Mahatma Jyotiba Phule Rohilkhand University, Bareilly

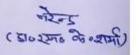
(A State University)



NEW REVISED SYLLABUS FOR POST-GRADUATION IN MATHEMATICS ACCORDING TO THE NEP PG ORDINANCE

M. J. P. ROHILKHAND UNIVERSITY, BAREILLY

TO BE IMPLEMENTED WITH EFFECT FROM THE ACADEMIC YEAR 2022 - 2023



Mission

- · To contribute towards building calibre of the students by providing quality education and research in Mathematics through updated curriculum, effective teaching learning process.
- · To impart innovative skills, team-work, ethical practices to the students so as to meet societal expectations.
- To build a strong base in Mathematics for various academic programs across the institute.

About the Mathematics

Mathematics is a powerful tool for global understanding and communication that organizes our lives and prevents chaos. Mathematics helps us understand the world and prov des an effective way of building mental discipline, Mathematics encourages logical reasoning, critical thinking, creative thinking, abstract or spatial thinking, problem-solving ability, and even effective communication skills. Mathematics is necessary to understand the other branches of knowledge. All depend on mathematics in one way or another. There is no science, art, or specialty except mathematics was the key to it. The discipline and mastery of any other science or art are very much related to the size of mathematics.

Duration:

M.Sc./M.A. Mathematics is a full-time postgraduate level program offered by the Department of Mathematics. This is a 2-years program, consisting of four semesters with two semesters per year.

Eligibility:

For M.Sc. in Mathematics, the candidates with the following qualification are eligible: B.Sc./B.A. (Hons.) in Mathematics from any recognized Indian or foreign university OR B.Sc./B.A. with Mathematics as one of the major subject of study.

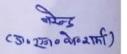
Program Educational Objectives (PEOs)

- Graduates will contributes rapidly growing multidisciplinary research that uses advanced computing capabilities to understand and solve complex problems.
- 2. Graduate of the programme will be capable of handling every problem existing around the world through mathematical structures.
- 3. Graduate of the programme will become competent users of mathematics and to provide mathematical solution to real life problems.
- 4. Graduates will continue lifelong learning and pursue higher studies in mathematical and statistical sciences

Program Outcome:

Graduate will be able to

- a) Progress the critical analysis and problem solving skills required for research and development organization and industry.
- b) Communicate confidently and effectively with industry and society at arge, regarding complex problem and solution of the problem, existing around.



- c) Engage independent and lifelong learning with a high level of enthusiasm and commitment to improve knowledge and competence continuously,
- d) Contribute significantly in academics through teaching and research.
- e) Demonstrate knowledge and understanding of various structure of mathematics and apply the same to one's own work, as a member and leader in a team, manage projects efficiently after consideration of economical and financial factors.
- f) Apply ethical principles and commit to professional ethics and responsibilities and norms of the professional practice.

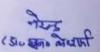
The board of studies for Master of Science in Mathematics of department of mathematics includes the following members:

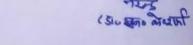
- 1. Dr N. K. Sharma, Associate Prof., Dept. of Maths., SM College, Chandausi, Convener
- 2. Prof. Sanjeev Rajan, Dept. of Maths., Hindu College, Moradabad, Member
- 3. Dr Arif Nadeem, Associate Prof., Dept. of Maths., Bareilly College, Bareilly, Member
- 4. Prof. T.S. Chauhan, Dept. of Maths., Bareilly College, Bareilly, Member
- 5. Dr Harish Chandra Srivastva, Associate Prof., Dept. of Maths., SS College. Shahjahanpur, Member
- 6. Dr Abdul Salam, Associate Prof., Dept. of Maths., GF College, Shahjahanpur, Member
- 7. Prof. M.C. Joshi, Kumayun University, Nainital
- 8. Prof. Sanjay Chadhary, B.R. Ambedkar Univeersity, Agra

Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive a master degree in the Mathematics. M.Sc./M.A. (Mathematics) post-graduates of this department are expected to demonstrate knowledge of major portion of pure and applied mathematics and the ability to provide an overview of scholarly debates relating to Mathematics. Also it is expected that after the completion of this course they will be in a position to pursue their research in Mathematics. Along with mathematical skills, it is also expected that they will lear life skills of argumentation, communication and general social values which are necessary to live rich, productive and meaningful lives. The list below provides a synoptic overview of possible career paths provided by a postgraduate training in Mathematics:

- 1. Teaching
- 2. Research
- 3. Engineering
- 4. Computer programming (In different MNC's)
- 5. Statistician
- 6. Defense Research and Development Organization (DRDO) and Indian Space Research Organization (ISRO).
- Can go for UPSC/Civil services exam.
- 8. Finance
- 9. Science and business





SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION SEMESTER-I

Core Course (CC), Discipline Centric Elective Courses (DCEC), Minor Elective Course (MEC)

Total Credits: 26 (CC: 22, MEC: 4)

Sr. No.	Course Code	Course name	Total Credits
1	MATHCC0411	Advanced Algebra	4
2	MATHCC0412	Real Analysis	4
3	MATHCC0413	Differential Equation with applications	4
4	MATHCC0414	Fluid Dynamics	4
5	MATHCC0415	Power point presentation and viva-voce	6
		Minor Elective Course	
6	MATHMEC0416	MOOC/MEC	4

Minor Elective Courses for M.Sc. (Mathematics)

(Students will choose any one paper.)

Course Code	Course name	Total Credits
MATHMEC0416A	Theory of Differential Equation	4
MATHMEC0416B	Information Theory-I	4

- Note: 1. One project/Dissertation/Survey/Industrial training should be allotted to each student in the second week of first semester in the supervision of faculty members of the department and the complete project should be submitted at end of the second semester.
- 2. If any student published any research paper in UGC Care listed journal during PG programme from this project report, he will be given 25% extra marks which he has been awarded out of 100 marks. Maximum obtained marks will be 100 only.

For example,

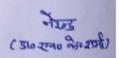
(i) if a student obtains 75 marks in project and he has published a research paper during his project work then his final marks will be

(ii) if a student obtains 88 marks in project and he has published a research paper during his project work then his final marks will be

$$88 + 25\%$$
 of $88 = 88 + 22 = 110$

4

But he will be awarded only 100 marks.





SEMESTER-II Total Credits: 26 (CC: 14, DCEC: 08, MEC: 04)

Sr. No.		Course name	Total Credits
7	MATHCC0421	Advanced Complex Analysis	4
8	MATHCC0422	Topology	4
9	MATHCC0423	Project/ Dissertation /Survey/Industrial training and viva-voce	6
-	1	Disability C. 11 M. sine Courses	
10	MATHDCEC0424	MOOCADORO	4
11	MATHDCEC0425	MOOC/DCEC	4

Discipline Centric Elective Courses for M.Sc. (Mathematics)

(Students will choose any two papers)

Course Code	Course name	Total Credits
MATHDCEC0424&425A	Advanced Discrete Mathematics	4
MATHDCEC0424&425B	Differential Geometry	4
MATHDCEC0424&425C	Advanced Abstract Algebra	4

1					
-			Minor Elective Course		
1	12	MATHMEC0426	MOOC/MEC	4	

Minor Elective Courses for M.Sc. (Mathematics)

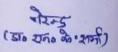
(Students will choose any one paper.)

Course Code	Course name	Total Credits
MATHMEC0426A	Mathematical Medelling	4
MATHMEC0426B	Number Theory	4

SEMESTER-III

Total Credits: 26 (CC: 18, DCEC: 4, MEC: 4)

Sr. No.	Course Code	Course name	Tota Credits
13	MATHCC0431	Partial Differential Equation with Applications	4
14	MATHCC0432	Operation Research	4
15	MATHCC0433	Functional Analysis	4
16	MATHCC0434	Seminar Presentation and Viva-Voce	6
		Discipline Centric Elective Courses	
17	MATHDCEC0435	MOOC/DCEC	4





Discipline Centric Elective Courses for M.Sc. (Mathematics)

Course Code	Course name	
TATUDOUGO 42 CA		Total Credits
MATHDCEC0435A	Difference Equations	4
MATHDCEC0435B	Fuzzy set Theory	4

Tan Income and	Minor Elective Course		
18 MATHMEC0436	MOOC/MEC	4	

Minor Elective Courses for M.Sc. (Mathematics)

(Students will choose any one paper.)

Course Code	Course name	Total Credits
MATHMEC0436A	Measure Theory and Integration	4
MATHMEC0436B	Introduction to Cryptography	4

- Note-1: One project/Dissertation/Survey/Industrial Training should be allotted to each student in the second week of third semester in the supervision of faculty members of the department and the complete project should be submitted at endof the fourth semester.
- 2. If any student published any research paper in UGC Care listed journal during PG Programme from this project report, he will be given 25% extra marks which he has been awarded out of 100 marks. Maximum obtained marks will be 100 only.

For example,

(i) if a student obtain 75 marks in project and he has published a research paper during his project work then his final marks will be

$$75 + 25\%$$
 of $75 = 75 + 18.75 = 93.75 = 94$

(ii) if a student obtain 88 marks in project and he has published a research paper during his project work then his final marks will be

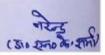
$$88 + 25\% \text{ of } 88 = 88 + 22 = 110$$

But he will be awarded only 100 marks.

SEMESTER-IV

Total Credits: 26 (CC: 14, DCEC: 8, MEC: 4)

Sr. No.	Course Code	Course name	Total Crec its
19	MATHCC0441	Mathematical Statistics	4
20	MATHCC0442	Advanced Fluid Dynamics	4
21	MATHCC0443	Project/Dissertation and viva-voce	6
	Militare	Discipline Centric Elective Cours	es
22	MATHDCEC0444	MOOC/DCEC	4
23	MATHDCEC0445	MOOC/DCEC	4



Discipline Centric Elective Courses for M.Sc. (Mathematics)

(Students will choose any two papers)

Course Code	Course name	Total Credits
MATHDCEC0444&445A	Integral Equation	4
MATHDCEC0444&445B	Theory of Elasticity	4
MATHDCEC0444&445C	Tensors and General Relativity	4
MATHDCEC0444&445D	Information Theory-II	4
MATHDCEC0444&445E	Bio-Mathematics	4
MATHDCEC0444&445F		
AT .	Mathematics for Finance and Insurance	4
MATHDCEC0444&445G	Wavelet Analysis	4
MATHDCEC0444&445H	Differential Geometry of	4

Minor	Elective	Course
T. WEST CAR	ALCOHOLD V.	Course

Differential Geometry of

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Day Is a constant of the const	Minor Elective Course		
24 MATHMEC0446	MOOC/MEC	4	
	ooc/indec		

Minor Elective Courses for M.Sc. (Mathematics)

Course Code	Course name	Total Credits
MATHMEC0446	Student has to take one minor elective course from any other stream/subject/department.	4

Note: The Programme of Post-Graduation in Mathematics will be two years duration. Each year is divided into two Semesters of equal durations. The Programme requires students to take a combination of Core Courses (Major), Discipline Centric Elective Courses, Electives (Minor) and Industrial Training/Survey/Research Project/Dissertation. A studentis required to complete a minimum of 104 Credits (52 Credits in 1st year and 52 Credits in 2st year) for the completion of the Programme and the award of the Master of Science in Mathematics degree. The entire Programme is based on CBCS system. In brief, the entire Programme of Post-Graduation in Mathematics has been organized into Four Semesters.

Criteria for Internal Class Evaluation for all 4 semester papers:

Class Test + Presentations/Assignments = 20 +10 = 30 marks

Guidelines for Industrial Training/ Project/Survey/Dissertation

In each year of the Programme of Post-Graduation in Mathematics (i.e., during both the Semesters) students will have to opt either Industrial Training/ Project/Survey/Dissertation. It will carry 6 Credits in Second Semester. The purpose of undertaking a project is to conduct a systematic study related to his/her opted papers. The entire project will be guided by a Faculty Member as well as by a Firm's Official. Students are advised to work in areas that would be of importance to the business organisation and provide policy recommendations for improvement. They will submit a Progress Report at the end of Ist Semester and 3rd Semester and a Detailed Final Report at the end of 1st year (2nd Semester) and 2nd year (4th Semester). This Detailed Final Report will be evaluated through a Viva - Voce jointly by the Supervisor and the External



Examiner. As regards the option for Dissertation, through this, students will undertake a research work based on the area of his/her research interest. The Dissertation work will be carried out under the guidance and supervision of a Faculty Member. At the end of the year, students will submit a complied Project Report/Dissertation and it will be evaluated through the Viva – Voce, jointly by the Supervisorand the External Examiner.

Course Curriculum Ist Semester

	MATHCC0411	Course Name	Advanced Algebra
Programme	M.A./M.Sc. Mathematics	Credits	4
Total hours	60	Credits	
Total Marks	100 (Class Int. Exam30 m	arka Univ Evam -70 marks	ď
Examination	3 Hours	Pre-requisite of course	NII.
Course Objective	This course introduces the rings. The philosophy of t fundamental role in mathe physics, computer science, economics and engineering	his course is that modern matics itself and in applic	algebraic notions play a

Course Outcomes:	After completing this course, student is expected to learn the following: 1: Explain the fundamental concepts of advanced algebra such as groups and rings and their role in modern mathematics and applied contexts. 2: Demonstrate accurate and efficient use of advanced algebraic techniques. 3: Demonstrate capacity for mathematical reasoning through analysing, proving and explaining concepts from advanced algebra. 4: Apply problem-solving using advanced algebraic techniques applied to diverse situations in physics, engineering and other mathematical contexts.
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Content of Each unit
Review of basic Group Theory, Cauchy's theorem, Sylow theorems, Direct product of groups, Normal and Subnormal Series, Compostion Series, Jordan-Holder theorem, Solvable groups, Nilpotent groups.
Review of basic Ring Theory, Ring homomorphism, Ideals and Factor rings, Prime and Maximal ideals, Euclidean domains, Principal ideal domains and unique factorization domains, Polynomial rings, Factorization of Polynomials.
Extension fields, Splitting fields, Algebraic and Transcendental extensions, Simple extensions, Separable extensions, Finite fields. Galois Theory, Fundamental Theorem of Galois Theory, Solvability of Polynomials by Radicals.
Modules, Submodules, Quotient modules, Homomorphism and Isomorphisms theorem, Nilpotent transformations, Jordan blocks and Jordan forms, Inner product space, Triangle inequality, Schwarz's Inequality, Bessel's Inequality.

Suggested Readings:

1. Gallian, J. A. Contemporary Abstract Algebra, 9th edition. Cengage Learning, 2115.

2. Lang, S. Algebra. 3rd edition, Springer 2012.

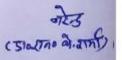
3. Herstein, I. N. Topics in Algebra. 2ndedition. John Wiley and Sons, 2006.

- 4. Bhattacharya, P. B. Jain, S. K. and Nagpaul, S. R. Basic Abstract Algebra. 2 nd e lition, Cambridge University Press, 2003.
- 5. Khanna, V. K. and Bhammbri, S. K. A Course in Abstract Algebra. Vikas Publi: hing house, 1999.

6. Cohn, P. M. Algebra. Vols. I & II, John Wiley & Sons, 1991.

- 7. Luther, S. and Passi, I. B. S. Algebra. Vol. I-Groups, Vol. II-Rings, Narosa Publishing House (Vol. I 1996, Vol. II 1990).
- 8. Axler, S.: Linear Algebra Done Right, 2nd edn. Undergraduate Texts in Mathematics. Springer, New York (1997)
- Brian C. Hall, Lie Groups, Lie Algebras, and Representations: An Elementary Ir treduction, GTM Springer, 2015

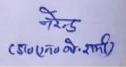
Course Code	MATHCC0412	Course Name	Real Analysis
Programme	M.A./M.Sc. Mathematics	Credits 4	
Total Hours	60		
Total Marks	100 (Class Int. Exam30 marks, Univ. Exam70 marks)		
Examination	3 Hours	Pre-requisite of course NIL	



Course Objective	The course will develop a deep and rigorous understanding of real line R and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. The course will also develop the understanding of metric spaces and convergence, compactness, sequential compactness and connectedness in metric spaces. These concepts have wide range of applications in real life scenario.
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Understand many properties of the real line and learn to define sequence in terms of functions from N to a subset of R. 2: Recognize bounded, convergent, divergent, Cauchy and monotonic sequences. To calculate the limit superior, limit inferior of sequences and limit of a bounded sequence, Riemann integration theory. 3: Recognize Riemann-Stieltjes integral and integration of vector valued function. 4: Recognize bounded variation, total variation, directional derivatives, partial derivative and derivative as a linear transformation.

Units	Content of Each unit
1	Sequences and series of real valued functions, pointwise convergence, uniform convergence, Cauchy's criterion and test for uniform convergence of sequence of functions. Tests for uniform convergence of series of functions (Weierstrass's M-test, Abel's test, Dirichlet's test). Uniform convergence and continuity, Dini's theorem, The Weierstrass approximation theorem.
2	Convergence of Sequences of Measurable Functions: Convergence in Measure, Uniform Convergence, Theorems on Convergence of Sequences of Measurable Functions, Lebesgue Convergence Theorem, Dominated Convergence Theorem, Beppo Levi's Theorem, Fatou's Lemma, Lebesgue Differentiation Theorem, Riemann integration of real valued functions, Existence of the integral, integral as a limit of a sum, first mean value theorem, Second mean value theorem.
3	Definition and existence of Riemann-Stieltjes integral, Properties of integrals, integration and differentiation, Fundamental theorem of calculus.
4	Function of bounded variation, function of bounded variations expressed difference of increasing functions, function of several variables, partial differentiation, partial derivative of functions of two variable, Integral as a function of parameter, inverse and implicit function theorems, Chain rule, Jacobian, Taylor's theorem for two variables, Tauber's theorem.

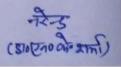
- 1. Walter, R. Principles of Mathematical Analysis. 3rdedition, McGraw-Hill, 2017.
- 2. Simmons, G. F. Introduction to Topology and Modern Analysis. McGraw-Hill Pvt. Ltd. 2016.
- 3. Kumaresan, S. Topology of Metric Spaces. Narosa Publishing House, 2011.
- 4. Terence T. Analysis II. Hindustan Book Agency, 2009.
- 5. Malik, S. C. and Arora, S. Mathematical Analysis. 2nd edition reprint. New Ag: International Publishers 2005.
- 6. Apostol, T. M. Mathematical Analysis. 2 nd edition. Wesley Publishing Co. 2002.
- Somasundram, D. and Chaudhary, B. A First Course in Mathematical Analysis. Narosa Publishing House, 1996.
- 8. Royden, H. L. Real Analysis, Macmillan Pub. Co., Inc. 4th edition, New York, 1993.





Course Code	MATHCC0413	Name with a		ferential Equation n applications
Programme	M.A./M.Sc. Mathematics	Credits		4
Total Hours	60			
Total Marks	100 (Class Int. Exam - 30 m	arks Univ Exan	n70 ma	arks)
Examination	3 Hours Pre-requisite of NIL		NIL	
Course Objective	The objective of this cour- equations, fundamental the equations (DE's).	se is to introduc	e the the	neory of ordinery differential d uniqueness differential
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Understand the stability and Poincare Bendixson theory of ordinary differential equations. 2: Understand the behaviour of solutions of differential equations. 3: Understand the Strum theory for second order ODEs. 4. Understand the construction of Greens functions and their applications to solve ODEs.			

Units	Content of Each unit
1	Lipschitz Condition, Equi-continuity, System of Differential Equations, m th Order Differential Equation in n-dimensions, Concept of Existence, Ascoli-Aerzela Theorem, A theorem of convergence of solutions of a family of initial value problems, Picard's Successive Approximation method, Picard's Theorem, Picard's Second Theorem, Picard-Lindelof Theorem, Existence and uniqueness theory, Cauchy Pearo's Theorem, Continuation of Solutions, BanachFixed Point Theorem, Wroskian.
2	Differential inequalities, One Sided Lipschitz Condition, Maximal and Mirimal Solutions, Differential and Integral Inequalities, The Gronwall's Inequality, Theorem of Wintner, Kamke's Uniqueness Theorem, Nagumo's Criteria, Osgood's Criteria, Successive Approximations.
3	Stability and Poincare Bendixon theory, Phase Plane, Critical Points, Isolated Critical Points, Some Special Critical Points, Centre, Saddle Point, Spiral or FocalPoint, Node, Liapunov Function, Liapunov Stability Theorem, Liapunov Asymptotic Stability Condition, Liapunov Instability Theorem, Non-Linear System, Bendixon Theorem, Poincare – Bendixon Theorem.
4	Strum theory in linear second order ODEs, Adjoint Differential Equation, Abel-Liouville Formula, Fundamental matrix, Adjoint System, Solution of Nonhomogeneous Differential Equation, Floquet Theory, Matrix method for solution of linear differential equations with constant coefficients, Abel's Formula, Strum Separation Theorem, Strum Comparison Theorem, Existence and uniqueness Theorem, Orthogonal and Orthonormal Functions, Strum-Liouville's Problems, Eigen Values and Eigen Functions, Strum – Liouville's Theorem, Eigen Values of Strum – Liouville's Problem.



Suggested Readings:

1. Reid, W. T. Ordinary Differential Equations. John Wiley and Sons, New York, 1971.

2. Simmons, G. F. Differential Equations with Applications and Historical Notes. 2rd edition, Tata McGraw Hill, New Delhi, 2016.

3. Ross, S. L. Differential Equations. 3rd edition, Wiley India, 2007.

4. Raisinghania, M. D. Advanced Differential Equations. S. Chand & Company Lt1., New Delhi, 2001.

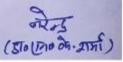
5. P. Hartman, Ordinary Differential Equations, John Wiley, 1964.

6. E.A Coddington and N. Levinson, Theory of ordinary differential equations, McGraw Hill, NY, 1955.

Course code	MATHCC0414	Course Name	Fluid Dynamics
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60	Citatio	
Total Marks	100 (Class Int. Exam30 mar)	cs Univ Exam70 ma	arks)
Examination	3 Hours	Pre-requisite of course	NIL
Course Objective	a standard where the student v range of important results and student with knowledge of the	will be able to apply the in research problems. fundamentals of fluid	t of topics in fluid dynamics to e techniques used in deriving a The objective is to provide the dynamics and an appreciation
Course Outcomes:	of their application to real world problems. After completing this course, student is expected to learn the following: 1: Understand the basic principles of fluid dynamics, such as Lagrangian and Eulerian approach etc. 2: Use the concept of stress in fluids with applications. 3: Analyse Irrotational and rotational flows in fluids and some of their properties 4: Find analytical solution of Navier Stoke equation and solutions of some benchmark problems		

COURSE SYLLABUS

Units	Content of Each unit		
1	Kinematics - Lagrangian and Eulerian methods. Equation of continuity. Boundary surfaces. Stream lines, Path lines and stream lines. Velocity potential. I rotational and rotational motions. Vortex lines.		
Equations of motion – Lagrange's and Euler's equations of motion, Conservative force, Bernoulli's Theorem, Equation of motion by flux method, Impulsive actio Circulation, Kelvin's circulation theorem, Minimum energy theorem.			
3	Motion in two dimensions: Stream function, Irrotational motion in two-dimensional Complex velocity potential, sources, sinks, doublets and images, Milne-Thomson cire. Theorem, Theorem of Blasius.		
4	Motion of Cylinder: Motion of a circular cylinder, Liquid streaming past a fixed circular cylinder, Motion of two co-axial cylinders, Elliptic cylinder moves in an infinite liquid, Liquid streaming past a fixed elliptic cylinder, Circulation about an elliptic cylinder, Kutta-Joukowski theorem,		





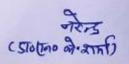
Suggested Readings:

- 1. Besaint, W.H. and Ramsey, A.S. A Treatise on Hydromechanics Part Ihydrost tics, Andesite
- 2. Kundu, P.K., Cohen, I. M. and Dowling, R. D. Fluid Mechanics, 6th edition, Academic Press, 2015.
- 3. O'Neil, M. E., and Chorlton, F. Ideal and Incompressible Fluid Dynamics. Ellis Horwood Ltd,
- 4. Yuan, S.W. Foundations of Fluid Mechanics. Prentice Hall of India Private Limited, New Delhi,
- 5. Curle, N. and Davies, H. J. Modern Fluid Dynamics. Vol1, D Van Nostrand Company Ltd, London, 1968.

Course MATHCC0415 code		Name and viva-voce		ACCOUNT OF THE PARTY OF THE PAR
Programme	M.A./M.Sc. Mathematics	Credits	4	
Total Hours	60 .			
Total Marks	100 (Class Int. Exam30 m	arks PPT and V	/iva-voce -70 marks)	
Course Objective	The purpose of this course is to enhance communication skills and presentation. How to face interviews in competitions.			
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Will be able to present the subject in interviews. 2: Get ability to face interviews. 3: Skills to write subject in own way. 4: Get knowledge of preparing Dissertation, Thesis and Books.			

Pattern

	1	Viva-voce and Presentation of assigned / selected problem /topic using PPT by each student ineach of the other four papers to be evaluated in the presence of one internal and one external
ı		examiner.



MOOC/MEC courses offered to M.Sc. (Mathematics) students:

Course code	MATHMEC0416A	Course Name	Theory of differentia Equations
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60		
Total Marks	100 (Class Int. Exam30 marks	Univ Exam70 mai	rks)
Examination		equisite of course	NIL

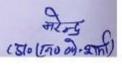
Course Objectice- The Objective of this course is to introduce the theory of ordinary differential equations, fundamental theorems for existence and uniqueness differential equations (DE's)

Unit:-

- Existence and uniqueness Theorem of Homogeneous and NonHomogeneous equations with constant coefficients. Theory of equations with variable coefficients. Method of variation of parameters and the formula for particular integral in terms of Wronskian.
- II. Series solution of second order linear differential equations near ordinary_point. Singularity and the solution in the neighborhood of regular singular point. Euler equation and Frobenius method.
- III. Solutions of Hypermite and Laguerre differential equations.
- IV. Solutions of Recti's equations.

REFERENCES

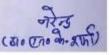
- 1. Earl A. Codington, An Introduction to Ordinary Differentia Equations.
- Elementary Differential Equations and Boundary value problems.
- D.A. Murray, Introductory Course on Differential Equations. Orient Longman (India), 1967.
- 4. A.R. Forsyth. A Trestise on Differential Equations, Macmillan &Co. Ltd., London.
- Differential equation with Applications and Historical notes: G.F.Simmons, CRC Press, Taylor & Francis Group.
- Advanced Differential Equations: M.D. Raisinghania, S. ChandPvt. Ltd., 2008,



Course code	MATHDCEC0416B	Course Name	Information Theory-I	
Programme	M.A./M.Sc. Mathematics	Credits	4	
Hrs/Weeks	- Wathematics		60	
Total Marks	100 (Class I + 7)	Total Hours		
Examination	100 (Class Int. Exam30 marks, 13 Hours	Univ. Exam70 mark	NIL	
Course Objective	The objective of this course is to introduce basic and advanced topics in information theory. This course further explains the different types of entropies, codes, discrete and			
Course Outcomes:	continuous channels and their applications. After completing this course, student is expected to learn the following: 1: Understand the basic concepts of information theory, different types of entropies withtheir properties and applications. 2: Analyse how different coding techniques will perform in different situations.3: Understand about discrete channels and their properties with applications. 4: Understand about continuous channels and their properties with applications.			

Units	Content of Each unit
1	Measure of information – axioms for a measure of uncertainty, the Shannon entropy and its properties, joint and conditional entropies, transformation and its properties, axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.
2	Noiseless coding - ingredients of noiseless coding problem, uniquely decipherable codes, necessary and sufficient condition for the existence of instantaneous codes, construction of optimal codes.
3	Discrete memory less channel - classification of channels, information processed by a channel, calculation of channel capacity, decoding schemes the ideal observer, the fundamental theorem of information theory and its strong and weak converses.
4	Continuous channels - the time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, the converse to the coding theorem for time-discrete Gaussian channel, the time-continuous Gaussian channel, bandlimited channels.

- 1. Ash, R. B. Information Theory. Courier Corporation, 2012.
- 2. Reza, F.M. An Introduction to Information Theory. Courier Corporation, 2012.
- 3. Hankerson, H. D., Harris, G. A. and Johnson, P. D. Introduction to Information Theory and Data Compression. Chapman and Hall/CRC, 2nd edition, 2003.
- 4. Aczel, J. and Daroczy, Z. On Measures of Information and their Characterizations. Academic Press, New York, 1975.





SEMESTER-II CC Course

Course Code	MATHCC0421	Course Name	Advanced Complex Analysis	
Programme	M.A./M.Sc. Mathematics	Contin	4	
Total Hours	60	Credits		
Total Marks	100 (Class Int. Exam30 mar	do the tree 70 marks		
Examination	3 Hours	Pre-requisite of course	NIII	
Course Objective	The primary objective of this course is to understand the notion of logarithmically convex function and its fusion with maximum modulus theorem, the spaces of continuous, analytic and meromorphic functions, Runge's theorem and topics related with it, introduce harmonic function theory leading to Dirichlet's problem, theory of			
Course Outcomes: After completing this course, student is expected to learn the following: 1: Understand the basics of logarithmically convex function that helps in emaximum modulus theorem. 2: Be familiar with metric on spaces of analytic, meromorphic and analytic fequi-continuity and normal families leading to Arzela-Ascoli and related the 3: Appreciate the richness of simply connected region which connects variet topology, analysis and algebra. 4: Know how big the range of an entire function is as well as Picard and theorems.		or the following: ction that helps in extending propriet and analytic functions, secoli and related theorems. Thich connects various fields		

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	COURSE SYLLABUS
Units	Content of Each unit
1	Maximum modulus principle, Minimum modulus principle, Schwarz's lemma, convex functions and Hadamard's threecircles theorem, Three circles theorem as a convexity theorem, Phragmen-Lindelof theorem, Taylor theorem, Laurentz theorem, Fundamental theorem of algebra, Argument principle.
2	The space of continuous functions, spaces of analytic functions, Weierstrans factorization theorem. Gamma function, Reimann zeta function, Residue, Residue theorem, Steadily increasing function, Jordan's Lemma, Integration round unit circle, Evaluat on of integrals when f(z) has no pole on real axis and poles on real axis, Rectangular contcurs.
3	Analytic continuation, Runge's theorem, Integral Function, Order of an Integral function, Canonical Product, Vitali's Convergence Theorem, Carleman's Theorem, Weierstrass's Theorem, Mittag-Leffier's theorem, Schwarz reflection principle. Hadamard's factorization theorem.
4	Basic properties of harmonic functions, Jensen's formula, Jensen's inecuality, Jensen's theorem, Poisson-Jensen Formula, Picard theorem, Schottky's theorem, Infinite Product General principle of convergence of Infinite product, Absolutely Convergence, Derangement of Factors, Problems related to convergence of Infinite Product.
L Ahl	ried Readings: Fors, L.V. Complex Analysis. 3rd edition, McGraw-Hill, 2017. Fors, D. A. Complex Analysis Problem Book, Birkhäuser, 2016.

- 3. Churchill, R. V. and Brown, J. W. Complex Variables and Applications. 9th ed tion, McGraw Hill Education, 2014.
- 4. Edward, S. B. and Snider, Arthur D. Fundamental of Complex Analysis with Applications to Engineering and Sciences. Pearson Education, 2014.

5. Lang, S. Complex Variable. Springer, 2013.

6. Conway J. B. Functions of One Complex Variable. Springer, 2000.

Course Code	MATHCC0422	Course Name	Topology	
Programme	M.A./M.Sc. Mathematics	Credits	4	
Total Hours	60			
Total Marks	100 (Class Int. Exam30 mark	cs. Univ. Exam70 marks)	The second second	
Examination	3 Hours	Pre-requisite of course	NIL	
Objective	This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics. It is a central of modern analysis, and many further interesting generalizations of metric space have been developed.			
Course Outcomes:	After completing this course, student is expected to learn the following 1: Construct topological spaces from metric spaces and using general properties of neighbourhoods, open sets, close sets, basis and sub-basis 2: Apply the properties of open sets, close sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems 3: Understand the concepts of countable spaces and separable spaces 4: Learn the concepts and properties of the compact and connected topological spaces			

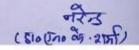
COURSE SYLLABUS

Units	Content of Each unit
1	Definition and examples of topological spaces, basis and sub-basis, oper sets, closed sets, neighbourhoods, interior points, limit points, boundary points, exterior points of a set, closure of a set, derivedset, Hausdorff spaces.
2	Continuous functions, Countable and uncountable sets. Infinite sets and the Axiom of Choice with Cardinal numbers and its arithmetic. Schroeder-Bernstein theorem. Cantor's theorem and the continuum hypothesis. Zom's lemma. Well-ordering theorem, open and closed mappings, homeomorphism, Tychonoff theorem.
3	Compactness and finite intersection property. Sequentially and countably compact sets. Local compactness and one point compactification. Stone vech compactification.
4	Separation axioms, T0, T1, T2, Lindelof spaces, regular and normal spaces. Urysohn Lemma, metrization theorems (Urysohnmetrization, Nagata-Smirnov metrization heorem), Tietze extension theorem, compactification.

1. Joshi, K. D. Introduction to General Topology. 2 nd edition, New Age International Private Limited, 2017.

2. Munkres, J. R. Toplogy. Pearson Education, 2017.

- 3. Simmons, G. F. Introduction to Topology and Modern Analysis. Tata McGraw-Hill Education, 2016.
- 4. Pervin, W. J. Foundations of General Topology. Academic Press, 2014.
- 5. Singh, T. B. Elements of Topology. CRC Press, Taylor Francis, 2013.
- 6. Kelley, J. L. General Topology, 2nd edition, Springer, New York, 1991.



Code	e Project/Survey/biss		Project/Survey/Dissertation/Industrial Training and Viva-Voce	
Total Marks	100 Mathemati	ics Credits	6	
Course Objective	The purpose of this course is to enhance writing and communication skills, presentation. How to present subject and on acids appears to the purpose of this course is to enhance writing and communication skills, presentation.			
Objective How to present subject and ongoing researches. After completing this course, student is expected to learn the following 1: Wil be able to present research work in the field. 2: Get ability to write subject in own way.3: Skills to know future of the subject. 4: Get knowledge of preparing Dissertation, Thesis and Books.				

Pattern

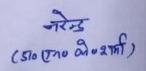
1	The Student will submit two copies of the project/dissertation/survey/ir dustrial training in the department at the end of the semester. Project/dissertation/survey/industrial training will be evaluated by one internal and one external examiner jointly, and a viva-voce examination.
2	One of the teacher will be chosen as supervisor under whose guidance the student will complete is project work/ Project/dissertation/survey/industrial training

Discipline Centric Elective Courses

Course Code	MATHDCEC0424&0425A	Course Name	Advanced Discrete Mathematics		
Programme	M.A./M.Sc. Mathematics	Credits	4		
Total Hours	60				
Total Marks	100 (Class Int. Exam30 marks, Univ.	Exam70 mark	(s)		
Examination	I Llama of course NII				
Course Objective	The main objective of the course is to introduce concepts of mather atical logic, but and graph theory and to give a brief introduction of Boolean algebra, bipartite graphs and trees and studying for their applications in real life.				
Course	After completing this course, student is expected to learn the following:				
Outcomes: 1: Analyse logical propositions using truth tables.					
	Understand the concept of lattice. Learn about the applications of Book	ean algebra in s	switching theory.		
	4: Use the concept of planar graphs, trees and study for their properties.				

Units	Content of Each unit
1_	Formal Logic: Statements, proposition, symbolic representation and tautologies, quantifiers, proposition logic. Lattices: Lattices as partially ordered sets, their properties, lattices as algebraic systems, some special lattices, e.g., complete, complemented and distributive lattices, some special lattices e.g., bounded, complemented & distributive lattices.
2	Boolean Algebra: Boolean algebra as lattices, various Boolean identities, the switching algebra example, join - irreducible elements, atoms and minterms, Boolean Forms and their equivalence, minterm Boolean forms, sum of products canonical forms, minimization of Boolean functions, applications of Boolean algebra to switching theory (using AND, OR and NOT gates), Kamaugh maps
	Trees, Binary tree, Spanning tree, Euler's Formula for connected Planar Graphs. Complete & Complete Bibarate Graphs. Kuratowski's Theorem (statement only) and its use, Cut-sets, Fundamental Cut-sets, and Cycles. Minimal Spanning Trees and Kruskal's Algorithm. Matrix Representations of Graphs, Incidence Matrix, Circuit Matrix, Cut-Set Matrix, Adjacency Matrix, Euler's Theorem on the Existence of Eulerian Paths and Circuits. Directed Craphs. In degree and Out degree of a vertex. Weighted Graphs. Dijkstra's Algorithm
4	Introductory Computability Theory-Finite State Machines and their Transition Table Diagrams, Finite Automata, Moore and Mealy Machines, Grammars and Languages-Phrase-Structure Grammars. Rewiting Rules, Derivations. SententialForms. Language generated by a Grammar. Regular, Context-Free, and Context Sensitive Grammars and Languages. Regular sets, Regular Expressions and the Pumping Lemma. Kleene's Theorem.

- 1. Tremblay, J.P. and Manohar, R. Discrete Mathematical Structures with Applications to Computer Science. Ist edition McGraw Hill Book Co., 2017.
- 2. Lepschutz, S. and Lipson, M. Linear Algebra. 5th edition, Tata McGraw Hill 2012.
- 3. Ram, B. Discrete Mathematics. Pearson Education, 2012.
- 4. Kenneth H. R. Discrete Mathematics and Its Applications, 7th edition, Tata McGraw Hill, 2011.
- 5. Liu, C. L. Elements of Discrete Mathematics. Tata McGraw Hill, 2000.



Course Code	MATHDCEC0424&425B	Course Name	Differential Georaetry	
Programme	M.A./M.Sc. Mathematics	Credits	4	
Total Hours	00			
Total Marks	100 (Class Int. Exam30 marks, Univ. E	(xam70 marks)		
Examination	3 Hours	Pre-requisite of course	NIL	
Course Objective	In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developables and geodesics.			
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Learn about the concepts of curvature, torsion, involutes and evolutes. 2: Familiarize with several concepts of tangent plane, Helicoids, metric and direction coefficients. 3: Understand the concepts of developable surfaces.			
	4: Use the several notions of curvatures such as geodesic curvature and Gaussian curvatures.			

Units	Content of Each unit
1	Tensor Algebra: Difference between tensor and vector, Contraction, Inner Product, Symmetric and skew-symmetric tensors, Reciprocal symmetric tensor, Relative tensor, Alternate tensor, Isotropic tensor, Christoffel Symbols and Covariant differentiation, Ricci tensor, Bianchi's identity.
2	Space Curves: Metric tensor of the Euclidean space of three dimensions, Tingent to a curve, Osculating plane, Serret Frenet formulae, Fundamental planes, Curvature of a curve, Torsion of a curve, Contact between curves and surfaces, Locus of centre of spherical curvature, Spherical Indicatrix, Tangent surface, involutes and evolutes, Helix.
3	Surfaces in Space: Parametric Transformation, Curves on a surface, Tangent plane and normal to the surface, First fundamental quadratic form of the surface, Angle between two parametric curves, Angle between a parametric curve and any general curve of the surface, Orthogonal Trajectories, Second fundamental tensor, Weingarten formulae
4	The Normal Curvature of a surface: Normal curvature of a surface, Principal directions, Principal curvatures, Lines of curvature on a surface, Conjugate directions on a surface, Asymptotic direction at a point of a surface, Mean curvature, Gaussian curvature, Minimal surface, Gauss characteristic equation, Mainardi-Codazzi equations. Geodesics: Normal property of geodesics, Torsion of a geodesic, Geodesic torsion of a curve, Geodesic curvature of a curve.
Sugge	sted Readings:

- 1. Weatherburn, C. E. Differential Geometry of Three Dimensions, Cambridge University Press, 2016.
- 2. Graustein, W. C. Differential Geometry. Courier Corporation, 2012.
- 3. Wilmore T. J. An Introduction to Differential Geometry, Dover Publications Inc , 2012.
- 4. Pressley, A. Elementary Differential Geometry. Springer, 2002.

Course Code	MATHDCEC0424&425C	Course Name	-	vanced Abstract ebra
Programme	M.A./M.Sc. Mathematics	Credits		4
Total Hours	60			
Total Marks	100 (Class Int. Exam30 marks, Univ. E			
Examination	3 Hours	Pre-requisite of course		NIL
Course Objective	knowledge of the central ideas of mod	course is to encourage students to develop a working as of modules like cyclic modules, simple, semi-simple rimary modules and theory of Noetherian and Artinian		

Outcomes: 1: Explain the fundamental concepts of modules and their role in moder mathematics and applied contexts. 2: Demonstrate accurate and efficient use of finitely generated Abelian g 3: Apply the theorems: fundamental structure theorem of finitely generated over principal ideal domain, Noether- Lasker theorem, Hilbert bas s Wedderburn - Artin theorem, Maschk's theorem CO4: Solve the problem using Nilradical and Jacobson radicals, operate extension and contractions applied to diverse situations in physics, engine mathematical contexts.	groups. erated modules s theorem and
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Units	Content of Each unit
1	Cyclic modules, simple and semi-simple modules, Schur's lemma, free modules, fundamental structure theorem of finitely generated modules over principal i leal domain and its applications to finitely generated Abelian groups.
2	Artinianmodules and rings with simple properties and examples.
3	Nilpotent ideals in Noetherian and Artinian rings, Hilbert basis theorem, Nakayama's lemma, Nilradical and Jacobson radicals, operations on ideals, extension and contraction.
4	Hom(R,R), opposite rings, Wedderburn-Artin theorem, Maschk's theorem, equivalent statement for left Artinian rings having non-zero nilpotent ideals.

Suggested Readings:

Rotman, J. J.Advanced Modern Algebra. 3rd edition. American Mathematical Soc., 2015.

Atiyah, M. F. and Macdonald, I. G. Introduction to Commutative Rings. Sarat Book House, 2007.

Curtis, C. W. and Reiner, I. Representation Theory of finite Groups and Associative

Algebras. American Mathematical Society, 2006.

Lam, T. Y. Lectures on Modules and Rings. GTM Vol. 189, Springer-Verlag, 1999.

Bhattacharya, P. B., Jain, S. K. and Nagpaul, S. R. Basic Abstract Algebra. 2 nd edition,

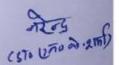
CambridgeUniversity Press, Indian edition, 1997.

Anderson, F. W. and Fuller, K. R. Rings and Categories of Modules. Springer-Verlag New York,1992.

Cohn, P. M. Algebra, Vols. I, II & III, John Wiley & Sons, (Vol. I-1982, Vol. II-1989, Vol-Ш1991.

Minor Elective Courses

	IVIIIIO	LIECTIVE	2001303			
Course Code	MATHMEC0426A		urse me	100000	athematical odelling	
Programme	M.A./M.Sc. Mathematics		Credits	N -	4	
Total Hours	60					
Total Marks	100 (Class Int. Exam30 marks	s, Univ. Exa				
Examination			Pre-requisite of course		NIL	
Course Objective	The objectives of this course are to: • Enable students understand how mathematical models are formulated, solved and interpreted. • Make students appreciate the power and limitations of mathematics in solving practical real-life problems. • Equip students with the basic mathematical modelling skills.					



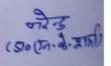


Course	After completing this course, student is expected to learn the following:
Outcomes:	1: Understand what a mathematical model is and explain the series of steps involved in
	a mathematical modelling process
	Use applications of mathematical modelling through difference equations. Understand and apply the concept of mathematical modelling through difference.
	equations in population dynamics, genetics and probability theory.
	4: Apply the concept of mathematical modelling through graph theory

	COURSE SYLLABUS
Units	Content of Each unit
1	Simple situations requiring mathematical modelling, techniques of mathematical modelling, classifications, characteristics and limitations of mathematical models, some simple illustrations, mathematical modelling in population dynamics, mathematical modelling of epidemics through systems of ordinary differential equations of first order mathematical models in medicine, battles and international trade in terms of systems of ordinary differential equations
2	The need for mathematical modelling through difference equations, linear growth and decay models, non-linear growth and decay models, basic theory of linear difference equations with constant coefficients, mathematical modelling through difference equations in economics and finance.
3	Mathematical modelling through difference equations in population dynamics and genetics, mathematical modelling through difference equations in probability theory, miscellaneous examples of mathematical modelling through difference equations.
4	Situations that can be modelled through graphs, mathematical models in terms of directed graphs mathematical models in terms of signed graphs, mathematical models in terms of weighted graphs.
Sugge	sted Readings:

- 1. Kapur J. N. Mathematical Modelling, 2nd edition, New Age International, 2015.
- 2. Meerschaert, M. M. Mathematical Modelling. Academic Press, 2013.
- 3. Rutherford, A. Mathematical Modelling Techniques. Courier Corporation, 2012
- 4. Clive, L. D. Principles of Mathematical Modelling. Elsevier, 2004.
- 5. Bender, E. A. An Introduction to Mathematical Modelling. Courier Corporation, 2000.

Course	MATHMEC0426B		Number Theory
Code		Name	
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60		
Total Marks	100 (Class Int. Exam30 marks, Univ. Exam70 marks)		
Examination	3 Hours	Pre-requisi of course	te NIL

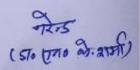




Course Objective	The purpose of the course is to give a simple account of classica number theory, prepare students to graduate-level courses in number theory and algebra, and to demonstrate applications of number theory. In this course, students will have a working knowledge of the fundamental definitions and theorems of elementary number theory, be able to work with congruence's, solve congruence equations and systems of equations with one and more variables, and be literate in the language and notation of number theory.
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Understand the properties of divisibility and prime numbers, con pute the greatest common divisor and least common multiples and handle linear Diophantine equations 2: Use the operations with congruence's, linear and non-linear congruence equations 3: Apply the theorems: Chinese Remainder Theorem, Lagrange theorem, Fermat's theorem, Wilson's theorem 4: Analyse arithmetic functions in areas of mathematics

Units	Content of Each unit
1	Representation of the real numbers by decimals, divisibility, G.C.D and L.C.M., primes, Fermat numbers, congruences and residues, theorems of Euler, Fermat and Wilson, solutions of congruences, linear congruences, Chinese remainder theorem.
2	Arithmetical functions $\phi(n)$, $\mu(n)$ and $d(n)$ and $\sigma(n)$, Mobius inversion formula, congruences of higher degree, congruences of prime power modulli and prime modulus, power residue.
3	Quadratic residue, Legendre symbols, lemma of Gauss and reciprocity law. Jacobi symbols, irrational numbers, irrationality of e and π . Finite continued fractions, simple continued fractions, infinite simple continued fractions.
4	Periodic continued fractions, approximation of irrational numbers by convergent, best possible approximation, Farey series, rational approximation, Pell's equations, Hurwitz theorem, Lagrange four square theorem.

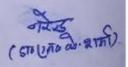
- 1. Apostol, T. M. Introduction to Analytic Number Theory. Springer 2014.
- 2. Niven, I. and Zuckerman, H. S. Introduction to the Theory of Numbers. John Wiley & Sons,
- 3. Burton, D. M. Elementary Number Theory. Tata McGraw Hill Publishing House, 2006.
- 4. Hardy, G. H. and Wright, E. M. Theory of Numbers. Oxford Science Publications, 2003.
- 5. Davenport, H. Higher Arithmetic. Cambridge University Press, 1999.



SEMESTER-III CC Course

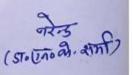
Code	MATHCC0431	Course Name	Partial Equation Applications	Differential with
Programme Total Hours	M.A./M.Sc. Mathematics	Credits	4	

Total Marks	100 (Class Int. Exam30 ma	rks, Univ. Exam70 mark	s)
Examination	3 Hours	Pre-requisite of course	NIL
Course Objective	The objectives of this course • Enable students understand Make students appreciate the	how general PDEs solved	l umerical solutions of PDEs.
Course Outcomes:	After completing this course.	student is expected to lea f first order PDEs by ch formula etc. solutions methods to sol arity solution methods.	rn the following: paracteristics method, Hamilton lvePDEs.



Content of Each unit
Charles
Green Function, Green function for Laplace equation, Harmonic function's properties, One and two dimensional wave equations, Heat equation, Method of separation of variables, Solution of Laplace equations in different co-ordinates system.
Non-linear First Order PDEs: Complete Integrals, Envelopes Characteristics, Hamilton-Jacobi Equations (Characteristic for the Hamilton-Jacobi Equation, Calculus of Variations, Hamilton's ODEs, Legendre's Transform, Hopf-Lax Formula, Weak Solution, Uniqueness), Conservation Laws (Lax-Oleinik Formula)
Solutions of PDEs by using separation of Variables Methods, Solution of PDEs by TransformMethods, Fourier Transform, Laplace Transform, Hankel Transform, Melin Transform, Hopf-Cole Transformation, Hodograph Transform, Legendre Transform, Potential Function Technique, Burger Equation, Cauchy-Kovalevskaya Theorem.
Numerical Methods for Solving PDEs: Deriving difference equations, Finite Difference Approximations to Derivatives, Elliptic Equations, Laplacian Difference Equation, Solution of Laplace Equation, Liebmann's Iterative Methods, Poisson's Equation, Parabolic Equations, Heat Conduction Equation, Bender-Schmidt Method, Explicit Method, The Crank-Nicolson Implicit Method, Hyperbolic Equations, Solution of Hyperbolic Equations.

- 1. Reid, W. T. Ordinary Differential Equations. John Wiley and Sons, New York, 1971.
- 2. Simmons, G. F. Differential Equations with Applications and Historical Notes. 2rd edition, Tata McGraw Hill, New Delhi, 2016.
- 3. Ross, S. L. Differential Equations. 3rd edition, Wiley India, 2007.
- 4. Raisinghania, M. D. Advanced Differential Equations. S. Chand & Company Lt 1., New Delhi, 2001.
- 5. P. Hartman, Ordinary Differential Equations, John Wiley, 1964.
- 6. E.A Coddington and N. Levinson, Theory of ordinary differential equations, McGraw Hill, NY, 1955.



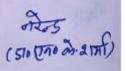
Course Code	MATHCC0432	Course Name	Operations Research
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	00		
Total Marks	100 (Class Int. Exam30 mar	ke Univ Evam -70 ma	arks)
Examination	3 Hours	Pre-requisite of	NIL.
Course Objective	This course is designed to int best results from a set of seve programming problems, tr unconstrained and constrained	roduce basic optimizateral possible solutions of ansportation problem	tion techniques in order to get f different problems viz. linear , assignment problem and
Course Outcomes:	I: Understand linear program different method. Understand the network program different method. Understand the network program different method.	student is expected to luming problems and to oblems. The rent queuing models are programming models.	learn the following: o find their solutions by using del using Game Theory. Also

	Content of Each unit
	Content of Each unit
	Linear Programming-Simplex and revised simplex Method, Dual Simplex method, Goal programming.
2	Network analysis, shortest path problem, Minimum Spinning tree, Maximum flow problem, Minimum cost flow problem, Project planning and control with PERT-CPM.
3	Queuing models: basic components of a queuing system, general birth-death equations, Integer Programming-Branch and Bound Technique.
	Game theory: two persons zero sum game, game with saddle points, rule of dominance; algebraic, graphical and linear programming, concept of mixed strategy. Sequencing problems: processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.

- 1. Besaint, W.H. and Ramsey, A.S. A Treatise on Hydromechanics Part Ihydrostatics, Andesite Press, 2017.
- 2. Kundu, P.K., Cohen, I. M. and Dowling, R. D. Fluid Mechanics, 6th edition, Academic Press,
- 3. O'Neil, M. E., and Chorlton, F. Ideal and Incompressible Fluid Dynamics. Ellis Horwood Ltd, 1986.
- 4. Yuan, S.W. Foundations of Fluid Mechanics. Prentice Hall of India Private Limited, New Delhi,
- 5. Curle, N. and Davies, H. J. Modern Fluid Dynamics. Vol1, D Van Nostrand Company Ltd, London, 1968.

	1		
	MATHCC0433	Course	Functional Analysis
Code	1	Name	
Programme	M.A./M.Sc. Mathematics	Credits	4

Tive	water water	Credits	
Total Hours	60		
Total Marks	100 (Class Int. Exam30 mar	ks Univ Exam70 m	narks)
Examination	3 Hours	Pre-recuisite of	NIL
Course Objective	To familiarize with the basic Banach spaces and Hilbert st the bounded linear operators	tools of Functional A	nalysis involving normed spaces, dependent on the d mension and ther.
Course Outcomes:	After completing this course, 1: Verify the requirements of between compactness and of operator and relate to continu compute the dual spaces. 2: Distinguish between Banac in terms of orthogonal completing	student is expected to f a norm, completenes limension of a space, hity, convergence of op the spaces and Hilbert sements.	learn the following s with respect to a rorm, relation check boundedness of a linear perators by using a suitable norm, paces, decompose a Hilbert space
	3: Check totality of orthonor functional in terms of inner prormal operators. 4: Extend a linear functional check reflexivity of a space.	ormal sets and sequer product, classify opera- under suitable condition, ability to apply unif- graph theorem, check	ones, represent a bounded linear ators into self-adjoint, unitary and ons, compute adjoint of operators, form boundedness theorem, open the convergence of operators and mences.



28

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	Units	Units Content of Each unit
	_	Metric Space, Euclidean Space, Pseudo-metric, sequences, Cauchy Sequences, Complete metric spaces and examples, Dimension of a linear space, Baire's theorem, Cantor intersection theorem and Banach fixed point principle, normed linear spaces.
	2	Banach spaces: Normed Linear Space, Banach spaces, examples of Banach spaces and subspaces, Sequence of Scalars, Holder's Inequality, Minkowski's Inequality, Cauchy's Inequality, Euclidean and unitary space, Subspaces and Quotient Spaces of Banach Spaces. Riesz-Fisher Theorem.
	6	Hilbert spaces: Inner Product Spaces, Hilbert spaces and examples, Schwarz Inequality. Parallelogram Law, Convex sets, Orthogonality, Pythagorean Theorem, Projection Theorem, Orthonormal sets, Bessel's inequality, Parseval's theorem, Characterization theorem for complete orthogonal sets, Riesz representation theorem for continuous linear functionals on a Hilbert space
	4	Adjoint operators, self-adjoint operators, Positive operator, normal and uni ary operators, weak and strong convergence, completely continuous operators, Hahn-Banach theorem and its applications, uniform boundedness principle, open mapping theorem, closed graph theorem.
	Sugge	Suggested Readings:

1. Simmons, G. F. Introduction to Topology and Modern Analysis. McGraw-Hill Fvt. Ltd. 2016.

Bachman, G. and Narici, L. Functional Analysis. Courier Corporation, 2012.
 Conway, J. B. A Course in Functional Analysis. Springer, 2010.
 Kreyszig, E. Introductory Functional Analysis with Applications. John Wiley, 2007.
 Royden, H. L. Real Analysis. MacMillan Publishing Co., Inc., New York, 4th ecition, 1993.

Seminar Presentation	and Viva-Voce	9	ırks	NIL	The purpose of this course is to enhance communication skills and presentation. How to face interviews in communication.	n the following:			DOOKS.
Course	Name	Credits	Thiy Exam-70 ma	Pre-requisite of course NIL	enhance communication	lent is expected to lear	ect in interviews.	vay.	ssertation, Thesis and
MATHCC0434		Programme M.A./M.Sc. Mathematics	100 (Class Int Exam-30 marks Thriv Exam-70 marks	3 Hours Pro	The purpose of this course is to c	After completing this course, student is expected to learn the following:	2: Get ability to foce interminant	3: Skills to write subject in own way.	4. Oet knowledge of preparing Dissertation, Thesis and Books.
Course	Code	Programme	Total Marks	Examination	Course	Course	Outcomes:		

Lancin	A: Viva and Presentation of assigned / selected problem /topic by each student	the other four papers to be evaluated by one Internal & one External	
	A: Viva a	in each of t	Examiner.

Discipline Centric Elective Courses

Programme M.A.M.Sc. Mathematics Credits 4 Total Hours 60 Pre-requisite of Course 100 (Class Int. Exam30 marks, Univ. Exam70 marks) Examination 3 Hours Pre-requisite of Course NIL Course Objective The objective of this course is to introduce the difference equations. Affer completing this course, student is expected to learn the following: Course After completing this course, student is expected to learn the following: 1: Understand the occurring of difference equations and linear difference equations. Also will be able to solve these equations and their linearization. 2: Understand the non-linear difference equations and their systems. 3: Understand the system of difference equations and their systems. 4. Understand the nonlinear difference equations.	Course Code	MATHDCEC0435A	Course	Difference Equations
	Programme	M.A./M.Sc. Mathematics	Credits	4
	Total Hours	09		
	Total Marks	100 (Class Int. Exam30 marks,	Univ. Exam701	narks)
	Examination	3 Hours	Pre-requisite of course	NIL
:so:	Course Objective	The objective of this course is Fundamental theorems for exists	to introduce the nce and uniquene	difference equations, solutions.
	Course Outcomes:	After completing this course, stu 1: Understand the occurring of di Also will be able to solve these of 2: Understand the non-linear diff 3: Understand the System of diff 4. Understand the nonlinear diff	dent is expected to fference equations evence equations erence equations erence equations.	o learn the following: and linear difference equations. and their linearization. and their systems.

COURSE SYLLABUS

Units	Content of Each unit
_	Introduction, difference calculus, difference operators, Greens furction, approximate
	summations, Linear difference equations of first order, existence and uniqueness of solutions, linear difference equations with constant coefficients,
2	Equations with variables coefficients, Non-linear equation that can be linearised, The z-
	reansform, Properties of 2-transform, minds and man water mediem, Defectal Solution of second order homogeneous difference equation, Matrix method for solving linear
	difference equations.
3	Systems of linear difference equations, qualitative behavior of solutions to linear difference equations, Generating function, Properties of generating function, Exponential
	generating function, Recurrence relation.



Nonlinear difference equations (Map): Steady states and their stability, the logistic difference equation, systems of nonlinear difference equations, stability criteria for second order equations, stability criteria for higher order system, Critical points, Lagrange's identity, Green's formula, Abel's formula.

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Suggested Readings:

1. Walter G. Kelly and Allen C. Peterson, Difference Equations: An Introduction with Applications, Academic Press, Harcourt Brace Joranovich Publishers, 1991.

2. Calvin Ahlbrandt and Allen C. Peterson, Discrete Hamiltonian System, Difference Equations, Continued fraction and Riccati equations, Kluwer, Bostan, 1996.

Course Code	MATHDCEC0435B	Course Name	Fuzzy set Theory			
Programme	M.A./M.Sc. Mathematics	Credits	4			
Total Hours	60					
Total Marks	100 (Class Int. Exam30 marks,	Univ. Exam70 marks)				
Examination	3 Hours	Pre-requisite of course NIL				
Course Objective	The course aims to introduce s relations, arithmetic operations applications.	tudents to fundamental con fuzzy sets, probability	concepts in fuzzy sets, fuzzy y theory, fuzzy logic and i			
Course Outcomes:	After completing this course, stu 1: Construct appropriate fuzzy collected data. 2: Understand the basic concepts 3: Use the concepts of appro- trapezoidal fuzzy number, bell s	numbers corresponding of t- norms, t- conforms a ximation of triangular f hape fuzzy number, crisp	and operation of - cut intervaluzzy number, operations			

COURSE SYLLABUS

and cylindrical extension

4: Analyse the Integration and differentiation of fuzzy function product set, and understand the basic concepts of composition of fuzzy relation, fuzzy graph, projection

Units	
1	Concepts of fuzzy set, standard operations of fuzzy set, fuzzy complement fuzzy union, fuzzy intersection, other operations in fuzzy set, t- norms and teonorms. Interval, fuzzy number, operation of interval, operation of - cut interval, examples of fuzzy number operation.
2	Definition of triangular fuzzy number, operation of triangular fuzzy number, operation of general fuzzy numbers, approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number, function with fuzzy constraint, propagation of fuzziness by crisp function, fuzzifying function of crisp variable, maximizing and minimizing set, maximum value of crisp function.
3	Integration and differentiation of fuzzy function product set, definition of relation, characteristics of relation, representation methods of relations, operations on relations, path and connectivity in graph, fundamental properties, equivalence relation, compatibility relation, preorder relation, order relation, definition and examples of fuzzy relation, fuzzy matrix, operations on fuzzy relation.
4	Composition of fuzzy relation, - cut of fuzzy relation, projection and cylindrical extension, extension by relation, extension principle, extension by fuzzy relation, fuzzy distance between fuzzy sets, graph and fuzzy graph, fuzzy graph and fuzzy relation, - cut of fuzzy graph.

- 1. Mohan, C. An Introduction to Fuzzy Set Theory and Fuzzy Logic. Anshan Publishers, 2015.
- 2. Lee, K. H. First Course on Fuzzy Theory and Applications. Springer International Edition, 2005,
- 3. Yen, J., Langari, R. Fuzzy Logic Intelligence, Control and Information. Pearson Education, 1999.
- 4. Zimmerman, H.J. Fuzzy Set Theory and its Applications. Allied Publishers Ltd., New Delhi, 1991.



Minor Elective Courses for M.Sc. (Mathematics)

	MATHMEC0436A		Course Name		Measure Theory and Integration	
Programme Total Hours	M.A./M.Sc. Mathematics	Cr	edits	4	The state of the s	
Total Marks	100 (Class Int. Exam30 marks	Liniv	Exam70 m	arks)		
Examination	3 Hours Pro	o roquis	ite of course	INI	I	
Course Objective	Measure theory provides a foundation for many branches of mathematics such as harmonic analysis, ergodic theory, theory of partial differential equations and probability theory. It is a central, extremely useful part of modern analysis, and many further interesting generalizations of measure theory have been developed.					
Course Outcomes:	After completing this course, st 1: Use the concepts of measura 2: State and explain the constru 3: Apply the theorems of monot 4: Describe the construction of	udent is ble set a ction of tone and	expected to and measurab the Lebesgu dominated of	learn le fu e inte	the following: nction egral and use it ergence and Fatou's lemma	

COURSE SYLLABUS

Units	Content of Each unit
1	Length of an open set, concept of measure, Lebesgue outer measure and measurable sets, example of non-measurable set, Sigma algebra, Borel sets, and –sets, Outer and inner regularity of Lebesgue measure.
2	Set function, abstract measure spaces, properties of measures, some examples of measures, measurable spaces, measurable functions, combinations of measurable functions, and limits of measurable functions.
3	Review of Riemann integral, integrable simple functions, the Lebesgue integration of a measurable function, integration with respect to a measure.
4	Almost everywhere convergence, convergence in measure, Fatou's Lemma, monotone and dominated convergence theorems.

Suggested Readings:

- 1. Berberian, S. K. Measure and Integration. AMS Chelsea Publications, 2011.
- 2. Royden, H. L. and Fitzpatrick P. M. Real Analysis. 4th edition, Pearson India, 2010.
- 3. Barra, G. de. Measure Theory and Integration. New Age International (P) Ltd., 2009.
- 4. Rana, I. K. An Introduction to Measure and Integration. 2nd edition, Narosa Publ shing House, 2004.
- 5. Folland, G. B. Real Analysis. John Wiley & Sons, Inc., New York, 1999.
- 6. Hewitt, E. and Stromberg, K. Real and Abstract Analysis. Springer-Verlag, New York, 1975.

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Course Code	e M.A./M.Sc Mathematica		Course Name	Introduction to Cryptography		
Programme			Credits	4		
Total Hours	60 Mathematics		Cicano	I MANAGEMENT OF THE PARTY OF TH		
Total Marks	100 (Class Int. Exam30 m	arke Hniv	Exam70 mark	(s)		
Examination	3 Hours		ite of course	NIL		
Course Objective	and theorems of elementar equations with one and mo	have a wor y congruence re variables.	king knowledges, solve cong They will und	of cryptography. Upon completion ge of the funcamental definitions ruence equations and systems of derstand the language, notation of also discussion on Diffie-Hellman		
Course Outcomes:	After completing this cours 1: Understand the operation equations. 2: Use the basics of RSA sethe basic concepts of remote 3: Apply the theorems: Ferri	ting this course, student is expected to learn the following: d the operations with congruence's, linear and non-linear congruence dies of RSA security and be able to break the simplest ir stances and analyse depts of remote coin flipping, elliptic curve based cryptography. Theorems: Fermat's last theorem, prime number theorem and zeta function and use the numbers: Perfect numbers, Fermat numbers, Mersenne primes				

Units	The state of the s
1	Modular arithmetic, congruence, primitive roots, cryptography introduct on, Caesar Cipher, Diffie-Hellman RSA public key cryptosystem, Knapsack cryptosystem, application of primitive roots to cryptography.
2	Applications of cryptography in primality testing and factorization of large composite numbers, remote coin flipping. Elliptic curve based cryptography.
3	Perfect numbers, Férmat numbers, Mersenne primes and amicable numbers. Fibonacci numbers, representation of integers as sum of Squares.
4	Linear and non-linear Diophantine equations, Fermat's last theorem, prime number theorem and zeta function.

- 1. Tilborg, H. C. A. Fundamentals of Cryptology. Springer, 2013.
- 2. Buchmann, J. A. Introduction to Cryptology. Springer Science & Business Media, 2012
- 3. Burton , D. M. Elementary Number Theory, Tata McGraw Hill Publishing House, 2006.
- 4. Menezes, A. J., V., Oorschot, P. C. and Vanstone, S. A. Handbook of Applied Cryptography. CRC Press, 1996.
- 5. Koblitz, N. A Course in Number Theory and Cryptography. 2 nd edition Springer, 1994.
- 6. Simmons, G. J. Contemporary Cryptology, The Science of Information Integrity.New York, IEEE Press. 1992



SEMESTER-IV

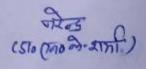
Course code	MATHCC0441	Course Name	Mathematical Statistics
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60	Credits	
Total Marks	100 (Class Int. Exam30	marke Univ Exa	m -70 marks)
Examination		isite of course	NIL
Course Objective	The aim of the course is measures, various types o	to enable the stud	ents with understanding of various types of ibutions and testing of hypothesis problems concepts of statistical techniques and their
Course Outcomes:	After completing this court: Explore the basic ideas kurtosis with their applicate: Demonstrate the under discrete distributions. 3: Explain the different ty	about measures of tions and basic id- standing of rando pes of continuous	ected to learn the following: f central tendency, dispersion, skewness and ea about probability theory. m variable, expectation, variance and some distributions and their utilization. er situations and their testing.

COURSE SYLLABUS

Content of Each unit
Measures of central tendency and dispersion, moments, measures of skewness and kurtosis, correlation and regression. axiomatic approach to the theory of probability, sample space, additive and multiplicative law of probability, conditional probability. Definition and properties of random variables, discrete and continuous random variables, probability mass and density functions, distribution function. Concepts of bivariate random variables, Bayes theorem, Booles Inequality, Mathematical expectation: Definition and its properties, variance, covariance, moment generating function- definitions and their properties.
Discrete distributions: Binomial, Poisson and Geometric, Negative binomial, Power series distributions with their properties.
Continuous distributions: uniform, exponential, gamma, beeta and normal distributions with their properties, Central Limit Theorem, Chi-Square distribution.
Statistical estimation, Theory of estimetors, Max. likelihood, Testing of hypothesis: Null and alternative hypotheses, simple and composite hypotheses, two types of errors, t, F and Chi-Square as sampling distribution and applications.

- 1. Meyer, P. L. Introductory Probability and Statistical Applications. 2nd edition, Addison-Wesley Publishing Company, 2017.
- Gupta, S. C. and Kapoor, V. K. Fundamentals of Mathematical Statistics. Sultan Chand & Sons, 2014.
 Mood, A. M., Graybill, F. A. and Boes, D. C. Introduction to the Theory of Statistics, Tata McGraw
- Hill, 2014.

 4. Spiegel, M. R., Schiller, J. J. and Srinivasan, R. A. Probability and Statistics. Tata McGraw-Hill, 2014.
- 5. Baisnab, A. P. and Jas, M. Element of Probability and Statistics, Tata McGraw Hill, 1993.





Course Code	MATHCC0442	Course Name		Advanced Fluid Dynamics		
Total Hours	M.A./M.Sc. Mathemati	cs	Credits		4	
	00					
Total Marks	100 (Class Int. Exam	O marke Hair	Evam -70	marks)		
Examination	3 Hours	Des com	isite of cou	rse	NIL	
Course Objective	The objective of this co boundary layer theory	urea ie ta aravi	de a treatm	ent of to	pics in magnet	o hydrodynamics
Course Outcomes;	After completing this c 1: Understand the stres 2. Understand the vorte 3. Understand the boun 4: Understand the mag	ourse, student s tensors ex motion	is expected	to learn	the following	

Content of Each unit
Motion of sphere through liquid at rest at infinity, Liquid streaming past a fixed sphere, Motion of concentric sphere, Three dimensional source and sink, Doublet, Image of source with respect to sphere and plane.
Vortexmotion and its elementary properties, Vortex filament, vortex doublet, vortex pair, image of vortex with respect to plane and circle, Kelvin's proof of permanence Motions due to circular and rectilinear vortices, Spiral vortex, Rectilinear vortex, Karman's vortex street, Kirchhoff vortex theorem.
Boundary Layer Theory: Prandtls' boundary layer theory and its importance, Drag and lift, The boundary layer equation in two dimensional flow. The boundary layer flow over a flat plate. Karman's integral equation, Application of the boundary layer in absence of pressure gradient. Application of the Karman's integral equation to boundary layer with pressure gradient: Karman momentum integral equation, Vorticity equation.
Stresses in Fluids: Strain and stress tensor, symmetry of stress tensor, transformation of strain components in two dimension, principal stress and principal stress direction, Navier Stokes equation, Reynold's Number, Prandtl number, Weber number, Steady flow between parallel planes, Laminar flow between parallel plates, Steady flow through a cylindrical pipe, Hagen-Poiseuille flow.

Suggested Readings:

- 1. Allen Jeffery Magnetohydrodynamics (Oliver & Boyd)
- 2. P. C. Kendell and C. Plumton Magnetohydrodynamics with hydrodynamics Vol 1 (Pergamon
- 3. F. Chorlton A Text Book of Fluid Dynamics.
- 4. M. D. Raisinghania& R.S. Agarwal Advanced Hydrodynamics & Fluid Dynamics.

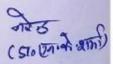
(डा॰ एना की आर्मी)

Code	MATHCC0443	Course Name	Project/Dissertation/Survey/Industrial Training and Viva-Voce
Total Marks	The same of the sa	Credits	6

Examination	3 Hours Pre-requisite of course NIL
Course Objective	The purpose of this course is to enhance writing and communication skills, presentation. How to present subject and ongoing researches.
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Will be able to present research work in the field. 2: Get ability to write subject in own way. 3: Skills to know future of the subject. 4: Get knowledge of preparing Dissertation, Thesis and Books.

Pattern

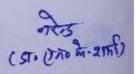
1	The Student will submit two copies of the project/dissertation/survey/industrial training in the department at the end of the semester. Project/dissertation/survey/industrial training will be evaluated by one internal and one external examiner jointly, and a viva-voce examination.
2	One of the teacher will be chosen as supervisor under whose guidance the student will complete is project work/ Project/dissertation/survey/industrial training.





Discipline Centric Elective Courses

Course code	MATHDCEC0444&445A	Co Na	urse me	Int	egral Equations
Programme	M.A./M.Sc. Mathematics		Credits		4
Total Hours	60				
Total Marks	100 (Class Int. Exam30 marks, Univ	z. Exa	m70 m	arks)	
Examination	3 Hours		Pre-requ of cours	nsite e	NIL
Course Objective	In this course we study in detail about integral equations and calculus of variations. Integral equations find numerous applications in real life physical problems. The main objective of the course is to make the learner familiarize with resolvent kernel, successive approximation, solution of homogeneous Fredholm integral equation for solving integral equations and variational problems. Differential equations can be studied for their solutions by transforming them into integro-differential equations using Laplace transform.				
Course Outcomes:	After completing this course, student 1: Use the concept of different kernel integral equations. 2: Find the solutions of Volterra integ 3: Understand the relation between di 4: Understanding of Hilbert Schmidt kernels.	s and ral eq	techniqu uations u	ies for ising N	Neumann series method.



	COURSESTEER
Units	Content of Each unit
1	Equation of Fredholm Integral Equations: Solution of Homogeneous Fredholm Integral Equation of the second kind with separable, Orthogonality and Reality of Eigen functions, Eigen values of Symmetric kernel, Determination of Eigen functions, Determination of Eigen values and Eigen functions of homogeneous equations, Fredholm Integral Equation with separable kernel, Complex Hilbert Space, Orthonormal System of functions, Gram-Schmidt Orthonormalization Process, Schwarz Inequality, Bessel's Inequality, Riesz-Fischer Theorem, Symmetric Kernel, Iterated Kernel, Mercer's Theorem, Hilbert's Theorem, Solution of Fredholm Integral Ferration of first kind
2	Solution of Fredholm Integral Equation of second kind by Successive Substitution: Solution of Volterra Integral Equation of second kind by Successive Substitution, Solution of Fredholm Integral Equation of second kind by Successive Approximation, Reciprocal kernel, Determination of Iterated kernel and resolvent kernel, Method of Successive Approximation, Reciprocal Function, Volterra's Solution of Fredholm Integral Equation of second kind, Reciprocal kernel of Volterra Integral Equation, Determination of resolvent kernel of Volterra Integral Equation, Solution of Volterra Integral Equation, Integral Equation by Successive Approximation method
3	Classical Fredholm Theory: Fredholm's Fundamental Relations, Hadamard's Theorem, Convergence of Fredholm's Determinant and Fredholm First Minor, Fredholm Fundamental Theorems, Fredholm's Second Fundamental Theorems, Existence of Eigen value, Orthogonality Theorem
4	Integral Transform Method: Some special types of Integral Equations Application of Laplace Transform to determine the solutions of Volterra Integral Equation with Convolution type kernels, Abel Integral Equation, Fourier Transform, Application of Fourier Transform to determine the solutions of Singular Integral Equations, Mellin Transform, Fox's Integral Equation
Sugge	sted Readings:

Suggested Readings:

- 1. Wazwaz, A. M. A First Course in Integral Equations. 2 nd edition World Scientific Publishing Co. 2015.
- 2. Kanwal, R. P. Linear Integral Equation. Theory and Techniques. Academic Press, 2014.
- 3. Gelfand, I. M. and Fomin, S. V. Calculus of Variations. Courier Corporation, 2012.
- 4. Hildebrand, F. B. Method of Applied Mathematics, Courier Corporation, 2012.
- 5. Raisinghania M. D. Integral Equation & Boundary Value Problem. S. Chand Publishing, 2007.
- 6. Jerri, A. Introduction to Integral Equations with Applications, John Wiley & Sors, 1999.

Course code	MATHDCEC0444&445	B Course Name	Theory of Elasticity		
Programme	M.A./M.Sc. Mathematics	Credits	4		
Total Hours	60				
Total Marks		-30 marks, Univ. Exam70 marks)			
Examination		re-requisite of course			
Course Objective	This course aims to familiarize the equations of elasticity. The course in Cartesian and polar coordinates	miliarize the students with tensors and the principles and basic The course will expose the students to two dimensional problems coordinates.			

(प्रा मिए की शामी)

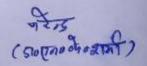


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Course	After completing this course, student is expected to learn the following:
Outcomes:	** Ose the indicial notation and knowledge of tensor
	2. Analyse strain stress and deformation
	3. Understand the basic principles and field equations of linear clastic solids
	1. Pormulate the solution strategies of various two dimensional problems
	5: Analyse the propagation of surface waves

Units	Content of Each unit
1	Cartesian tensor: Coordinate transformation, Cartesian tensor of different order, sum or difference and product of two tensors, contraction theorem, quotient law, symmetric & skew symmetric tensors, Kronecker tensor, alternate tensor and relation between them, scalar invariant of second order tensor, eigen values & vectors of a symmetric second order tensor, gradient, divergence & curl of a tensor field. Analysis of strain: affine transformations, infinitesimal affine transformation, geometrical interpretation of the components of strain.
2	Strain quadric of Cauchy, principal strains and invariants, general infinitesimal deformation. Saint- Venant's equations of compatibility. Analysis of stress: stress tensor, equations of equilibrium, transformation of coordinates, stress quadric of Cauchy, principal stress and invariants, maximum normal and shear stresses.
3	Equations of elasticity: Generalized Hooke's law, homogeneous isotropic media, elastic moduli for isotropic media, equilibrium and dynamic equations for an isotropic elastic solid, strain energy function and its connection with Hooke's law, Beltrami-Michell compatibility equations.
4	Two-dimensional problems: Plane strain, plane stress, generalized plane stress, Airy's stress function, general solution of bi-harmonic equation, stresses and displacements in terms of complex potentials, propagation of waves in an isotropic elastic solid medium, waves of dilation and distortion, elastic surface waves such as Rayleigh and Love waves.

- 1. Sadd, M. H. Elasticity: Theory, Applications and Numerics. Academic Press, 2014.
- 2. Love, A. E. H. A Treatise on Mathematical Theory of Elasticity. Cambridge [Eng.] University Press,
- 3. Timoshenko, S. P. and Goodier, J. N. Theory of Elasticity. New York McGraw-Hill, 2010.
- 4. Narayan, S. Text Book of Cartesian Tensors. S. Chand & Co., 1968.
- 5. Sokolnikoff, I. S. Mathematical Theory of Elasticity. McGraw-Hill Inc, 2nd edition, 1956.

Course code	MATHDCEC0444&	445C	Course Name	Tensors and General Relativity
Programme	M.A./M.Sc. Mathematics		Credits	4
Total Hours	60			
Total Marks	100 (Class Int. Exam30 mar	ks, Univ	. Exam70 marl	ks)
Examination		Pre-requisite of course		NIL
Course Objective	The objectives of this course a	are to stu	dy tensor and g	eneral theory of relativity.





Course Outcomes:	After completing this course, student is expected to learn the following:1: Understand tensor and symbols used for tensor. 2. Understands the Riemannian metric. 2: Understands the Einstein's field equations. 3: Understand the keplers law and Schwarzschild external solution.	
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Units	Content of Each unit
1	Transformation of coordinates, Tensors, Algebra of Tensors, Symmetric and skewsymmetric Tensors, Contraction of tensors and quotient law.
2	Riemannian metric, Christoffel Symbols, Covariant derivatives, Intrinsic derivatives and geodesics. Riemann-Christoffel curvature tensor and its symmetryproperties. Bianchi identities and Einstein tensor.
3	Review of the special theory of relativity and the Newtonian Theory of gravitation, Principles of equivalence and general covariance, geodesic principle, Newtoniar approximation of relativistic equations of motion. Finetein's field equations and its Newtonian approximation.
4	Schwarzschild external solution and its isotropic form, Planetary orbits and analogues of Kepler's Laws in general relativity. Advance of perihelion of a planet, Bending of light rays in gravitational field, gravitational red-shift of spectral lines. Radar echo delay.

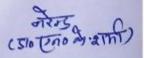
Suggested Readings:

 C. E. Weatherburn. An Introduction of Riemannian Geometry and Tensor Calculus, CambridgeUniversity, Press, 1950.

 H. Stephani, Genereal Relativity. An Introduction of the theory of the gravitational field. CambridgeUniversity Press, 1982.

3. A. S. Eddington, The Mathematical Theory of Relativity, Cambridge University, Press, 1965.

Course code	MATHDCEC0444&445	D Course Name	Information Theory- II	
Programme	M.A./M.Sc. Mathematics	Credits	4	
Total Hours	60			
Total Marks	100 (Class Int. Exam30 marks, U	niv. Exam70 ma	rks)	
Examination	3 Hours Pre-requ	site of course	NIL	
Course Objective	The objective of this course is to introduce basic and advanced topics in information theory. This course further explains the different types of entropies, codes, discrete and continuous channels and their applications.			
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Understand the basic concepts of information theory, different types of entropies with their properties and applications. 2: Analyse how different coding techniques will perform in different situations. 3: Understand about discrete channels and their properties with applications. 4: Understand about continuous channels and their properties with applications.			



	COURSEST
Units	Content of Each unit
Ī	Measure of information – axioms for a measure of uncertainty, the Shan on entropy and its properties, joint and conditional entropies, transformation and its properties, axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.
2	necessary and sufficient condition for the existence of instantaneous codes, construction of optimal codes.
3	Discrete memory less channel - classification of channels, information processed by a channel, calculation of channel capacity, decoding schemes the ideal observer, the fundamental theorem of information theory and its strong and week converses.
4	Continuous channels - the time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, the converse to the coding theorem for time-discrete Gaussian channel, the time-continuous Gaussian channel, bandlimited channels.

Suggested Readings:

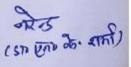
1. Ash, R. B. Information Theory. Courier Corporation, 2012.

2. Reza, F.M. An Introduction to Information Theory. Courier Corporation, 2012.

3. Hankerson, H. D., Harris, G. A. and Johnson, P. D. Introduction to Information Theory and Data Compression. Chapman and Hall/CRC, 2nd edition, 2003.

4. Aczel, J. and Daroczy, Z. On Measures of Information and their Characterizations. Academic Press, New York, 1975.

Course code	MATHDCEC0444&04	45E Course Name	Bio-Mathematics
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60		
Total Marks	100 (Class Int. Exam30 marks,	Univ. Exam70 marks)	
Examination		Pre-requisite of course	NIL
Course Objective	The objective of this course is to introduce basic and advanced topics in information theory. This course further explains the different types of entropies, codes, discrete and continuous channels and their applications.		
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Understand the basic concepts of information theory, different types of entropies with their properties and applications. 2: Analyse how different coding techniques will perform in different situations. 3: Understand about discrete channels and their properties with applications. 4: Understand about continuous channels and their properties with applications.		



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	COURSEST			
Units	Content of Each unit			
1	Measure of information – axioms for a measure of uncertainty, the Shannon entropy and its properties, joint and conditional entropies, transformation and its properties, axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.			
2	Noiseless coding - ingredients of noiseless coding problem, uniquely decipherable codes, necessary and sufficient condition for the existence of instantaneous codes, construction of optimal codes.			
3	Discrete memory less channel - classification of channels, information processed by a channel, calculation of channel capacity, decoding schemes the ideal observer, the fundamental theorem of information theory and its strong and weak converses.			
4	Continuous channels - the time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, the converse to the coding theorem for time-d screte Gaussian channel, the time-continuous Gaussian channel, band-limited channels.			

Suggested Readings:

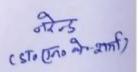
I. Ash, R. B. Information Theory. Courier Corporation, 2012.

2. Reza, F.M. An Introduction to Information Theory. Courier Corporation, 2012.

3. Hankerson, H. D., Harris, G. A. and Johnson, P. D. Introduction to Information Theory and Data Compression. Chapman and Hall/CRC, 2nd edition, 2003.

4. Aczel, J. and Daroczy, Z. On Measures of Information and their Characterizations. Academic Press, New York, 1975.

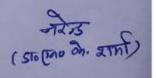
Course code	MATHDCEC0444&04	145F Course Name	Mathematics for Finance and Insurance
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60		
Total Marks	100 (Class Int. Exam30 marks, Univ. Exam70 marks)		
Examination	3 Hours P	re-requisite of course	NIL
Course Objective	This course introduces the basic concepts of Financial Management such as Insurance and Measurement of returns under uncertainty situations. The philosophy of this course is that Time value of Money - Interest rate and discount rate play a fundamental role in Life Insurance Mathematics – Construction of Morality Tables.		





Course Outcomes:	After completing this course, student is expected to learn the following: 1: Demonstrate knowledge of the terminology related to nature, scope, goals, risks and decisions of financial management. 2: Predict various types of returns and risks in investments and take necessary protective measures for minimizing the risk. 3: Develop ability to understand, analyse and solve problems in bonds, finance and insurance. 4: Build skills for computation of premium of life insurance and claims for general insurance using probability distributions.
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Uni	ts Content of Each unit
1	Financial Management - overview Nature and scope of financial management. Goals and main
	decisions of financial management, Difference between risk, Speculation and gambling. Time



	value of Money - Interest rate and discount rate. Present value and future value discrete case as well as continuous compounding case. Annuities and its kinds.
2	Meaning of return. Return as Internal Rate of Return (IRR). Numerical methods like Newton Raphson method to calculate IRR. Measurement of returns under uncertainty situations. Meaning of risk. Difference between risk and uncertainty. Types of risks Measurements of risk. Calculation of security and Portfolio Risk and Return-Markowitz Model. Sharpe Single Index ModelSystematic Risk and Unsystematic Risk. Taylor spring.
3	Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds. Insurance Fundamentals – Insurance defined. Meaning of loss. Chances of loss, Peril, Hazard, proximate cause in insurance. Costs and benefits of insurance to the society and branches of insurance-life insurance and various types of general insurance. Insurable loss exposures- feature of a loss that is ideal for insurance.
4	Life Insurance Mathematics – Construction of Morality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life. Determination of claims for General Insurance – Using Poisson Distribution and Negative Binomial Distribution –the Polya Case. Determination of the amount of Claims of General Insurance – Compound Aggregate claim model and its properties, Claims of reinsurance. Calculation of a compound claim density function F, Recursive and approximate formulae for F.

Suggested Readings:

1. Ross, S. M. An Introduction to Mathematical Finance. Cambridge University Press, 2019.

2. Elliott, R. J. and Kopp, P. E. Mathematics of Financial Markets. Sprigner Verlag, New York Inc, 2018.

3. Damodaran, A. Corporate Finance - Theory and Practice. John Wiley & Sons, Inc, 2012.

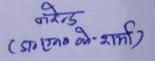
4. Hull, J. C. Options, Futures, and Other Derivatives. Prentice-Hall of India Private Ltd, 2010.

5. Daykin, C. D., Pentikainen, T. and Pesonen, M. Practical Risk Theory for Actuaries. Chapman & Hall, 2008.

 Dorfman, M. S. Introduction to Risk Management and Insurance. Prentice Hall, Englwood Cliffs, New Jersey, 1999.

7. Neftci, S. N. An Introduction to the Mathematics of Financial Derivatives. Academic Press, Inc, 1991

Course code	MATHDCEC0444&0445G	Course Name	Wavelet Analysis
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60		
Total Marks	100 (Class Int. Exam30 marks, Univ.		
Examination		quisite of course	NIL
Course Objective	The course aim is to introduce a flexible system which provide stable reconstruction and analysis of functions (signals) and the construction of variety of or:honormal bases by applying operators on a single wavelet function		
Course Outcomes:	After completing this course, student is expected to learn the following: 1: Understand the approximation of functions (signals) by frame theory. 2: Use the applications of frames in stable analysis and decompositions of functions. 3: Learn the applications of wavelets in the construction of orthonormal bases by wavelets. 4: Analyse different types of transforms in term of operators.		

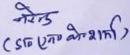




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Units	Content of Each unit
1	Review of inner product spaces, orthonormal systems, frames in Cn, frames algorithms, frames and Bessel sequences in infinite dimensional Hilbert spaces, frame sequence, the Gram matrix associated with Bessel sequences
2	versus Riesz bases, conditions for a frame being a Riesz basis, frames containing a Riesz basis, perturbation of frames
3	Wavelets, Haar wavelets, basic properties of the Haar scaling function, Haar decomposition and reconstruction algorithms, the Daubechies wavelets, wavelet bases, scaling function, multire solution analysis (MRA), construction of wavelets from MRA.
4	Windowed Fourier transform (WFT), continuous Fourier transform (CFT), continuous wavelet transform (CWT), comparison between CFT and CWT, continuous wavelet transform as an operator, inversion formula for continuous wavelet transform.

- 1. Boggess, A. and Narcowich, F.J. A First Course in Wavelets and Fourier Analysis. John Wiley & amp; Sons, 2010.
- 2. Mallat, S. A Wavelet Tour of Signal Processing. Academic Press, 2009.
- 3. Han, D., Kornelson, K., Larson, D. and Weber, E. Frames for Undergraduates, Student Math. Lib., (AMS) Vol. 40, 2007.
- 4. Christensen, O. An Introduction to Frames and Riesz Bases. Birkhauser, 2003.
- 5. Harnendez, E. and Weiss, G. A First Course on Wavelets, CRC Press, 1996.

Course code	MATHDCEC0444&04451	Course Name	Differential Geometry of Manifolds
Programme	M.A./M.Sc. Mathematics	Credits	4
Total Hours	60 -		
Total Marks	100 (Class Int. Exam30 marks, Uni-	. Exam70 marks	
Examination	3 Hours Pre-r	equisite of course	NIL
Course	The objectives of this course are to study tensor and manifolds.		
Objective	The objectives of this course are to st	ady tender and man	



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Units	Content of Each unit
1	Transformation of coordinates, Tensors, Algebra of Tensors, Alternate tensor, Symmetric and skewsymmetric Tensors, Reciprocal and Relative tensors, Contraction of tensors and quotient law. Riemannian metric, Christoffel Symbols, Covariant derivatives, Intrinsic derivatives and geodesics. Riemann-Christoffel curvature tensor and its symmetry properties. Bianchi identities and Einstein tensor.
2	Ricci tensor, Riemannian curvature tensor of first and second kind, Definition and examples of differentiable manifolds. Tangent spaces, Immersions and imbedding of manifolds.
3	Riemannian manifolds: Length of a curve in Riemannian manifold, Magnitude of a vector in Riemannian manifold, Angle between two vectors in Riemannian manifold, Parallelism of vectors, Geodesics, Riemannian Coordinate system, Recurrent Riemannian manifold, Riemannian curvature, Einstein space.
4	Hypersurfaces: Generalised Gauss formulae, Normal curvature, Asymptotic line, Meunier's theorem, Weingarten equations. Lines of curvature. Generalized Gauss and Mainardi-Codazzi equations.

- R.S. Mishra, A course in tensors with applications to RiemannianGeometry, Pothishala 1. (Pvt.) Ltd., 1965.
- R.S. Mishra, Structures on a differentiable manifold and theirapplications, Chandrarna Prakashan, Allahabad, 1984.
- B.B. Sinha, An Introduction to Modern Differential Geometry, Kalyani Publishers, 3. New Delhi, 1982.
- K. Yano and M. Kon, Structure of Manifolds, World Scientific Publishing Co. Pvt. 4. Ltd., 1984.

