2001/090.pdf.
5. **S.S. Al-Riyami and K.G. Patterson: Certificate less public key cryptography,** Available at http://eprint,iacr,org/2003/126.pdf.
6. **H. Xiong, Z. Qin and** A. V. Vasilakos**: Introduction to Certificateless Cryptography,** CRC Press; 1st Edition, 2016.

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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-I or II, Mathematical Biology

Programme/Class: M.A./M.Sc.	**Year:** PG 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

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.	12

II	Background on DNA, An Introduction to Probability, Conditional Probabilities, Matrix Models for base substitution, Phylogenetic Distances, Phylogenetic Trees.	12
III	Asexual Cell Reproduction, Sexual Reproduction, Classical Genetics, A Final Look at Darwinian Evolution, The Hardy-Weinberg Principle, The Fixation of a Beneficial Mutation. Mendelian genetics, Probability distribution in Genetics, Linkage, Gene Frequency in populations.	12
IV	Infectious Disease Modeling; Elementary Epidemic Models, Threshold Values and Critical Parameters, Variations on a Theme, Multiple Population and Differentiated Infectivity.	12
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.	12

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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-III Or IV
Mathematical Programming

Programme/Class: M.A/ M.Sc.	**Year:** PG 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**Course Title:** Mathematical Programming	Theory

Course Objectives:
This course presents the theory and applications of Mathematical Programming. It extends thetheory 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
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.	12
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.	12
III	Lagrangian saddle points, Duality in nonlinear programming, Strong duality in convex-programming, Duality for linear and quadratic programming.	12
IV	Quadratic programming: (i) Wolfe's algorithm (ii) Beale's algorithm (iii) Theil and Vande Pannealgorithm.	12
V	Duality theory of quadratic and convex programming, separable programming, sequential unconstrained minimization.	12

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

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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-III Or IV Advanced Topology

Programme/Class: M.A/M.Sc.	**Year:** PG 2nd Year	**Semester:** Fourth
Subject: Mathematics		
Course Code:	**Course Title:** Advanced Topology	Theory

Course Objectives:
Topology is a modern branch of geometry. It serves to lay the foundations to study the Analysis and Geometry. It is also a prerequisite for Functional Analysis. The course is designed to developan understanding of topological ideas & techniques and their role in Analysis.
At the end of the course, students should be able to understand and appreciate the central results of general topology, sufficient for the main applications in geometry, number theory and analysis.

Course outcomes:

C01: Define topology on a non-empty set, open, closed, closure, limit point, interior, exterior, and boundary of a set, and explain the relations between these sets.

CO2: Explain how to generate a topology from a collection of subsets under certain conditions, and without any conditions.

CO3: Explain how a metric generate a topology, and the metrizability problem.

CO4: Reconstruct homeomorphism functions between topological spaces

CO5: The beauty of the subject is to gain proficiency in dealing with abstract concepts, with emphasis on clear explanations of such concepts to others

CO6: A necessary course for employability in research institutions as well as in teaching profession.

Credits: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

Unit	Topics	No. of Lectures Total 60
I	Separation axioms – T0, T1, T2, T3, T3(1/2), T4, their characterizations and basic properties.Urysohn's lemma and Teitze Extension Theorem, Statement of Urysohn's Metrization Theorem	12
II	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.	12
III	Countability axioms – First and second countable spaces, Lindelof's Theorems, Separablespaces, Second countability and Separability.	12
IV	The Tychonoff's Product Theorem and Stone-cech Compactification Theorem	12
V	Metrization Theorems and Paracompactness: Local Finiteness, The Nagata- Smirnov Metrization Theorem, Paracompactness, The Smirnov Metrization Theorem.	12

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

Suggested Readings:

1. **Dugundji ,J.: Topology,** Allyn and Bacon, (Reprinted in India by PHI), 1966.
2. **Joshi ,K D, Introduction to General Topology,** New Age International Publisher, 2014.
3. **Munkres ,J. R.: Topology, A First Course,** PHI Pvt. Ltd., N. Delhi, 2018.
4. **Pervin ,W. J.: Foundations of General Topology**, Academic Press Inc., New York,1964
5. **Simmons, G. F.: Introduction to Topology and Modern Analysis**, Tata McGraw-HillEducation Pvt. Ltd., 2016.
6. **Willard, S.: General Topology**, Addison-Wesley, Reading, 1970.

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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-IV

Fuzzy Sets and Its Applications

Programme/Class: M.A./M.Sc.	**Year:** PG 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**Course Title:** Fuzzy Sets 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

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.	12
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.	12
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.	12
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, properties of plausibility measure; necessity measure, properties of possibility and necessity measure, relation between belief measure and plausibility measure.	12
V	Fuzzy Controller and Fuzzy Inference System: Fuzzification, Defuzzification (Center of area (COA), Center of maxima (COM), Min of max method (MOM), Center of sums, Weighed average method) Fuzzy rules, Fuzzy controller, Fuzzy inference systems (Mamdani, Sugeno's and Tsukamoto), Fuzzy linear programming.	12

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, **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
3. **Lee, Kwang H.,** First Course on Fuzzy Theory and Applications, **Springer International Edition, 2009.**
4. **Ross, Timothy J.**, Fuzzy Logic with Engineering Applications, McGraw Hills inc., 2004 New Delhi
5. **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
6. **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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-III Or IV
Mathematical Modeling & Simulation

Programme/Class: M.A/ M.Sc.	**Year:** P.G. 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**Course Title:** Mathematical Modeling & Simulation	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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

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.	12
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.	12
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.	12

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.	12
V	**Simulation:** Simulation to study differential equations and stochastic models, Software simulation of simple dynamical systems, Linear feedback control systems, Simulation of piecewise linear systems, Simulation of nonlinear mathematical models. Simulation of Mechanical Systems.	12

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.

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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-III Or IV
File Structure and Data Base Management

Programme/Class: M.Sc.	**Year:** PG. 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**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,
5. To design and implementation of Database Modeling,
6. To transform ERD (Entity Relationship Diagram) into relations,
7. 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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 5-1		
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.	12
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.	12
III	Structural Query Language (SQL): Data definition, Data manipulation, Condition Specification, Arithmetic and aggregate operators, SQL join, Set Manipulation, Categorization, Updates.	12
IV	Relational Database Design: Functional dependencies, First, second third and BCNF normal Forms, Data integrity and recovery.	12
V	Database Security, Integrity and Control Security and Integrity threats, Defense mechanism, Integrity, Auditing and Control, Recent trends in DBMS- Distributed and Deductive Database**.**	12

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 **(**2nd 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:
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M.A./M.Sc. II (SEMESTER-IV) PAPER-III Or IV Algebraic Topology

Programme/Class: M.A/M.Sc.	**Year:** PG. 2nd Year	**Semester**: Fourth
Subject: Mathematics		
Course Code:	**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: 5	**Core Elective**
Max. Marks: 100	Min. Passing Marks:

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

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.	12
II	Deformation retract sandhotopy type, Fundamental group of S^n, Essential and inessential maps, Fundamental theorem of Algebra.	12
III	Topology of E^n, Borsuk's separation theorem, Deformation of subsets of E^{n+1}, Jordan curve theorem, Fiber spaces, Hurwicz Uniformization theorem.	12
IV	Classification of surfaces: Fundamental groups of surfaces, Homology of Surfaces, Cutting and pasting, Classification theorem.	12
V	Short Exact Sequences, Long Exact Sequences, Mayer -Vietoris Sequence, Excision Theorem, Invariance of domain.	12

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.
3. **Greenberg, Marwin J and Harper, J. R.** Algebraic Topology – A First Course (1st Edition**)**, CRC Press, 2018
4. **Massey, W.S.:** Algebraic Topology- An Introduction**,** Springer India, 2010
5. **Munkres, James R.:** Topology – A First Course, Prentice Hall of India, Delhi 2018.
6. **Spanier, E.H.:** Algebraic Topology **(**3rd Edition**),** Springer, 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, and NPTEL. E-contents from different online libraires.

Further Suggestions:
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Pre-Ph.D.

Course work Syllabus

Sem.	Paper Code	Title of the Paper	No. of Lectures(hrs.)/Duration	Credits
One	H-049	Research Methodology	60	04
		Advanced Mathematics I	60	06
		Advanced Mathematics II	60	06
		Survey/Research Project	One semester	Qualifying

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

Programme: Pre-Ph.D. Course work	**Duration**: Six Months	**Semester**: First
Subject: Mathematics		
Course Code: **H-049**	**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.
3. Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project.
4. 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**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 4-1

Unit	**Topics**	**No. of Lectures 50**
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.	10
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.	10
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.	10
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.	10
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.	10

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:
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Pre-Ph.D. COURSE WORK PAPER II, ADVANCED MATHEMATICS I

Programme: Pre- Ph.D. Course work	**Duration:** Six months	**Semester: First**
Subject: Mathematics		
Course Code:	**Course Title:** Advance Mathematics I	Theory

Course Objectives: The objective of this paper is

1. To introduce the basic concept of reliability theory, non-linear programming,
2. 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 Constructions of Fuzzy Sets and Operations on Fuzzy Sets, Fuzzy Optimization, Fuzzy control and fuzzy expert systems,
4. 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.
5. To introduce the basic concept of Vedic mathematics

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

CO1. Apply theoretical concepts in topology to understand real world applications.
CO2. Demonstrate knowledge and understanding of concepts of non-linear programming, stability theory.
CO3. Knowledge and understanding thoroughly account for industrial applications of different methods in reliability theory
CO4. Understand the basic ideas of fuzzy sets, operations and properties of fuzzy sets and also about fuzzy relations.

Credits: 6	**Core Compulsory**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 6-0

Unit	Topics	No. of Lectures 60
I	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
II	Basic Concepts of Reliability: General Reliability Function, Failure and Failure modes, Hazard Rate, Bath tub Curve, Mean Time to Failure, Availability concepts. System Reliability: Reliability of Series, Parallel, Stand by Redundancy, k-out-of-n Configuration, Series-Parallel, Parallel-Series configurations and Bridge Structure.	10
III	Convergence of nets and filters, Arbitrary product of topological spaces, Arbitrary product of connected spaces, Path connectedness, Compactness: Compactness through nets and filters, Tychonoff' theorem, Urysohn metrization theorem , Stone-Cech compactification, Para compactness and Nagata-Smirnov Metrization theorem, Bingmetrization theorem.	10

IV	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
V	Automorphism on a finite field, Structure of multiplicative group of a finite field, Uniqueness of the splitting field, Determining the degree of the splitting field of polynomials over a field, Finding the splitting field of polynomials over a field, Galois group of a polynomial over a field, Determining the elements of the Galois group of polynomials over a field, Solvability by radicals, Solvability of Galois group of a polynomial over a field.	10
VI	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	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:
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Suggested Readings:

1. **Balagurusamy. E:** Reliability Engineering, Tata McGraw Hill Publications, New Delhi, 2010.
2. **Dubosisand. D, Prade. H:** Fuzzy Sets and Systems Theory and Applications, Academic Press, New York, 1980.
3. **Bazara. M. S., Sherali. H.D, Shetty .C.M:** Nonlinear Programming-Theory and Algorithms (3rd Edition), John Wiley& Sons, Inc., Hoboken, New Jersey, 2006.
4. **Bourbaki.N**: General Topology, Part-I, Addison-Wesley,1966.
5. **Cai, Kai-Yuan**: Introduction to Fuzzy Reliability, Kluwer Academic Publishers, Boston/Dordrecht/London,1996.
6. **Chauthaiwale. Shriram.:** Enjoy Vedic Mathematics", Art of Living international Bangluru, India
7. **George J. Klir and BoYuan:** Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi, 2009.
8. **Lidl. R. , Niederreiter. H** : Introduction to Finite Fields and their Applications (2nd Edition), Cambridge University Press, 1994.
9. **Munkres, J.R.:** Topology, Pearson Education Pvt Ltd, Delhi, 2018.
10. **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:
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Pre-Ph.D COURSE WORK PAPER II, ADVANCED MATHEMATICS II

Programme: Pre-Ph.D. Course work	**Duration:** Six months	Semester: First
Subject: Mathematics		
Course Code:	**Course Title:** Advance Mathematics II	Theory

Course Objectives: The objective of this paper is
1. To study the basic concept of inventory theory, demand, deterioration, shortages etc.
2. To study the Reliability Evaluation Techniques, Software Reliability.
3. To study the basic concept of stability theory, Normal mode technique, stability of flow between two parallel plates.
4. To study the Secret key cryptography and Public key cryptography.
5. To study the Inner product spaces, Hilbert spaces.

6. To study the Derivative and Its Applications , Integrations and Its Applications by Vedic mathematics

Course Outcomes: On completion of this course, students will be able to:

CO1. 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),

CO2. Thoroughly account for industrial applications of different methods in reliability theory

CO3. Provide security of the data over the network, Do research in the emerging areas of cryptography and network security

CO4. Understand the notions of dot product and Hilbert space and apply the spectral theorem to the resolution of integral equations

Credits: 6	**Core Compulsory**
Max. Marks: 100	Min. Passing Marks:

Total No. of Lectures-Tutorial (in hours per week): L-T: 6-0

Unit	**Topics**	**No. of Lectures 60**
I	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
II	Reliability Evaluation Techniques: Binomial Theorem to evaluate Network Reliability, State Space Approach, Minimal Cut Set Method, Two identical unit active and passive redundant systems with constant failure and repair rates, Software Reliability. Fuzzy Methods in Probist system, Profust Reliability Theory, Pos bist Reliability Theory.	10
III	Basic concepts of stability theory, Normal mode technique, Stability of flow between two parallel plates: Instability of an inviscid fluid layer, Instability of plane poiseuille flow. Thermal instability of layer of fluid heated from below: the Benard convection, the Boussinesq approximation, the principle of exchange of stabilities and the first variational principle.Stability of superposed fluids: the Rayleigh Taylor instability, stability of non-viscous and viscous stratified fluid, effect of surface tension, effect of rotation, effect of horizontal and vertical magnetic field.	10
IV	Secret key cryptography and Public key cryptography, The discrete logarithm problem, Discrete logarithm problem over a finite field. Diffie-Hellman Key Exchange. Elliptic curves, Elliptic curves over finite field, The elliptic curve discrete logarithm problem. Elliptic curve cryptography: Elliptic curve Diffie-Hellman Key Exchange, Elliptic curve Elgamal cryptosystem.	10
V	Inner product spaces, Hilbert spaces and their examples, Apolloniu's identity, Schwarz inequality, Triangle inequality, Orthogonality, Pythagorean theorem, Gram-Schmidt orthonormalization process, Continuity of inner product, Completion of an inner product space, Subspace of a Hilbert space, Orthogonal complements and direct sums, Projection, Projection theorem, Dual basis and dual spaces, Riesz representation theorem for bounded linear functionals on a Hilbert space, Strong and weak convergence.	10
VI	Osculator, Recuuring Decimals, Quadratic Equations by Vedic Methods, Bi-quadratic Equations by Vedic Methods, Encryptions, Derivative and Its Applications , Integrations and Its Applications.	10

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

Suggested Readings:

1. **Arya, Vedaveer.:** Indian Contributions to Mathematics and Astronomy , Aryabhata Publications.
2. **Barlowand. R.F, Proschan. F.:** Mathematical Theory of Reliability, John Wiley and Sons, 1996.
3. **Chandrasekhar. S.:** Hydro dynamic and Hydromagnetic Stability-ChaptersI, II,VII,X, XI, Dover, NewYork, 1981.
4. **Eminent Bharatiya** Mathematicians: Dr Shriram Chauthaiwale, Dr Deviprasad Verma Devendra Deshmukh published by Vidya Bharati, Kurukshetra.
5. **G., Whitin. T.M.:** Analysis of Inventory-Systems, Prentice Hall Inc.,1963.
6. **Hoffstein. J, Pipher. J, J.H. Silverman:** An Introduction to Mathematical Cryptography (2nd Edition), Springer, 2014.
7. **Kreyszig. E.:** Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1978.
8. **Meijer. A.R.** : Algebra for Cryptologists (1st Edition), Springer,2016.

9. **Naddor.E**; Inventory System, John Wiley & Sons, Wiley, New York, 1966.
10. **Nath, L.S.Sri:** Mathematical Theory of Reliability, Affiliated East West Press Pvt. Ltd, 2009.
11. **Rathy, R.K.:**An Introduction of Fluid Dynamics Chapter XIII, Oxford and IBH Publishing Company, New Delhi, 1976.

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:
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