**DEPARTMENT OF MATHEMATICS**
**FACULTY OF ARTS, SCIENCE AND HUMANITIES**
**PG PROGRAM (CBCS) – M.Sc. Mathematics**
**(2021–2022 Batch and onwards)**

| Course code | Name of the course | Objectives and Out Comes | | Instruction Hours / Week | | | Credit(s) | Maximum Marks | | | P.No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PEOs | POs | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | 40 | 60 | 100 | |
| **SEMESTER – I** | | | | | | | | | | | |
| **21MMP101** | Advanced Algebra | III | a, c, e | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 5 |
| **21MMP102** | Real Analysis | I | a, g, e | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 7 |
| **21MMP103** | Numerical Analysis | I | b, d, g | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 9 |
| **21MMP104** | Theory of Ordinary Differential Equations | II | b, d, e | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 11 |
| **21MMP105A** | Classical Mechanics | I | a, g | 4 | 0 | 0 | 4 | 40 | 60 | 100 | 13 |
| **21MMP105B** | Formal Languages & Automata Theory | I | a | | | | | | | | 15 |
| **21MMP105C** | Finite Element Methods | II | c, e | | | | | | | | 17 |
| **21MMP111** | Numerical Computing – Practical | I | a | 0 | 0 | 4 | 2 | 40 | 60 | 100 | 19 |
| Journal Paper Analysis & Presentation | | | | 2 | - | - | - | - | - | - | |
| **Semester Total** | | | | **26** | **0** | **4** | **22** | **240** | **360** | **600** | |
| **SEMESTER II** | | | | | | | | | | | |
| **21MMP201** | Linear Algebra | III | c, e | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 21 |
| **21MMP202** | Complex Analysis | I | a, c | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 23 |
| **21MMP203** | Optimization Techniques | III | f | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 25 |
| **21MMP204** | Theory of Partial Differential Equations | II | d, e | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 27 |
| **21MMP205A** | Advanced Graph Theory | I | a | 4 | 0 | 0 | 4 | 40 | 60 | 100 | 29 |
| **21MMP205B** | Fluid Dynamics | II | c, e | | | | | | | | 31 |
| **21MMP205C** | Fundamentals of Actuarial Mathematics | III | b, g | | | | | | | | 33 |
| **21MMP211** | Optimization Techniques – Practical | II | g | 0 | 0 | 4 | 2 | 40 | 60 | 100 | 35 |
| Journal Paper Analysis & Presentation | | | | 2 | - | - | - | - | - | - | |
| **Semester Total** | | | | **26** | **0** | **4** | **22** | **240** | **360** | **600** | |
| **SEMESTER III** | | | | | | | | | | | |
| **21MMP301** | Topology | III | c, e | 5 | 0 | 0 | 5 | 40 | 60 | 100 | 37 |
| **21MMP302** | Number Theory | I | a, g | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 39 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **21MMP303** | Measure Theory | III | f, g | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 41 |
| **21MMP304** | Mathematical Statistics | I | i, j | 5 | 0 | 0 | 4 | 40 | 60 | 100 | 43 |
| **21MMP305A** | Fuzzy Sets and Fuzzy Logic | I | e, i | 4 | 0 | 0 | 4 | 40 | 60 | 100 | 45 |
| **21MMP305B** | Control Theory | II | d | | | | | | | | 47 |
| **21MMP305C** | Neural Networks | III | b, e | | | | | | | | 49 |
| **21MMP311** | Mathematical Statistics - Practical | I | a | 0 | 0 | 4 | 2 | 40 | 60 | 100 | 51 |
| Journal Paper Analysis & Presentation | | | | 2 | - | - | - | - | - | - | |
| **Semester Total** | | | | **26** | **0** | **4** | **23** | **240** | **360** | **600** | |
| **SEMESTER IV** | | | | | | | | | | | |
| **21MMP401** | Functional Analysis | III | c, e | 5 | 0 | 0 | 5 | 40 | 60 | 100 | 53 |
| **21MMP402** | Mathematical Methods | I | g, e, j | 5 | 0 | 0 | 5 | 40 | 60 | 100 | 55 |
| **21MMP403** | Stochastic Processes | II | j, g | 5 | 0 | 0 | 5 | 40 | 60 | 100 | 57 |
| **21MMP491** | Project | III | **e** | - | | - | 8 | 80 | 120 | 200 | 59 |
| **Semester Total** | | | | **15** | **0** | **0** | **23** | **200** | **300** | **500** | |
| **Grand Total** | | | | **93** | **0** | **12** | **90** | **920** | **1380** | **2300** | |

**Electives Courses***

| **Elective I** | | **Elective II** | | **Elective III** | |
|---|---|---|---|---|---|
| **Course code** | **Name of the course** | **Course code** | **Name of the course** | **Course code** | **Name of the course** |
| **21MMP105A** | Classical Mechanics | **21MMP205A** | Advanced Graph Theory | **21MMP305A** | Fuzzy Sets and Fuzzy Logic |
| **21MMP105B** | Formal Languages & Automata Theory | **21MMP205B** | Fluid Dynamics | **21MMP305B** | Control Theory |
| **21MMP105C** | Finite Element Methods | **21MMP205C** | Fundamentals of Actuarial Mathematics | **21MMP305C** | Neural Networks |

# DEPARTMENT OF MATHEMATICS
# FACULTY OF ARTS, SCIENCE AND HUMANITIES
# PG PROGRAM (CBCS) – M.Sc. Mathematics
# (2021–2022 Batch and onwards)

## PROGRAMME OUTCOMES (POs)

a. Solve intricate mathematical problems using the knowledge of pure and applied Mathematics.
b. Explain the knowledge of modern issues in the field of mathematics.
c. Proficiency in all lectureship exams approved by UGC.
d. Solve differential equations governing real life issues.
e. Pursue further studies and conduct research.
f. Mathematical lifelong learning through continuous professional development.
g. Employ technology in solving and understanding mathematical problems.

## PROGRAM SPECIFIC OUTCOMES (PSOs)

h. Acquire knowledge of mathematics and its applications in all the fields.
i. Acquaint with the recent advances in applied mathematical sciences such as numerical computations and mathematical modeling.
j. Capable of formulating and analyzing mathematical models of real life applications.

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

**PEOI:** To engender problem-solving skills and apply them to the problems of pure and applied Mathematics.

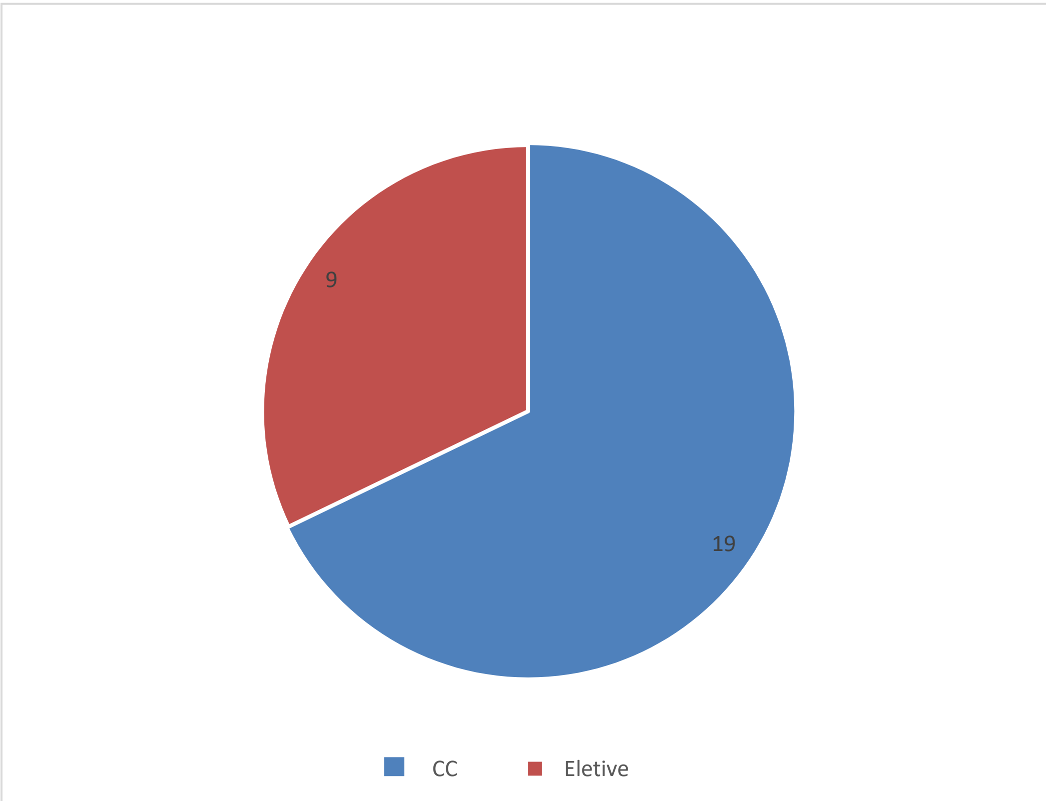
**PEO II: To** assimilate complicated mathematical concepts and arguments.

**PEO III: To** enhance your own learning and create mathematical thinking

## MAPPING OF POs AND PEOs

| Pos | a | b | C | D | E | f | g | H | I | j |
|---|---|---|---|---|---|---|---|---|---|---|
| PEO I | X | | X | | X | | | X | | X |
| PEO II | X | | | X | | | X | | | X |
| PEO III | | X | | | | X | | | X | |

## COURSE DETAIL USING PIE CHART



| | | |
|---|---|---|
| **21MMP101** | **ADVANCED ALGEBRA** | **Semester – I**<br>**5H – 4C** |
| **Instruction Hours / week: L:5T:0 P:0** | **Marks:** Internal: **40** | External: **60** Total:**100 End Semester Exam:3Hours** |

**Course Objectives**

This course enables the students to learn

- Sylow's theorems, Cauchy's theorem and Index theorem.
- The concepts of direct products.
- The basic central ideas of polynomial rings.
- To test if a polynomial is irreducible finite field (Galois Fields).
- The concepts of finite field and Wedderburn's theorem.
- The fundamental concepts of algebraic ring theory and fields.

**Course Outcomes (COs)**

On successful completion of this course the students will be able to

1. Define conjugate and conjugate classes.
2. Recognize some advances of the theory of groups.
3. Formulate some special types of rings and their properties.
4. Understand the fundamental theorem of Galois theory.
5. Know about the concept of finite field.
6. Understand the concepts of solvable group–the commutator subgroup.

**UNIT I**

**SYLOW'S THEOREMS**

Conjugate – Normalizer – Conjugate classes–application–Cauchy's theorem – Sylow's theorems – p-Sylow's subgroup –second and third proof of Sylow's theorem.

**UNIT II**

**FINITE ABELIAN GROUP**

Double co-set–Sylow's in doubt co-set. Internal and external direct product–isomorphism–Finite abelian groups–invariant.

**UNIT III**

**POLYNOMIAL RINGS**

Polynomial rings – Degree of polynomial – Polynomials over the rational field– Primitive – Content of the polynomial – Gauss lemma – integer monic – Eisenstein Criterion –Polynomial rings over commutative rings– unique factorization domain.

**UNIT IV**

**GALOIS THEORY**

More about roots – derivative –simple extension–fixed field–Normal extension– Splitting field – Galois group–fundamental theorem of Galois theory.

**UNIT V**

**FINITE FIELD**

Solvable group–the commutator subgroup–solvability by radicals–Finite fields–Wedderburn's theorem on finite division rings.

**SUGGESTED READINGS**


1. Herstein I. N., (2006). Topics in Algebra, Second edition, Wiley and sons Pvt, Ltd, Singapore.
2. Michiel Hazewinkel., Nadiya Gubareni., and Kirichenko V.V., (2011). Algebras, Rings and Modules, Vol.1, Springer International Edition, (Indian Print).
3. Artin M., (2015). Algebra, Pearson Prentice-Hall of India, New Delhi.
4. Fraleigh J.B., (2013). A First Course in Abstract Algebra, Seventh edition, Pearson Education Ltd, New Delhi.
5. Kenneth Hoffman., and Ray Kunze., (2015). Linear Algebra, Second edition, Prentice Hall of India Pvt Ltd, New Delhi.
6. Vashista A.R., (2014). Modern Algebra, Krishna Prakashan Media Pvt Ltd, Meerut.


**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. https://ocw.mit.edu/courses/mathematics/18-702-algebra-ii-spring-2011/index.htm
3. https://www.youtube.com/watch?v=PN-cro0J_v8&list=PLEAYkSg4uSQ1Yhxu2U-BxtRjZElrfVVcO
4. http://172.16.25.76/course/view.php?id=1646

**Semester – I**

**21MMP102** **REAL ANALYSIS** **5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The derivative of real functions.
- The principles of Riemann – Stieltjes Integral.
- The concept of sequence and series of functions.
- Applications of mathematical concepts and principles in power series.
- The concept of inverse implicit function and relevant theorem.
- To identify sets with various properties such as finiteness, countability, and infiniteness.

**Course Outcomes (COs)**

On successful completion of this course, students will be able to

1. Apply the concept of mean value theorem for differentiable functions.
2. Get specific skill in Riemann Stieltjes integral and Lebesgue integral.
3. Attain working knowledge in sequence and series.
4. Understand exponential and logarithmic functions.
5. Apply implicit and inverse function theorem moving towards calculus on manifolds.
6. Describe the fundamental concepts of some special functions.

**UNIT I**

**DIFFERENTIATION**

The derivative of real function – mean value theorems-The continuity of derivatives L'Hospital's rule – Derivatives of higher order – Taylor's theorem. Differentiation of vector-valued functions.

**UNIT-II**

**THE RIEMANN STIELTJES INTEGRAL**

The Riemann-Stieltjes integral: Definition and existence of the integral – Properties of the integral - Integration and differentiation - Integration of vector valued functions – Rectifiable curves.

**UNIT III**

**SEQUENCES OF FUNCTIONS**

Sequences and series of functions: Discussion of Main problem–Uniform Convergence-Uniform convergence and continuity - Uniform convergence and Integration - Uniform convergence and differentiation - Equicontinuous families of functions - The Stone-Weierstrass theorem.

**UNIT IV**

**SOME SPECIAL FUNCTIONS**

Some special functions: Power series - The exponential and Logarithmic functions - The trigonometric functions - The algebraic completeness of the complex field – Fourier Series - The Gamma functions.

**UNIT V**

**IMPLICIT FUNCTIONS AND EXTREMUM PROBLEMS**

Introduction–Functions with non zero Jacobian determinant–Inverse function theorem–Implicit function theorem – Extrema of real valued functions of one variable and several variables

**SUGGESTED READINGS**

1. Rudin W., (2013). Principles of Mathematical Analysis, Tata McGraw Hill, New York.
2. Balli N.P., (2017). Real Analysis, Laxmi Publication Pvt Ltd, New Delhi.
3. Bartle R. G., and Sherbert D. R., (2015). Introduction to Real Analysis, John Wiley and Sons (Asia) Pvt. Ltd.
4. Gupta S. L., and Gupta N. R., (2003). Principles of Real Analysis, Second edition, Pearson Education Pvt. Ltd, Singapore.
5. Royden H. L., (2002). Real Analysis, Fourth edition, Prentice Hall of India, New Delhi.
6. Sterling K., and Berberian., (2020). A First Course in Real Analysis, Springer Pvt Ltd, New Delhi.
7. Apostol M., (2002). Mathematical Analysis, Second edition, Narosa Publishing House, New Delhi.

**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. https://ocw.mit.edu/courses/mathematics/18-100c-real-analysis-fall 2012/index.htm3.http://172.16.25.76/course/view.php?id=1647.

**Semester – I**

**21MMP103** **NUMERICAL ANALYSIS** **5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The working knowledge on different numerical techniques.
- To solve system of equations by various methods.
- Appropriate numerical methods to solve differential equations.
- Suitable and effective methods for obtaining numerical results to boundary value problems.
- To obtain the numerical solutions for partial differential equations.
- A basic understanding of the derivation, analysis, and use of these numerical methods.

**Course Outcomes (COs)**

On successful completion of this course, students will be able to

1. Identify the concept of numerical differentiation and integration.
2. Provide information on methods of iteration.
3. Solve ordinary differential equations by using Euler and modified Euler method.
4. Study in detail the concept of boundary value problems.
5. Attain mastery in the numerical solution of partial differential equations.
6. Apply numerical methods to obtain approximate solutions to mathematical problems.

**UNIT I**

**SOLUTIONS OF NON-LINEAR EQUATIONS**

Newton's method- Convergence of Newton's method-Barstow's method for quadratic factors. Numerical Differentiation and Integration: Derivatives from difference tables – Higher order derivatives – divided difference. Trapezoidal rule– Romberg integration – Simpson's rules.

**UNIT II**

**SOLUTIONS OF SYSTEM OF EQUATIONS**

The Elimination method: Gauss Elimination and Gauss Jordan Methods – LU decomposition method. Methods of Iteration: Gauss Jacobi and Gauss Seidel iteration-Relaxation method.

**UNIT III**

**SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS**

One step method: Euler and Modified Euler methods–Runge kutta methods. Multistep methods: Adams Moulton method – Milne's method.

**UNIT IV**

**BOUNDARY VALUE PROBLEMS AND CHARACTERISTIC VALUE PROBLEMS**

The shooting method: The linear shooting method – The shooting method for non-linear systems. Characteristic value problems –Eigen values of a matrix by Iteration-The power method.

**UNIT V**

**NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS**

Classification of Partial Differential Equation of the second order – Elliptic Equations. Parabolic equations: Explicit method – The Crank Nicolson difference method. Hyperbolic equations – solving wave equation by Explicit Formula.

**SUGGESTED READINGS**


1. Gerald C. F., and Wheatley P. O., (2009). Applied Numerical Analysis, Seventh edition, Dorling Kindersley (India) Pvt. Ltd. New Delhi.
2. Jain M. K., Iyengar S. R. K., and Jain R. K., (2012). Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, New Delhi.
3. Burden R. L., and Douglas Faires J., (2014). Numerical Analysis, Seventh edition, P.W. S. Kent Publishing Company, Boston.
4. Sastry S. S., (2009). Introductory methods of Numerical Analysis, Fourth edition, Prentice Hall of India, New Delhi.


**WEBSITE LINK**

1. https://ocw.mit.edu/courses/mathematics/18-330-introduction-to-numerical-analysis-spring-2012/index.htm
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
3. http://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=&course%5B%5D=Numerical+analysis&domain%5B%5D=Physical+%26+Basic+Sciences
4. http://172.16.25.76/course/view.php?id=1648

**Semester –I**

**21MMP104 THEORY OF ORDINARY DIFFERENTIAL EQUATIONS 5H–4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:** 3 Hours

## Course Objectives

This course enables the students to learn

- About the concept of differential equations with variable coefficients.
- The formulation and solutions of second order ordinary differential equations.
- The concept of the system of first order equations with solving technique.
- The existence of uniqueness and non-uniqueness of solutions in the systems.
- The concepts of elementary linear and nonlinear oscillations.
- Problem solving procedures to thoroughly investigate relevant physical models.

## Course Outcomes (COs)

On successful completion of this course, students will be able to

1. Understand the standard methods and method of variation of parameters.
2. Understand the existence and uniqueness of solution to differential equations.
3. Identify non homogeneous equations, linear system with constant coefficients.
4. Solve higher order and system of differential equations by Successive approximations.
5. Understand the difficulty of solving problems for elementary linear oscillations.
6. Solve physical situations whose behavior can be described by ordinary differential equations.

**UNIT I**
**LINEAR EQUATIONS**

Linear independence – Equations with Constant Coefficients- Equations with Variable Coefficients - A formula for the Wronskian – Variation of parameters- Some Standard Methods- Method of Laplace Transforms.

**UNIT II**

**SECOND ORDER LINEAR EQUATIONS**

Second order linear equations with ordinary points – Legendre equation and Legendre polynomial- Second order equations with regular singular points – Bessel equation.

**UNIT III**
**SYSTEMS OF LNEAR DIFFERENTIAL EQUATIONS**

System of first order equations – existence and uniqueness theorems – fundamental matrix. Nonhomogeneous linear system–linear systems with constant coefficient – Linear systems with periodic coefficients.

**UNIT IV**

**SUCCESSIVE APPROXIMATION AND NON-UNIQUENESS SOLUTIONS**

Successive approximation – Picard's theorem – Non uniqueness of solution – Continuation and dependence on initial conditions – Existence of solution in the large existence and uniqueness of solution in the system.

**UNIT V**

**OSCILLATION THEORY**

Fundamental results – Strum's comparison theorem – Elementary linear oscillations – Comparison theorem of Hille winter – Oscillations of $x'' + a(t)x = 0$ elementary nonlinear oscillations.

**SUGGESTED READINGS**

1. Earl A Coddington., (2004). An introduction to Ordinary differential Equations, Prentice Hall of India Private limited, New Delhi.
2. Deo S. G., Lakshmikantham V., and Raghavendra V., (2005). Ordinary Differential Equations and Stability Theory, Second edition, Tata McGraw Hill Publishing Company limited, New Delhi.
3. Rai. B., Choudhury D. P., and Freedman H. I., (2004). A course of Ordinary differential Equations, Narosa Publishing House, New Delhi.
4. George F Simmons., (2017). Differential Equations with application and historical notes, 3rd edition by Taylor & Francis Group, LLC.
5. Sanchez D.A., (1968). Ordinary Differential Equations and Stability Theory, W. H. Freeman & Co., San Francisco.

**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. https://www.youtube.com/watch?v=4QllSn2v7p4&list=PLbMVogVj5nJSGlf9sluucwobyr_zz6glD&index=14
3. http://172.16.25.76/course/view.php?id=1649

Semester – II

**21MMP105A** **CLASSICAL MECHANICS** **4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:3Hours**

## Course Objectives

This course enables the students to learn

- Momentums applications Lagrange and D'Alembert's principle.
- Applications of differential equations in advanced mathematical problems.
- Parameters defining the motion of mechanical systems and their degrees of freedom.
- About canonical transformations.
- The principal and characteristic functions of Hamilton Jacobi equations.
- The Hamilton-Jacobi equation of the variation methods.

## Course Outcomes (COs)

On successful completion of this course, students will be able to

1. Understand the concept of the D'Alembert's principle.
2. Derive the Lagrange's equation for holomonic and non holomonic constraints.
3. Solve the problems of Hamilton equations of motion.
4. Study in details about the canonical transformations.
5. Know the concept of Hamilton Jacobi theory.
6. Concepts of Routh's procedure.

## UNIT I

## SURVEY OF ELEMENTARY PRINCIPLES

Constraints - Generalized coordinates, Holonomic and non- holonomic systems, Scleronomic and Rheonomic systems. D'Alembert's principle and Lagrange's equations – Velocity – dependent potentials and the dissipation function – some applications of the Lagrange formulation.

## UNIT II

## VARIATION PRINCIPLES AND LAGRANGE'S EQUATIONS

Hamilton's principle – Some techniques of calculus of variations – Derivation of Lagrange's Equations from Hamilton's principle – Extension of Hamilton's principle to non-holonomic systems – Conservation theorems and symmetry properties.

**UNIT III**

**HAMILTON EQUATIONS OF MOTION**

Legendre Transformations and the Hamilton Equations of motion-canonical equations of Hamilton – Cyclic coordinates and conservation theorems – Routh's procedure - Derivation of Hamilton's equations from a variational principle – The principle of least action.

**UNIT IV**

**CANONICAL TRANSFORMATIONS**

The equations of canonical transformation – Examples of Canonical transformations – Poisson Brackets and other Canonical invariants – integral invariants of Poincare, Lagrange brackets.

**UNIT V**

**HAMILTON JACOBI THEORY**

Hamilton Jacobi equations for Hamilton's principal function – Harmonic oscillator problem - Hamilton Jacobi equation for Hamilton's characteristic function – Separation of variables in the Hamilton-Jacobi equation.

**SUGGESTED READINGS**

1. Goldstein H., (2011). Classical Mechanics Third Edition, Narosa Publishing House, New Delhi.
2. Gantmacher F., (2013). Lectures in Analytic Mechanics, MIR Publishers, Moscow.
3. Gelfand I. M., and Fomin S.V., (2003). Calculus of Variations, Prentice Hall, New Delhi.
4. Loney S. L., (2015). An Elementary Treatise on Statics, Kalyani Publishers, New Delhi.

**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. https://www.youtube.com/playlist?list=PLq-Gm0yRYwTjpY9BlDxFGNXIaQJIOQRdo
3. http://172.16.25.76/course/view.php?id=1650

**Semester – I**

**21MMP105B FORMAL LANGUAGES AND AUTOMATA THEORY 4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The basic concepts in automata theory and theory of computation.
- To identify different formal language classes and their relationships.
- About the construction of regular expressions.
- Design free grammars for accepting or generating a certain language.
- Design grammars and recognizers for different formal languages
- To use of Grammars Rules in construct/validate sentences of the language.

**Course Outcomes (COs)**

On successful completion of this course the students will be able to

1. Understand the concepts of automata.
2. Know about the different concepts in formal languages and context-free languages.
3. Apply the procedure of regular expressions.
4. Applications of Pumping Lemma in theory of computations.
5. Study context-free grammars accepting or generating certain languages.
6. Acquire the knowledge of regular sets and Grammars.

**UNIT I**

**FINITE AUTOMATA**

Definition of an Automation - Description of Finite Automaton – Transition systems - Property of transition functions - Acceptability of a string by a finite Automaton - Non deterministic finite automaton - The equivalence of DFA and NDFA.

**UNIT II**

**FROMAL LANGUAGES**

Formal Languages - Basic Definitions and examples - Chomsky classification of Languages - Languages and their relation - Recursive and Recursively Enumerable sets- Operations on Languages**.**

**UNIT III**

**REGULAR EXPRESSIONS AND LANGUAGES**

Regular expressions - Finite Automata and Regular expressions.

**UNIT IV**
**REGULAR SETS**
Pumping Lemma for Regular sets - Applications of Pumping Lemma - Closure Property of Regular sets - Regular sets and Regular grammars.

**UNIT V**
**CONTEXT FREE GRAMMARS**
Context free Languages and Derivation trees - Ambiguity in Context free grammars - Simplification of Context free grammars (examples only).

**SUGGESTED READINGS**


1. Mishra K. L. P., and Chandrasekaran N., (2008). Theory of Computer Science, Automata Languages and Computation, Prentice Hall of India, New Delhi.
2. John E Hopcroft., Rajeev Motwani., and Ullman J. D., (2006). Introduction to Automata theory, Languages and Computation, Third Edition, Prentice Hall of India, New Delhi.
3. Aho A.V., and Ullman J. D., (2002). Principles of compiler design, Narosa Publishing Company, London.
4. Rakesh Duke., Adesh Pandey., and Ritu Gupta., (2007). Discrete Structures and Automata Theory, Narosa Publishing Company, New Delhi.


**WEBSITE LINK**

1. https://core.ac.uk/download/pdf/53839529.pdf
2. https://www.iitg.ac.in/dgoswami/Flat-Notes.pdf
3. https://www.youtube.com/watch?v=APRPT4KrzMA&list=PLLvKknWU7N4zvTGcw9N2_7eZSTTkryb0U
4. https://www.youtube.com/watch?v=fp0RKpQHBVw

**Semester – I**

**21MMP105C** **FINITE ELEMENT METHODS** **4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The fundamental concepts of the theory of the finite element method.
- The purpose of Galerkin method, global & local finite element models in one dimension.
- Finite elements method with a focus on one- and two-dimensional problems.
- The zero order Hermitian interpolations functions and sample of planner rectangular Lagrange elements.
- The global interpolation and the solution of one-dimensional heat and wave equations.
- The design and heat transfer problems with application of finite element method.

**Course Outcomes (COs)**

On successful completion of this course the student will be able to

1. Develop the ability to generate the governing finite element equations for systems governed by partial differential equations.
2. Analyze the composite laminates with local effects global /local finite element methods.
3. Develop triangular and rectangular elements for the general plain elasticity problems.
4. Understand the concepts Lagrangian and Hermit elements methods in finite element method.
5. Understand the application and uses of the Finite element method for heat transfer problem.
6. Apply the computational technique to obtain the approximate solutions of boundary value problems.

**UNIT I**

Finite Element Method: Variation formulation–Raayleigh- ritz minimization- weighted residuals- Galerkin method applied to boundary value problems.

**UNIT II**

Global and local finite element models in one dimension-derivation of finite element equation.

**UNIT III**

Finite element interpolation-polynomial elements in one dimension, two dimensional elements- natural coordinates-triangular elements-rectangular elements.

**UNIT IV**

Lagrangian and Hermit elements for rectangular elements-global interpolation functions.

**UNIT V**

Local and global forms of finite element equations-boundary conditions-methods of solutions for a steady state problems –Newton-Raphson continuation-one dimensional heat and wave equations.

**SUGGESTED READINGS**

1. Reddy J. N., (2009). An Introduction to the Finite element Method. McGraw Hill, NY.
2. Chung., (2001). Finite element Analysis in Fluid Dynamics., Mc Graw Hill, Inc.
3. Singiresu S., and Rao., (2004). The Finite Element Method in Engineering, Fourth edition, ElsevierInc.
4. Chennakesava R., and Alavala., (2012). Finite Element Method, PHI, New Delhi.
5. Zienkiewicz O. C., and Talor R. L., (2010). Finite Element Method its Basis and Fundamentals, Elsevier, New Delhi.

**WEBSITE LINK**

1. https://research.iaun.ac.ir/pd/atrian/pdfs/UploadFile_2613.pdf
2. https://www.kth.se/social/upload/5261b9c6f276543474835292/main.pdf
3. https://www.youtube.com/watch?v=C6X9Ry02mPU
4. https://www.youtube.com/watch?v=hVleTL6CeKw

**Semester–I**

**21MMP111** **NUMERICAL COMPUTING–PRACTICAL** **4H–2C**

**Instruction Hours/week:L:0 T:0 P:4** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

## Course Objectives

This course enables the students to learn

- In-depth understanding of functional, logic, and programming paradigms.
- To implement several programs in languages other than the one emphasized in the core curriculum.
- The basic concepts and techniques of numerical solution of algebraic equations.
- Introduction to the field of numerical analysis.
- Understand the concept of Gauss elimination method.
- To find appropriate solution to differential equation through numerical methods.

## Course Outcomes (COs)

On successful completion of this course, the student will be able to

1. Know the concepts for problem solving.
2. Acquire working knowledge in numerical computing.
3. Comprehend important issues related to the development of computer-based systems in a professional context using a well-defined process.
4. Familiar with programming with numerical packages.
5. Be aware of the use of numerical methods in modern scientific computing.
6. To develop the mathematical skills in the areas of numerical methods.

## List of Practical

1. Solution of non-linear equation-Bairstow's method for quadratic factors.
2. Solution of simultaneous equations-Gauss Elimination.
3. Solution of simultaneous equations-Gauss Jordan.
4. Solution of simultaneous equations-Gauss Jacobi.
5. Solution of simultaneous equations-Gauss Seidel.
6. Solution of simultaneous equations- Triangularization.
7. Numerical integration-Trapezoidal rule.
8. Numerical integration-Simpson's rules.
9. Solution for ordinary differential equation-Euler method.

10. Solution for ordinary differential equation- Runge Kutta Second order.
11. Solution for parabolic equation – Explicit method.
12. Solution for parabolic equation - The Crank Nicolon method.

**SUGGESTED READINGS:**

1. LAB Manual.
2. Kirani Singh. Y & Chaudhuri. B.B., (2008). MATLAB Programming, Prentice-Hall of India Pvt. Ltd, New Delhi.
3. Desmond. J. Higham & Nicholas J. Hiham., (2005). MATLAB Guide MATLAB Guide, MATLAB Guide, 2nd edition, SIAM.
4. Hema Ramachandran, Achuthsankar S. Nair, Computer SCILAB–A Free Software to MATLAB, First Edition, S. Chand & Company Ltd, New Delhi.

**WEBSITE LINK:**

1. http://spoken-tutorial.org/
2. http://wiki.scilab.org/Tutorialsarchives
3. https://www.scilab.org/tutorials

**Semester – II**

**21MMP201** **LINEAR ALGEBRA** **5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:3Hours**

## Course Objectives

This course enables the students to learn

- The concepts of linear transformations.
- Momentous properties of algebra of polynomials.
- About determinants and its properties.
- To tell if two vectors are Normalization of vectors.
- The concept of cyclic decomposition.
- The solution in canonical and vector forms.

## Course Outcomes (COs)

On successful completion of this course, the student will be able to

1. Recognize some advances of vector spaces and linear transformations.
2. Understand the concept of prime factorizations of polynomials.
3. Attain mastery in determinant functions.
4. Decompose a given vector space in to certain canonical forms.
5. Know the concept of rational form.
6. Formulate several classes of linear transformations and their properties.

## UNIT I
## LINEAR TRANSFORMATIONS

Linear transformation–null space–rank–nullity–Algebra of linear transformation. The algebra of linear transformations-Isomorphism – Representation of transformations by matrices – Linear functional.

## UNIT II
## POLYNOMIALS

Linear algebras over the field – Algebra of polynomials– Lagrange Interpolation– isomorphic – Polynomial ideals– root – Taylor’s Formula – ideal – greatest common divisor – relatively prime – the prime factorization of a polynomial.

**UNIT III**
**DETERMINANTS**

Commutative Ring– Determinant Functions– n-linear – Permutations– degree of permutation – Signature of permutation – the Uniqueness of Determinants– Additional Properties of Determinants.

**UNIT IV**
**ELEMENTARY CANONICAL FORM**

Introduction– Characteristic Values– Characteristic vector – Characteristic space – example – Diagonalizable – Annihilating Polynomials– Invariant Subspaces– Simultaneous Triangulation– Simultaneous Diagonalization.

**UNIT V**
**THE RATIONAL AND JORDAN FORM**

Cyclic Subspaces and Annihilators– Cyclic Decompositions theorem – generalized Cayley Hamilton theorem – The Jordon Form.

**SUGGESTED READINGS**

1. Kennath M Hoffman., and Ray Kunze., (2015). Linear Algebra, 2 Edition, Pearson India Publishing, New Delhi.
2. Herstein I. N., (2006). Topics in Algebra, 2nd Edition, John Wiley & Sons, Singapore.
3. Vivek Sahai., and Vikas Bist., (2013). Linear Algebra, Second edition, Narosa Publishing House.
4. Rao A. R., and Bhimashankaram P., (2000). Linear Algebra, Tata Mc Graw Hill, New Delhi.
5. Golan J. S., (2010). Foundations of linear Algebra, Kluwer Academi publisher.
6. Kumaresan S., (2006). Linear Algebra A Geometric Approach, Prentice Hall of India.

**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. http://vidyamitra.inflibnet.ac.in/index.php/content/index/5704c5378ae36c6ab9b0b0fa
3. https://ocw.mit.edu/courses/mathematics/18-06sc-linear-algebra-fall-2011/
4. https://ocw.mit.edu/courses/mathematics/18-s096-topics-in-mathematics-with-applications-in-finance-fall-2013/video-lectures/lecture-2-linear-algebra/

**Semester – II**

**21MMP202** **COMPLEX ANALYSIS** **5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

**Course Objectives**

This course enables the students to learn

- The concepts of oriented circles and level curves.
- Fundamental concepts of complex integration.
- Primary facts about harmonic function.
- About Stirling's Formula and Jensen's formula.
- The development of the complex variable in boundary behaviour.
- The fundamental theorem of calculus and Cauchy's integral formula.

**Course Outcomes (COs)**

On successful completion of this course, students will be able to

1. Explain the role of the Conformal mapping.
2. Evaluate complex contour integrals and some of their consequences.
3. Determine the Taylor series or the Laurent series of an analytic function in a given region
4. Describe the convergence properties of a power series.
5. Know the basic properties of singularities of analytic functions.
6. Demonstrate familiarity with a range of examples of these concepts of conformal mapping.

**UNIT I**

**CONFORMALITY**

Conformal mapping-Linear transformations- cross ratio- symmetry- Oriented circles-families of circles-level curves.

**UNIT II**

**FUNDAMENTAL THEOREMS**

Complex integration - rectifiable Arcs- Cauchy's theorem for Rectangle and disc - Cauchy's integral formula - higher derivatives.

**UNIT III**

**HARMONIC FUNCTIONS**

Harmonic functions - mean value property-Poisson's formula-Schwarz theorem, Reflection principle-Weierstrass theorem- Taylor series and Laurent series.

**UNIT IV**

**PARTIAL FRACTIONS**

Partial Fractions- Infinite products – Canonical products-The gamma function – Stirling's Formula – Entire functions – Jensen's formula.

**UNIT V**

**THE RIEMANN MAPPING THEOREM**

Riemann Mapping Theorem – Boundary behavior – Use of Reflection Principle – Analytical arcs – Conformal mapping of polygons- The Schwartz – Christoffel formula.

**SUGGESTED READINGS**

1. Lars V Ahlfors., (2017). Complex Analysis, Third edition, Mc-Graw Hill Book Company, New Delhi.
2. Ponnusamy S., (2019). Foundation of Complex Analysis, Second edition, Narosapublishing house, New Delhi.
3. Choudhary B., (2005). The Elements of Complex Analysis, New Age International Pvt. Ltd, New Delhi.
4. Vasishtha A. R., (2014). Complex Analysis, Krishna Prakashan Media Pvt. Ltd.,Meerut.
5. Walter Rudin., (2017). Real and Complex Analysis, 3rd edition, McGraw Hill Book Company, NewYork.

**WEBSITES LINK:**

1. https://nptel.ac.in/courses/111107056/
2. https://nptel.ac.in/courses/111103070/
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25

**Semester – II**

**21MMP203** **OPTIMIZATION TECHNIQUES** **5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The basic concepts of integer linear programming.
- To solve quadratic programming problems, dynamic programming problems and non-linear programming problems.
- The concepts of inventory models.
- Real life applications in decision analysis.
- Different optimization technique in NLP.
- Fundamentals of Linear Programming and Dynamic Programming problems.

**Course Outcomes (COs)**

On successful completion of this course, the students will be able to

1. Understand the concept of linear programming and integer programming.
2. Develop dynamic programming problems.
3. Familiarize with real life applications of inventory control.
4. Skill in decision analysis.
5. Mastery in Beale's method and simplex method.
6. Use classical optimization techniques and numerical methods of optimization.

**UNIT I**

**INTEGER LINEAR PROGRAMMING**

Types of Integer Linear Programming Problems - Concept of Cutting Plane - Gomory's All Integer Cutting Plane Method-Gomory's mixed Integer Cutting Plane method Branch and Bound Method. Zero-One Integer Programming–Real life application in Integer Linear Programming.

**UNIT II**

**DYNAMIC PROGRAMMING**

Characteristics of Dynamic Programming Problem - Developing Optimal Decision Policy - Dynamic Programming under Certainty - DP approach to solve LPP.

**UNIT III**

**INVENTORY CONTROL:**

Introduction – Costs involved in Inventory – Deterministic EOQ Models – Purchasing Model without and with Shortage, Manufacturing Model without and with Shortage -Price Break.

**UNIT IV**

**DECISION ANALYSIS**

Real life application - Decision making under certainty- Analytic hierarchy process. Decisions under Risk- Decision Trees-based expected value criterion, variations of the expected value criterion. Decisions under Uncertainty Real life application in Decision Analysis

**UNIT V**

**NON-LINEAR PROGRAMMING METHODS**

Examples of NLPP - General NLPP - Graphical solution - Quadratic Programming - Wolfe's modified Simplex Methods - Beale's Method.

**SUGGESTED READINGS**

1. Sharma J. K., (2019). Operations Research Theory and Practice, Fourth edition, Macmillan India Ltd.
2. Handy A Taha., (2017). Operations Research, Tenth edition, Prentice Hall of India Pvt Ltd, New Delhi.
3. Kantiswarup., Gupta P. K., and Manmohan., (2019). Operations Research, Twelfth edition, Sultan Chand & Sons Educational Publishers, New Delhi.
4. Panneerselvam R., (2016). Operations Research, Second edition, Prentice Hall of India Private Ltd, New Delhi.
5. Singiresu S., and Rao., (2010). Engineering Optimization Theory and Practice, Third edition New Age International Pvt Ltd, New Delhi.
6. Sivarethina Mohan R., (2008). Operations Research, First edition, Tata McGraw Hill Publishing Company Ltd, New Delhi.

**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. http://172.16.25.76/course/view.php?id=2082

**Semester –II**

**21MMP204 THEORY OF PARTIAL DIFFERENTIAL EQUATIONS 5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- Linear partial differential equations with constant and variable coefficients.
- The behavior of solutions in terms of eigen function expansions.
- Neumann problems for a rectangle with solving procedure.
- Method of image and eigen functions.
- Solution of one-dimensional wave equations.
- The existence and uniqueness of solutions.

**Course Outcomes (COs)**

On successful completion of this course the students will be able to

1. Classify linear and Nonlinear first order differential equations with constant coefficients.
2. Describe the method of separable variables and integral transforms.
3. Solve the elementary Laplace equation with symmetry.
4. Explain the Delta Function and Green' function.
5. Acquire the knowledge of wave equation and vibrating membranes.
6. Enrich their knowledge about diffusion equations with sources.

**UNIT I**

**FIRST ORDER PARTIAL DIFFERENTIAL EQUATIONS**

Nonlinear partial differential equation of first order –Compatible systems of first order equations – Special type of first order equations- Partial differential equations of second order – The origin of second order equations –Linear partial differential equations with constant coefficient equations with variable coefficients.

**UNIT II**

**METHOD OF SEPARATION OF VARIABLES**

Separation of variables–The vibrating string problem-Existence and Uniqueness of solution of the vibrating string problem. The heat conduction problem-existence and uniqueness of solution of the heat conduction problem –The Laplace and beam Equations.

**UNIT III**

**BOUNDARY VALUE PROBLEMS**

Elementary solutions of Laplace equations -Families of Equi-potential surfaces–Interior Dirichlet and Neumann problems- Separation of variables--Dirichlet problems for a circular annulus-Neumann problem for a circle Dirichlet’s problems for a rectangle – Neumann problems for a rectangle – problems with axial symmetry.

**UNIT IV**

**GREEN FUNCTION**

The Delta Function-Green’ function – Method of green’s function-Dirichlet problem for Laplace operator – Method of image – Method of eigen functions.

**UNIT V**

**WAVE EQUATION**

Elementary solutions of one-dimensional wave equation-Vibrating membrane – Applications of calculus of variations–Diffusion equation - Elementary solution of Diffusion equation–Separation of variables.

**SUGGESTED READINGS**


1. Sharma J. N., and Keharsingh., (2009). Partial Differential Equations for Engineering and Scientists, Narosa Publishing House, New Delhi.
2. Ian N Sneedon., (2006). Elementary Partial differential equations, Tata Mcgraw Hill Ltd.
3. Geraold B., and Folland., (2001). Introduction to Partial Differential Equations, Prentice Hall of India Private limited, New Delhi.
4. Sankara Rao K., (2011). Introduction to Partial Differential Equations, Third edition, Prentice Hall of India Private limited, New Delhi.
5. Veerarajan T., (2004). Partial Differential Equations and Integral Transforms, Tata McGraw- Hill Publishing Company limited, New Delhi.
6. John F., (1991). Partial Differential equations, Third edition, Narosa publication co, New Delhi.
7. Tyn-Myint-U., and Lokenath Debnath., (2008). Linear Partial Differential Equations for Scientists and Engineers, Fourth Edition, Birkhauser, Berlin.
8. Evans L. C., (2003). Partial Differential Equations, Second edition, AMS, ProvidenceRI.


**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. http://vidyamitra.inflibnet.ac.in/index.php/search?subject%5B%5D=&course%5B%5D=Partial+differential+equations&domain%5B%5D=Physical+%26+Basic+Sciences

**Semester – II**

**21MMP205A** **ADVANCED GRAPH THEORY** **4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

**Course Objectives**

This course enables the students to learn

- The fundamental concepts in graphs and trees.
- The matching and factors.
- About graph colouring and notation.
- Analyze the planarity concepts and related theorems.
- Know the concept of domination in graphs.
- Central theorems about trees, matching, connectivity, colouring and planar graphs.

**Course Outcomes (COs)**

On successful completion of this course, the students will be able to

1. Apply the knowledge of graphs and trees to solve the real-life problem.
2. Study in detail about the independent sets and its properties.
3. Understanding the basic concepts of colouring, free graphs and chromatic polynomial.
4. Analyze planarity of graphs.
5. Understanding the basic concepts of dominating set and domination number.
6. Identify induced subgraphs, cliques, matchings and covers in graphs.

**UNIT I**

**CONNECTIVITY**

Vertex Cuts and Edge Cuts - Connectivity and Edge - Connectivity, Trees: Definitions, Characterization and Simple Properties - Counting the Number of Spanning Trees - Cayley's Formula.

**UNIT II**

**INDEPENDENT SETS AND MATCHINGS**

Vertex Independent Sets and Vertex Coverings - Edge Independent Sets -Matchings and Factors - Eulerian Graphs - Hamiltonian Graphs.

**UNIT III**

**GRAPH COLOURINGS**

Vertex Coloring - Critical Graphs - Triangle - Free Graphs - Edge Colorings of Graphs - Chromatic Polynomials- Vizing's theorem.

**UNIT IV**

**PLANARITY**

Planar and Nonplanar Graphs - Euler Formula and its Consequences - $K_5$ and $K_{3,3}$ are Nonplanar Graphs - Dual of a Plane Graph - The Four Colour Theorem and the Heawood Five - Colour Theorem - Kuratowski's Theorem.

**UNIT- V**

**DOMINATION IN GRAPHS**

Introduction – Terminology and concepts – Applications – Dominating Set and domination number – Independent set and independent number.

**SUGGESTED READINGS**

1. Bondy J. A., and Murty U. S. R., (2013). Graph Theory with Applications, Elsevier, New York.
2. Deo N., (2016). Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India Pvt Ltd, New Delhi.
3. Balakrishnan R., and Ranganathan K., (2008) A Textbook of Graph Theory, Springer, International Edition, New Delhi.
4. Teresa W Haynes., Stephen T Hedetniemi., and Peter J Slater., (1998). Fundamentals of Domination in Graphs, Marcel Dekker, New York.
5. Arumugam S., Ramachandran S., (2006). Invitation to graph theory, Scitech publications, Chennai.
6. Harary F., (2001). Graph Theory, Addison- Wesley Publishing Company Inc USA.

**WEBSITE LINK**

1. http://vidyamitra.inflibnet.ac.in/index.php/content/index/5704c5378ae36c6ab9b0b602
2. http://172.16.25.76/course/view.php?id=2085

**Semester – II**

**21MMP205B** **FLUID DYNAMICS** **4H –4C**

**Instruction Hours/week: L:4T:0 P:0** **Marks:** Internal:**40** External: **60** Total:**100**

**End Semester Exam:3Hours**

## Course Objectives

This course enables the students to learn

- The concepts of fluid, its properties and behavior under various conditions of internal and external flows.
- The fundamentals of Fluid Dynamics, which is used in the applications of Aerodynamics, Hydraulics, Marine Engineering, Gas dynamics etc.
- About the Two-Dimensional Motion of the fluid.
- Vorticity and circulation in a viscous fluid.
- Identify the fundamental kinematics of a fluid element.
- State the conservation principles of mass, linear momentum, and energy for fluid flow.

## Course Outcomes (COs)

On successful completion of this course, students will be able to

1. Classify and exploit fluids based on the physical properties of a Stream Lines and Path Lines.
2. Apply the conservation principles of mass, linear momentum, and energy to fluid flow systems.
3. Understand the concepts of two dimensional flow and lift forces of a fluid element.
4. Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.
5. Provide the basic mathematical background and tools to boundary layer concepts.
6. Calculate the flow of an ideal fluid in a variety of situations.

## UNIT I

## INTRODUCTORY NOTIONS

Velocity – Stream Lines and Path Lines – Stream Tubes and Filaments – Fluid Body – Density – Pressure. Differentiation following the Fluid – Equation of continuity – Boundary conditions – Kinematical and physical – Rate of change of linear momentum – Equation of motion of an inviscid fluid.

## UNIT II

## EQUATION OF MOTION OF A FLUID

Euler's momentum Theorem – Conservative forces – Bernoulli's theorem in steady motion – Energyequationforinviscidfluid–Circulation–Kelvin'stheorem–Vortexmotion–Helmholtz equation.

**UNIT III**

**TWO-DIMENSIONAL FLOW**

Two Dimensional Motion – Two Dimensional Functions – Complex Potential – Basic singularities – Source–Sink–Vortex–Doublet–Circle theorem. Flow past a circular cylinder with circulation – Blasius Theorem – Lift force. (Magnus effect)

**UNIT IV**

**VISCOUS FLOWS**

Viscous flows – Navier-Stokes equations – Vorticity and circulation in a viscous fluid – Steady flow through an arbitrary cylinder under pressure – Steady Couettc flow between cylinders in relative motion – Steady flow between parallel planes.

**UNIT V**

**LAMINAR BOUNDARY LAYER IN INCOMPRESSIBLE FLOW**

Boundary Layer concept – Boundary Layer equations – Displacement thickness, Momentum thickness–Kinetic energy thickness–Integral equation of boundary layer–Flow parallel to semi-infinite flat plate – Blasius equation and its solution in series.

**SUGGESTED READINGS**


1. Milne Thomson L. M., (2011). Theoretical Hydrodynamics, Fifth edition, Dover Publications INC, New York.
2. Curle N., and Davies H.J., (1971). Modern Fluid Dynamics Volume-I , D Van Nostrand Company Ltd., London.
3. Yuan S.W., (1988). Foundations of Fluid Mechanics, Prentice- Hall, New Delhi.
4. Shanthiswarup., (2019). Fluid dynamics, Krishna Prakasan media Pvt Ltd, Meerut.


**WEBSITE LINK**

1. https://ocw.mit.edu/courses/mechanical-engineering/2-06-fluid-dynamics-spring- 2013/
2. http://172.16.25.76/course/view.php?id=2086

**Semester –II**

**21MMP205C FUNDAMENTALS OF ACTUARIAL MATHEMATICS 4H–4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

**Course Objectives**

This course enables the students to learn

- How to assess the suitability of actuarial, financial and economic models in solving actuarial problems
- The fundamental theories of actuarial science as they apply in life insurance, general insurance and superannuation.
- Interpretation and critically evaluating the various values of annuities.
- About the concept of premiums annuity plan.
- Understand the Premium Conversion tables for calculation of Policy values.
- The concept of Premiums for Annuity Plans.

**Course Outcomes (COs)**

On successful completion of this course the student will be able to

1. Explain the basic concepts of accounts and calculations of interest rates in banking / financial institution system.
2. Describe about Premiums of Life Insurance and Endowment Assurance (Pure, Double and Marriage) and Educational Annuity plan.
3. Define Annuity and Summarize / calculate different values of Annuities.
4. Leant about annual premiums and annuity plans.
5. Find the Annuity values for various Annuities.
6. Calculation of Net Premiums for Assurance Plans.

**UNIT I**

**BASIC CONCEPTS OF ACTUARIAL MATHEMATICS**

Accumulated Value – Present Value – Formula for present value- Annuities Certain- present Values-Amounts - Deferred Annuities –Perpetuities - Present Value of an Immediate Annuity Certain–Accumulated Value of Annuity – Relation between $S_n$ and $a_n$ –Present Value of Deferred Annuity Certain – Accumulated Value of a term of n years – Perpetuity – Present Value of an Immediate Perpetuity of 1p.a. – Present Value of a Perpetuity due of 1 p.a. – Deferred Perpetuity with Deferment Period of m years – Mortality Table – The Probabilities of Survival and Death.

**UNIT II**

**CALCULATION OF DIFFERENT INSURANCE PREMIUMS**

Life Insurance Premiums – General considerations - Assurance Benefits – Pure Endowment Assurance – Endowment Assurance – Temporary Assurance or Term Assurance - Whole Life Assurance – Pure Endowment Assurance – Endowment Assurance – Double Endowment Assurance Increasing Temporary Assurance – Increasing Whole Life Assurance – Fixed Term (Marriage) Endowment – Educational Annuity Plan.

**UNIT III**

**VARIOUS VALUES OF ANNUITIES**

Life Annuities and Temporary Annuities – Commutation Functions Nx – To Find the Present ValueofanAnnuityDueofRe.1p.a.for Life–Temporary Immediate Life Annuity–Expression for ax : n – Deferred Temporary Life Annuity – Variable Life Annuity – Increasing Life Annuity – Variations in the Present Values of Annuities – Life Annuities Payable at Frequent Intervals.

**UNIT IV**

**ANNUAL PREMIUMS AND ANNUITY PLANS**

Net Premiums for Assurance Plans – Natural Premiums – Level Annual Premium – Symbols for Level Annual Premium under Various Assurance Plans – Mathematical Expressions for level Annual Premium under Level Annual Premium under Various Plans for Sum Assure of Re. 1 – Net Premiums – Consequences of charging level Premium – Consequences of withdrawals – Net Premiums for Annuity Plans – Immediate Annuities – Deferred Annuities.

**UNIT V**

**POLICY VALUE AND ITS CALCULATION**

Premium Conversion tables – Single Premium Conversion tables – Annual Premium Conversion Tables – Policy Values – Two kinds of Policy values – Policy value in symbols – Calculation of Policy Value for Unit Sum Assure – Other Expressions for Policy Value – Surrender Values – Paid up Policies – Alteration of Policy Contracts.

**SUGGESTED READING**

1. Mathematical Basis of Life Insurance - Insurance Institute of India

**WEBSITE LINK**

1. https://www.youtube.com/watch?v=Z95I07ZauOo
2. https://www.youtube.com/watch?v=Uun217imHhs

Semester –II

**21MMP211 OPTIMIZATION TECHNIQUES–PRACTICAL 4H–2C**

**Instruction Hours/week:L:0 T:0 P:4** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- An exposure to develop well-structured optimization techniques knowledge arising process in various level of science.
- The course aims at building capabilities in the students for analyzing different situations in the industrial/ business scenario involving limited resources and finding the optimal solution within constraints.
- This module aims to introduce students to use Probabilistic Model and techniques.
- The course aims at providing fundamental knowledge and exposure of the concepts, theories and practices in the field of management.
- Study the basic components of an optimization problem.
- Formulation of design problems as mathematical programming problems.

**Course Outcomes**

On successful completion of this course, the student will be able to

1. Use the object oriented concepts for implementation of Optimization Techniques.
2. Implement the data structure concepts for Optimization Techniques problems.
3. Acquire skills to solve various multivariable optimization problems
4. Solve of different optimization problems.
5. Identify and develop operational research models from the verbal description of the real system. Understand the mathematical tools that are needed to solve optimization problems.
6. Use mathematical software to solve the proposed models.

**List of Practical:**

1. Solution for a system of equations- Simplex method.
2. EOQ for purchasing model without shortage
3. EOQ for manufacturing model without shortage
4. EOQ for manufacturing model with shortage
5. EOQ for purchasing model with shortage
6. Probabilistic Model-EOQ.

7. Decision making with minimax criterion.
8. Decision making with maximin criterion.
9. Decision making under risk.
10. Decision making with Hurwicz criterion.

**SUGGESTED READINGS:**


1. LAB Manual.
2. Kirani Singh. Y & Chaudhuri. B.B., (2008). MATLAB Programming, Prentice-Hall of India Pvt. Ltd, New Delhi.
3. Desmond. J. Higham & Nicholas J. Hiham., (2005). MATLAB Guide MATLAB Guide, MATLAB Guide, 2nd edition, SIAM.
4. Hema Ramachandran, Achuthsankar S. Nair, Computer SCILAB–A Free Software to MATLAB, First Edition, S. Chand & Company Ltd, New Delhi.


**WEBSITE LINK:**

1. http://spoken-tutorial.org/
2. http://wiki.scilab.org/Tutorialsarchives
3. https://www.scilab.org/tutorials

**Semester – III**

**21MMP301** **TOPOLOGY** **5H –5C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

## Course Objectives

This course enables the students to learn

- The concepts of metric spaces and topological spaces.
- Topological properties of sets.
- The properties of connected spaces local connectedness.
- To explore the foundations of compact spaces and compact subspace.
- Metrizability of topological spaces.
- Interior, closure and boundary applications in geographic information systems.

## Course Outcomes (COs)

On successful completion of this course, students will be able to

1. Understand concept of metric spaces.
2. Acquire knowledge about various types of topological spaces and product topologies.
3. Discuss components and local connectedness.
4. Know the result of Compactness problems and theorems.
5. Create examples and counterexamples in the fundamental concepts of separation space.
6. Develop their abstract thinking skills on topological concepts.

## UNIT I

## TOPOLOGY OF METRIC SPACES

Topological spaces-Basis for a topologies-The order topology-The product topology X x Y-The subspace topology.

## UNIT II

## TOPOLOGICAL PROPERTIES

Closed set and limit points-Continuous functions-The product topologies-The metric topologies.

## UNIT III

## CONNECTEDNESS

Connected spaces-Connected subspaces of the real line-Components and local connectedness.

## UNIT IV

## COMPACTNESS

Compact spaces-Compact subspaces of the Real line-Limit point compactness-Local compactness.

**UNIT V**

**COUNTABILITY AND SEPARATION AXIOMS**

The countability axioms-The separation axioms-Normal spaces-The Urysohn lemma, The Urysohn metrization theorem-The Tietze Extension theorem.

**SUGGESTED READINGS**


1. James R Munkres., (2008). Topology, Second edition, Pearson Prentice Hall, New Delhi.
2. Simmons G. F., (2017). Introduction to Topology and Modern Analysis, Tata McGraw Hill, New Delhi.
3. Deshpande J. V., (1990). Introduction to topology, Tata McGraw Hill, New Delhi.
4. James Dugundji., (2002). Topology, Universal Book Stall, New Delhi.
5. Joshi K. D., (2017). Introduction to General Topology, New Age International Pvt Ltd, New Delhi.


**WEBSITE LINK**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. https://ocw.mit.edu/courses/mathematics/18-901-introduction-to-topology-fall-2004/index.htm
3. http://vidyamitra.inflibnet.ac.in/index.php/content/index/5a5dcf758007be2bd1bc30b
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|---|---|---|
| | | **Semester – III** |
| **21MMP302** | **NUMBER THEORY** | **5H –4C** |

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**
This course enables the students to learn

- Fundamentals of congruences.
- Momentous number theoretic functions.
- The challenging problems in number theory.
- How number theory is related to and used in cryptography.
- Greatest common divisor, prime, and prime-factorization.
- The Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.

**Course Outcomes (COs)**
On successful completion of this course, the student will be able to

1. Understand the concepts of divisibility and prime,
2. Know about the Fermat's Little theorem.
3. Mastery in Mobius Inversion formula.
4. Familiar with the concepts of primitive roots
5. Acquire working knowledge in cryptography.
6. Acquire knowledge of the Legendre symbol and its properties.

**UNIT I**
**DIVISIBILITY, PRIMES AND CONGRUENCES**
Linear Diophantine equation - Prime counting function - Statement of prime number theorem - Goldbach conjecture - Linear congruences - Complete set of residues - Chinese Remainder theorem.

**UNIT II**
**FERMAT'S LITTLE THEOREM**
Fermat's little theorem - Wilson's theorem. Number theoretic functions - Sum and number of divisors Totally multiplicative functions - Definition and properties of the Dirichlet product.

**UNIT III**
**NUMBER THEORETIC FUNCTIONS**
The Mobius Inversion formula - The greatest integer function - Euler's phi-function - Euler's theorem reduced set of residues- Some properties of Euler's phi-function.

**UNIT IV**

**PRIMITIVE ROOTS AND INDICES**

Order of an integer modulo n, primitive roots for primes- Composite numbers having primitive roots- Euler's criterion - The Legendre symbol and its properties.

**UNIT V**

**THE QUADRATIC RECIPROCITY LAW**

Quadratic reciprocity- Quadratic congruences with composite moduli. Public key encryption, RSA encryption and decryption -The equation $x^2 + y^2 = z^2$ - Fermat's Last theorem.

**SUGGESTED READINGS**

1. David M. Burton, (2007). Elementary Number Theory, Sixth Edition, Tata McGraw-Hill, Delhi.
2. Neville Robinns, (2007). Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi.
3. Neal Koblitz., (2006). A course in Number theory and cryptography, Second Edition, Hindustan Book Agency, New Delhi.

**WEBSITE LINK:**

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
2. http://vidyamitra.inflibnet.ac.in/index.php/content/index/5704c5378ae36c6ab9b0b9d1
3. http://172.16.25.76/course/view.php?id=1653

**Semester – III**

**21MMP303** **MEASURE THEORY** **5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The concepts of measure theory and their measure.
- The fundamental principles of measure theory and integration.
- the concept of differentiation of monotone functions.
- The basic concepts Riemann integral and Lebesgue integral.
- Momentous of signed measures.
- Imperative of measure theory to deal with concept such as probability, statistics.

**Course Outcomes (COs)**

After successful completion of this course the students will be able to:

1. Get a clear view of the fundamentals of measure theory.
2. Acquaint with the proofs of the fundamental theorems underlying the theory of Lebesgue integration.
3. Identify the impact of measure theory in differentiation of an integral.
4. Mastery in the measure spaces and its properties.
5. Apply Lebesgue decomposition and the Radon-Nikodym theorem.
6. Apply the theorems of monotone and dominated convergence and Fatou's lemma.

**UNIT I**
**MEASURES**

Introduction – Outer measure – Measurable sets and Lebesgue Measure – A non-measurable set – Measurable functions – Littlewoods's three principles.

**UNIT II**
**FUNCTIONS AND INTEGRALS**

The Riemann integral – The Lebesgue integral of a bounded function over a set finite measure – The integral of a non-negative function–The general Lebesgue integral–Convergence in measure.

**UNIT III**
**DIFFERENTIATION**

Differentiation of monotone function– Functions of bounded variation–differentiation of an integral-Absolute continuity.

**UNIT IV**

**MEASURESPACES**

Measure spaces-Measurable functions-Integration-General convergence Theorems.

**UNIT V**

**SIGNED MEASURES**

Signed measures-The Radon-Nikodym theorem-the $L^P$ spaces.

**SUGGESTED READINGS**

1. Royden H. L., (2008). Real Analysis, Third Edition, Prentice – Hall of India Pvt.Ltd,New Delhi.
2. Keshwa Prasad Gupta., (2014). Measure Theory, Krishna Prakashan Ltd,Meerut.
3. Donald L Cohn., (2013). Measure Theory, United States.
4. Paul R Halmos., (2008). Measure Theory, Princeton University Press Dover Publications, NewYork.
5. Rudin W., (2017). Real and Complex Analysis, 3rd Edition, Mcgraw–Hill Education India PvtLtd, New Delhi.
6. G de Barra., (2014), Measure Theory and Integration, Ist Edition, New Age International Publishers, India

**WEBSITE LINK:**

1. https://ocw.mit.edu/courses/mathematics/18-125-measure-and-integration-fall-2003/
2. https://www.youtube.com/playlist?list=PLgMDNELGJ1CYKDzKdGcM1-kuH_a1NCfQA
3. http://172.16.25.76/course/view.php?id=2069

**Semester – III**

**21MMP304 MATHEMATICAL STATISTICS 5H –4C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:3Hours**

## Course Objectives

This course enables the students to learn

- To understand the basic concepts in probability generating functions, sample moments and their functions, sampling, significance tests and statistical measures
- Probability distributions, significance of testing hypothesis and its interpretation.
- About non parametric tests.
- Estimation, ANOVA and their applications in various disciplines.
- The knowledge of fixed-sample and large-sample statistical properties of point and big data concepts.
- Understanding of how to design experiments and surveys for efficiency.

## Course Outcomes (COs)

On successful completion of this course, the students will be able to

1. Explain the concepts of probability, including conditional probability.
2. Explain the concepts of a statistical tests.
3. Summarize the main features of a data set and test statistical hypotheses.
4. Define basic estimations and analysis of variance.
5. Explain the concepts of Artificial intelligence and Machine Learning.
6. Describe the main methods of estimation and the main properties of estimators, and apply them.

## UNIT I

## INTRODUCTION TO PROBABILITY AND HYPOTHESIS TESTING

Random Events – Preliminary remarks – random events and operations performed on them – the system of axioms of the theory of probability – conditional probability – Bayes theorem – Independent Events – functions of random variables –Introduction to hypothesis testing, Population and Sample - Parameter and Statistic, Sampling and its methods, type-I and type-II errors, standard error, confidence interval, confidence limits. Level of Significance and degrees of freedom.

## UNIT II

## PARAMETRIC TESTS

Concept of a statistical test, Small and Large sample tests - t- test, two sample t- test, Z- test -one tailed test about population mean when sigma known, two tailed test about population mean when sigma known, one tailed test about population mean when sigma unknown, two tailed test about population means.

**UNIT III**

**NON-PARAMETRIC TESTS**

Difference between Parametric and Non-parametric tests. Non-parametric tests - Chi-square test-Goodness of fit test, Independence Tests by contingency tables. Kolmogorov Theorem-Smirnov Theorem-Tests of Kolmogorov and Smirnov test for comparing two populations, The Wald-Wolfovitz and Wilcoxon-Mann-Whitney tests.

**UNIT IV**

**ESTIMATION AND ANALYSIS OF VARIANCE (ANOVA)**

Preliminary notion-Consistency Estimation - Unbiased estimates – Sufficiency – Efficiency - Asymptotically most efficient estimates -methods of finding estimates -confidence Interval. Analysis of Variance: One way classification and two-way classification.

**UNIT V**

**STATISTICAL LEARNING AND DATA ANALYTICS**

Introduction to Big data concepts, Artificial intelligence and Machine Learning, Classification of Data Analytics and Popular Software used for Data Analytics - EXCEL, SPSS, Python, R-Programming.

**SUGGESTED READINGS**


1. Marek Fisz., (1980). Probability Theory and Mathematical Statistics, John Wiley and Sons, New York.
2. Meyer., (2006). Introduction to Probability and Statistical applications, Oxford and IBH Publishing Co. Pvt Ltd. New Delhi.
3. Dinesh Kumar D., (2017). Business Analytics: The Science of Data - Driven Decision Making, Wiley, New Delhi.
4. Srivastava T.N., and Shailaja Rego., (2012). 2e, Statistics for Management, McGraw Hill Education, New Delhi.
5. Sheldon M Ross., (2009). Introduction to probability and statistics for engineers and scientists, Third edition, Academic press.
6. Parimal Mukhopadhyay., (2012). Theory of Probability, New central book agency, Calcutta.


**WEBSITE LINK:**

1. https://ocw.mit.edu/courses/mathematics/18-175-theory-of-probability-spring-2014/index.htm
2. https://www.youtube.com/playlist?list=PLRw1YtKsDxwqIE8WVFtL2Q_s8Sk7LkC8e
3. http://172.16.25.76/course/view.php?id=1655

**Semester –III**

**21MMP305A** **FUZZY SETS AND FUZZY LOGIC** **4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

**Course Objectives**

This course enables the students to learn

- The basic knowledge of fuzzy sets.
- Momentous properties of fuzzy relations.
- Be exposed to basic fuzzy relation equations.
- The basic concepts of modeling in systems using possibility theory.
- Applications of fuzzy logic.
- The importance of tolerance of imprecision and uncertainty for design of robust &low cost intelligent machines.

**Course Outcomes (COs)**

On successful completion of this course, the student will be able to

1. Differentiate crisp sets and fuzzy sets.
2. Understand the concepts of fuzzy relations.
3. Attain mastery in fuzzy relations equations.
4. Understand the fundamental concepts of possibility theory.
5. Apply fuzzy concepts in decision making.
6. Understand the concept of fuzzy measures.

**UNIT I**

**CRISP SETS AND FUZZY SETS**

Introduction-Crisp sets: An over view-The Notion of Fuzzy Sets-basic concepts of Fuzzy sets. Classical Logic: complement-Fuzzy Union-Fuzzy interaction – Combination of operations– general aggregation of operations.

**UNIT II**

**FUZZY RELATIONS**

Crisp and Fuzzy relations – Binary relations – Binary relations on a single set – Equivalence and similarity relations – Compatibility on Tolerance Relations-Orderings – Morphism – fuzzy relations Equations.

**UNIT III**
**FUZZY RELATION EQUATIONS**

General Discussion, Problem Partitioning, Solution Method, Fuzzy Relation Equations Based on Sup-i Compositions, Fuzzy Relation Equations Based on Inf-$w_i$Compositions, Approximate Solutions, The Use of Neural Networks

**UNIT IV**
**POSSIBILITY THEORY**

Possibility Theory, Fuzzy Sets and Possibility Distributions, Possibility and Necessity Measures Probability of Fuzzy Events, Probability of a Fuzzy Event as a Scalar, Probability of a Fuzzy Event as a Fuzzy Set, Possibility vs. Probability

**UNIT V**
**FUZZY LOGIC**

Classical Logic: An Overview, Multi valued Logics, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic, Hedges, Inference from Conditional Fuzzy Propositions, Inference from Conditional and Qualified, Propositions, Inference from Quantified Propositions

**SUGGESTED READINGS**

1. George J Klir., and Bo Yuan., (1988). Fuzzy Sets and Fuzzy Logic, Prentice Hall ofIndia.
2. George J Klir., and Tina A Folger., (2015). Fuzzy Sets, Uncertainty and Information, pearson publications.
3. Zimmerman. H. J., (2006). Fuzzy Set Theory and Its Applications, Kluwer Academic publishers.
4. DuBois D., and Prade H. M., (1994). Fuzzy Sets and Systems: Theory and Applications, Academic Press.
5. Ross T. J., (2016). Fuzzy Logic with Engineering Applications,4th edition, Willey Publications.

**WEBSITE LINK**

1. https://youtu.be/BFEwuFatM4Q.
2. http://videolectures.net/acai05_berthold_fl/

**Semester – III**

**21MMP305B** **CONTROL THEORY** **4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:3Hours**

**Course Objectives**

This course enables the students to learn

- The concepts of observability and non-linear systems.
- The basic principles underlying the analysis and designing of control systems.
- The Stability and Uniform stability.
- The basic concepts of Stabilizability**.**
- The concepts Linear time invariant systems and Nonlinear Systems.
- How the problem of finding a control law for a given system.

**Course Outcomes (COs)**

On successful completion of the course, students will be able to:

1. Understand the control theory concepts and properties including observability.
2. Apply the concept of controllability in state models.
3. Explain stability and asymptotic stability of linear systems.
4. Familiarize with Stabilization via linear feedback control – Bass method.
5. Find a control law for a given system.
6. Purview on the concept of control theory.

**UNIT-I**
**OBSERVABILITY**

Linear Systems – Observability Grammian – Constant coefficient systems –Reconstruction kernel – Nonlinear Systems.

**UNIT-II**
**CONTROLLABILITY**

Linear systems – Controllability Grammian – Adjoint systems – Constant coefficient systems– Steering function – Nonlinear systems.

**UNIT-III**
**STABILITY**

Stability – Uniform stability – Asymptotic stability of linear systems - Linear time-varying systems – Perturbed linear systems – Nonlinear systems.

**UNIT-IV**
**STABILIZABILITY**
Stabilization via linear feedback control – Bass method – Controllable subspace – Stabilization with restricted feedback.

**UNIT-V**
**OPTIMAL CONTROL**
Linear time varying systems with quadratic performance criteria – Matrix Riccati equation – Linear time invariant systems – Nonlinear Systems.

**SUGGESTED READINGS**


1. Balachandran K., and Dauer J. P., (2012). Elements of Control Theory, Narosa Publishing House, New Delhi.
2. Conti R., (1976). Linear Differential Equations and Control, Academic Press, London.
3. Curtain.R.F and Pritchard.A.J., (1977). Functional Analysis and Modern Applied Mathematics, Academic Press, New York.
4. Klamka. J., (2018). Controllability and Minimum Energy Control Kluwer Academic Publisher, Dordrecht.
5. Roger W Brockett., (2015). Finite Dimensional Linear Systems, Siam, New York.


**WEBSITE LINK**

1. https://ocw.mit.edu/courses/mathematics/18-s997-introduction-to-matlab-programming-fall-2011/
2. https://www.youtube.com/playlist?list=PLRWKj4sFG7-6_Xr9yqg6SMr_F80KdFVhN

Semester – III

**21MMP305C NEURAL NETWORKS 4H –4C**

**Instruction Hours/week:L:4 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:** 3 Hours

**Course Objectives:**
This course enables the students to learn

- The neural networks for classification and regression
- The design methodologies for neural networks
- About the multi-layer perceptron.
- The introduction and different architectures of Back propagation Algorithm.
- The fundamental concepts of optimization in neural networks.
- Tto develop and train radial-basis function networks.

**Course Outcomes (COs)**
On successful completion of this course the student will be able to

1. Comprehend the concepts of feed forward neural networks
2. Analyze the various Linear Associator.
3. Design single and multi-layer feed-forward neural networks
4. Analyze the various Back Propagation Algorithm
5. Supervised learning and unsupervised learning.
6. Analyze the performance of neural networks in directional derivatives.

**UNIT- I**
**EVOLUTION OF NEURAL NETWORKS**
Mathematical Neuron Model- Network Architectures- Perceptron-Hamming Network-Hopfield Network-Learning Rules.

**UNIT – II**
**PERCEPTRON LEARNING RULE**
Perceptron Architectures and Learning Rule with Proof of Convergence. Supervised Hebbian Learning -Linear Associator.

**UNIT I- III**
**MULTI-LAYER PERCEPTRONS**
The Hebb Rule-Pseudo inverse Rule-Variations of Hebbian Learning-Back Propagation - Multilayer Perceptrons.

**UNIT – IV**
**BACK PROPAGATION**
Back propagation Algorithm-Convergence and Generalization –Performances Surfaces and Optimum Points-Taylor series.

**UNIT V**

**OPTIMITATION IN NEURAL NETWORK**

Directional Derivatives - Minima-Necessary Conditions for Optimality-Quadratic Functions-Performance Optimizations-Steepest Descent-Newton's Method-Conjugate Gradient.

**SUGGESTED READINGS**


1. Martin T Hagan., Howard B Demuth., and Mark Beale., (2014). Neural Network Design,Vikas, Publishing House, New Delhi,
2. James A Freeman., and David M Skapura., (2011). Neural Networks Algorithms, Applications and Programming Techniques, Pearson Education.
3. Robert J Schalkoff., (2000). Artificial Neural Network, McGraw-Hill International Edition.


**WEBSITE LINK**

1. https://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-641j-introduction-to-neural-networks-spring-2005/
2. https://www.youtube.com/watch?v=xbYgKoG4x2g&list=PL53BE265CE4A6C056

**Semester –III**

**21MMP311 MATHEMATICAL STATISTICS-PRACTICAL 4H –2C**

**Instruction Hours/week:L:0T:0P:4** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

## Course Objectives

This course enables the students to learn

- In-depth understanding of SPSS Software Package.
- It is well recognized nowadays the importance of Statistics as an indispensable tool for obtaining and spreading information.
- Importance has been enhanced by the use of computational resources and particularly the software SPSS, that showed, during the last decades, to be an effective tool for treating and analyzing statistical data.
- Ability to use SPSS procedures in handling data files and performing statistical analysis, and to interpret the outputs provided by the program.
- Acquiring sensitivity and critical thinking towards arguments and conclusions based on statistical studies.
- Understanding the fundamental principles underlying descriptive and inferential statistical reasoning.

## Course Outcomes (COs)

On successful completion of this course, the student will be able to

1. Describe and classify data using statistical terminology.
2. Use SPSS to conduct basic descriptive analyses and graphical presentations.
3. Define the null hypothesis and the alternative hypothesis and Interpret P values and confidence intervals.
4. Understand different measures of effect (e.g. mean difference).
5. Know when to use basic statistical hypothesis tests (t-tests, chi-squared tests, correlation) and how to carry out these tests using SPSS.
6. Appreciate how to present and interpret these results in scientific reports.

## List of Practical

1. Various Software Package available for Data Analytics
2. Introduction to SPSS Software Package for Data Analytics
3. Drawing of graphs and diagrams using software
4. Calculation of Standard deviation for individual and discrete series.
5. Calculation of Standard deviation continuous series.
6. Calculation of Coefficient of Variation.

7. Calculation of Karl Pearson's Correlation
8. Calculation of Rank Correlation Coefficient
9. Fitting of Linear Regression
10. Hypothesis Testing for small sample test (t - test)
11. Hypothesis Testing for two sample t -test
12. Hypothesis Testing for Large sample(Z-test)
13. Testing Hypothesis using chi-square - test (for Goodness off it)
14. Testing Hypothesis using chi-square - test (for Contingency Table)

**SUGGESTED READINGS**

1. SPSS Lab Manual
2. U Dinesh Kumar., (2017). Business Analytics: The Science of Data - Driven Decision Making, Wiley, New Delhi.
3. Daniel Y Chen., (2017). Pandas for everyone - Python data Analysis,
4. Evans James R., (2017), Business Analytics, 2nd edition, Pearson Education, New Delhi.

**Semester – IV**

**21MMP401** **FUNCTIONAL ANALYSIS** **5H –5C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:** 3 Hours

## Course Objectives

This course enables the students to learn

- The concept of Banach spaces and related properties.
- Open mapping and closed graph theorems.
- The specific techniques for bounded operators over normed and Hilbert spaces.
- Significant applications of the theory of operators.
- The properties of Banach algebra.
- Applications of spectral analysis in integral equations.

## Course Outcomes (COs)

On successful completion of this course the students will be able to:

1. Develop Banach spaces from vector spaces.
2. Describe the open mapping theorem.
3. Discuss Hilbert spaces and its properties.
4. Study in detail about the adjoint of an operator.
5. Handle complex problems concerning topics within the area of regular and singular elements.
6. Understand and apply fundamental theorems of normed and Banach spaces.

## UNIT I
## BANACH SPACES

Banach Spaces–Normed linear space – Definitions and Examples-Theorems. Continuous Linear Transformations–Some theorems - Problems. The Hahn-Banach Theorem – Lemma and Theorems. The Natural imbedding of N in N**–Definitions and Theorems.

## UNIT II
## OPEN MAPPING THEOREM

The Open Mapping Theorem– Theorem and Examples –Problems. The closed graph theorem. The conjugate of an operation–The uniform boundedness theorem–Problems.

## UNIT III
## HILBERT SPACES

The Definition and Some Simple Properties – Examples and Problems. Orthogonal Complements –Some theorems. Ortho-normal sets– Definitions and Examples-Bessel's inequality–The conjugate space H*.

**UNIT IV**

**THE ADJOINT OF AN OPERATOR**

Definitions and Some Properties–Problems. Self-adjoint operators – Some Theorems and Problems. Normal and Unitary operators –theorems and problems. Projections –Theorems and Problems.

**UNIT V**

**BANACH ALGEBRAS**

Matrices–Determinant and Spectrum of bounded operator–The spectral Theorem–The definition and some examples of Banach algebra – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius.

**SUGGESTED READINGS**

1. Simmons G. F., (2015). Introduction to Topology & Modern Analysis, Tata Mc Graw-Hill Publishing Company Ltd, New Delhi.
2. Balmohan V., and Limaye., (2014). Functional Analysis, Second edition, New Age International Pvt. Ltd, Chennai.
3. Chandrasekhara Rao K., (2006). Functional Analysis, Second edition, Narosa Publishing House, Chennai.
4. Choudhary B., and Sundarsan Nanda., (2003). Functional Analysis with Applications, New Age International Pvt. Ltd, Chennai.
5. Ponnusamy S., (2002). Foundations of functional analysis, Narosa Publishing House, Chennai.

**WEBSITE LINK**

1. https://ocw.mit.edu/courses/mathematics/18-102-introduction-to-functional-analysis-spring-2009/
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=25
3. http://vidyamitra.inflibnet.ac.in/index.php/content/index/5704c5378ae36c6ab9b0b5bf
4. http://vidyamitra.inflibnet.ac.in/index.php/content/index/5704c5378ae36c6ab9b0b5a9
5. http://172.16.25.76/course/view.php?id=1652

Semester – IV

**21MMP402** **MATHEMATICAL METHODS** **5H –5C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**

**End Semester Exam:**3Hours

**Course Objectives**

This course enables the students to learn

- Range of mathematics tools with emphasis on engineering applications.
- To think quantitatively and analyse problems critically.
- The concept of Volterra integral and Fredholm theory.
- Fundamentals of integral equations for ordinary differential equations.
- The concepts of functional dependent on higher order derivatives.
- About the variation and its properties.
- To develop mathematical curiosity and use inductive and deductive reasoning when solving problems.

**Course Outcomes (COs)**

On successful completion of this course, the students will be able to

1. Calculate the Fourier transform of elementary functions from the definition.
2. Find the Fourier transforms for partial differential equations.
3. Understand the concepts of integral equations and its types.
4. Equation with boundary value problems and singular integral equations.
5. Find the solution by using variation methods.
6. Understand the concept of functionals of the integral forms.

**UNIT I**

**FOURIER TRANSFORM**

Fourier Transforms – Definition of Inversion theorem –Fourier cosine transforms - Fourier sine transforms – Fourier transforms of derivatives -Fourier transforms of some simple functions - Fourier transforms of rational function.

**UNIT II**

**PARTIAL DIFFERENTIAL EQUATION OF FOURIER TRANSFORM**

The convolution integral – convolution theorem – Parseval’s relation for Fourier transforms – solution of PDE by Fourier transform – Laplace’s Equation in Half plane – Laplace’s Equation in an infinite strip - The Linear diffusion equation on a semi-infinite line - The two-dimensional diffusion equation.

**UNIT III**
**INTEGRAL EQUATIONS**

Types of Integral equations–Equation with separable kernel- Fredholm Alternative Approximate method–Volterraintegralequations–ClassicalFredholmtheory–Fredholm'sFirst, Second, Third theorems-Conversion of ordinary differential equation into integral equation - Method of converting initial value problem into a Volterra integral equation - Boundary value problem - Method of converting a boundary value problem into a Fredholm integral equation.

**UNIT IV**
**INTEGRAL EQUATIONS FOR ORDINARY DIFFERENTIAL EQUATIONS**

Application of Integral equation to ordinary differential equation – initial value problems – Boundary value problems – singular integral equations – Abel Integral equation- The solution of Abel's integral equation – Some general form of Abel's singular integral equation - Problem- Applications of integral equation and Green's functions to ordinary differential equation.

**UNIT V**
**CALCULUS OF VARIATION**

Variation and its properties – Euler's equation – Functionals of the integral forms - Functional dependent on higher order derivatives – functionals dependent on the functions of several independent variables – variational problems in parametric form.

**SUGGESTED READINGS**


1. Sneedon I. N., (1974). The Use of Integral Transforms, Tata McGraw Hill, New Delhi.
2. Kanwal R. P., (2013). Linear integral Equations Theory and Technique, Academic press, NewYork.
3. Elsgots L., (2003). Differential Equations and Calculus of Variation, Mir Publication Moscow.
4. Gelfand I. M., and Francis S. V., (2000). Calculus of Variation, Prentice Hall, India.
5. Tricomi F. G., (2012). Integral Equations, Dover, New York.
6. Srivastava A.N., and Mohammad Ahmad., (2012). Integral Transforms and Fourier Series, Alpha Science International, Limited.


**WEBSITE LINK**

1. http://vidyamitra.inflibnet.ac.in/index.php/content/index/570b7b068ae36c5432d66dbb
2. http://vidyamitra.inflibnet.ac.in/index.php/content/index/570b7b068ae36c5432d66dcd
3. http://172.16.25.76/course/view.php?id=1657

**Semester – IV**

**21MMP403** **STOCHASTIC PROCESSES** **5H –5C**

**Instruction Hours/week:L:5 T:0 P:0** **Marks:**Internal:**40** External: **60** Total:**100**
**End Semester Exam:**3Hours

**Course Objectives**
This course enables the students to learn

- The mathematical theory of random variables and random processes
- The essential mathematical tools for handling Markov processes.
- Markov processes in discrete and continuous time.
- The theoretical concepts and techniques for solving problems that arises in branching processes.
- Applications of queueing models in the study of networks.
- The stochastic simulation techniques.

**Course Outcomes (COs)**
On successful completion of the course, students will be able to:

1. Acquire in dept knowledge about stochastic models.
2. Application of birth and death process in random models.
3. Proficient in Markov process with continuous state space.
4. Attain working knowledge in branch processes.
5. Proficient in solving stochastic queueing models.
6. Attain mastery in Markov models with their applications.

**UNIT I**
**STOCHASTIC PROCESSES**
Definition of Stochastic Processes–Markov chains: definition, order of a Markov Chain–Higher transition probabilities – Classification of states and chains.

**UNIT II**
**MARKOV PROCESS WITH DISCRETE STATE SPACE**
Poisson process – and related distributions – Properties of Poisson process, Generalizations of Poisson Processes – Birth and death Processes – continuous time Markov Chains.

**UNIT III**
**MARKOV PROCESSES WITH CONTINUOUS STATE SPACE**
Introduction, Brownian motion – Weiner Process and differential equations for Weiner process, Kolmogrov equations–First passage time distribution for Weiner process–Ornstein–Uhlenbech process.

**UNIT IV**

**BRANCHING PROCESSES**

Introduction – properties of generating functions of Branching process– Distribution of the total number of progeny, Continuous- Time Markov Branching Process, Age dependent branching process: Bellman-Harris process.

**UNIT V**

**STOCHASTIC PROCESSES IN QUEUING SYSTEMS**

Concepts–Queuing model M/M/1–transient behavior of M/M/1model–Birth and death process in Queuing theory: M/M/1 – Model related distributions – M/M/1 - M/M/S/S – loss system - M/M/S/M – Non birth and death Queuing process: Bulk queues –M(x)/M/1.

**SUGGESTED READINGS**


1. Medhi J., (2019). Stochastic Processes, Fourth edition, New age international Private limited, New Delhi.
2. Basu K., (2003). Introduction to Stochastic Process, Narosa Publishing House, New Delhi.
3. Goswamiand Rao B. V., (2006). A Course in Applied Stochastic Processes, Hindustan Book Agency, New Delhi.
4. Grimmett G., and Stirzaker D., (2001). Probability and Random Processes, 3rd Ed., Oxford University Press, New York.
5. Papoulis A., and Unnikrishna Pillai., (2017). Probability, Random variables and Stochastic Processes, Fourth Edition, McGraw-Hill, New Delhi.
6. Sundarapandian V., (2009). Probability statistics and Queuing theory, PHI learning private limited, New Delhi.


**WEBSITE LINK**

1. https://ocw.mit.edu/courses/mathematics/18-445-introduction-to-stochastic-processes-spring-2015/
2. http://172.16.25.76/course/view.php?id=2070

**Semester – IV**

**21MMP491** **PROJECT** **–8C**

**Instruction Hours/week:L:0T:0P:0** **Marks:Internal:80** **External:120Total:200**
**End Semester Exam: -**

## LIST OF VALUE ADDED COURSES

- Data Analysis using SPSS
- LATEX
- Vedic Mathematics
- MATLAB
- MAPLE
- GEOGEBRA
- DIA
- Data Analysis Using Advanced Excel
- Mathematical Modelling with Excel
- Productivity Analysis and Audit
- Data Analysis Using R Programming
- Statistical Quality Control
- Six Sigma Analysis