STRUCTURE AND SYLLABUS
of
B. Sc. (Honours) in Mathematics

(As recommended by the Board of Studies (BOS) for Mathematics on 10th March, 2018)
(w. e. f. Academic Session 2018 -2019)

Under
CHOICE BASED CREDIT SYSTEM
(CBCS)

Department of Mathematics
Siksha Bhavana
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COURSE STRUCTURE FOR CHOICE BASED CREDIT SYSTEM (CBCS) IN B.SC. (HONOURS) MATHEMATICS

SEMESTER	**CORE COURSE (14)**	**ABILITY ENHANCEMENT COMPULSORY COURSE (AECC) (2)**	**SKILL ENHANCEMENT COURSE (SEC) (2)**	**DISCIPLINE SPECIFIC ELECTIVE (DSE) (4)**	**GENERIC ELECTIVE (GE) (4)**
SEM I	CCMA-1 (ANALYSIS-I) (CREDIT 6) CCMA-2 (ALGEBRA –I) (CREDIT 6)	AECC-1 (MODERN INDIAN LANGUAGE) (CREDIT 2) TAGORE STUDIES-1 (CREDIT 4)			GEMA-1 **(CALCULUS)** (CREDIT 6)
SEM II	CCMA-3 (ANALYSIS-II AND ALGEBRA-II) (CREDIT 3+3=6) CCMA-4 (GEOMETRY AND VECTOR CALCULUS) (CREDIT 3+3=6)	TAGORE STUDIES-2 (CREDIT 4)			GEMA-2 **(INTRODUCTORY ALGEBRA)** (CREDIT 6)
SEM III	CCMA-5 (ANALYSIS-III) (CREDIT 6) CCMA-6 (ALGEBRA –III) (CREDIT 6) CCMA-7 (DIFFERENTIAL EQUATIONS-I) (CREDIT 6)	AECC-2 (ENVIRON MENTAL SCIENCE) (CREDIT 2)	SECMA-1 (BOOLEAN ALGEBRA AND CIRCUIT DESIGN) (CREDIT 2)		GEMA-3 **(DIFFERENTIAL EQUATIONS AND ITS APPLICATIONS)** (CREDIT 6)
SEM IV	CCMA-8 (ANALYSIS-IV AND DIFFERENTIAL EQUATIONS-II) (CREDIT 3+3=6) CCMA-9 (MECHANICS-I) (CREDIT 6) CCMA-10 (MATHEMATICAL PROBABILITY) (CREDIT 6)		SECMA-2 (TENSOR CALCULUS) (CREDIT 2)		GEMA-4 **(LINEAR PROGRAMMING PROBLEM AND NUMERICAL METHODS)** (CREDIT 6)

SEM V	CCMA-11 (ANALYSIS-V AND DIFFERENTIAL EQUATIONS-III) (CREDIT 3+3=6)			DSEMA-1 (MECHANICS-II) (CREDIT 6)	
	CCMA-12 (NUMERICAL ANALYSIS) (CREDIT 6)			DSEMA-2 (LINEAR PROGRAMMING PROBLEM, GAME THEORY AND MATHEMATICAL STATISTICS) (CREDIT 3+3=6)	
SEM VI	CCMA-13 (ANALYSIS-VI) (CREDIT 6)			DSEMA-3 (COMPUTER FUNDAMENTALS AND COMPUTER LABORATORY) (CREDIT 6)	
	CCMA-14 (ALGEBRA-IV) (CREDIT 6)			DSEMA-4 (MATHEMATICAL MODELLING) (CREDIT 6)	

Details of courses under B.Sc. (Honours) Mathematics

Sl. No.	Course/credit	Theory+Practical	Theory+Tutorial	Marks
1.	Core Course (14 Papers) Core Course Theory, Practical/Tutorial	1 Paper 1x4=4 1x2=2 06	13 Papers 13x5=65 13x1=13 78	**84x12.5=1050**
2.	Elective Courses (8 Papers) Discipline Specific Elective (4 Papers) Generic Elective/Interdisciplinary (4 Papers)		8 Papers 4x5=20 4x1=4 24 4x5=20 4x1=4 24	**48x12.5=600**

3.	Ability Enhancement Courses (4 papers) Ability Enhancement Compulsory Courses (AECC) (2 Papers) Skill Enhancement Courses (SEC) (2 Papers)		 2x2=4 04 2x2=4 04	**8x12.5=100**
4.	Tagore Studies (2 Papers)		2x4=8 08	**8x12.5=100**
	Total	**06**	**142**	**1850**

CORE COURSES

SEMESTER - I
CCMA-1 (Analysis-I) (Credit 6)

Functions of single real variable: Basic properties of limits, Bounded functions, Continuous functions, Elementary properties of continuous functions, Discontinuous functions, Classification of discontinuities, Concepts of differentiability and differential of a function.

Hyperbolic functions, Higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x, e^{ax+b}\cos x, (ax+b)^n \sin x, (ax+b)^n \cos x$,

Curve tracing in Cartesian coordinates, Tracing in polar coordinates of standard curves.

Indeterminate forms : L'Hospital's rule, Applications in business, economics and life sciences.

The continuum of real numbers: A brief idea of real numbers.
Elements of linear point set theory: Sets, Bounds, Limit points, Bolzano-Weierstrass theorem, Theorem of lub and glb of sets (Statements and implications), Archimedean Principle, Dense property.

Real sequences : Bounded sequences, Monotone sequences, Convergent sequences, Limit of a sequence, Theorem on limits of sequences, Cauchy's limit theorems, Theorem of nested intervals, Cauchy's sequence and Cauchy's general principle.

Mean Value Theorems: Rolle's theorem, Lagrange's and Cauchy's mean value theorems and applications, Darboux's theorem.

Reduction formulae, Derivations and illustrations of reduction formulae of the type
$\int \sin nxdx, \int \cos nxdx, \int \tan nxdx, \int \sec nxdx, \int (\log x)^n dx.$

Books Recommended:

1. L.J Goldstein, David Lay, N.I.Asmar, David I. Schneider, Calculus and Its Applications, Pearson, New International Edition, 2014.
2. S. N. Mukhopadhyay and A. Layek – Mathematical Analysis – Vol-I, U. N. Dhar & Sons. Pvt. Ltd., 2nd Edition.
3. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Wiley India Pvt. Ltd, 4th Edition.
4. Shantinarayan, P.K. Mittal, Integral Calculus, S. Chand Publishing, 10th Edition, 2012.
5. S. K. Mapa, Introduction to Real Analysis, Sarat Book Distributors, Revised 6th Edition.
6. R.K. Ghosh and K.C. Maity, An introduction to Analysis: Differential Calculus: Part-I, New Central Book Agency, 13th revised Edition, 2011.
7. K.C. Maity and R.K. Ghosh, An introduction to Analysis: Integral Calculus, New Central Book Agency, 2003.

SEMESTER - I
CCMA-2 (Algebra-I) (Credit 6)

Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications.

General properties of polynomials and equations. Descarte's rule of signs:positive and negative rule. Relation between the roots and the coefficients of equations. Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Algebraic solutions of the cubic and biquadratic equations.

The inequality involving AM$\geq$ GM$\geq$ HM, Cauchy-Schwartz inequality.

Systems of linear equations, homogeneous and non-homogeneous systems. Solving a linear system. Question of existence and uniqueness of solution.

Elementary row reduction and echelon forms, uniqueness of reduced echelon form. Pivot positions, basic and free variables. Existence and uniqueness theorem.

Vector equations, geometric description of R^2, algebraic properties of R^n. Linear combinations and spanning subset, geometric description of the subsets spanned by one or two vectors in R^3.

The matrix equation AX=b, conditions equivalent to existence of solution. Solution sets of linear systems, Parametric vector form of the solutions of homogeneous and nonhomogeneous system.

Applications of linear systems.

Linear dependence and independence, characterization of linearly dependent set. Equivalence of the linear independence of the columns of A and uniqueness of solution of AX=b.

Introduction to linear transformations, matrix of a linear transformation, geometric linear transformations.

Inverse of a matrix, equivalent characterizations of invertible matrices.

Subspaces of R^n, Null space and column space and linear transformations. Basis and dimension of subspaces of R^n, rank of a matrix.

Eigen values, Eigen vectors and characteristic equation of a matrix.

Books Recommended:

1. Titu Andreescu and Dorin Andrica, *Complex Numbers from A to Z,* Birkhauser, 2006.
2. W. S. Burnside and A. W. Panton, The Theory of Equations, Dublin University Press, 1954.
3. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory,* 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005**.**
4. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

SEMESTER - II
CCMA-3 (Analysis-II and Algebra-II) (Credit 3+3=6)
Unit-I : Analysis-II (Credit 3)

Taylor's and Maclaurin's theorems with different forms of remainder, Taylor's and Maclaurin's series, Expansion of functions $e^x, \sin x, \cos x, \log(1+x), (1+x)^n$

Maxima and Minima, Envelope, Asymptotes, Curvature, Concavity and convexity, Points of inflexion, Multiple points, Quadrature, Rectification, Volumes and Surfaces of Revolution.

Sub-Sequences : Existence of monotone subsequence, Cluster points, Bolzano-Weierstrass theorem for sequences, Limit superior and limit inferior and its properties.

Topology of real line : Open sets, closed sets, Neighbourhood of a point, Limit points, Closure and interior of a set, Structure of open sets, Open covering, Lindelöf covering theorem, Heine-Borel theorem and its converse.

Books Recommended:

1. S. N. Mukhopadhyay and A. Layek – *Mathematical Analysis – Vol-I* , U. N. Dhar & Sons. Pvt. Ltd., 2nd Edition,
2. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, Wiley India Pvt. Ltd, 4th Edition.
3. S. C. Malik & S. Arora, *Mathematical Analysis*, New Age International Publishers, 4th Edition, 2010.
4. S. K. Mapa, *Introduction to Real Analysis,* Sarat Book Distributors, Revised 6th Edition
5. R.K. Ghosh and K.C. Maity, *An introduction to Analysis: Differential Calculus: Part-I,* New Central Book Agency, 13th revised Edition, 2011.

Unit-II : Algebra-II (Credit 3)

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set.

Well-ordering property of positive integers, Principles of Mathematical Induction, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, prime numbers and statement of Fundamental Theorem of Arithmetic.

Linear congruences, complete set of residues, Chinese remainder theorem.
Fermat's little theorem, Wilson's theorem. Number theoretic functions, sum and number of divisors, Euler's phi-function, Euler's theorem, some properties of Euler's phi-function.

Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups.

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.

Books Recommended:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, NewDelhi, 1999.
4. Joseph J. Rotman, *An Introduction to the Theory of Groups*, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.
6. I. Niven, H. Zuckerman and H. L. Montgomary, *An Introduction to Theory of Numbers*, 5th Ed., John Wiley and Sons, 1991.
7. David M Burton, *Elementary Number Theory*, 7th Ed., Tata McGraw-Hill Education, 2012.

SEMESTER - II

CCMA-4 (Geometry and Vector Calculus) (Credit 3+3=6)

Unit – I : Geometry (Credit 3)

Geometry (Two dimensions)

Transformation of axes: Translation, Rotation, Invariants, Rigid motion, Oblique axes.

General equation of second degree: Classification of quadratic equations representing lines, Parabola, Ellipse, Hyperbola. Tangent and Normal, Poles and Polars. Normal forms.

Polar equations: Polar Co-ordinates, Polar equation of straight line, Conics, Tangent, Normal, Chord of contact.

Geometry (Three dimensions)

Sphere: Equation in different forms, Section of a sphere with a given plane, Section of two spheres.

Radical plane and line, Co-axial systems of spheres.

Cone: Cone with vertex at origin, Condition for general equation of second degree to represent a cone, Right circular cone, Intersection of cone by a plane, Condition for three mutually perpendicular generators.

Conicoids: Paraboloid, Ellipsoid, Hyperboloid and their tangent planes and normals.

Generating Lines: Ruled surfaces, Generating lines of hyperboloid of one sheet, Hyperbolic paraboloid, Properties of generators, Condition for a straight line to be a generator of a given conicoid.

Other Co-ordinate systems: Spherical polar co-ordinates, cylindrical polar co-ordinates.

Books Recommended:

1. E. H. Askwith, The analytical geometry of the conic sections, Radha Publishing House, Kolkata, 1988.
2. M. C. Chaki, A text book of analytical geometry, Calcutta Publishers, Kolkata.
3. S. L. Loney, The Elements of Co-ordinate Geometry, Macmillan and Company, London.
4. R. J. T. Bell, An elementary treatise on co-ordinate geometry of three dimensions, Macmillan India Ltd.
5. Shanti Narayan, Analytical solid geometry, S. Chand & Co. (Pvt.) Ltd, New Delhi.

Unit – II : Vector Calculus (Credit 3)

Products: Scalar products and vector products, Properties of scalar and vector products, Applications in geometrical problems.

Limit and continuity of vector functions.

Vector Differentiation: Derivative of a vector function and its properties. Tangent and normal vectors. Serret-Frenet formula.
Directional derivative, gradient, divergence , curl, Laplacian and their properties. Applications.

Vector Integration: Line integrals, surface integrals, volume integrals,
Green's theorem, Stokes' theorem, Gauss's divergence theorem. Applications.

Orthogonal Curvilinear Coordinates:
Arc length, surface area and volume element in curvilinear coordinate system.
Gradient, divergence, curl and Laplacian in curvilinear coordinate system**.**
Cylindrical Co-ordinate system, spherical polar coordinate system. Applications.

Books Recommended:

1. Vector Calculus, S. J. Colley. (Pearson)
2. Vector Calculus, J. E. Marsden and A. J. Tromba (Freeman, W. H. & Company)
3. Vector Analysis, M. R. Spiegel (Schaum's Outlines)
4. Vector and Tensor Analysis, U. Chatterjee and N. Chatterjee (Academic Publisher)
5. Vector Analysis, J.G. Chakravorty and P.R. Ghosh (U. N. Dhur & Sons)
6. Vector Analysis with Applications, A. A. Shaikh and S. K. Jana (Narosa Publishing House Pvt. Ltd., New Delhi)
7. A Text Book of Vector Analysis, Shanti Narayan (S. Chand Publishing)

SEMESTER - III
CCMA-5 (Analysis-III) (Credit 6)

Series: Convergence and Divergence, Series of non-negative terms, p-series.
Test for convergence : Comparison test, D'Alembert ratio test, Cauchy's root test, Kummer's test, Raabe's test, Logarithmic test, Gauss test.
Alternating series: Leibnitz's test, Absolute convergence, Conditional convergence.

Functions defined on a linear set : Properties of continuous functions, Uniform Continuity, Monotone functions and its points of discontinuity, Intermediate value property for derivatives.

Functions of bounded variations: Simple properties, Jordan decomposition theorem

Real Numbers as a section of rational numbers, Properties of real numbers, Dedekind's theorem, Theorem of existence of lub and glb, Equipotent sets, Schauder Bernstein's theorem, Countable and uncountable sets, Countability of the set of rational numbers and uncountability of real numbers.

Riemann integration: Inequalities of upper and lower sums, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two Definitions, Riemann integrability of monotone and continuous functions, Properties of the Riemann integral, Definition and integrability of piecewise continuous and monotone functions, Intermediate value theorem for Integrals, Fundamental theorems of Calculus.

Riemann-Stieltjes Integral: Definition and Properties, Existence of the integral, Stieltjes integral as a Riemann integral. Mean Value Theorems.

Books Recommended:

1. W. Rudin, Principles of Mathematical Analysis, TMH, Third Edition , Indian Edition, 2013.
2. T. M. Apostal, Mathematical Analysis, Narosa Book Disributors Pvt. Ltd., 2nd Edition, 2000.
3. S. C. Malik & S. Arora, Mathematical Analysis, New Age International Publishers, 4th Edition, 2010.
4, S. N. Mukhopadhyay and S. Mitra – Mathematical Analysis – Vol-II (U. N. Dhar & Sons. Pvt. Ltd.), 2014.
5. Konrad Knopp, Infinite sequences and series, Dover Publication, 1990.
6. Shanti Narayan, A course of Mathematical Analysis, S. Chand and Co.Ltd., 1st Edition, 2005.
7 . V.Karunakaran, Real Analysis, Perason Education, 2011.

SEMESTER - III
CCMA-6 (Algebra-III) (Credit 6)

Properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. Normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group. Order of a permutation, conjugates of a permutation.

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality.

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
7. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India,1999.
8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,* 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. D.A.R. Wallace, *Groups, Rings and Fields*, Springer Verlag London Ltd., 1998.

SEMESTER - III
CCMA-7 (Differential Equations-I) (Credit 6)

Ordinary Differential Equations:

Basic Concepts:

Definitions of ordinary differential equation (ODE).
Formation of ODEs by elimination of arbitrary constants.
Formation of ODEs from real-world problems.
Meaning of the solution of ODEs (Geometrical and Physical).
Concept of linear and nonlinear ODEs.
Concept of initial value problems and boundary value problems in ODEs.
Concept of direction field and isocline.

First Order ODEs of first Degree:

Existence and uniqueness theorem for 1st order and higher order differential equations (Statement only).
General solution and particular solution of 1st order IVP.
Separable equations and equations reducible to this form.
Homogeneous equations.
Non-homogeneous equations.
Exact equations and condition for exactness.
Integrating factor and methods of finding integrating factors.
Linear equations.
Equations reducible to 1st order linear equations.
Solution of 1st order ODE by variation of parameter.
Orthogonal and oblique trajectories.
Applications of 1st order differential equations.

Riccati's equation, Method of solving Riccati's equation.

First Order ODEs of Higher Degree:

Equations solvable for p.
Equations solvable for x.
Equations solvable for y.
Clairaut’s equation. Equations reducible to Clairaut’s form. Lagrange's Equation.
p-discriminant and c-discriminant relations. Node-locus. Cusp locus. Tac Locus.
Singular solution. Geometrical significance of singular solutions.

Higher Order Linear ODEs with Constant Coefficients:

Linearly dependent and independent solutions.
Wronskian and its properties.

General solution of homogeneous equation of second order.
Principle of superposition for homogeneous equation.
Finding out Particular Integrals (P.I.) by symbolic operator D.
Solution of higher order ODEs by variation of parameters.
Applications of higher order differential equations.

Higher Order Linear ODEs with Variable Coefficients:

Cauchy-Euler homogeneous equations. Criterion of an exact differential equation, linear and nonlinear exact equations.

Books Recommended:

1. Elementary Differential Equations, E. D. Rainville , P. E. Bedient, R. E. Bedient. (Pearson)
2. A First Course in Differential Equations with Modeling Applications, D.G. Zill (Cengage)
3. Differential Equations, S. L. Ross (Wiley)
4. Differential Equations, P. R. Ghosh and J. G. Chakraborty (U. N. Dhar & Sons)
5. An introduction to Differential Equations, R. K. Ghosh, K. C. Maity, (New Central)
6. Elementary Differential Equations and Boundary Value Problems, W. E. Boyce, and R. C. DiPrima (Wiley)
7. Theory of Ordinary Differential Equations, E.A. Coddington, N. Levinson (Tata McGraw-Hill)
8. Differential Equations- H. T. H. Piaggio (G. Bell and Sons)

SEMESTER - IV

CCMA-8 (Analysis-IV and Differential Equations-II) (Credit 3+3=6)

Unit - I : Analysis-IV (Credit 3)

Functions of Several Variables: Limit and Continuity, Partial derivatives, Homogeneous Functions and Euler's Theorem, Differentiability, Chain rules, Total differentials, Schwarz's and Young's theorems, Theorem of existence and uniqueness of implicit functions, Jacobians and their simple properties, Statement of inversion theorem, Mean value theorem, Taylor's theorem, Maxima, Minima and saddle points, Lagrange's multiplier method.

Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, cylindrical and spherical co-ordinates.

Books Recommended:

1.K.C. Maity and R.K.Ghosh, An introduction to Analysis, Integral Calculus, Books and Allied (P) Ltd.
2. R.R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd.
3. P.C. Bhakta, A Course of Real analysis, Sarat Book Distributors.
4. David. V. Widder, Advanced Calculus, Prentice Hall of India Private Limited
5.S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Ltd. Publishers.

Unit – II : Differential Equations-II (Credit 3)

Second order ODEs with variable coefficients:
Change of dependent variable, Change of independent variable, Reduction to normal form, Factorization of the operators, Reduction of order.

Simultaneous linear differential equations:
Methods of solving simultaneous equations of Type-I.
Methods of solving simultaneous equations of Type-II.
Geometrical Interpretation.

Total differential equations:
Conditions for integrability.
Methods of solving total differential equations.
Geometrical Interpretation.

Series solution of ODEs:
Ordinary point, series solution at an ordinary point. Singular point, series solution about regular singular point: The method of Frobinious, Solutions of Bessel's and Legendre's equations.

Systems of linear differential equations:
Types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two equations in two unknown functions.

Books Recommended:

1. Differential Equations, S. L. Ross (Wiley)
2. Differential Equations: J. G. Chakraborty and P. R. Ghosh (U. N. Dhar & Sons)
3. Differential Equations with Applications and Historical Notes, G. F. Simmons (CRC Press, Taylor and Francis Group)
4. Elementary Differential Equations and Boundary Value Problems, W. E. Boyce and R. C. DiPrima (Wiley)
5. Differential Equations and Boundary Value Problems: Computing and Modeling, C. H. Edwards and D. E. Penny (Pearson Education India)

SEMESTER - IV
CCMA-9 (Mechanics-I) (Credit 6)
Unit – I : Dynamics of a particle (Credit 3)

1. Fundamental definitions and principles.
2. Motion in a straight line; Harmonic oscillator; Damped forced oscillation.
3. Motion in a plane: Tangential and Normal Accelerations; Radial and Cross-radial accelerations; Path for a given law of force.
4. Motion of a particle under central forces; Planetary motion.
5. Motion in a resisting medium.

Books Recommended:

1. S L Loney – An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies (McGraw-Hill)
2. F Chorlton – A Text Book of Dynamics, (John Wiley & Sons, New York) 2nd Edition, 1983.
3. A. S. Ramsey – Dynamics (Vols. I & II) , (Cambridge, 1973).
4. Murray Spiegel – Theoretical Mechanics (Schaum's outline series).

Unit – II : Statics (Credit 3)

1. Coplanar forces: Conditions of equilibrium; Astatic equilibrium and Astatic centre.
2. Principle of virtual work for a single particle and rigid body, Examples.
3. Forces in three dimensions: Moment of a force about a line; Axis of a couple; Resultant of any couples acting on a body; Conditions of equilibrium of a system of forces acting on a body; Poinsot's central axis; Wrench, Pitch, Intensity and Screw.

Books Recommended:

1. S. L.Loney-An Elementary Treatise on Statics, Radha Publishing House, Kolkata.
2. M.C.Ghosh-Analytical Statics, Sreedhar Prakashani, Kolkata.
3. A.S.Ramsay-Statics
4. H.Lamb-Statics and Hydrostatics
5. Murray Spiegel-Theoretical Mechanics, McGraw Hill-Schaum.

SEMESTER - IV
CCMA-10 (Mathematical Probability) (Credit 6)

Definition and basic concepts: Random experiments, events --- simple and compound, event space, examples of the same. Probability of an event --- classical definition of probability --- limitations; statistical regularity --- frequency definition of probability. Fundamental axioms --- axiomatic definition of probability --- properties; general addition rule --- the match problem; conditional probability --- general multiplication rule --- Polya's urn problem; Bayes' theorem --- Laplace's urn problem; Stochastic independence. Compound experiments --- Repeated independent trials --- Bernoulli trials, Binomial law. Poisson approximation to the binomial law, Poisson trials. The multinomial law. Infinite sequence of Bernoulli trials. Markov chains.

Probability distributions: Random variables --- continuous and discrete; Distribution functions and their properties --- continuous and discrete distributions in one and two dimensions; Bivariate continuous distribution; conditional distributions; transformation of random variables in two dimensions. Mathematical expectations --- Mean, variance and moments of different distributions; Moment generating function of a random variable; Characteristic functions; Median, mode. Expectation for bivariate distributions, covariance, correlation coefficient; Joint characteristic function, Multiplication rule for expectations; reproductive properties of some distribution functions; Conditional expectation. Regression lines and parabolic curve fittings.

Convergence in probability: Tchebycheff's inequality and convergence in probability, Tchebycheff's theorem; Bernoulli's theorem; Law of large numbers.

Some ideas on limit theorem: De-Moivre-Laplace limit theorem, Asymptotically normal distribution, Central limit theorem and limit theorem for characteristic functions.

Stochastic processeses: Markov process. Poisson process. Pure-birth process. Birth and Death process. Formulation of simple models and their analyses.

Books Recommended:

1. Amritava Gupta, Groundwork of Mathematical Probability and Statistics, Academic Press
2. W. Feller, An Introduction to Probability Theory and its Applications, Vols. I and II, Wiley Eastern
3. J. V. Uspensky, Introduction to Probability, Tata McGraw-Hill.
4. B.V. Gnedenko, The Theory of Probability, Tata McGraw-Hill.

SEMESTER - V

CCMA-11 (Analysis-V and Differential Equations-III) (Credit 3+3=6)

Unit – I : Analysis-V (Credit 3)

Improper integrals; Convergence and Absolute Convergence, Cauchy's Criterion (Statement only), Comparison tests, Abel's and Dirichlet's tests, Convergence of Beta and Gamma functions.

Pointwise and uniform convergence of sequence of functions, Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.
Series of functions : Theorems on the continuity and derivability of the sum function of a series of functions, Cauchy criterion for uniform convergence and Weierstrass M-Test.

Power series: Radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series, Abel's Theorem, Weierstrass Approximation Theorem.

Fourier Series: Determination of Fourier coefficients, Statement of Dirichlet's conditions of convergence, Sine and cosine series.

Differentiation under integral sign, Leibnitz rule.

Books Recommended:

1. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Ltd. Publishers.
2. S.K. Mapa, Introduction to Real Analysis, Sarat Book Distributors.
3. K.C. Maity and R.K. Ghosh, An introduction to Analysis,(Part-I) Differential Calculus, Books and Allied (P) Ltd.
4. R.R. Goldberg, Method of Real analysis, Oxford and IBH Publishing Co.
5. D. Soma Sundaram and B. Choudhury, A first Course in Mathematical Analysis, Norosa Publishing House.
6. Robert G. Bertle and Donald R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, Inc.
7. K.C. Maity and R.K. Ghosh, An introduction to Analysis (Part II) Differential Calculus, Books and Allied (P) Ltd.

Unit – II : Differential Equations-III (Credit 3)

Partial Differential Equations (PDEs):

First order PDEs:
Introduction. Formation of PDE and geometrical interpretation. Genesis of first order PDEs. Classification of integrals. Canonical forms of first order linear equations. Method of separation of variables for solving first order PDEs. Cauchy's problem for first order PDEs. The Cauchy-Kowaleewskaya theorem. Lagrange's method to solve quasi-linear PDEs.

Compatible systems of first order PDEs.

Charpit's method to solve a nonlinear PDEs. Integral surface through a given curve.

Monge cone, Characteristic strip, Cauchy's method of characteristic.

Second order PDEs:
Second order PDEs with constant coefficients. Simple techniques to solve second order PDEs with variable coefficients.

Applications of PDEs.

Books Recommended:

1. An Elementary Course in Partial Differential Equations, T. Amarnath, (Narosa)
2. Partial Differential Equations, F. Prasad and R. Ravindran (New Age International Publishers)
3. Elements of Partial Differential Equations, I. N. Sneddon, (Tata McGraw-Hill)
4. Linear Partial Differential Equations for Scientists and Engineers, Tyn Myint-U, L. Debnath (Birkhäuser)
5. Nonlinear Partial Differential Equations for Scientists and Engineers, L. Debnath (Birkhäuser)

SEMESTER - V
CCMA-12 (Numerical Analysis) (Credit 6)

Accuracy of Approximate Calculations:
Approximate numbers, Significant figures, Rounding off numbers, Absolute, Relative and Percentage errors, General formula for errors and its applications, Propagation of round off errors in arithmetic operations. Inherent errors in numerical computations.

Interpolation:
Weierstrass' approximation theorem (statement only), Polynomial interpolation, Existence and uniqueness of interpolating polynomial, Derivation of the error in interpolation , Finite differences: Forward and Backward, Difference operators (Forward and Backward), Shifting operator, Properties and Relations between these operators; Difference table, Error in the entry values -noise level, Differences of a polynomial, Newton's forward and backward interpolation formulae, Lagrange's interpolation formula, Inverse interpolation.

Numerical Differentiation: Differentiation formulae based on Newton's forward and backward interpolation formulae. Error in differentiation .

Numerical Integration:
Newton-Cotes quadrature formula (without error), Degree of precision, Trapezoidal rule, Simpson's one-third rule, Weddle's rule, Composite rules, Derivation of the error for Trapezoidal and Simpson's 1/3 rd rules.

Numerical Solution of Nonlinear Equations:
Tabulation method, Bisection method, Regula-Falsi Method, Fixed point iteration method, Newton-Raphson method, Geometrical significance and convergence of these methods, Graeffe's root-squaring method.

Numerical Solution of a System of Linear Equations:
Directs methods: Gaussian elimination, Gauss-Jordan elimination; Operation counts, Matrix inversion.
Iterative methods: Jacobi, Gauss-Seidel and their convergence.

Initial Value Problems: Solution of first order ordinary differential equations: Picard's method, Taylor's method, Euler's method and its modified form (concept of Predictor-Corrector method), Error estimate and its convergence, Runge-Kutta method of second and fourth orders (derivation of second order formula only) and their significance.

Books Recommended:

1. P. Niyogi, Numerical Analysis and Algorithms, Tata McGraw-Hill Publishing Company Limited, (2003).
2. A. Gupta and S.C. Bose, Introduction to Numerical Analysis, Academic Publisher, (1989).
3. M.K. Jain, S.R. K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Limited, (1991).
4. N. Dutta and R.N. Jana, Introductory Numerical Analysis, Shreedhar Prakashani, (2001).
5. J. B. Scarborough, Numerical Mathematical Analysis, Oxford and IBM Pub. Co. (1966).

SEMESTER - VI
CCMA-13 (Analysis-VI) (Credit 6)

Unit – I : Complex Analysis (Credit 3)

Functions of a Complex Variable: Limits of Functions, Theorems on Limits, Continuous Functions, Continuity in terms of Real and Imaginary parts.

Differentiability of Functions: Definition and Examples, The Cauchy-Riemann Equations, Sufficient conditions for differentiability, Cauchy- Riemann equations in polar form.

Analytic Functions: Definition and examples, Harmonic functions, Conjugate harmonic functions, Construction of an analytic function whose real part is given (Related theorem is to be assumed).

Sequences and Series: Sequences, Limit and limit points of a sequence, Cauchy's General Principle of convergence, Infinite Series, Absolutely convergent series. Stereographic projection and extended complex plane.

Bilinear Transformations: Definition, Cross ratio, Fixed points of a bilinear transformation, Normal form of a bilinear transformation, Inverse points, Circles, Orientation principle.

Definite integrals of functions. Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals. Cauchy-Goursat theorem (Statement only), Cauchy integral formula. Derivatives of Cauchy integral formula
Liouville's theorem and the fundamental theorem of algebra

Unit – II : Metric Spaces (Credit 3)

Metric Spaces: Definition, Example of Metric Spaces.
Closed and Open sets: Convergence of a sequence, Spherical Neighbourhood, Closure of a Set, Closed Sets, Open Sets, Interior and Boundary Points.
Complete Metric Spaces: Cauchy sequences, Example of complete metric spaces, Example of incomplete metric Spaces, Diameter of a set, Bounded Set, Cantor's Intersection Theorem, Baire's category theorem , Isometry, Completion of metric spaces.
Continuous mappings, sequential criterion and other characterizations of continuity Connectedness, Connected subsets of R.
Fixed Point Theorems: Contraction mapping, Idea of fixed point, Banach's contraction principle Theorem and its simple applications.

Books Recommended:

1. Complex Analysis, B. K. Lahiri, The World Press Private Limited.
2. Complex Variables and Applications, R.V. Churchil and J. W. Brown, McGraw-Hill, New York.
3. Elements of Complex Analysis, Sobhakar Ganguly, Academic Publisher.
4. An introduction to the theory of functions of a Complex Variable, E.T.Copson, Oxford University Press.
5. Complex Analysis, L. F. Ahlfors, McGraw-Hill, New York.
6. Metric Spaces, B. K. Lahiri, The World Press Private Limited.
7. Introduction to Topology and Modern Analysis, G. F. Simmons, McGraw-Hill.
8. Metric Spaces, P. K. Jain and Khalil Ahmad, Narosa Publishing House.
9. Metric Spaces, M. N. Mukherjee, Academic Publishers.

SEMESTER - VI
CCMA-14 (Algebra-IV) (Credit 6)

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

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups.

Ring homomorphisms, properties of ring homomorphisms, First, Second and Third isomorphism theorems,field of quotients.

Linear transformations, null space, range, rank and nullity of a lineartransformation, Isomorphisms, invertibility and isomorphisms, Isomorphism theorems.

Matrix representation of a linear transformation, algebra of linear transformations, change of coordinate matrix, similarity of matrix representations.

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators.

Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem.

The adjoint of a linear operator, least squares approximation, minimal solutions to systems of linear equations, normal and self-adjoint operators, orthogonal projections and spectral theorem.

Books Recommended:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002**.**
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
5. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
6. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
7. S.H. Friedberg, A.L. Insel and L.E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., 2004.

SKILL ENHANCEMENT COURSES

SEMESTER - III

SECMA-1 (Boolean Algebra and Circuit Design) (Credit 2)

Boolean Algebra-definition and basic concepts-principle of duality, uniqueness of complement, absorption, idempotency, De-Morgan's law. Boolean expression-different standard forms and their representations. Minimization of Boolean expressions-Karnaugh map method and Quine-McClusky's method. Boolean functions and their representations.

Number systems-binary, ternary, octal, decimal, hexadecimal-representation and their conversions. Complement of a number-radix complement and diminished radix complement. Complemented arithmetic-addition, subtraction, multiplication and division.

Implementation of Boolean functions-logic gates-AND, OR, NOT, NAND, NOR gates. Combinational circuit design-comparator, code-convertor. Single bit memory elements-flip-flops. Sequential ciruit design-Counters, Shift registers.

Books Recommended:

1. J.E.Whitesitt, Boolean algebra and its applications, Dover Publications, Inc., New York.
2. M.H.Stone, The theory of representations for Boolean Algebras, Transactions of American Mathematical Scoiety, 40, 1936, 37-111.
3. M. Phister Jr., Logical design of digital computers, D. Van Nostrand, 1955.
4. R.M.M.Oberman, Digital circuits for binary arithmetic, Macmillan, 1979.
5. B.Holdsworth, Digital logic design, Affiliated East-West Press Pvt. Ltd. 1991.

SEMESTER-IV
SECMA-2 (Tensor Calculus) (Credit 2)

Contravariant and Covariant vectors and tensors. Mixed Tensors. Algebra of tensors. Quotient laws. Fundamental and Associate tensors. Christoffel's symbols. Covariant differentiation of vectors and tensors. Riemann-Christoffel tensors. Permutation tensors.

Books Recommended:

1. I.S. Sokolnikoff, Tensor Analysis, Theory and applications to Geometry and Mechanics of Continua, John Wiley & Sons Inc.
2. B. Spain, Tensor Calculus, Oliver & Boyd.
3. T. J. Willmore, An introduction to Differential and Riemann Geometry, Oxford University Press.
4. J. A. Thorpe, Introduction to Differential Geometry, Springer-Verlag.
5. B.O. Neil, Elementary Differential Geometry, Academic Press.
6. S. Sternberg, Lectures on Differential Geometry. Prentice-Hall.
7. M.C. Chaki, Tensor Calculus, Calcutta Publishers.

DISCIPLINE SPECIFIC ELECTIVES
SEMESTER - V
DSEMA-1 (Mechanics-II) (Credit 6)
Unit – I : Dynamics of a rigid body (Credit 4)

1. Kinetics of a rigid body: Moments and products of inertia of a rigid body; Simple cases of moments of inertia; Momental ellipsoid; Principal axes, Examples.
2. Motion of a rigid body: D'Alembert's principles; General equations of motion of a rigid body in space.
3. Motion about a fixed axis, Examples; Compound pendulum; Motion about a fixed axis under repulsive forces; Centre of percussion.
4. Motion in two dimensions: Motion in a plane under finite forces; Kinetic energy, moment of a force and angular momentum.

Books Recommended:

1. S. L. Loney – An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies (McGraw-Hill)
2. F. Chorlton – A Text Book of Dynamics, (John Wiley & Sons, New York) 2^{nd} Edition, 1983.
3. A. S. Ramsey – Dynamics (Vols. I & II) , (Cambridge, 1973).
4. Murray Spiegel – Theoretical Mechanics (Schaum's outline series)

Unit – II : Hydrostatics (Credit 2)

1. Pressure at a point in a fluid
2. Pressure of heavy fluids in equilibrium under gravity.
3. Equilibrium of fluids in a given field of force: Pressure gradient; Surface of equi-pressure; Condition of equilibrium for a system of given forces.
4. Thrust on plane surfaces.
5. Centre of pressure; Depth of centre of pressure of a plane area under gravity; Effect of additional depth without rotation.

Books Recommended:

1. W.H.Besant and A.S.Ramsay-A Treatise on Hydromechanics, Part -1 Hydrostatics, ELBS and G Bell and Sons Ltd., London.
2. H.Lamb-Statics and Hydrostatics
3. J.M.Kar-Hydrostatics, K P Basu Publishing Co.
4. Murray Spiegel-Theoretical Mechanics, McGraw Hill-Schaum.

SEMESTER - V
DSEMA-2 (Linear Programming Problem, Game Theory and Mathematical Statistics) (Credit 6)
Unit – I : Linear Programming Problem, Game Theory (Credit 3)

Introduction to Linear Programming Problem (LPP), Mathematical formulation of L.P.P., Graphical method of solution, Nature of solutions.

Basic Concepts: Basis, replacing a vector in a basis. Solution of a system of linear equations- Basic solution, Basic feasible solution. Convex set- Extreme points. Matrix formulation of L.P.P. Standard form of LPP. Relation among the optimal solution of a LPP, Basic feasible solution and Extreme point of the convex set of all feasible solutions.

Fundamental theorem of LPP, Theory of Simplex method, Reduction of a feasible solution to a B.F.S.; improving a basic feasible solution; Optimality checking, Unboundedness; Existence of alternative optimal solution. Simplex algorithm and the simplex tableau, Slack, Surplus and Artificial variables-introduction and its subsequent removal, Inconsistency and redundancy. Two-phase Simplex method.

Concept of degeneracy- cycling, Methods of solving L.P.P. involving Degeneracy and Cycling. Charnes' perturbation method. Problems having degeneracy at (i) the initial stage, (ii) a subsequent stage.

Concept of Duality- Its economic interpretation. Construction of dual. The relation between feasible solution of dual and primal problems. Fundamental properties of Dual Problems. Weak duality theorem, Strong duality theorem, Fundamental duality theorem. Computational aspects of Simplex method and duality. Dual simplex method-The Algorithm and Difference between Regular Simplex method and Dual Simplex method.

Transportation Problems-Mathematical Formulation; finding an initial basic feasible solution; The Transportation Algorithm-checking for optimality, improving a B.F.S. Degeneracy in Transportation Problem. Resolution of degeneracy in the initial stage. Resolution of degeneracy during solution stage. Unbalanced Transportation Problems. Maximization in Transportation Problems.

Assignment Problems-Mathematical Formulation; Hungarian Assignment Method, Unbalanced Assignment Problem. Maximization in Assignment Problem. Travelling Salesman Problem.

Game theory: Definition and basic concepts. The maximin and minimax principle. Saddle point – its existence. Games without a saddle point – mixed strategies. Solution of rectangular games with mixed strategy. Concept of dominance – general rules. Two person zero-sum 2xn or nx2 games – Graphical and Algebraic methods of solution. Formulation of game problem as a LPP and its solution. Fundamental theorem of rectangular game.

Books Recommended:

1. Linear Programming and Game theory, Chakraborty & Ghosh; Moulik Library, Kolkata.
2. Operations Research: An introduction, Hamdy A. Taha, 10th Edition, Pearson, 2011.
3. Operations Research: Principles and Practice-Ravindran, Phillips, Solberg; Wiley India.
4. Operations Research-Richard Bronson, Govindasami Naadimuthu, Tata McGraw-Hill.
5. Principles of Operations Research, Harvey M. Wagner, PHI.
6. Operations Research: Theory and Applications, J.K.Sharma, Macmillian India Ltd.
7. An introduction to Linear Programmig, Mukhopadhyay, Maity & Mazumdar, Kalimata Pustakalaya, Kolkata.
8. Game Theory: A nontechnical introduction, M. D. Davis, Basic Books, N.Y.
9. Introduction to the theory of games, J.C.C. Mckinsey, Tata McGraw-Hill B.C.,N.Y.
10. Linear Programming, S.I.Gass, Tata McGraw-Hill B.C., N.Y.

Unit – II : Mathematical Statistics (Credit 3)

Random samples: Basic concept of populations and random samples, Distribution of the sample, table and graphical representations, Sample characteristics.

Sampling distribution: Sampling distribution of a statistic (mean and variance), Estimates-Consistent and Unbiased, Exact sampling distribution of the Normal population.

Some ideas on Special distribution: $\chi 2$, t and F distributions.

Statistical Inference I: Estimation of parameters: Methods of finding point estimators of parameters --- moment method, maximum likelihood method, least square method. Criterion for evaluating goodness of estimators --- unbiased estimator, relatively efficient estimator, minimum variance unbiased estimator, sufficient estimator, consistent estimator. Interval estimation. Confidence intervals for Binomial and Normal Population parameters. Approximate Confidence Interval for Parameter with MLE. Criteria for Evaluating Confidence Intervals.

Statistical Inference II: Testing of hypothesis. Statistical hypothesis --- Simple and Composite; Two types of errors. Methods of finding tests --- Likelihood Ratio Tests, Invariant Tests, Bayesian Tests and Union-Intersection and Intersection-Union Tests. Best critical region for simple hypothesis, Neyman-Pearson theorem. Application to Normal population. Methods for evaluating the goodness of a test procedure --- Powerfulness, Unbiasedness and Invariancy and Local Powerfulness. Goodness of fits tests --- Pearson Chi-squared test.

Books Recommended:

1. Aitken, A. C. (1944). Statistical Mathematics. 3rd edn. Edinburgh and London: Oliver and Boyd.
2. Gupta, A. (2015). Groundwork of Mathematical Probability and Statistics. Academic Press.
3. Fisher, R. A. (1922), On the mathematical foundations of theoretical statistics. Reprinted in Contributions to Mathematical Statistics (by R. A. Fisher) (1950), J. Wiley & Sons, New York.
4. Hogg, R. V. and Craig, A. T. (1978). Introduction to Mathematical Statistics. New York: Macmillan.
5. Taylor, L. D. (1974). Probability and Mathematical Statistics. New York: Harper & Row.
6. Sahoo, P. (2013). Probability and mathematical Statistics. Louisville, USA.
7. Gupta, S. C. and Kapoor, V. K. (2000) Fundamentals of Mathematical Statistics, Sultan Chand and Sons, Delhi.
8. Das, N. G. (2008) Statistical Methods (Part-II), McGraw Hill Education.

SEMESTER - VI

DSEMA-3 (Computer Fundamentals and Computer Laboratory) (Credit 6)

DSEMA – 3A : Computer Fundamentals (Credit 2)

Computer Language: Algorithm, Flowchart, Concept of programming languages, Machine language, Assembly language, Low and high-level languages, Interpreter, Compiler, Assembler. Source and Object programs.

Programming Language in Fortran: Characters, Constants and their classifications; Variables and their classifications. Assignment statement, Arithmetic statement, Control statements: Logical IF, Block IF, Arithmetic IF. Data statement, Input / Output statements, STOP and END statements, DO statement, Computed GOTO statement, Continue statement. Type declaration statements, Executable and non-executable statements. Rules for the usage of DO statement. Arithmetic statement function.

Subscripted variables: Concept of array variables in programming language. DIMENSION statement, Simple programs. Sub-program: Concept of function sub-program, purpose of sub-program, Subroutines, purpose of using subroutines. Format specifications, Format statement.

DSEMA – 3B : Computer Laboratory (Credit 4)

Fortran programming for

Problem-I: Interpolation (taking at least six points) by

(a) Newton's Forward Difference formula
(b) Newton's Backward Difference formula
(c) Lagrange's formula

Problem-II: Numerical Differentiation by

(a) Newton's Forward Difference Interpolation formula
(b) Newton's Backward Difference Interpolation formula

Problem-III: Solution of system of linear equations by

(a) Gauss elimination method (excluding pivotal condensation)
(b) Gauss-Seidel iterative method

Problem-IV: Finding a real root of an equation by

(a) Fixed-point iteration method
(b) Bisection method
(c) Regula-Falsi method
(d) Newton-Raphson method

Problem-V: Numerical Integration (taking at least ten sub-intervals) by

(a) Trapezoidal rule
(b) Simpson's $1/3^{rd}$ rule
(c) Weddle's rule

Problem-VI: Solution of a first order ordinary differential equation by

(a) Modified Euler's method

(b) Fourth order Runge-Kutta method

Books Recommended:

1. Computer Programming in Fortran 90 and 95, V. Rajaraman, Prentice-Hall of India Private Limited, New Delhi, India (2006).
2. Programming with Fortran, Ram Kumar, Tata McGraw-Hill Publishing Company Limited, New Delhi, India (1990).

SEMESTER - VI
DSEMA-4 (Mathematical Modelling) (Credit 6)

Introduction, Emergence of Mathematical Modeling on simple situations; Basic steps of Mathematical Modeling - its needs; Process / technique of Mathematical Modeling; Some characteristics of Mathematical Models; Importance of the usage of mathematical models over physical models; Classification of mathematical models; Deterministic and Stochastic models and their distinctive features with illustrations; Limitations of Mathematical Modeling.

Physical System: Formulation of some mathematical models and their analyses for (i) harmonic oscillator, (ii) damped and forced oscillator. Simple pendulum; Compound pendulum; Electric circuits (L-R, R-C, L-R-C).

Derivation of Heat equation, Wave equation (linear wave and non-linear wave), Laplace equation.

Boundary value problems for infinite and semi-infinite string.

Autonomous dynamical system and its classification, Jacobian matrix, System reducible to autonomous system, Time-dependent system, Fixed points and their characterization – node, saddle point, focus, centre and concept of limit cycle with simple illustrations, Stability of fixed points.

Biological System: Population Models: (i) Single-species models – Exponential, Logistic and Gompertz growth models; Stochastic birth and death processes; Discrete-time models. (ii) Interacting populations – A classical predator-prey model; Stability of equilibrium positions; Derivation of Lotka-Volterra model; Two competing species model and its stability analysis; Mutualism model and its stability. Harvest models and optimal control theory.

Diffusion and diffusion-reaction models: Fick's laws of diffusion; Diffusion equation – one and two dimensional forms; Predator-prey model with diffusion; Competition model with diffusion; Influence of diffusion on stability of both predator-prey and competition models.

Books Recommended:

1. Mathematical Models, Richard Haberman, Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632 (1977).

2. Elements of Mathematical Ecology, Mark Kot, Cambridge University Press (2003).

3. Introduction to Differential Equations with Dynamical System, Stephen L Campbell and Richard Haberman, Princeton University Press (2008).

4. Concept of Mathematical Modeling, W. Meyer, McGraw-Hill, New York (1994).
5. Mathematics for Dynamic Modeling, E. Beltrami, Academic Press, Orlando, Florida (1987).
6. Mathematical Modeling with case Studies, A Differential Equation Approach using Maple and Matlab, Belinda Barnes and Glenn R. Fulford, Taylor and Francis Group (2009).
7. Differential Equations and Boundary Value Problems: Computing and Modeling, C. H. Edwards and D. E. Penny, Pearson Education India (2005).

GENERIC ELECTIVES
SEMESTER - I
GEMA-1 (Calculus) (Credit 6)

Unit - I : Differential Calculus

Rolle's theorem (Statement only). Lagrange's and Cauchy's mean value theorems. Taylor's and Maclaurin's theorems (Statement only). Necessary conditions for existence of Power series.
Expansion of functions --e^x, sin x, cos x, log (1+x), $(1+x)^n$.
Indeterminate forms , L'Hospital's rule.
Curve tracing in Cartesian and polar coordinates of standard curves , Maxima and Minima. Envelope. Asymptotes. Curvature. Concavity and convexity. Points of inflexion.
Functions of Several Variables: Limit and continuity. Partial derivatives. Differentiability. Statement of Schwarz's and Young's theorems. Homogeneous Functions. Euler's theorem (For functions of two variables).

Unit - II : Integral Calculus

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx\, dx$, $\int \cos nx\, dx$, $\int \tan nx\, dx$, $\int \sec nx\, dx$, $\int (\log x)^n\, dx$, $\int \sin^n x \cos^m x\, dx$.
Parameterizing a curve, Quadrature, Rectification, Volumes and Surfaces of Revolution.
Improper integrals, Beta function and Gamma function.

Unit – III : Vector Calculus

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.
Concepts of scalar and vector fields, Directional derivative. Gradient of a scalar field, Divergence and Curl of a vector field.
Line Integrals as integrals of vectors, circulation, irrotational vector, work done, conservative force. Surface integrals-parametric representations of a surface, area of a parametric surface.
Volume integrals. Statements and verifications of Green's theorem, Stokes' theorem and Gauss' Divergence theorem. Applications.

Books Recommended:

1. G. B. Thomas, M. D. Weir, J. R. Hass, Thomas Calculus , Pearson, 12th Edition, 2010.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
5. L.J Goldstein, David Lay, N.I.Asmar, David I. Schneider, Calculus and Its Applications, Pearson, New International Edition, 2014
6. Shantinarayan, P.K. Mittal, Integral Calculus, S. Chand Publishing, 10th Edition, 2012
7. Shantinarayan, Mathematical Analysis, S. Chand and Company Ltd, 1st Edition, 2005.
8. J. Edwards, Differential Calculus for Beginners, MacMilan, 1996.
9. B. Williamson, An Elementary Treatise on the Integral Calculus, D. Appleton and Co., 1977
10. A. A. Shaikh & S. K. Jana, Vector Analysis with Applications, Narosa Publishing House Pvt. Ltd., New Delhi, 2009.
11. L. Brand, Vector Analysis, Dover Publications Inc., 2006.
12. Shanti Narayan**,** A Text Book of Vector Analysis, S.Chand publishing, 19th Edition,2013.
13. M. Spiegel, S. Lipschutz, D. Spellman, Vector Analysis, Tata McGraw-Hill, 2nd Edition, 2009.

SEMESTER-II
GEMA-2 (Introductory Algebra) (Credit 6)

Complex numbers: Polar representation of complex numbers, n th roots of unity, De Moivre's theorem for rational indices and its applications.

Polynomials: General properties of polynomials, repeated roots and derivative of a polynomial.

Theory of equations: Relation between roots and coefficients of equations, symmetric functions, applications of symmetric function of roots. Transformation of equations.Solution of cubic and biquadratic equations.

System of linear equations and matrices : Solving system of linear equations, method of Gaussian eliminations. Row reduced echelon matrix, use of row reduced echelon matrix to solve a system of linear equations. Invertibility of coefficient matrix and its equivalent conditions.

Transpose of a matrix, diagonal, triangular, symmetric, skew-symmetric and orthogonal matrices.

Vectors in $\mathbf{R^n}$: Sum andscalar multiplication in$\mathbf{R^n}$**,** subspaces. Null space of a matrix.Generating set and linearly independent set, basis and dimension of a subspace.Geometry of the subspaces of $\mathbf{R^3}$.Row space and column space of a matrix, rank of a matrix.

Orthogonality in $\mathbf{R^n}$. Orthogonality of row space and null space of a matrix.Orthogonal and orthonormal basis in $\mathbf{R^n}$. Gram-Schmidt orthonormalization.

Vector spaces: Real and complex vector spaces, Examples viz. $\mathbf{C^n}$,$M_{m\times n}$**(R)**, $M_{m\times n}$(**C**), F[a,b], etc. Subspaces, linear independence, basis and dimension. Every linearly independent subset can be extended to a basis. [Emphasis to be given on finding basis and dimension of some spaces other than $\mathbf{R^n}$]

Eigen values, eigen vectors and diagonalization: Eigen values and eigenvectors of a square matrix over **R** and **C**. Characteristic polynomial. Eigen spaces, linear independence of eigen vectors.

Similarity of matrices and diagonalizability.Orthogonal diagonalization of symmetric matrices.

Books Recommended:

1. W. S. Burnside and A. W. Panton, The Theory of Equations, Dublin University Press, 1954.
2. Bernard Kolman and David R. Hill, Introductory Linear Algebra – An Applied First Course, Pearson Education (Indian Edition).
3. Howard Anton and Chris Rorres, Elementary Linear Algebra – Application Version.
4. David C. Lay, Linear Algebra and its Applications, Pearson Education (Indian Edition).
5. Gilbert Strang, Linear Algebra and its Applications, Brooks/Cole Cengage Learning (Indian Edition).

SEMESTER-III

GEMA-3 (Differential Equations and its Applications) (Credit 6)

Ordinary Differential Equations:

Basic Concepts:

Definitions of ordinary differential equation (ODE).
Formation of ODEs by elimination of arbitrary constants.
Formation of ODEs from real-world problems.
Meaning of the solution of ODEs (Geometrical and physical).
Concept of linear and nonlinear ODEs.
Concept of initial value problems and boundary value problems in ODEs.

First Order ODEs of first Degree:

Existence and uniqueness theorem for 1st order and higher order differential equations (Statement only).
General solution and particular solution of 1st order IVP.
Separable equations and equations reducible to this form.
Homogeneous equations.
Exact equations and condition for exactness.
Integrating factor and methods of finding integrating factors.
Linear equations.
Equations reducible to 1st order linear equations.
Orthogonal and oblique trajectories.
Applications of 1st order differential equations.

First Order ODE of Higher Degree:

Equations solvable for p, x, and y.
Clairaut's equation.
Singular solution.

Higher Order Linear ODEs with Constant Coefficients:

Linearly dependent and independent solution.
Wronskian and its properties.
General solution of homogeneous equation of second order.
Principle of super position for homogeneous equation.
Finding out Particular Integrals (P.I.) by symbolic operator D.
Solution of 2nd order ODEs by variation of parameters.
Linear simultaneous differential equations.
Applications of higher order differential equations.

Homogeneous Linear ODEs with Variable Coefficients:
Euler's Equation, Exact higher order ODEs and some special forms.

Partial Differential Equations (PDEs):

Definitions. Order and degree of partial differential equations. Concept of linear and non-linear partial differential equations. Formation of first order partial differential equations.
Linear partial differential equation of first order. Lagrange's method. Charpit's method.
Applications of partial differential equations.

Books Recommended:

1. Differential Equations, P. R. Ghosh and J. G. Chakraborty (U. N. Dhar & Sons)
2. Elementary Differential Equations, E. D. Rainville , P. E. Bedient, R. E. Bedient. (Pearson)
3. A First Course in Differential Equations with Modeling Applications, D.G. Zill (Cengage)
4. Introduction to Ordinary Differential Equations, S. L. Ross (Wiley)
5. Elementary Differential Equations and Boundary Value Problems, W. E. Boyce, and R. C. DiPrima (Wiley)
6. Theory of Ordinary Differential Equations, E.A. Coddington, N. Levinson (Tata McGraw-Hill)
7. Elements of Partial Differential Equations, I. N. Sneddon, (Tata McGraw-Hill)
8. Linear Partial Differential Equations for Scientists and Engineers, Tyn Myint-U, L. Debnath (Birkhäuser)
9. Nonlinear Partial Differential Equations for Scientists and Engineers, L. Debnath (Birkhäuser)

SEMESTER - IV

GEMA-4 (Linear Programming Problem and Numerical Methods) (Credit 6)

Unit – I : Linear Programming Problem (Credit 3)

Introduction: Linear Programming Problem (LPP), Mathematical formulation of L.P.P., Graphical method of solution, Nature of solutions.

Basic Concepts: Basis, replacing a vector in a basis. Solution of a system of linear equations- Basic solution, Basic feasible solution. Convex set- Extreme points. Matrix formulation of L.P.P. Standard form of LPP. Relation among the optimal solution of a LPP, Basic feasible solution and Extreme point of the convex set of all feasible solutions.

Fundamental theorem of LPP-Simplex method, Reduction of a feasible solution to a B.F.S.; improving a basic feasible solution; Optimality checking; Unboundedness; Existence of alternative optimal solution. Simplex algorithm and the simplex tableau; Slack, Surplus and Artificial variables-introduction and its subsequent removal; Inconsistency and redundancy. Two-phase Simplex method.

Concept of Duality- Its economic interpretation. Construction of dual. The relation between feasible solution of dual and primal problems. Fundamental properties of Dual Problems. Weak duality theorem, Strong duality theorem, Fundamental duality theorem. Computational aspects of Simplex method and duality. Dual simplex method-The Algorithm and Difference between Regular Simplex method and Dual Simplex method.

Transportation Problems-Mathematical Formulation; finding an initial basic feasible solution; The Transportation Algorithm-checking for optimality, improving a B.F.S. Degeneracy in Transportation Problem. Resolution of degeneracy in the initial stage. Resolution of degeneracy during solution stage. Unbalanced Transportation Problems. Maximization in Transportation Problems.

Assignment Problems-Mathematical Formulation; Hungarian Assignment Method; Unbalanced Assignment Problem. Maximization in Assignment Problem. Travelling Salesman Problem.

Books Recommended:

1. Linear Programming and Game theory, Chakraborty & Ghosh, Moulik Library, Kolkata.
2. Operative Research: An introduction, Hamdy A. Taha, Pearson.
3. Operations Research: Principles and Practice, Ravindran, Phillips, Solberg, Wiley India.
4. Operations Research, Richard Bronson, Govindasami Naadimuthu, Tata Mc Graw-Hill.
5. Principles of Operations Research, Harvey M. Wagner, PHI.
6. Operations Research: Theory and Applications, J.K.Sharma, Macmillian India Ltd.

Unit – II : Numerical Methods (Credit 3)

Approximate numbers. Significant figures, Rounding off numbers. Errors – Absolute, Relative and percentage errors. The general formula for errors and its applications

Finite differences, Difference table, propagation of error in a difference table. Differences of a polynomial.

Polynomial interpolation. Error in polynomial interpolation. Newton's forward and backward interpolation formulae. Lagrange's interpolation formula .

Numerical integration : Trapezoidal rule, Simpson's one-third rule. Composite rules. Geometrical significance. (No derivation of error term)

Numerical solution of algebraic and transcendental equations. Bisection method, Method of fixed point iteration, Newton Raphson's method. Geometrical significance and convergence.

Numerical solution of a system of linear equations : Iterative methods : Gauss Jacobi and Gauss Seidel.

Books Recommended:

1. P. Niyogi, Numerical Analysis and Algorithms, Tata McGraw-Hill Publishing Company Limited, 2003.
2. A. Gupta and S.C. Bose, Introduction to Numerical Analysis, Academic Publisher, 1989.
3. M.K. Jain, S.R. K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Limited, 1991.
4. N. Dutta and R.N. Jana, Introductory Numerical Analysis, Shreedhar Prakashani, 2001.
5. J. B. Scarborough, Numerical Mathematical Analysis, Oxford and IBM Pub. Co., 1966.

SEMESTER-I
AECC-1 (Modern Indian Language) (Credit 2)

SEMESTER-III
AECC-2 (Environmental Science) (Credit 2)

SEMESTER-I
Tagore Studies-1 (Credit 4)

SEMESTER-II
Tagore Studies-2 (Credit 4)