Proposed Syllabus and Scheme of Examination

for

B.Sc. (Hons.) / B.A. (Hons.) / B.Com (Hons.) Mathematics

Submitted to

Dhanamanjuri University

Manipur

under the

Choice Based Credit System

May 2020

DHANAMANJURI UNIVERSITY, IMPHAL

UNDERGRADUATE SYLLABUS IN MATHEMATICS

CBCS Course Structure for B.Sc./B.A (Hons.) Mathematics Programme		
Courses	*Credits Theory + Practical	Theory + Tutorial
I. Core Courses (14 Papers)	$14 \times 4 = 56$	$14 \times 5 = 70$
Core Course Practical / Tutorial* (14 Practicals/Tutorials*)	$14 \times 2 = 28$	$14 \times 1 = 14$
II. Elective Courses (8 Papers)		
A.1. Discipline Specific Elective (4 Papers)	$4 \times 4 = 16$	$4 \times 5 = 20$
A.2. Discipline Specific Elective Practical/ Tutorial* (4 Papers)	$4 \times 2 = 8$	$4 \times 1 = 4$
B.1. Generic Elective/ Interdisciplinary (4 Papers)	$4 \times 4 = 16$	$4 \times 5 = 20$
B.2. Generic Elective Practical/ Tutorial* (4 Papers) I	$4 \times 2 = 8$	$4 \times 1 = 4$
III. Ability Enhancement Courses		
1. Ability Enhancement Compulsory Courses (AECC) (2 Papers of 4 credits each) Environmental Science /English /MIL Communication	$2 \times 4 = 8$	$2 \times 4 = 8$
2. Ability Enhancement Elective (Skill Based) (Minimum 2) (SEC) (2 Papers of 4 credits each)	$2 \times 4 = 8$	$2 \times 4 = 8$
Total credits:	148	148

Semester wise Details of B.Sc./B.A (Hons.) Mathematics Course & Credit Scheme

Semester	Core course(14)	Ability Enhancement Compulsory Course (AECC)(2)	Skill Enhancement Course (SEC)(2)	Discipline Specific Elective (DSE)(4)	Generic Elective (GE)(4)	Total Credits
I	MATH101: Calculus MATH102: Algebra	English Communication			GE-1	
L+T/P	5+1=6,5+1=6	4			5+1=6	22
II	MATH203: Real Analysis MATH204: Differential Equations	Environmental Science			GE-2	
L+T/P	5+1=6,5+1=6	4			5+1=6	22
III	MATH305: Theory of Real Functions MATH306: Group Theory-I MATH307: Partial Differential Equations Laplace Transforms		SEC-1 1. LaTeX and HTML Or MATLAB /Maple/LATEX or Analytical Geometry		GE-3	
L+T/P	5+1=6,5+1=6,5+1=6		4		5+1=6	28
IV	MATH408: Numerical Methods BMATH409: Riemann Integration and Series of Functions MATH410: Ring Theory and Linear Algebra-I		SEC-2 Computer Algebra system and related software or C programming or Network Analysis and Project Management		GE-4	
L+T/P	5+1=6,5+1=6,L+5+1=6		4		5+1=6	28
V	MATH511: Multivariate Calculus MATH512: Group Theory-II			DSE-1 DSE-2		
L+T/P	5+1=6, 5+1=6			5+1=6, 5+1=6		24
VI	MATH613: Metric Spaces and Complex Analysis MATH614: Ring Theory and Linear Algebra-II			DSE-3 DSE-4		
L+T/P	5+1=6, 5+1=6			5+1=6, 5+1=6		24
						Total Credits = 148

Note: L: Lecture Class; T: Tutorial Class; P: Practical Class Note: One-hour lecture per week equals 1 Credit; 2 Hours practical class per week equals 1 credit. 'Generic Elective (GE)' Course is an elective course may be chosen generally from an unrelated discipline/subject, with an intention to seek exposure to other disciplines.

List of Discipline Specific Elective (DSE) Courses:

DSE-1 (including practical): Any one of the following (at least two shall be offered by the college)

(i). Linear Programming and Applications

(ii). C++ Programming for Mathematics

(iii). Differential Geometry and Tensor

DSE-2: Any one of the following (at least two shall be offered by the college)

(i). Number Theory

(ii). Logic and Boolean Algebra

(iii). Inventory Systems and Marketing Management

DSE-3: Any one of the following (at least two shall be offered by the college)

(i). Cryptography and Network Security

(ii). Introduction to Coding Theory

(iii). Probability and Statistics

DSE-4: Any one of the following (at least two shall be offered by the college)

(i). Mathematical Modelling and Graph Theory

(ii). Mechanics

(iii). Biomathematics

Skill Enhancement Course (SEC)

Choices for SEC 1 (choose one)

2. LaTeX and HTML
3. MATLAB

3. Analytical Geometry

Choices for SEC 2 (choose one)

1. Computer Algebra Systems and Related Software

2. C Programming

3. Network Analysis and Project Management

Course Wise Content Details for B.Sc. (Hons.) Math/B.A.(Hons)Math

FIRST YEAR MATHEMATICS

MATH101: SEMESTER-I

[CALCULUS]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) ,Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful to the real-world problems. .

Course Learning Outcomes: This course will enable the students to:

i) Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.
ii) Apply derivatives in Optimization, Social sciences, Physical sciences and Life sciences etc.
iii) Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

Course Contents:

Unit-I: Successive Differentiation (Lectures: 15)

Successive differentiation, Indeterminate forms and L. Hospital's Rule, Leibnitz theorem. Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, Rolle's theorem, Lagrange's and Cauchy's mean value theorems, Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainder, Expansion of standard functions: e^x, $\sin x$, $\cos x$, $\log(1+x)$, $(1+x)^n$, $\tan^{-1}x$

Unit -II: Derivatives and its applications (Lectures: 15)

. Function of Two and three variables, Limit and Continuity for functions of two and three variables, Partial differentiation, successive partial differentiations, Euler's theorem

on Homogeneous functions of two and three variables, Maxima and Minima of functions of two variables.

Curvature, Radius of curvature for the Cartesian equation, parametric equation, implicit equation and polar equation, Asymptotes. The first-derivative test for relative extrema, Concavity and inflection points, Second derivative test for relative extrema, Curve sketching using first and second derivative tests, concavity and inflection points, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves

Unit –III: Volume and Area of Surfaces (Lectures: 20)

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sinnxdx, \int cosnxdx$, $\int tannxdx, \int secnxdx$, $\int (logx)^n dx$, $\int sin^n x sin^m x dx$. Evaluation of double integrals, Change of the order of integration, Change of variables in double integrals, Areas and lengths of curves in the plane, Volumes and Surface areas of solid of revolution.

Unit -IV: Vector Calculus and its Applications (Lectures: 20)

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions. Differentiation of Vectors, Gradient, Divergence and Curl of a vector. Integration of vector functions, Ordinary integrals of vectors. Line integrals, Surface integrals and Volume integrals,

Books Recommended:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). John Wiley & Sons Singapore Pte. Ltd. Indian Reprint (2016) by Wiley India Pvt. Ltd. Delhi.

2. Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.

3. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

4. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

References:

1. Das and Mukherjee - Differential Calculus, U.N. Dhur and Sons Pvt. Ltd, Kolkata.
2. Das and Mukherjee-Integral Calculus, U.N. Dhur and Sons Pvt. Ltd, Kolkata.
3. B Das, Analytical Geometry with Vector Analysis, Orient Book Company, Kolkata.
4. Ghosh and Maity, Vector Analysis, New Central Book Agency.

MAT102: SEMESTER-I

[ALGEBRA]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Employ De Moivre's theorem in a number of applications to solve numerical problems.
ii) Apply Euclid's algorithm and backwards substitution to find greatest common divisor.
iii) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
iv) Find eigenvalues and corresponding eigenvectors for a square matrix.

Course Contents:

Unit -I: De Moivre's theorem and its application (Lectures: 15)

Polar representation of complex numbers, The nth roots of unity, De Moivre's theorem for integer and rational indices and its applications. Expansion of trigonometric functions, Exponential values for circular functions, Complex argument, Gregory's series, Hyperbolic functions, Summation of series including C+iS method, Infinite product-sin x and cos x.

Unit-II: Theory of Equations (Lectures:15)

Arithmetic mean, Geometric mean, Harmonic mean, Cauchy-Schwartz inequality, Holder's inequality, Minkowski's inequality. Elementary theorems on the roots of an equation, Polynomials, The remainder and factor theorem, Synthetic division, Factored form of a polynomial, The Fundamental theorem of algebra, Relations between the roots and the coefficients of polynomial equations, Imaginary roots occur in pairs, Integral and rational roots;

Unit -III: Equivalence Relations and Basic number theory (Lectures: 20)

Equivalence relations, The division algorithm, Divisibility and the Euclidean algorithm, The fundamental theorem of arithmetic, Modular arithmetic and basic properties of congruence; Congruence relation between integers, Principles of mathematical induction and well ordering principle. Descartes rule of signs, Fundamental

theorem of Algebra (Statement only). Transformation of equations, Solution of cubic equations by Cardan's method and of biquadratic equation by Ferrari's method.

Unit -IV: Theory of Matrices and its Applications (Lectures: 20)

Systems of linear equations, Row reduction and echelon forms, Vector equations, The matrix equation AX = b, Solution sets of linear systems, Linear independence, The rank of a matrix and applications; Introduction to linear transformations, The matrix of a linear transformation; Matrix operations, The inverse of a matrix, Characterizations of invertible matrices, Eigenvectors and eigenvalues, The characteristic equation and the Cayley-Hamilton theorem.

Books Recommended:

1. Andreescu, Titu & Andrica Dorin. (2014). Complex Numbers from A to...Z. (2nd ed.). Birkhäuser.

2. Dickson, Leonard Eugene (2009). First Course in The Theory of Equations. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785)

3. Goodaire, Edgar G., & Parmenter, Michael M. (2005). Discrete Mathematics with Graph Theory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2015.

4. Kolman, Bernard, & Hill, David R. (2001). Introductory Linear Algebra with Applications (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.

5. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). Linear Algebra and its Applications (5th ed.). Pearson Education.

References:

1. Chandrika Prasad- Algebra and Theory of Equations, Pothisala Private Limited.
2. Shanti Narayan and P.K. Mittal- A text Book of Matrices, S. Chand and Co. New Delh
3. Bhattacharya, Jain and Nagpaul-First Course in Linear Algebra, Wiley Eastern, N. Delhi

MATH203: SEMESTER-II

[Real Analysis]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives:

The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts have wide range of applications to the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line.
ii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
iii) Apply the ratio test, root test, comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Contents:

Unit-I: Real number system **(Lectures: 10)**

The algebraic and order properties of R, Absolute value of a real number, Finite and infinite sets, definition and examples of countable and uncountable sets, Real line, bounded and unbounded sets, supremum and infimum of a non-empty set.

Unit-II: Properties of R **(Lectures: 20)**

The order completeness property in R (statement only), Archimedean property of R,

Definition and types of Intervals, Neighbourhood of a point, Limit point of a set , Bolzano-Weierstrass theorem on set, Open and closed sets, their related properties. Concept of Compactness, Heine Borel Theorem.

Unit-III: Sequence in R **(Lectures: 20)**

Real Sequence, Bounded sequence, Convergence sequence, Cauchy sequence, Cauchy convergence criterion, order preservation and squeeze theorem, monotonic sequence and their convergence, monotonic convergence theorem(statement only),subsequence, limit point of a sequence, Bolzano-Weierstrass theorem of sequence , Limit superior and limit inferior of a sequence(definition and examples only), nested interval theorem,

Unit-IV: Series in R **(Lectures: 20)**

Infinite series,a necessary condition for convergence of infinite series, convergence and divergence of geometric series and p- series, Comparison test, limit comparison test, D'Alembert's ratio test, Cauchy's root test, alternating series, Leibnitz's test, Definition and examples of absolute and conditional convergence.

Books Recommended 1. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, 1John Wiley and Sons (Asia) P. Ltd., 2000.

2. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

3. E. Fischer, Intermediate Real Analysis, Springer Verlag, 1983.

4. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Limited.
5. K.C. Maity & R.K. Ghosh, An Introduction to Analysis, Differential Calculus Part-I ,
6. Shanti Narayan and M.D. Raisinghania, Elements of Real Analysis, S. Chand & Company

MATH204: **SEMESTER-II**

[Differential Equations]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week),Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs) Examination: 3 Hrs.

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of Differential Equations, Mathematical Modeling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Formulate Differential Equations for various Mathematical models.

ii) Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.

iii) Apply these techniques to solve and analyse various mathematical models.

Course Contents:

Unit -I: Differential Equations (Lectures: 20)

Order and degree of a differential equation, Exact differential equations and integrating factors of first order differential equations, Reducible second order differential equations, Equations of first order and first degree: Exact equations and integrating factor (Euler), Linear equations and equations reducible to linear form, Solutions of simultaneous equations of the form: $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, Total differential equations of the form: Pdx + Qdy +Rdz=0, Method of solutions and their geometrical interpretations, Orthogonal trajectories.

Unit-II: Mathematical Modelling (Lectures: 20)

Equations of first order but not of first degree: Equations solvable for x, y and p, Clairaut's equations and the singular solutions. Application of first order differential equations to equations to acceleration-velocity model, Growth and decay model. Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin), Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, case study of alcohol in the bloodstream), Exponential growth of population, Limited growth of population, Limited growth with harvesting.

Unit-III: Second and Higher Order Differential Equations (Lectures: 20)

General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation; Wronskian, its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, Method of undetermined coefficients, Method of variation of parameters, Applications of second order differential equations to mechanical vibrations.

Unit-IV: Analysis of Mathematical Models (Lectures: 10)

Interacting population models, Epidemic model of influenza and its analysis, Predator-prey model and its analysis, Equilibrium points, Interpretation of the phase plane, Battle model and its analysis.

Books recommended:

1. Barnes, Belinda & Fulford, Glenn R. (2015). Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.

2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.

3. Ross, Shepley L. (2004). Differential Equations (3rd ed.). John Wiley & Sons. India

References:

i. Ross, Clay C. (2004). Differential Equations: An Introduction with Mathematica® (2nd ed.). Springer.

ii. Piaggio-An Elementary Treatise on Differential Equation and Their Application, CBS Publishers and Distributors, New Delhi.

SECOND YEAR MATHEMATICS

MATH305: SEMESTER-III

[Theory of Real Functions]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: It is a basic course on the study of real valued functions.

Course Learning Outcomes: This course will enable the students to learn:

i) To have an understanding of the concept of limit of a function.

ii) The applications of mean value theorem and Taylor's theorem.

Course Contents:

Unit-I: Limits of Functions (Lectures: 15)

Limits of functions (ε δ – approach), Sequential criterion for limits, Divergence criteria, Limit theorems, One-sided limits, Infinite limits and limits at infinity.

Unit-II: Continuous Functions and their Properties (Lectures: 25)

Continuous functions, Sequential criterion for continuity and discontinuity, Algebra of continuous functions, Properties of continuous functions on closed and bounded intervals; Uniform continuity, Non-uniform continuity criteria, Uniform continuity theorem.

Unit -III: Derivability and its Applications (Lectures: 20)

Differentiability of a function, Algebra of differentiable functions, Carathéodory's theorem and chain rule; Relative extrema, Interior extremum theorem, Rolle's theorem, Mean- value theorem and its applications, Intermediate value property of derivatives - Darboux's theorem.

Unit-IV: Taylor's Theorem and its Applications (Lectures:10)

Taylor polynomial, Taylor's theorem with Lagrange form of remainder, Application of Taylor's theorem in error estimation; Relative extrema, and to establish a criterion for convexity; Taylor's series expansions of , sin x e x and cos . x

Books Recommended: 1. Bartle, Robert G., & Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.). Wiley India Edition. New Delhi.

References:

i. Ghorpade, Sudhir R. & Limaye, B. V. (2006). A Course in Calculus and Real Analysis. Undergraduate Texts in Mathematics, Springer (SIE). First Indian reprint.
ii. Mattuck, Arthur. (1999). Introduction to Analysis, Prentice Hall.
iii. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprin

MATH306: SEMESTER-III

[Group Theory-I]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The objective of the course is to introduce the fundamental theory of groups.

Course Learning Outcomes: The course will enable the students to:

i) understand the mathematical concepts about the groups, and classify them as abelian, cyclic and permutation groups, etc;
ii) Explain the significance of the notion of subgroups, cyclic groups, cosets, normal subgroups, and factor groups.

Course Contents:

Unit-I: Groups and its Elementary Properties (Lectures: 10)

Symmetries of a square, The Dihedral groups, Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), Elementary properties of groups.

Unit-II: Subgroups and Cyclic Groups (Lectures:15)

Subgroups and examples of subgroups, Centralizer, Normalizer, Center of a group, Product of two subgroups; Properties of cyclic groups, Classification of subgroups of cyclic groups.

Unit-III: Permutation Groups and Lagrange's Theorem (Lectures: 25)

Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups; Properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem; Normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Unit-IV: Group Homomorphisms (Lectures: 20)

Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Cayley's theorem, Properties of isomorphisms, First, Second and Third isomorphism theorems for groups.

Books recommended: 1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression, 2015.

2. Kenneth Hoffman and Ray Kunze: Linear Algebra, Pearson.
3. V.K. Khanna & S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, New Delhi.
4. S. Kumaresan, Linear Algebra, Prentice Hall of India.
5. Shanti Narayan & P.K. Mittal, A Text Book of Matrices, S Chand & Co., New Delhi.
6. Joseph A. Gallan, Contemporary Algebra, Narosa Publishing House, New Delhi.
7. Surjeet Singh and QaziZameerudin, Modern Algebra, Vikas Publishing House.
8. P.B. Bhattacharya, S.K. Jain and S. R. Nagpaul: Basic Abstract Algebra, CUP.
9. Michael Artin, Algebra, Prentice Hall of India.
10. N. Jacobson, Basic Algebra Vol. I & II, Hindustan Publishing Corporation, New Delhi.

Referrence: Rotman, Joseph J. (1995). An Introduction to The Theory of Groups (4th ed.). Springer Verlag, New York

MATH307: SEMESTER-III

[Partial Differential Equations and Laplace transforms]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations and Laplace transforms.

Course Learning Outcomes:

This course will enable the students to:

i) Formulate, classify and transform partial differential equations into canonical form.
ii) Solve linear and non-linear partial differential equations using various methods; and apply these methods in solving some physical problems.
iii) Concepts of Laplace transforms and its applications.

Course Contents:

Unit-I First order PDE (Lectures:15)

Introduction, Classification, Construction and geometrical interpretation of first order partial differential equations (PDE), Method of characteristic and general solution of first order PDE, Canonical form of first order PDE, Method of separation of variables for first order PDE. Formation of PDE by eliminating arbitrary constants and arbitrary functions, Cauchy's problem of First order equation, Definitions of (i) Complete Integral (ii) Particular Integral (iii) Singular Integral (iv) General Integral, Equations of 1^{st} order but not of 1^{st} degree (i) Solvable for p (ii) Solvable for y (iii) Solvable for x.

Unit-II Non-linear PDE of order one (Lectures:15) .

Different Standard Forms (i) Only p and q present (ii) Only p, q and z present (iii) f(x, p) = F(y, q) (iv) Analogous to Clairaut's form. Partial differential equations of 1^{st} order but of any degree: (i) Two independent variables - Charpit's method and (ii) Three or more independent variables-Jacobi's method.

Unit-III Mathematical Models and Classification of 2nd Order Linear PDE

(Lectures: 20)

Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solution Introduction to Higher Order PDEs (constant coefficients only), Origin of second order equations**.** Solution of Linear Homogeneous PDE with constant coefficients, To find the complete solution of the equations namely (i) f(D, D')z = 0 and (ii) f(D, D')z = F(x, y), Equations reducible to linear form with constant coefficients, Monge's method of integrating (i) Rr + Ss + Tt = V (ii) Rr + Ss + Tt +U($rt-s^2$) = V. Cauchy problem for second order PDE, Homogeneous wave equation, Initial boundary value problems, Non-homogeneous boundary conditions,

Unit-IV: Laplace Transforms **(Lectures: 20)**

Definition of Laplace Transformations, Kernel of the Integral transformation, Existence of Laplace Transformation Transformations of some elementary functions such as f(t) = e^{-at} , cos at, sin at, cosh at, sinh at, t^n etc. Properties of Laplace Transformation, First Translation or Shifting Theorem, Second Translation or Heaviside's shifting Theorem, Differentiation property, Change of scale property with examples, Laplace Transformation of Derivatives of order n with Theorems, Inverse Laplace transformations, Theorems on multiplication by s and 1/s, First and Second Shifting properties with examples, Convolution Theorem, Properties of Convolution, Examples and Application of Laplace Transformation in solving PDE.

Books recommended: 1. Myint-U, Tyn & Debnath, Lokenath. (2007). Linear Partial Differential Equation for Scientists and Engineers (4th ed.). Springer, Third Indian Reprint, 2013.

Referrence:

i. Sneddon, I. N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.

iii. Stavroulakis, Ioannis P & Tersian, Stepan A. (2004). Partial Differential Equations:

iv. H.T.H. Piaggio, An elementary treatise on differential equations and their applications.

v. K. Sankara Rao, Introduction to partial differential equation.

vi. Pundir & Pundir, Advanced partial differential equations (with Boundary value problems).

vii. W.E. Williams, Partial Differential Equations, Oxford.

viii. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, Wiley Eastern, New Delhi.
ix. J.k.Goyal, K.P.Gupta (2019). Integral Transforms (28th ed.),Pragati Prakashan, Meerut

Skill Enhancement Paper SEC-1: SEMESTER-III

MATHSEC-1(i):315(SEMESTER-III)

[LaTeX and HTML]

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50) Workload: 2 Lectures, 4 Practicals (per week) Credits: 4 (2+2) Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and webpages.

Course Learning Outcomes: After studying this course the student will be able to: i) Typeset mathematical formulas, use nested list, tabular & array environments. ii) Create or import graphics. iii) Use beamer to create presentation and HTML to create a web page.

Course Contents:

Unit -I: Getting Started with LaTeX (Lectures: 6)

Introduction to TeX and LaTeX, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.

Unit-II: Mathematical Typesetting with LaTeX (Lectures: 6)

Accents and symbols, Mathematical Typesetting (Elementary and Advanced): Subscript/ Superscript, Fractions, Roots, Ellipsis, Mathematical Symbols, Arrays, Delimiters, Multiline formulas, Spacing and changing style in math mode.

Unit –III: Graphics and Beamer Presentation in LaTeX (Lectures: 8)

Graphics in LaTeX, Simple pictures using PS Tricks, Plotting of functions, Beamer presentation.

Unit -IV: HTML (Lectures: 8)

HTML basics, Creating simple web pages, Images and links, Design of web pages.

Books recommended: 1. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.

2. Lamport, Leslie (1994). LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Pearson Education. Indian Reprint.

Referrence: i. Dongen, M. R. C. van (2012). LaTeX and Friends. Springer-Verlag.

ii. Robbins, J. N. (2018). Learning Web Design: A Beginner's Guide to HTML (5th ed.). O'Reilly Media Inc.Department of Mathematics, University of Delhi 32 Practical/Lab work to be performed in Computer Lab.

Practicals: [1] Chapter 9 (Exercises 4 to 10), Chapter 10 (Exercises 1 to 4 and 6 to 9), Chapter 11 (Exercises 1, 3, 4, and 5), and Chapter 15 (Exercises 5, 6 and 8 to 11).

Skill Enhancement Paper SEC-1: SEMESTER-III

MATHSEC-1(i):315(SEMESTER-III)

[MATLAB]

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50) Workload: 2 Lectures, 4 Practicals (per week) Credits: 4 (2+2) Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: The purpose of this course is to acquaint students with the use of MATLAB.

Course Learning Outcomes: After studying this course the student will be able to:

i) Data analysis and curve fitting by using the software.

ii) 2-D graphics and 3-D graphics-general purpose graphic functions, colour maps and colour functions

Course Contents:

UNIT-I: Basic tools **(Lectures: 06)**

Simple arithmetical operations, variables, round-off errors, formatting printing, common mathematical functions, script M-files, File Input-Output. Two-dimensional graphics, three-dimensional graphics

UNIT-II: Simple arithmetical operations **(Lectures: 06)**

Generating matrices, colon operator, manipulating matrices, simple arithmetical operations, operator procedure, common mathematical functions, data manipulation commands, sparse matrices

UNIT-III: Solving linear system of equations **(Lectures: 08)**

Solving linear system of equations-square linear system, Catastrophic round-off error, over determined and undetermined linear system, Initial-valued ordinary differential equations.

UNIT-IV: Programming in MATLAB **(Lectures: 08)**

Programming in MATLAB-Flow control and logic variables, matrix relational operators and logical operators, function M-files.

PRACTICAL - 50 MARKS (List of practical topics based on MATLAB)

(Lectures:56)

1. Plotting of functions
2. Matrix operations, vector and matrix manipulation, matrix function
3. Data analysis and curve fitting
4. Use of FFT algorithm
5. Numerical Integration
6. Differential equations
7. 2-D graphics and 3-D graphics-general purpose graphic functions, colour maps and colour functions
8. Sparse matrices-Iterative methods for sparse linear equations, eigenvalues of sparse matrices.

Instructions for Practical [**Two Programs Only** a) Program writing **10 marks**, b) Output – **30 marks** c) Viva Voce **5 marks d) Note book 5 marks**]

RECOMENDED BOOKS:

1. Y.Kirani Singh & B.B.Chaudhury- MATLAB Programming
2. S.Swapana Kumar & Lenina SVB- MATLAB-Easy Way of Learning
3. Ram N.Patel and Ankush Mittal-Programming in MATLAB-A Problem Solving Approach

Skill Enhancement Paper SEC-1: SEMESTER-III

MATHSEC-1(ii):315(SEMESTER-III)

[Analytical Geometry]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload:
4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.) Examination: 3 Hrs.

Course Objectives: The goal of this paper is to acquaint students with certain ideas about conic sections, vectors in coordinate system.

Course Learning Outcomes: After completion of this paper, the students will be able to:

i) Classify different types of conic sections – the circle, the ellipse, the hyperbola and the parabola – in Cartesian and polar coordinates.
ii) Visualize three dimensional objects – spheres and cylinders.

Course Contents:

Unit-I Two Dimensional Geometry: (Lectures: 16)

Change of axes: Change of Origin without changing the direction of axes, Change of Direction of axes of co-ordinates without changing the origin. Pair of straight lines: Homogeneous equation of second degree, Angle between pair of lines given by homogeneous equation, Bisectors of angles between the pair of lines, Condition for the general equation of second degree to represent a pair of straight lines, Point of intersection, Equation of the pair of straight lines joining the origin to the point of intersection of lines and a curve.

Unit-II: Systems of conics: (Lectures: 20)

System of conics: Every general equation of second degree in two variables always represents a conic section, Centre of a conic, Reduction of the general equation of second degree into central and non- central conics, Equation of tangent at a point on a conic, Condition that a line be a tangent to a conic, Chord of contact, pole and polar, Diameters and Conjugate diameters, Intersection of two conics, pair of tangents.Polar equation of conics: Polar equation of a conic with respect to focus as pole, Equation of chord, tangent and normal, Confocal conics: Equations and properties of confocal conics.

Unit-III: Sphere, Cone and Cylinder: (Lectures: 20)

Sphere: Equations of sphere, Condition for the general equation of second degree to represent a sphere, Plane section of a sphere, Intersection of two spheres, Equation of a tangent plane, Condition for a plane to be a tangent plane to a sphere.Cone: Equation of a cone with a conic as guiding curve, Enveloping cone of a sphere, Quadratic cones with vertex at origin, Condition for the general equation of second degree to represent a cone, Reciprocal cone, Right circular cone. Cylinder: Equation of cylinder, Enveloping cylinder, Right circular cylinder.Paraboloids & Central Conicoids: Equations and their properties.

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola by using software say maple/Mathematica/MATLAB. Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.

Recommened Books:

1. B Das, Analytical Geometry with Vector Analysis, Orient Book Company, Kolkata.
2. Ghosh and Maity, Vector Analysis, New Central Book Agency.
3. Shanti Narayan and P K Mittal, Analytical Solid Geometry, S Chand & Co.

4. S L Loney, Co-Ordinate Geometry of Two Dimensions, Macmillan and Co.
5. S L Loney, Co-Ordinate Geometry of Three Dimensions, Macmillan and Co.
6. R J T Bell, An Elementary Treatise on Co-Ordinate Geometry of Three Dimensions, Macmillan and Co.

MATH408: SEMESTER-IV

[Riemann Integration & Series of Functions]

Total Marks: 100 (Theory: 75 and Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: To understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration.

Course Learning Outcomes: The course will enable the students to learn about:

i) Some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.

ii) Beta and Gamma functions and their properties.

iii) The valid situations for the inter-changeability of differentiability and integrability with infinite sum, and approximation of transcendental functions in terms of power series.

Course Contents:

Unit -I: Riemann Integration (Lectures: 20)

Definition of Riemann integration, Inequalities for upper and lower Darboux sums, Necessary and sufficient conditions for the Riemann integrability, Definition of Riemann integration by Riemann sum and equivalence of the two definitions, Riemann integrability of monotone functions and continuous functions, Properties of Riemann integrable functions, Definitions of piecewise continuous and piecewise monotone functions and their Riemann integrability, intermediate value theorem for integrals, Fundamental theorems (I and II) of calculus, and the integration by parts.

Unit-II: Improper Integral (Lectures: 15)

Improper integrals of Type-I, Type-II and mixed type, Convergence of Beta and Gamma functions, and their properties. Abel's test(Statement only) and Dirichilet's test (Statement only), Frullani's Integral.

Unit-III: Sequence and Series of Functions (Lectures: 25)

Pointwise and uniform convergence of sequence of functions, Theorem on the continuity of the limit function of a sequence of functions, Theorems on the interchange of the limit and derivative, and the interchange of the limit and integrability of a sequence of functions. Pointwise and uniform convergence of series of functions, Theorems on the continuity, Derivability and integrability of the sum function of a series of functions, Cauchy criterion and the Weierstrass M-Test for uniform convergence.

Unit-IV: Power Series (Lectures: 10)

Definition of a power series, Radius of convergence, Absolute convergence (CauchyHadamard theorem), Uniform convergence, Differentiation and integration of power series, Abel's Theorem.

Books Recommended: 1. Bartle, Robert G., & Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.). Wiley India Edition. Delhi.

3. Denlinger, Charles G. (2011). Elements of Real Analysis. Jones & Bartlett (Student Edition). First Indian Edition. Reprinted 2015.

2. Ghorpade, Sudhir R. & Limaye, B. V. (2006). A Course in Calculus and Real Analysis. Undergraduate Texts in Mathematics, Springer (SIE). First Indian reprint.

4. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer.

Referrences:

. 1.S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Limited.

2. K.C. Maity & R.K. Ghosh, An Introduction to Analysis, Differential Calculus Part-II , Integral Calculus,

3. Shanti Narayan and M.D. Raisinghania, Elements of Real Analysis, S. Chand & Company

MATH409: SEMESTER-IV

[Ring Theory & Linear Algebra-I]

Total Marks: 100 (Theory: 75 and Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The objective of this course is to introduce the fundamental theory of two objects, namely - rings and vector spaces, and their corresponding homomorphisms.

Course Learning Outcomes: The course will enable the students to learn about:

i) The fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms.

ii) The concept of linear independence of vectors over a field, the idea of a finite dimensional vector space, basis of a vector space and the dimension of a vector space.

iii) Basic concepts of linear transformations, the Rank-Nullity Theorem, matrix of a linear transformation, algebra of transformations and the change of basis. Course Contents:

Course Contents:

Unit -I: Introduction of Rings (Lectures: 20)

Definition and examples of rings, Properties of rings, Subrings, Integral domains and fields, characteristic of a ring. Ideals, Ideal generated by a subset of a ring, Factor rings, Operations on ideals, Prime and maximal ideals.

Unit -II: Ring Homomorphisms (Lectures: 10)

Ring homomorphisms, Properties of ring homomorphisms, First, Second and Third Isomorphism theorems for rings, The Field of quotients.

Unit -III: Introduction of Vector Spaces (Lectures: 20)

Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces.

Unit -IV: Linear Transformations (Lectures: 20)

Linear transformations, Null space, Range, Rank and nullity of a linear transformation, Matrix representation of a linear transformation, Algebra of linear transformations. Isomorphisms, Isomorphism theorems, Invertibility and the change of coordinate matrix.

Books recommended: 1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

2. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). Linear Algebra (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.Department of Mathematics, University of Delhi 40

Referrences:

i. Dummit, David S., & Foote, Richard M. (2016). Abstract Algebra (3rd ed.). Student Edition. Wiley India.

ii. Herstein, I. N. (2006). Topics in Algebra (2nd ed.). Wiley Student Edition. India.

iii.Hoffman, Kenneth, & Kunze, Ray Alden (1978). Linear Algebra (2nd ed.). PrenticeHall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.

MATH410: Semester-IV

[Numerical Methods]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives:

i) to find approximate value for possible root(s) of non-algebraic equations,
ii) to find the approximate solutions of system of linear equations and ordinary differential equations.
iii) Also, the use of Computer Algebra System (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem solving skills.

Course Learning Outcomes: The course will enable the students to learn the following:

i) Some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
ii) Interpolation techniques to compute the values for a tabulated function at points not in the table.
iii) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions

Course Contents:

Unit -I: Methods for Solving Algebraic and Transcendental Equations

(Lectures: 16)

Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method

Unit -II: Techniques to Solve Linear Systems (Lectures: 12)

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Partial and scaled partial pivoting, LU decomposition and its applications, Iterative methods: Gauss-Jacobi, Gauss-Seidel and SOR methods.

Unit-III: Interpolation (Lectures: 12)

Lagrange and Newton’s methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Piecewise linear interpolation.

Unit-IV: Numerical Differentiation and Integration (Lectures: 16)

First order and higher order approximation for first derivative, Approximation for second derivative. Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Composite Trapezoidal rule, Composite Simpson's rule. Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four. Euler's method to solve ODE's.

Books recommended: 1. Bradie, Brian. (2006). A Friendly Introduction to Numerical Analysis. Pearson Education, India. Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.

Referrences: i. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2012). Numerical Methods for Scientific and Engineering Computation. (6th ed.). New Age International Publisher, India, 2016.

ii. Gerald, C. F., & Wheatley, P. O. (2008). Applied Numerical Analysis (7th ed.). Pearson Education. India.

iv. M.K. Jain, S.R.K. Iyenger, R.K. Jain, Numerical methods for scientific and engineering computation, New Age International (P) Ltd.

v. James B. Scarborough, Numerical Mathematical Analysis, Oxford and IBH Publishing Co. Pvt. Ltd.

vi. H.C. Saxena, Finite differences and numerical analysis, S Chand & Co. Ltd, New Delhi.

Skill Enhancement Paper SEC-2: Semester-IV

MATHSEC-2(i):416(Semester-IV)

[Computer Algebra Systems and Related Software]

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50) Workload: 2 Lectures, 4 Practical (per week) Credits: 4 (2+2) Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: This course aims at familiarizing students with the usage of computer algebra systems (/Mathematica/MATLAB/Maxima/Maple) and the statistical software R..

Course Learning Outcomes: This course will enable the students to:

i) Use CAS as a calculator, for plotting functions, animations and various applications of matrices.

ii) Understand the use of the software R for entry, summary calculation, pictorial representation of data and exploring relationship between data.

iii) Analyse, test, and interpret technical arguments on the basis of geometry.

Course Contents:

Unit -I: Introduction to CAS and Applications (Lectures: 10)

Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and ContourPlot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

Unit -II: Working with Matrices (Lectures: 6)

Simple programming in a CAS, Working with matrices, Performing Gauss elimination, operations (transpose, determinant, inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, eigenvector and diagonalization.

Unit -III: R - The Statistical Programming Language (Lectures: 6)

R as a calculator, Explore data and relationships in R. Reading and getting data into R: Combine and scan commands, Types and structure of data items with their properties. Manipulating vectors, Data frames, Matrices and lists. Viewing objects within objects. Constructing data objects and conversions.

Unit -IV: Data Analysis with R (Lectures: 6)

Summary commands: Summary statistics for vectors, Data frames, Matrices and lists. Summary tables. Stem and leaf plot, Histograms. Plotting in R: Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and bar charts. Copy and save graphics to other applications.

Books recommended: 1. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.Department of Mathematics, University of Delhi 42

2. Torrence, Bruce F., & Torrence, Eve A. (2009). The Student's Introduction to Mathematica®: A Handbook for Precalculus, Calculus, and Linear Algebra (2nd ed.). Cambridge University Press.

3. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley.

Referrences: i. Verzani, John (2014). Using R for Introductory Statistics (2nd ed.). CRC Press, Taylor & Francis Group. Note: Theoretical and Practical demonstration should be carried out only in one of the CAS: Mathematica/MATLAB/Maxima/Scilab or any other.

Skill Enhancement Paper SEC-2: SEMESTER-IV

MATHSEC-2(ii):416(SEMESTER-IV)

[C Programming]

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50) Workload: 2 Lectures, 4 Practicals (per week) Credits: 4 (2+2) Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: This course aims at familiarizing students with the usage of basic computer programming.

Course Learning Outcomes: This course will enable the students to:

i) Understand and apply the programming concepts of C which is important to mathematical investigation and problem solving.
ii) Use mathematical libraries for computational objectives.

Course Contents:

Unit-I: C-programming (Lectures: 10)

Introduction to C-programming: Basic model of a computer, Algorithm, Flow Chart, Programming language, Compilers and operating system, character set, identifiers and keyword, constant, variables and data type, operations and expressions, operator precedence and associativity, Basic input/output statement, simple C-programs.

Unit-II: C-programming with conditional operators (Lectures: 09)

Conditional statements and loops, Decision making with a program, logical and conditional operators, if statement, nested if else statement, loops, while loop, do-while loop, for loop, nested loops, break statement, switch statement, continue statement, go-to statement, the comma operator.

Unit-III: Arrays: (Lectures: 09)

Arrays: One dimensional arrays, declaration and initialization of one dimensional array, searching, insertion and deletion of an element from an array, sorting an array, Two dimensional arrays.

Function: Defining a function, accessing a function, function declaration/prototype, function parameters, return values, passing arguments to a function, call by reference, call by value, function calls, recursion, passing arrays to function.

Practical:

Programs for practical:

1. To convert octal to decimal, decimal to octal, binary to decimal, decimal to binary
2. To find multiplication and division of any two positive integers without using direct Multiplication and Division.
3. To find sum of odd integers less than 100 or odd multiples of 3 less than 100.

4. To find the sum of the series

   (i) $\frac{x}{1!}-\frac{x^3}{3!}+\frac{x^5}{5!}-.....$ (ii) $1-\frac{x^2}{2!}+\frac{x^4}{4!}-.....$

   (iii) $\frac{1}{1!}-\frac{2}{3!}+\frac{3}{5!}-.....$ (iv) $1-\frac{1}{2}+\frac{1}{3}-.....+\frac{1}{10}$

   (v) 1+(1+3)+(1+3+5)+…….up to 10 terms. (vi)
   1+(1+2)+(1+2+3)+….+(1+2+3..…..+100).

   (vii) 1+2!+3!+4!+…….+9!
5. To read a positive number from the keyboard and check whether the number is prime or not.
6. To generate prime numbers up to n terms.
7. To generate multiplication tables of 2,3,4,,…,10.
8. To reverse an integer greater than 10.
9. To find GCD and LCM of two given numbers.
10. To find GCD of two given numbers using recursion.
11. To find the factorial of a positive integer using and without using function.
12. To generate Fibonacci series of numbers up to n terms whose leading terms are 0, 1 and 1,1.
13. To implement Matrix – Addition, Multiplication, Transpose.
14. Searching: (i) Linear Search (ii) Binary Search
15. Insertion: (i) Sorted array (ii) Unsorted array
16. Deletion of an element from an array.
17. Sorting : (i) Selection Sort (ii) Bubble Sort (iii) Insertion Sort
18. Linear equation (i) Gauss Elimination method.
19. Non-linear equation: (i) Bisection (ii) Secant (P-5)and (iii) Newton-Raphson method
20. Numerical Integration: (i) Trapezoidal rule and (ii) Simpson's 1/3 rule.
21. Ordinary differential equation: (i) Euler's method and (ii) Runge-Kutta method.

References:

vii. Byron Gottfried, Programming with C, Tata McGraw Hill.
viii. E. Balaguruswami, Programming with ANSI-C, Tata McGraw Hill.
ix. RG Dromey, How to solve it by computer, Prentice Hall of India.
x. K.E. Atkinson, An introduction to numerical analysis, John Wiley and Sons.
xi. M.K. Jain, S.R.K. Iyenger, R.K. Jain, Numerical method, New Age International (P) Ltd.
xii. R.Y. Rubinstein, Simulation and Monte-Carlo method, John Wiley.
xiii. C.E. Froberg, Introduction to numerical analysis, Addison Wesley.

Skill Enhancement Paper SEC-2: SEMESTER-IV

MATHSEC-2(iii):416(SEMESTER-IV)

[Network Analysis and Project Management]

Total Marks: 100 (Theory; 38 Internal Assessment: 12, Report writing: 30, and presentation: 20) Workload: 2 Lectures, 4 Practical (per week) Credits: 4 (2+2) Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) Examination: 2 Hrs.

Students are expected to carry out independent project in the industry on a topic assigned to him/her under the supervision of faculty member. At the completion of project students are expected to write a report and make a presentation.

Course Objectives: This course aims at familiarizing students with the Network analysis.

Course Learning Outcomes: This course will enable the students to:

Acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member.

Unit-I: Project Management (Lectures: 03)

Project Management Objective: This course offers practical approach to managing projects, focusing on organizing, planning, and controlling the efforts in the project.

Unit-II: Mathematical models (Lectures: 13)

Basics of project management, feasibility and technical analysis: materials and equipment, project costing & financing, financial aspects, cost benefit analysis, success criteria and success factors, risk management Mathematical models: project selection, project planning, cost-time trade-off, resource handling/leveling.

Graph Theory Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Unit-III: Project management through PERT/CPM (Lectures: 12)

Network Analysis and Theory of Sequencing Flows in networks. Maximal flow. Shortest path and travelling salesman problem. Construction of minimal spanning tree and its applications. Project management through PERT/CPM, Updating of PERT Charts. Project Crashing,

. References /Suggested Readings: 1. Ravi Ravindran: Operations Research and Management Science Handbook, CRC Press, 2008.

2. Harold Kerzner: Applied Project Management: Best Practices on Implementation, John Wiley & Sons, Inc., 2000.

3. J.C. Goodpasture: Quantitative Methods in Project Management, J Ross Publishing, Boca Raton, Florida, USA, 2003.

4. J.R. Meredith and S.J. Mantel Jr.: Project Management: A Managerial Approach, John Wiley,New York. 2004.

5. R.K. Ahuja T. L. Magnanti, B. Orlin, Network Flows-Theory, Algorithm and Applications, Prentice Hall, NJ, 1993.

7. J.D. Wist, F.K. Levy, A Management Guide to PERT/CPM, 2nd Ed., PHI, 1967 (Reprint 2007)

THIRD YEAR MATHEMATICS

MATH511: SEMESTER V

[Multivariate Calculus]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables.
Course Learning Outcomes: This course will enable the students to learn:

i) The conceptual variations when advancing in calculus from one variable to multivariable discussions.

ii) Inter-relationship amongst the line integral, double and triple integral formulations.

Course Contents:

Unit -I: Calculus of Functions of Several Variables (Lectures: 20)

Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Tangent planes, Total differential and differentiability, Chain rule, Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent planes and normal lines.

Unit-II: Extrema of Functions of Two Variables and Properties of Vector Field

(Lectures: 8)

Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

Unit-III: Double and Triple Integrals (Lectures: 16)

Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by

triple integrals, triple integration in cylindrical and spherical coordinates, Change of variables in double and triple integrals.

Unit-IV: Green's, Stokes' and Gauss Divergence Theorem (Lectures: 12)

Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Books recommended: 1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

Referrences: i. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). Basic Multivariable Calculus. Springer (SIE). First Indian Reprint.

MATH512: SEMESTER V

[Group Theory-II]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The course will develop an in-depth understanding of one of the most important branch of the abstract algebra.

Course Learning Outcomes: The course shall enable students to learn about:

i) Automorphisms for constructing new groups from the given group, External direct product.
ii) Group actions, Sylow theorems and their applications to check non simplicity.

Course Contents:

Unit -I: Automorphisms and Properties (Lectures: 10)

Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.

Unit-II: External and Internal Direct Products of Groups (Lectures: 15)

External direct products of groups and its properties, The group of units modulo n as an external direct product, Applications to data security and electric circuits; Internal direct products, Classification of groups of order 2 p , where p is a prime; Fundamental theorem of finite Abelian groups and its isomorphism classes.

Unit-III: Group Action (Lectures: 20)

Group actions and permutation representations; Stabilizers and kernels of group actions; Groups acting on themselves by left multiplication and consequences; Conjugacy in . n S

Unit -IV: Sylow Theorems and Applications (Lectures: 25)

Conjugacy classes, The class equation, p-groups, The Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications. Simplicity of 5 A .

Books recommended: 1. Dummit, David S., & Foote, Richard M. (2016). Abstract Algebra (3rd ed.). Student Edition. Wiley India.

2. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

Referrence: 1.Rotman, Joseph J. (1995). An Introduction to The Theory of Groups (4th ed.). Springer Verlag, New York.

2. V.K. Khanna & S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, New Delhi.
3. S. Kumaresan, Linear Algebra, Prentice Hall of India.
4. Shanti Narayan & P.K. Mittal, A Text Book of Matrices, S Chand & Co., New Delhi.
5. Joseph A. Gallan, Contemporary Algebra, Narosa Publishing House, New Delhi.
6. Surjeet Singh and QaziZameerudin, Modern Algebra, Vikas Publishing House.
7. P.B. Bhattacharya, S.K. Jain and S. R. Nagpaul: Basic Abstract Algebra, CUP.
8. Michael Artin, Algebra, Prentice Hall of India.
9. N. Jacobson, Basic Algebra Vol. I & II, Hindustan Publishing Corporation, New Delhi.

Discipline Specific Elective (DSE-1) Course -1

Any one of the following (at least two shall be offered by the college):

DSE-1 (i): Linear Programming and Applications

DSE-1 (i): C++ Programming for Mathematics

DSE-1 (i): Differential Geometry and Tensor

MATHDSE-1 (i): 517(Semester-V)

[Linear Programming and Applications]

Total Marks: 100 (Theory: 75 and Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear Programming with applications to Transportation, and Assignment.

Course Learning Outcomes: This course will enable the students to learn:

i) Solve linear programming models of real life situations.
ii) The graphical solution of LPP with only two variables, and illustrate the concept of convex set and extreme points.
iii) The relationships between the primal and dual problems and their solutions with applications to transportation, and assignment.

Course Contents:

Unit-I: Introduction to Linear Programming (Lectures: 15)

The Linear Programming Problem: Standard, Canonical and matrix forms, Graphical solution. Hyperplanes, Extreme points, Convex and polyhedral sets. Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points.

Unit-II: Methods of Solving Linear Programming Problem (Lectures: 25)

Simplex Method: Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.

Unit-III: Duality Theory of Linear Programming (Lectures: 10)

Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; Complimentary Slackness.

Unit-IV: Applications (Lectures: 20)

Transportation Problem: Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving Transportation Problem. Assignment Problem: Mathematical formulation and Hungarian method of solving.

Books recommended: 1. Bazaraa, Mokhtar S., Jarvis, John J., & Sherali, Hanif D. (2010). Linear Programming and Network Flows (4th ed.). John Wiley and Sons.

2. Hadley, G. (1997). Linear Programming. Narosa Publishing House. New Delhi.

3. Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.). Pearson.

Referrences: i. Hillier, Frederick S. & Lieberman, Gerald J. (2015). Introduction to Operations Research (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.

ii. Thie, Paul R., & Keough, G. E. (2014). An Introduction to Linear Programming and Game Theory. (3rd ed.). Wiley India Pvt. Ltd.

iii. Kanti Swarup, P.k. Gupta and Man Mohan(2020), Operations research, Sultan chand & Sons, New Delhi

MATHDSE-1 (ii): 517(SemesterV)

[C++ Programming for Mathematics]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives:

This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.

Course Learning Outcomes: After completion of this paper, student will be able to:

iii) Understand and apply the programming concepts of C++ which is important to mathematical investigation and problem solving.
iv) Use mathematical libraries for computational objectives.
v) Represent the outputs of programs visually in terms of well formatted text and plots.

Course Contents:

Unit-I: C++ Essentials (Lectures: 16)

Fundamentals of programming, Organization of logic flow in stored program model of computation, C++ as a general purpose programming language, Structure of a C++ program, Common compilers and IDE's, Basic data-types, Variables and literals in C++, Operators, Expressions, Evaluation precedence, and Type compatibility. Outline of program development in C++, Debugging and testing. Applications: Greatest common divisor, and Random number generation.

Unit -II: Working with Structured Data (Lectures: 12)

Structured data-types in C++, Arrays and manipulating data in arrays with applications in factorization of an integer and finding Euler's totient; Objects and classes: Information hiding, Modularity, Constructors and Destructors, Methods and Polymorphism. Applications: Cartesian geometry using points (2 & 3-dimensional), and Pythagorean triples.

Unit-III: Working with Containers and Templates (Lectures: 16)

Containers and Template Libraries: Sets, Iterators, Multisets, Vectors, Maps, Lists, Stacks and Queues. Applications: Basic set algebra, Modulo arithmetic, Permutations, and Polynomials.

Unit-IV: Using Mathematical Libraries and Packages (Lectures: 12)

Arbitrary precision arithmetic using the GMP package; Linear algebra: Two-dimensional arrays in C++ with applications in finding Eigenvalues, Eigenvectors, Rank, Nullity, and Solving system of linear equations in matrices. Features of C++ for input/output and visualization: Strings, Streams, Formatting methods, Processing files in a batch, Commandline arguments, Visualization packages and their use in plots.

Books recommended: 1. Scheinerman, Edward (2006). C++ for Mathematicians: An Introduction for Students and Professionals. Chapman & Hall/CRC. Taylor & Francis Group, LLC.

Referrences: i. Dale, Nell & Weems, Chip (2013). Programming and Problem Solving with C++ (6th ed.). Comprehensive Edition. Jones & Bartlett Learning.

ii. Gottschling, Peter (2016). Discovering Modern C++: An Intensive Course for Scientists, Engineers, and Programmers. Addison-Wesley. Pearson Education, Inc.

iii. Josuttis, Nicolai M. (2012). The C++ Standard Library: A Tutorial and Reference (2nd ed.). Addison-Wesley. Pearson Education, Inc.

Practical / Lab work to be performed in Computer Lab:

A: Preparatory (Practical Sessions: 8 Hrs.)

1. Setting up of C++ programming environment on Linux/Windows/Mac-OS; gcc/g++/mingw/cc, Program-development methodology and use IDE's or other tools.

2. Demonstration of sample programs for a. "Hello World" b. Sum of an arithmetic progression. c. Value of sin x using series expansion.

3. Finding/demonstrating: a. Machine epsilon. b. Integer and float overflow/underflow. c. Iteration and selection based logic. (provide a list of 8-10 problems suitable to learners needs)

B: Evaluative:

Set-I: (Practical Sessions: 8 Hrs.)

1. Greatest common divisor (including Euclid's Method).

2. Random number generation (including a Monte Carlo Program).

Set-II: (Practical Sessions: 12 Hrs.)

1. Factorization of an integer, and Euler's totient.

2. Cartesian geometry using points (2 & 3-dimensional).

3. Pythagorean triples.

Set-III: (Practical Sessions: 16 Hrs.)

1. Basic set algebra.

2. Modulo arithmetic.

3. Permutations.

4. Polynomials.

Set-IV: (Practical Sessions: 12 Hrs.)

1. Arbitrary precision arithmetic using the GMP package.

2. Finding Eigenvalues, Eigenvectors, Rank, Nullity, and Solving system of linear equations in matrices.

3. Plots (using the GNU plotutils package).

Note. Exception handling in lab-exercises (SET-I to IV), Comments/Documentation using Doxygen may be emphasized.

MATHDSE-1 (iii): 517(Semester-V)

[Differential Geometry and Tensor]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: This course aims at introducing the concepts of Differential Geometry and Tensor.

Course Learning outcomes: After the course, the student will be able to understand the concepts of:

i) Differential Geometry and their properties.

ii) Tensor and its applications

Course Contents:

Unit-I: Differential equation of a geodesic (Lectures:20)

Geodesics, Differential equation of a geodesic, Single differential equation of a geodesic, Geodesic on a surface of revolution, Geodesic curvature and torsion, Gauss-Bonnet theorem, Gauss's formulae, Gauss's characteristic equation, Weingarten equations, Mainardi-

Coddazi equations, Fundamental existence theorem for surfaces.

Unit-II: Tensor analysis **(Lectures: 20)**

Tensor analysis, Tensor and their transformation laws, Contraction, Quotient law, Reciprocal tensors, Kronecker delta, symmetric and skew-symmetric tensors, metric tensors, Riemann space, Christoffel symbols and their transformation laws,

Unit-III: Covariant differentiation **(Lectures: 15)**

Covariant differentiation of tensors, Ricci's theorem, Intrinsic derivative. Geodesic co-ordinates.

Unit-IV: Riemann-Christoffel tensor **(Lectures: 15)**

Riemann-Christoffel tensor and its properties, Covariant curvature tensor, Einstein space, Bianchi's identity, Einstein tensor, Flate space, Isotropic point, Schurz's theorem.

References:

1. **TJ Wilmore**, An Introduction to Differential Geometry, Dover Publication.
2. **CE Weatherburn**, An Introduction to Riemann Geometry & Tensor, Cambridge University Press.
3. **Ruchard S Millman & George D Parker**, Elements of Differential Geometry, Pearson Publication.
4. **Brain F Doolin**, An Introduction to Differential Geometry for Engineers, Dover Pub. Inc.

Discipline Specific Elective (DSE-2) Course - 2

Any one of the following (at least two shall be offered by the college):

DSE-2 (i): Number Theory

DSE-2 (ii): Logic and Boolean Algebra

DSE-2 (iii): Inventory systems and Marketing management

MATHDSE-2 (i): 518(Semester-V)

[Number Theory]

Total Marks: 100 (Theory: 75 and Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: In number theory there are challenging open problems which are comprehensible at undergraduate level, this course is intended to build a micro aptitude of understanding aesthetic aspect of mathematical instructions and gear young minds to ponder upon such problems.

Course Learning Outcomes: This course will enable the students to learn:

i) Some of the open problems related to prime numbers, viz., Goldbach conjecture etc.

ii) About number theoretic functions and modular arithmetic.

ii) Public crypto systems, in particular, RSA.

Course Contents:

Unit -I: Distribution of Primes and Theory of Congruencies (Lectures: 15)

Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Fermat and Mersenne primes, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.

Unit -II: Number Theoretic Functions (Lectures: 15)

Number theoretic functions for sum and number of divisors, Multiplicative function, The Mobius inversion formula, The greatest integer function. Euler's phi-function and properties, Euler's theorem.

Unit-III: Primitive Roots (Lectures:20)

The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots; Definition of quadratic residue of an odd prime, and Euler's criterion.

Unit-IV: Quadratic Reciprocity Law and Public Key Encryption (Lectures: 20)

The Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli; Public key encryption, RSA encryption and decryption.

Books recommended: 1. Burton, David M. (2012). Elementary Number Theory (7th ed.). Mc-Graw Hill Education Pvt. Ltd. Indian Reprint.

2. Jones, G. A., & Jones, J. Mary. (2005). Elementary Number Theory. Undergraduate Mathematics Series (SUMS). First Indian Print.

Referrence: i. Neville Robinns. (2007). Beginning Number Theory (2nd ed.). Narosa Publishing House Pvt. Limited, Delhi.

MATHDSE-2 (ii): 518 (Semester-V)

. **[Logic and Boolean Algebra**]

Total Marks: 100 (Theory: 75 and Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Contents:

Unit-I: Logical equivalence (Lectures: 16)

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Unit-II: Sets and properties (Lectures: 16)

Sets, subsets, Set operations, the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation.

Unit-III: Boolean Algebra (Lectures: 24)

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sub lattices, products and homomorphisms.

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Books Recommended:

1. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.

2. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

3. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.

4. P.R. Halmos, Naive Set Theory, Springer, 1974. 3. E. Kamke, Theory of Sets, Dover Publishers, 1950.

MATHDSE-2 (iii): 518(Semester-V)

[Inventory systems and Marketing management]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: This course aims at introducing the concepts of Inventory systems and marketing management.

Course Learning outcomes: After the course, the student will be able to understand the concepts of:

i) different Inventory models

ii) applications of the models in real life situations.

Course Contents:

Unit- I: Inventory systems (Lectures: 20)

Concepts and problems in Inventory Systems, Objectives of Scientific Inventory Control, classification of Inventory Systems, different costs in Inventory Systems and method of their estimation. The concept of EOQ

Unit- II: Deterministic Inventory models (Lectures: 30)

Deterministic Inventory models with and without lead time. Deterministic Inventory models with and without shortages.

Unit -III: Concepts of marketing management and related models (Lectures: 20)

Concept of marketing and its role in organization. Marketing decisions, scientific marketing analysis. Uses and limitations of mathematical models in marketing , classification of market structure in competitive conditions.

Unit -IV: Concepts of joint optimization of price (Lectures: 20)

Demand elasticity, joint optimization of price, quality and promotional efforts. Pricing decisions, media allocation for advertisement. Brand switching analysis.

Books Recommended 1. G. Hadley, T.M. Whitin, Analysis of Inventory Systems, D.B. Taraporevala and Sons, Published by arrangement with Prentice Hall Inc., 1979.

2. Zipkin, Foundations of Inventory Management, McGraw Hall Inc., 2000.

3. Donald Waters, Inventory Control, John Wiley, 2003.

4. Philip Kotler, Marketing Management, 13th Ed., Prentice Hall of India, 2008.

5. Tony Curtis, Marketing for Engineers, Scientists and Technologists, John Wiley & Sons Inc., 2008.

6. Graham J. Hooley and Michael K. Hassey, Quantitative Methods in Marketing, 2nd Ed., International Thomson Business Press, 1999.

7. Grahame R. Dowling, The Art and Science of Marketing –Marketing for Marketing Managers, Oxford University press, 2005.

8. Gary L. Lilien, Philip Kotler, K. Sridhar Moorthy, Marketing Models, Prentice Hall of India, 2003

MATH613: SEMESTER VI

[Metric Spaces and Complex Analysis]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The course aims

i) at providing the basic knowledge pertaining to metric spaces such as open and closed balls, neighbourhood, interior, closure, subspace, continuity, compactness, connectedness etc.

ii) to introduce the basic ideas of analysis for complex functions in complex variables.

Course Learning Outcomes: The completion of the course will enable the students to:

i) Understand the basic concepts of metric spaces and

ii) Understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.

Unit –I: Basic Concepts and Topology of Metric Spaces (Lectures: 25)

Metric spaces: Definition and examples, Sequences in metric spaces, Cauchy sequences, Complete metric space.

Open and closed ball, Neighborhood, Open set, Interior of a set, limit point of a set, derived set, closed set, closure of a set, diameter of a set, Cantor's theorem, Subspaces, Dense set.

Unit-II: Continuity & Uniform Continuity in Metric Spaces (Lectures: 15)

Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mapping, Banach fixed point theorem. Connectedness, Connected subsets of, Connectedness and continuous mappings,

Unit -III: Analytic Functions and Cauchy-Riemann Equations (Lectures: 15)

Functions of complex variable, Mappings; Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples.

Unit -IV: Elementary Functions and Integrals (Lectures: 15)

Exponential function, Logarithmic function, Branches and derivatives of logarithms, Trigonometric function, Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals,

Books recommend: 1. Shirali, Satish & Vasudeva, H. L. (2009). Metric Spaces, Springer, First Indian Print.

2. Brown, James Ward, & Churchill, Ruel V. (2014). Complex Variables and Applications (9th ed.). McGraw-Hill Education. New York.

Referrences: i. Kumaresan, S. (2014). Topology of Metric Spaces (2nd ed.). Narosa Publishing House. New Delhi.

ii. Simmons, George F. (2004). Introduction to Topology and Modern Analysis. McGraw-Hill Education. New Delhi

iii. Bak, Joseph & Newman, Donald J. (2010). Complex Analysis (3rd ed.). Undergraduate Texts in Mathematics, Springer. New York.

iv. Zills, Dennis G., & Shanahan, Patrick D. (2003). A First Course in Complex Analysis with Applications. Jones & Bartlett Publishers, Inc.

v. Mathews, John H., & Howell, Rusell W. (2012). Complex Analysis for Mathematics and Engineering (6th ed.). Jones & Bartlett Learning. Narosa, Delhi. Indian Edition. (For practicals: Sample materials of files in the form Mathematica/Maple 2011.zip,

MATH614: SEMESTER VI

[Ring Theory and Linear Algebra-II]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: This course introduces the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers, used in finite fields.

Courses Learning Outcomes: On completion of this course, the student will be able to:

i) Appreciate the significance of unique factorization in rings and integral domains.

ii) Compute with the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.

Course Contents:

Unit -I: Polynomial Rings and Unique Factorization Domain (UFD)

(Lectures: 25)

Polynomial rings over commutative rings, Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion, Unique factorization in Z[x]; Divisibility in integral domains, Irreducible, Primes, Unique factorization domains, Euclidean domains.

Unit-II: Dual Spaces and Diagonalizable Operators (Lectures: 15)

Dual spaces, Double dual, Dual basis, Transpose of a linear transformation and its matrix in the dual basis, Annihilators; Eigenvalues, Eigenvectors, Eigenspaces and characteristic polynomial of a linear operator; Diagonalizability, Invariant subspaces and Cayley-Hamilton theorem; The minimal polynomial for a linear operator.

Unit -III: Inner Product Spaces (Lectures: 15)

Inner product spaces and norms, Orthonormal basis, Gram-Schmidt orthogonalization process, Orthogonal complements, Bessel's inequality.

Unit -IV: Adjoint Operators and Their Properties (Lectures: 15)

The adjoint of a linear operator, Least squares approximation, Minimal solutions to systems of linear equations, Normal, Self-adjoint, Unitary and orthogonal operators and their properties.

Books recommended: 1. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). Linear Algebra (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.

2. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

Referrences: i. Herstein, I. N. (2006). Topics in Algebra (2nd ed.). Wiley Student Edition. India.

ii. Hoffman, Kenneth, & Kunze, Ray Alden (1978). Linear Algebra (2nd ed.). PrenticeHall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.

iii. Lang, Serge (1987). Linear Algebra (3rd ed.). Springer.

Discipline Specific Elective (DSE) Course - 3

Any one of the following (at least two shall be offered by the college):

DSE-3 (i): Cryptography and Network Security

DSE-3 (ii): Introduction to Coding Theory

DSE-3 (iii): Probability Theory and Statistics

MATHDSE-3 (i): 619(Semester-VI)

[Cryptography and Network Security]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: This course helps the students to develop skills and knowledge of standard concepts in cryptography and demonstrates how cryptography plays an important role in the present digital world by knowing encryption and decryption techniques and secure data in transit across data networks.

Course Learning Outcomes: After the course, the student will be able to:

i) Understand the fundamentals of Cryptography, Public-key Cryptography and Network Security.

ii) Encrypt and decrypt messages using block ciphers

Course Contents:

Unit -I: Cryptography and Data Encryption Standard (DES) (Lectures: 20)

Overview of Cryptography, Computer security concepts, Security attacks, Symmetric cipher model, Cryptanalysis and brute-force attack, Substitution techniques, Caesar cipher, Monoalphabetic ciphers, Playfair cipher, Hill cipher, Polyalphabetic ciphers, One-time pad, Transposition techniques, Binary and ASCII, Pseudo-random bit generation, Stream ciphers and Block ciphers, The Feistal cipher, The data encryption standard (DES), DES example.

Unit -II: Algorithms and Advanced Encryption Standard (AES) (Lectures: 20)

Review of basic concepts in Number theory and Finite Fields: Divisibility, Polynomial and modular arithmetic, Fermat's and Euler's theorems, The Chinese remainder theorem, Discrete logarithm., Finite fields of the form GF(p) and GF(2n). Advanced encryption standard (AES), AES transformation functions, AES key expansion, AES example.

Unit -III: Public-key Cryptography (Lectures: 15)

Principles of public-key cryptosystems, The RSA algorithm and security of RSA, Elliptic curve arithmetic, Elliptic curve cryptography, Cryptographic Hash functions, Secure Hash algorithm.

Unit--IV: Digital Signatures and Network Security (Lectures: 15)

Digital signatures, Elgamal and Schnorr digital signature schemes, Digital signature algorithm. Wireless network and mobile device security, Email architecture, formats,

threats and security, Secure/Multipurpose Internet Mail Extension (S/MIME) and Pretty Good Privacy (PGP).

Books rercommended: 1. Stallings, William (2017). Cryptography and Network Security, Principles and Practice (7th ed.). Pearson Education Limited. England.

2. Trappe, Wade & Washington, Lawrence C. (2006). Introduction to Cryptography with Coding Theory (2nd ed.). Pearson Education International.

Referrence: 1. Stinson, Douglas R. (2005). Cryptography Theory and Practice (3rd ed.). CRC Press.

2. Hans Delfs and Helmut Knebl: Introduction to cryptography, (Principles & Applications), Springer verlag, revised 3rd Edition, 2002.
3. David M Burton : Elementary Number Theory, Tata McGraw Hill Educational Pvt. Ltd., New Delhi, Sevent Reprint, 2009.
4. Abraham Robinson: Numbers & Ideals; Yale University, Reprinted, 1965.

MATHDSE-3 (ii): 619 (Semester-VI)

[Introduction to Coding Theory]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: This course aims to introduce the basic aspects of Coding Theory.

Course Learning Outcomes: This course will enable the students to learn:

i) The detection & correction of errors while transmission.

ii) Representation of a linear code by matrices and its encoding and decoding.

Course Contents:

Unit 1: Introduction to Coding Theory **(Lectures: 10)**

A model of communication system, A quantitative measure of information, Binary unit of information, A measure of uncertainty Block codes, Hamming distance, maximum likelihood decoding principle, Error detection, Error Correction, Matrix encoding techniques, Generator and parity check matrix.

Unit-II : Concepts of Coding **(Lectures: 20)**

Polynomial Codes, Hamming Codes, Construction of finite fields and Bose-Chaudhuri-Hocquenghem BCH codes, Linear code, equivalent codes, Dual code of a linear code, weight distribution of the dual code of a binary linear code.

Unit-III : Cyclic codes **(Lectures: 20)**

New code obtained from given code, Cyclic codes, BCH and Hamming codes as cyclic code, Non- binary Hamming code. Orthogonality relation, Encoding of linear codes, Decoding of linear codes,

Unit-III : Maximum distance separable (MDS) codes **(Lectures: 20)**

Maximum distance separable (MDS) codes, Generator and parity check matrices of MDS codes, weight distribution of the MDS codes, Necessary and sufficient condition for a linear code to be MDS code

1. **References:** 1. L.R. Vermani, , Elements of Algebraic Coding Theory, Chapmann and Hall 1996.
2. E.R. Berlekamp, Algebraic Coding Theory, McGraw Hill, New York, 1968.
3. F.J Mac Williams and N.J.A Sloane, Error-correcting codes, North Holland Publishing Company,1977.
4. W.W. Peterson and E.J Weldon, Error-correcting codes, MIT press , Cambridge, Massachusetts, 1972.

5. Roth, Ron M. (2007). Introduction to Coding Theory. Cambridge University Press.

Referrence: i. Ash, Robert B. (1965). Information Theory. Dover Publications, Inc. New York. Reprint in 1990.

ii. Goldman, Stanford (1968). Information Theory, Dover Publications, Inc. New York. Reprint in 1990.

iii. Ling, San & Xing, Chaoping (2004). Coding Theory: A First Course. Cambridge University Press.

MATHDSE-3 (ii): 619 (Semester-VI)

[Probability Theory and Statistics]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.

Course Learning Outcomes: This course will enable the students to learn:

i) Distributions to study the joint behaviour of two random variables.
ii) To establish correlation and linear regression.
iii) Central limit theorem, which helps to understand the remarkable fact that: the empirical frequencies of so many natural populations, exhibit a bell shaped curve.

Course Contents:

Unit -I: Probability Functions and Moment Generating Function (Lectures: 20)

Sample space, Probability set function, Real random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions, Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit-II: Univariate Discrete and Continuous Distributions (Lectures: 20)

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

Unit -III: Bivariate Distribution (Lectures: 10)

Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

Unit-IV4: Correlation, Regression and Central Limit Theorem (Lectures: 20)

The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

Books recommended: 1. Hogg, Robert V., McKean, Joseph W., & Craig, Allen T. (2013). Introduction to Mathematical Statistics (7th ed.). Pearson Education, Inc.

2. Miller, Irwin & Miller, Marylees. (2014).John E. Freund's Mathematical Statistics with Applications (8th ed.). Pearson. Dorling Kindersley (India).

3. Ross, Sheldon M. (2014). Introduction to Probability Models (11th ed.). Elsevier Inc.

Discipline Specific Elective (DSE-4) Course - 4

Any one of the following (at least two shall be offered by the college):

DSE-4 (i): **Mathematical Modelling and Graph Theory**

DSE-4 (ii): **Mechanics**

DSE-4 (iii): **Biomathematics**

MATHDSE-4 (i): 620(Semester-VI)

[Mathematical Modelling and Graph Theory]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The main objective of this course is to teach students how to model physical problems.

Course Learning Outcomes: The course will enable the students to learn the following:

The basic concepts of graph theory, simulation and formation of mathematical models.

Course Contents:

Unit -I: Overview of optimization modelling (Lectures: 25)

Overview of optimization modelling; Linear Programming Model: Geometric solution, Algebraic solution, Simplex method, Sensitivity analysis.

Unit-II: Graph Theory (Lectures: 20)

Introduction to graphs,; Definition, examples and basic properties of graphs, Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, connected graphs, tree, binary trees and algorithms,, Cayley's theorem, Spanning trees, Eulerian circuits, Hamiltonian paths and circuits, Konigsberg Bridges problem, Instant insanity game, Adjacency and incidence matrix, Path matrix, Circuit matrix, Directed graphs, Digraph, Euler's Digraphs, Matrix representation of Digraphs, Weighted graph, Travelling salesman problem, Shortest path, Dijkstra's algorithm.

Unit-III: Network Analysis and Sequencing (Lectures: 15)

Flows in networks. Maximal flow. Shortest path and travelling salesman problem. Construction of minimal spanning tree and its applications. Project management through PERT/CPM, Updating of PERT Charts.

Sequencing Problems. Processing n jobs through two/three machines. General n/m job-shop problem.

Unit-IV: Monte Carlo Simulation (Lectures: 10)

Monte Carlo Simulation Modeling: Simulating deterministic behaviour (area under a curve, volume under a surface); Generating Random Numbers: Middle square method, Linear congruence;

Books recommended: 1. Aldous, Joan M., & Wilson, Robin J. (2007). Graphs and Applications: An Introductory Approach. Springer. Indian Reprint.

2. Giordano, Frank R., Fox, William P., & Horton, Steven B. (2014). A First Course in Mathematical Modeling (5th ed.). Brooks/Cole, Cengage Learning.

3. R.K. Ahuja T. L. Magnanti, B. Orlin, Network Flows-Theory, Algorithm and Applications, Prentice Hall, NJ, 1993. 4. J.D. Wist, F.K. Levy, A Management Guide to PERT/CPM, 2nd Ed., PHI, 1967 (Reprint 2007).

4. A. Ravindran, D.T. Phillips and James J. Solberg, Operations Research- Principles and Practice, John Wiley and Sons, 2005.

5. Kanti Swarup, P.k. Gupta and Man Mohan(2020), Operations research, Sultan chand & Sons, New Delhi

MATHDSE-4 (ii): 620(Semester-VI)

[Mechanics]

Total Marks: 100 (Theory: 75, Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques.

Course Learning Outcomes: The course will enable the students to understand:

i) Motion of particles in resisting medium, Equilibrium of forces in two and three dimensions

ii) Foundations of Frictional force.

ii) Moment of inertia of a rigid body about an arbitrary axis.

iii) Course Contents:

Unit-I: Motion in resisting medium (Lectures: 20)

Simple Harmonic Motions. Motion in resisting medium including projectile, Motion of varying mass. Radial and Cross-Radial Components of velocities and accelerations. Tangential and Normal Components of velocities and accelerations. Dynamics of a particle: Motion of a particle on smooth and rough plane curves, Central orbit, Apses.

Unit-II: Forces in Equilibrium (Lectures: 10)

Coplanar force systems; Three-dimensional force systems; Moment of a force about a point and an axis, Principle of moments, Couple and couple moment, Moment of a couple about a line, Resultant of a force system, Distributed force system, Rigid-body equilibrium, Equilibrium of forces in two and three dimensions, Free-body diagrams, General equations of equilibrium, Constraints and statically determinacy.

Unit-III: Friction, Centre of Gravity and Moments of Inertia (Lectures:20)

Equations of equilibrium and friction, Laws of Friction, Equilibrium of particle constrained to rest on a rough curve under any given forces. Center of gravity, Center of mass and Centroid of a body and composite bodies;

Unit-IV: Rigid Body Motion (Lectures: 20)

Moments and products of inertia for areas, composite areas and rigid body, Parallel axis theorem, Moment of inertia of a rigid body about an arbitrary axis, Principal moments and principal axes of inertia. D' Alembert's principle, Conservative force fields, Conservation of mechanical energy, Work-energy equations, Kinetic energy and work-kinetic energy expressions based on center of mass, Moment of momentum equation for a single particle and a system of particles.

Books recommended: 1. Hibbeler, R. C. (2016). Engineering Mechanics: Statics & Dynamics (14th ed.). Pearson Prentice Hall (Pearson Education), New Jersey.

2. Shames, Irving H., & Rao, G. Krishna Mohan (2009). Engineering Mechanics: Statics and Dynamics (4th ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi.

Referrence:

i. Nelson, E. W., Best, Charles L. & McLean, W. G. (1998). Theory and Problems of Engineering Mechanics: Statics and Dynamics (5th ed.). McGraw-Hill,
ii. Schaum's Outline Series. S.L. Loney, An Elementary Treatise on Dynamics of a Particle and of Rigid Bodies, Cambridge University Press.
iii.S.L. Loney, An Elementary Treatise on Statics, Cambridge University Press.
iv.M. Ray, Dynamics, S. Chand & Co.
v.R.S. Verma,Text book on Statics, Pothisala Private Ltd.
vi.H. Goldstein: Classical Mechanics, Narosa Publishing House, New Delhi
vii.C.R. Mondal: Classical Mechanics, Prentice Hall of India, New Delhi.
viii.B.C. Das, B.N. Mukherjee, Dynamics, U.N.Dhur & Sons (private Ltd.),Kolkata
ix..B.C. Das, B.N. Mukherjee, Statics, U.N.Dhur & Sons (private Ltd.),Kolkata

MATHDSE-4 (iii): 620(Semester-VI)

[Biomathematics]

Total Marks: 100 (Theory: 75 + Internal Assessment: 25) Workload: 5 Lectures, 1 Tutorial (per week) Credits: 6 (5+1) Duration: 14 Weeks (70 Hrs.) Examination: 3 Hrs.

Course Objectives: The focus of the course is on scientific study of normal functions in living systems.

Course learning outcomes: The course will enable the students to understand

i) Analysis and interpretation of bio mathematical models.

ii) Develop the skills in mathematical modelling.

Course Contents:

Unit-I: Modelling Biological Phenomenon (Lectures: 15)

Population growth, Administration of drugs, Cell division, Systems of linear ordinary differential equations, Heartbeat, Nerve impulse transmission, Chemical reactions, Predatorprey models.

Unit-II: Mathematics of Heart Physiology and Nerve Impulse Transmission

(Lectures: 25)

Stability and oscillations: Epidemics, The phase plane and the Jacobian matrix, Local stability, Stability, Limit cycles, Forced oscillations; Mathematics of Heart Physiology: The local model, The Threshold effect, The phase plane analysis and the heartbeat model, A model of the cardiac pacemaker; Mathematics of Nerve Impulse Transmission: Excitability and repetitive firing, Travelling waves.

Unit-III: Bifurcation and Chaos (Lectures: 15)

Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, The Poincaré plane.

Unit-IV: Modeling Molecular Evolution and Genetics (Lectures: 15)

Modelling Molecular Evolution: Matrix models of base substitutions for DNA sequences, The Jukes-Cantor model, The Kimura models, Phylogenetic distances; Constructing Phylogenetic Trees: Phylogenetic trees, Unweighted pair-group method with arithmetic means (UPGMA), Neighbour joining method; Genetics: Mendelian genetics, Probability distributions in genetics.

Books recommended:

1. Allman, Elizabeth S., & Rhodes, John A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press.

2. Jones, D. S., Plank, M. J., & Sleeman, B. D. (2009). Differential Equations and Mathematical Biology (2nd ed.). CRC Press, Taylor & Francis Group, LLC.

Referrences: i. Murray, J. D. (2002). An Introduction to Mathematical Biology (3rd ed.). Springer.

ii. Myint-U, Tyn (1977). Ordinary Differential Equations. Elsevier North-Holland, Inc.

iii. Simmons, George F., & Krantz, Steven G. (2015). Differential Equations. McGrawHill Education. Indian Reprint.

iv.Strogatz, Steven H. (2009). Nonlinear Dynamics and Chaos (2nd ed.). Perseus Book

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