Learning Outcome based Curriculum Framework (LOCF)

For

Choice Based Credit System (CBCS)

Syllabus

B.Sc. (Honours) in <Mathematics>

w.e.f. Academic Session 2020-21

Kazi Nazrul University

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Preamble:

The LOCF (Learning Outcomes based Curriculum Framework) committee constituted by University Grants Commission (UGC) is pleased to submit its report concerning the syllabi for B.A./B.Sc. (Honours) Mathematics and B.A./B.Sc. with Mathematics as a subject. The committee discussed the framework of syllabi in its meetings and suggests the implementation of these syllabi in the Departments/Schools of Mathematics in Universities/Colleges/Institutes based on following facts:

1. The learning outcomes of each paper are designed so that these may help learners to understand the main objectives of studying the course.
2. This will enable learners to select elective papers depending on the individual inclinations and contemporary requirements.
3. The objectives of LOCF are to mentally prepare the students to learn Mathematics leading to graduate degree with honours in Mathematics or with Mathematics as a subject.
4. These syllabi in Mathematics under CBCS are recommended keeping in view of the wide applications of Mathematics in science, engineering, social science, business and a host of other areas.
5. The study of the syllabi will enable the students to be equipped with the state of the art of the subject and will empower them to get jobs in technological and engineering fields as well as in business, education and healthcare sectors.
6. The LOCF committee in Mathematics has prepared this draft paying suitable attention to objectives and learning outcomes of the papers. These syllabi may be implemented with minor modifications with appropriate justifications keeping in view regional, national and international context and needs.
7. The outcomes of each paper may be modified as per the local requirements.
8. The text books mentioned in references are denotative/demonstrative. The divisions of each paper in units are specified to the context mentioned in courses. These units will help the learners to complete the study of concerned paper in certain periods and prepare them for examinations.
9. The papers are organized considering the credit load in a particular semester. The core papers of general interest are suggested for semesters I to IV. The elective courses and advanced courses are proposed for the B.A./B.Sc. (Hons.) students of semesters V & VI and the elective courses for the students of B.A./B.Sc. semesters V & VI having Mathematics as a subject.
10. The mathematics is a vast subject with immense diversity. Hence it is very difficult for every student to learn each branch of mathematics, even though each paper has its unique importance. ii Under these circumstances, LOCF in Mathematics suggests a number of elective papers along with compulsory papers. A student can select elective papers as per her/his needs and interests.
11. The committee expects that the papers may be taught using various Computer Algebra Systems (CAS) softwares such as Mathematica, MATLAB, Maxima and R to strengthen the conceptual understanding and to widen up the horizon of students' self-experience.
12. The committee of the LOCF in Mathematics expects that the concerned departments/colleges/institutes/universities will encourage their faculty members to include necessary topics in addition to courses suggested by LOCF committee. It is hoped that the needs of all round development in the careers of learners/students will be fulfilled by the recommendations of LOCF in Mathematics.

SEMESTER-I

CORE COURSE-1

Course Name: Calculus, Geometry & Differential Equations

Course Code: BSCHMTMC101

Course Type: **Core (Theoretical)**	Course Details: **CC-1**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand various kinds of standard functions and graphs, techniques of integrations and limits.
- Learn about real numbers and its basic properties.
- Understand the concepts on three-dimensional geometry.
- Understand the genesis of ordinary differential equations.
- Understand the various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.

Unit –1: Hyperbolic functions, higher order derivatives, Successive differentiation, Leibnitz rule and its applications to problems of type $e^{ax+b}sinx, e^{ax+b}cosx, (ax+b)^n sinx, (ax+b)^n cosx$, L'Hospital's rule. concavity and inflection points, envelopes, asymptotes, Maxima and Minima, Curvature, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves,

Unit–2: Review of Algebraic and Order Properties of ℝ, ε–neighbourhood of a point in ℝ . Idea of countable sets, uncountable sets and uncountability of ℝ.. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets. Suprema and Infima. Completeness Property of ℝ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in ℝ, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano–Weierstrass theorem for sets, compact sets in ℝ, Heine–Borel Theorem.

Unit–3: Reduction formulae, derivations and illustrations of reduction formulae for the integration of sin $nx, cosnx, tan\, nx, sec\, nx, (log\, x)^n, \sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics.

Unit –4: Reflection properties of conics, translation and rotation of axes and second degree equations, classification of conics using the discriminant, Tangent, Normal, pole, polar, Diameter and conjugate diameters, Asymptotes. Polar equations of conics. Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Unit –5: Differential equations and mathematical models. General, particular, explicit, implicit and singular
solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Graphical Demonstration (Teaching Aid)

1. Plotting of graphs of function $e^{ax+b}, \log(ax+b), 1/(ax+b), \sin(ax+b), \cos(ax+b), |ax+b|$ and to illustrate the effect of a and b on the graph
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative
   graph and comparing them.
3. Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in Cartesian coordinates/polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, and
   hyperbolic paraboloid using Cartesian coordinates

References:

1. G. B. Thomas and R. L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
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) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
5. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
6. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co. 1897.
7. G. F. Simmons, Differential Equations, Tata Mcgraw Hill, 1991.
8. T. Apostol, Calculus, Volumes I and II. Vol-I, 1966, Vol-II, 1968.
9. S. Goldberg, Calculus and Mathematical analysis, 1989.
10. R. K. Ghosh & K. C. Maity, An Introduction to Analysis: Differential Calculus: Part I, New Central Book Agency (P) Ltd. Kolkata (India).
11. D. Sengupta, Application of Calculus, Books and Allied (P) Ltd (1st edition, 2012).
12. S. Bandyopadhyay and S. K. Maity, Application of Calculus, Academic Publishers (2nd edition, 2011).
13. R. M. Khan, Analytical Geometry of Two and Three Dimensions and Vector Analysis, New Central Book Agency (2010).
14. A. Mukherjee and N. K. Bej, Analytical Geometry of Two and Three Dimensions, Books and Allied (P) Ltd. (2013).
15. P. R. Ghosh & J. G. Chakraborty, Differential Equations, U. N. Dhur and Sons Pvt. Ltd.

16. R. K. Ghosh and K. C. Maity, Introduction to Differential Equations, New Central Book Agency (P) Ltd.
17. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Company Ltd. (18th edition).

CORE COURSE-2

Course Name: Algebra

Course Code: BSCHMTMC102

Course Type: **Core (Theoretical)**	Course Details: **CC-2**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand the importance of roots of real and complex polynomials and learn various methods of obtaining roots.
- Employ De Moivre's theorem in a number of applications to solve numerical problems.
- Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
- Find eigenvalues and corresponding eigenvectors for a square matrix.

Unit -1: Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications.
Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs, Cubic and biquadratic equations. Reciprocal equation, separation of the roots of equations, Strum's theorem.
Inequality: The inequality involving $AM \geq GM \geq HM$, Cauchy-Schwartz inequality

Unit-2: Equivalence relations and partitions, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Unit -3: Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation $Ax = b$, solution sets of linear systems, applications of linear systems, linear independence.

Unit –4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Definition and examples of vector spaces and subspaces, Vector Spaces R^n, Subspaces of R^n, dimension of subspaces of R^n , rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley–Hamilton theorem and its use in finding the inverse of a matrix.

References:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. K. B. Dutta, Matrix and linear algebra, 2004.
5. K. Hoffman, R. Kunze, Linear algebra, 1971.
6. W. S. Burnstine and A.W. Panton, Theory of equations, 2007.
7. J. G. Chakravorty & P. R. Ghosh, Advanced Higher Algebra, U. N. Dhur & Sons Pvt. Ltd.
8. A. N. Das, Advanced Higher Algebra, Books & Allied (P) Ltd.
9. P. K. Nayak, Linear Algebra, Books & Allied (P) Ltd.
10. S. K. Mapa, Higher Algebra: Classical, Sarat Book House.
11. S. K. Mapa, Higher Algebra: Abstract and Linear, Sarat Book House.

SEMESTER-II

C O R E C O U R S E - 3

Course Name: Real Analysis

Course Code: BSCHMTMC201

Course Type: **Core (Theoretical)**	Course Details: **CC-3**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand many properties of the real line R and learn to define sequence in terms of functions from R to a subset of R.
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
- Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
- Understand the theory and concepts of Riemann integration.

- Understand the applications of the fundamental theorems of integration.

Unit−1: Limit and Continuity: ε-δ definition of limit of a real valued function, Limit at infinity and infinite limits; Continuity of a real valued function, Properties of continuous functions, Intermediate value theorem, Geometrical interpretation of continuity, Types of discontinuity; Uniform continuity.

Unit-2: Differentiability: Differentiability of a real valued function, Geometrical interpretation of differentiability, Relation between differentiability and continuity, Differentiability and monotonicity, Chain rule of differentiation; Darboux's theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems; Maclaurin's and Taylor's theorems for expansion of a function in an infinite series, Taylor's theorem in finite form with Lagrange, Cauchy and Roche–Schlomilch forms of remainder;

Unit−3:Real sequence: Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, Limit Theorems. Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria. Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Limit superior and Limit inferior of a sequence of real numbers, Cauchy sequence, Cauchy's Convergence Criterion.

Unit−4:Series: Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Raabe's test, Gauss test, Cauchy condensation test, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence.

Unit−5: Riemann Integration: Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, First mean value theorem, Bonnet and Weierstrass forms of second mean value theorems.

Unit-6: Uniform convergence and Improper integral: Pointwise and uniform convergence of sequence and series of functions, Weierstrass's M-test, Dirichlet test and Abel's test for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiability, Improper integrals, Dirichlet test and Abel's test for improper integrals.

Graphical Demonstration (Teaching Aid)

1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano−Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
5. Cauchy's root test by plotting nth roots.
6. Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

References:

1.R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
4. S. K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.
5. Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 1981.
6. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer, 1999.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 1953.
8. Terence Tao, Analysis I, Hindustan Book Agency, 2006
9. S. Goldberg, Calculus and mathematical analysis, 1989.
10. S. K. Mukherjee, First Course in Real Analysis, Academic Publishers.
11. S. Bandyopadhyay & B. Guhathakurta, Mathematical Analysis, Academic Publishers.
12. R. K. Ghosh & K. C. Maity, An Introduction to Analysis: Differential Calculus: Part I, New Central Book Agency (P) Ltd. Kolkata (India).
13. S. N. Mukhopadhyay & A. K. Layek, Mathematical Analysis Volume-I, U. N. Dhur & Sons Pvt. Ltd.
14. B. K. Kar (2013), An Introduction to Modern Analysis (Volume I), Books & Allied Ltd.
15. S. C. Malik and S. Arora, Mathematical Analysis, New Age International (P) Ltd publishers (3rd edition, 2009).
16. S. K. Mapa, Real Analysis, Sarat Book Distributors (5th edition, 2008).
17. Shanti Narayan & M. D. Raisinghania, Elements of Real Analysis, S. Chand & Company Ltd. (14th edition, 2013).

CORE COURSE-4

Course Name: Differential Equations and Vector Calculus

Course Code: BSCHMTMC202

Course Type: **Core (Theoretical)**	Course Details: **CC-4**		L-T-P: **5-1-0**		
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Learn the Picard's method of obtaining successive approximations of solutions of first order ordinary differential equations.
- Know how to solve linear homogeneous and non-homogeneous equations of higher order with constant coefficients.
- Understand the system of linear differential equations and the solution techniques.

- Learn conceptual differences between usual solution and power series solution of some second order ODEs .
- Understand the theory and applications of vector analysis.

Unit-1: Lipschitz condition and Picard's Theorem (Statement only).Existence and uniqueness of the solution of first and second order ODE, General solution of homogeneous equation of second order, principle of super position for 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. Reduction of order of ODE and solution.

Unit -2: Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Matrix Method. Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Unit-3: Equilibrium points, Interpretation of the phase plane and phase portrait.its Rough sketching, Power series solution of a differential equation about an ordinary point, solution about a regular singular point. Legendre's equation, its solution, polynomial, Rodrigues formula, orthgonality, Frobenius method, Bessel's equation, Bessel functions and their properties, its recurrence relations.

Unit- 4: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, vector equations and its simple applications, differentiation and integration of vector functions. Differential operators.

Graphical Demonstration (Teaching Aid) :

1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

References:

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
2. C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
3. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
5. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co, 1897.
6. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 2012.
7. G. F. Simmons, Differential Equations, Tata McGraw Hill, 1991.
8. J. Marsden & Tromba, Vector Calculus, McGraw Hill, 1987.
9. K. C. Maity & R. K. Ghosh, Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India), 1999.

10. M. R. Speigel, Schaum's outline of Vector Analysis, McGraw Hill, 1980.
11. M. D. Raisinghania, Advanced Differential Equations, S. Chand Publishing, 2018.
12. J. G. Chakravorty and P. R. Ghosh, Differential Equations, U. N. Dhur & Sons Private Ltd.
13. R. K. Ghosh and K. C. Maity, Introduction to Differential Equations, New Central Book Agency (P) Ltd.
14. N. Mandal & B. Pal, Differential Equations (Ordinary and Partial), Books & Allied Ltd.
15. J. G. Chakravorty & P. R. Ghosh, Vector Analysis, U. N. Dhur & Sons Private Ltd (10th edition, 2010).
16. Shanti Narayan & P. K. Mittal, A Textbook of Vector Calculus, S. Chand & Company Ltd.

SEMESTER- III

CORE COURSE-5

Course Name: Multivariable Calculus

Course Code: BSCHMTMC301

Course Type: **Core (Theoretical)**	Course Details: **CC-5**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

Course Learning Outcomes: This course will enable the students to

- Learn conceptual differences while advancing from one variable to several variables in calculus.
- Apply multivariable calculus in various optimization problems.
- Understand inter-relationship amongst the line integral, double and triple integral formulations.
- Visualise the structure of curves and surfaces in plane and space etc.
- Learn the applications of multivariable calculus in different fields like Physics, Economics, Medical Sciences, Animation & Computer Graphics etc.
- Realize importance of Green, Gauss and Stokes' theorems in other branches of Mathematics.

[**Prerequisites:** Concepts of limit, continuity and differentiability in single variable, Sequences, Sequential criteria for limit and continuity in one variable.]

Unit-I: Limit, Continuity and Partial Differentiation
Functions of several variables, Level curves and surfaces, Limits and continuity of functions of several variables, Partial differentiation, Linear approximation and tangent planes, Chain rule, Directional derivatives, The gradient, Maximal and normal properties of the gradient, Tangent planes and normal lines.

Unit-II: Differentiability and Total Differentiation
Higher order and mixed partial derivatives, Total differential and differentiability, Sufficient condition for differentiability, Jacobians, Change of variables, Implicit function theorem, Functional dependence, Inverse function theorem, Euler's theorem for homogeneous functions, Taylor's theorem for functions of several variables, Envelopes and evolutes.

Unit-III: Extrema of Functions and Vector Field
Critical points and extrema of functions of two and more variables, Local extrema and absolute extrema, Constrained optimization problems, Method of Lagrange multipliers with various applications, Definition of vector field, Vector operators such as divergence, curl, gradient and the related vector identities.

Unit-IV: Double and Triple Integrals
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, Dirichlet integral.

Unit-V: Green's, Stokes' and Gauss Divergence Theorem
Line integrals, Applications of line integrals**:** Mass and Work done, Fundamental theorem for line integrals, Path independence, Conservative vector fields, Green's theorem, Area as a line integral, Surface integrals, Integrals over parametrically defined surfaces, Stokes' theorem, Volume as a surface integral, Gauss divergence theorem.

References:
1. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009), *Basic Multivariable Calculus*, Springer India Pvt. Limited.

2. James Stewart (2012). *Multivariable Calculus* (7th edition), Brooks/Cole, Cengage.
3. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011), *Calculus* (3rd edition), Pearson Education, Dorling Kindersley (India) Pvt. Ltd.
4. George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir (2018), *Thomas' Calculus* (14th edition), Pearson Education.
5. Sudhir R. Ghorpade & Balmohan V. Limaye (2009), *A Course in Multivariable Calculus and Analysis*, Springer.
6. Terence Tao (2015), *Analysis II* (3rd edition), Hindustan Book Agency.
7. Susan Jane Colley (2012), Vector Calculus (4th edition), Pearson Education.
8. R. K. Ghosh & K. C. Maity, *An Introduction to Analysis: Differential Calculus: Part I*, New Central Book Agency (P) Ltd. Kolkata (India).
9. B. K. Kar (2013), *An Introduction to Modern Analysis (Volume I)*, Books & Allied Ltd.
10. Subir Kumar Mukherjee (2019), *Advanced Differential Calculus of Several Variables* (5th edition), Academic Publishers.

CORE COURSE-6

Course Name: Group Theory

Course Code: BSCHMTMC302

Course Type: **Core (Theoretical)**	Course Details: **CC-6**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks
		Practical	Theoretical	Practical	Theoretical
		……	**10**	……	**40**

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

- Recognize the mathematical objects called groups.
- Link the fundamental concepts of groups and symmetries of geometrical objects.
- Explain the significance of the notions of cosets, normal subgroups, and factor groups.
- Analyze consequences of Lagrange's theorem.
- Learn about structure preserving maps between groups and their consequences.

Unit-1: Binary Compositions ; Semigroups , Monoids ,Groups : Examples & elementary Properties ;Abelian group ; Permutations ; Finite groups : symmetric group, alternating group ,Klein's 4-group ,group of all n-th roots of unity , etc. ; Examples of infinite groups ;Order of an element .

Unit-2: Subgroups : definitions ,examples and elementary properties ;Centre of a group ; Centraliser of an element in a group ;Cyclic groups : definitions ,examples and elementary properties ;Properties of Cosets; Lagrange's theorem .

Unit-3: Normal Subgroups and their properties ;Simple group ;Normaliser of a subgroup;Self-conjugate subgroup ; Quotient group ;Conjugacy relation in a group ; Class equation of a group .

Unit-4: Homomorphisms ,monomorphisms , epimorphisms ,isomorphisms : definitions ,examples and their elementary properties ;Caley's theorem on isomorphism ; First ,second and third isomorphism theorems ;Automorphism ; Inner automorphism ;

References:
1. Michael Artin (2014). Algebra (2nd edition). Pearson.
2. John B. Fraleigh (2007). A First Course in Abstract Algebra (7th edition). Pearson.
3. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition). Cengage.
4. I. N. Herstein (2006). Topics in Algebra (2nd edition). Wiley India.
5. Nathan Jacobson (2009). Basic Algebra I (2nd edition). Dover Publications
6. Ramji Lal (2017). Algebra 1: Groups, Rings, Fields and Arithmetic. Springer .
7. I.S. Luthar & I.B.S. Passi (2013). Algebra: Volume 1: Groups. Narosa.

CORE COURSE-7

Course Name: Probability and Statistics

Course Code: BSCHMTMC303

Course Type: **Core**	Course Details: **CC-7**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		…	**10**	**…….**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand distributions in the study of the joint behaviour of two random variables.
- Establish a formulation helping to predict one variable in terms of the other that is correlation and linear regression.
- Understand central limit theorem, which establish the remarkable fact that the empirical frequencies of so many natural populations, exhibit a bell shaped curve.

Unit-1: Basic notions of probability, Conditional probability and independence, Baye's theorem; Random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions; Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit-2: 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-3: 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-4: 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.

References:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller and John E. Freund, Mathematical Statistics with Applications, 7th Ed. Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007
5. A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers, 1983.
6. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan, Chand & Sons, 1989.
7. A. P. Baisnab and M. Jas, Elements of Probability and Statistics, McGraw Hill Education India, 2017.
8. Arup Mukherjee, Fundamental treatise on Probability and Statistics, Shreetara Prakashani, 2014.

SKILL ENHANCEMENT COURSE-1

(Choose any one from the following)

Course Name: Mathematical Logic

Course Code: BSCHMTMSE301

Course Type: **SE**	Course Details: **SEC-1**		L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the syntax of first-order logic and semantics of first-order languages
- Understand about truth table, different propositions, predicates and quantifiers, basic Theorems like the Compactness Theorem, Meta Theorem and Post Tautology Theorem.
- Grasp the concept of completeness interpretations and their applications with special stress on applications in Algebra.

Unit −1: First-order languages, Terms of language, Formulas of language, First order theory.

Unit –2: Structures of first order languages, Truth in a structure, Model of a theory, Embeddings and isomorphism.

Unit –3: 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 –4: Proof in first-order logic, Meta theorems in first-order logic, Some meta theorem in arithmetic, Consistency and completeness.

Unit –5: Completeness theorem, Interpretation in a theory, Extension by definitions, Compactness theorem and applications, Complete theories, Applications in algebra.

Reference:

1. Richard E. Hodel , An Introduction to Mathematical Logic, Dover Publications, 2013
2. Yu I. Manin , A Course in Mathematical Logic for Mathematicians, Springer, 2nd Edition, 2010
3. Elliot Mendelson , Introduction to Mathematical Logic, Chapman & Hall/CRC, 6th Edition, 2015
4. Shashi Mohan Srivastava, A Course in Mathematical Logic, Springer, 2nd Edition, Springer, 2013
5. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998

Course Name: Programming Language in C

Course Code: BSCHMTMSE302

Course Type: **SE**	Course Details: **SEC-1**		L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Acquire knowledge of different computer languages.
- Understand basic structure, characters, keywords, identifiers, data types, operators, expressions, etc. in C language.
- Write flow chart and corresponding C-program for solving problems requiring decision making, branching, looping and other control statements.
- Learn to implement arrays and functions in C programming.
- Familiarise with the concepts of structure, union and pointers.

Unit-1: An overview of theoretical computers, history of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object-oriented language, programming language and importance of C programming.

Unit-2: Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration. Operation and Expressions: Arithmetic operators, relational operators, logical operators.

Unit-3: Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement. Control Statements: While statement, do-while statement, for statement.

Unit-4: Arrays and Functions: One Dimensional Arrays: Array Manipulation; Searching, Insertion, Deletion of an element from an Array; Finding the largest / smallest element in an Array; Two Dimensional Arrays: Addition and Multiplication of two matrices, Transpose of a square matrix, representation of Sparse matrices.

Unit-5: Functions: Elements of User-Defined Functions, Definition of Functions, Return Values and their Types, Function Calls: call by value, call by reference, Function Declaration, Category of Functions, Nesting of Functions, Recursion, Passing Arrays to Functions, Scope of variables.

Unit-6: Structures, Unions and Pointers: Structure variables, Initialization, Structure Assignment, Structures and Functions, Structures and Arrays, Unions. Pointers: Address operators, Pointer Type Declaration, Pointer Assignment, Pointer Initialization, Pointer Arithmetic.

References:

1. B. W. Kernighan and D. M. Ritchi: The C-Programming Language, 2nd Edi. (ANSI Refresher), Prentice Hall, 1977.
2. E. Balagurnsamy: Programming in ANSI C, Tata McGraw Hill, 2004.
3. Y. Kanetkar: Let Us C; BPB Publication, 1999.
4. C. Xavier: C-Language and Numerical Methods, New Age International.
5. V. Rajaraman: Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

SEMESTER IV

C O R E C O U R S E - 8

Course Name: Mechanics

Course Code: BSCHMTMC401

<table>
<tr><td>Course Type: C</td><td colspan="3">Course Details: CC-8</td><td colspan="2">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>……</td><td>10</td><td>.......</td><td>40</td></tr>
</table>

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

- Familiarize with subject matter, which has been the single centre, to which were drawn mathematicians, physicists, astronomers, and engineers together.
- Understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.
- Determine the centre of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.
- Deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.
- Learn that a particle moving under a central force describes a plane curve and know the Kepler's laws of the planetary motions, which were deduced by him long before the mathematical theory given by Newton.

Unit-I: Statics: Force and Couple, Resultant force and Resultant Couple, Varignon's theorem, Equilibrium of a particle, Equilibrium of a system of particles, Necessary conditions of equilibrium, Moment of a force about a point, Moment of a force about a line, Moment of a couple, Astatic equilibrium, Equipollent system of forces, Work and potential energy, Principle of virtual work for a system of coplanar forces acting on a particle or at different points of a rigid body, Forces which can be omitted in forming the equations of virtual work.

Unit-II: Centres of Gravity and Common Catenary: Centres of gravity of plane area including a uniform thin straight rod, triangle, circular arc, semi-circular area and quadrant of a circle, Centre of gravity of a plane area bounded by a curve, Centre of gravity of a volume of revolution; Flexible strings, Common catenary, Intrinsic and Cartesian equations of the common catenary, Approximations of the catenary.

Unit-III: Rectilinear Motion: Simple harmonic motion (SHM) and its geometrical representation, Damped and forced vibrations, SHM under elastic forces, Motion under inverse square law, Motion in resisting media, Concept of terminal velocity.

Unit-IV: Motion in a Plane: Kinematics and kinetics of the motion, Expressions for velocity and acceleration in Cartesian, polar and intrinsic coordinates; Motion in a vertical circle, projectiles in a resisting medium, Tangential and Normal equations of motion, cycloidal motion etc.

Unit-V: Central Orbits: Equation of motion under a central force, Differential equation of the orbit, (p, r) equation of the orbit, Apses and apsidal distances, Areal velocity, Characteristics of central orbits, Stability of nearly circular orbits, Kepler's laws of planetary motion.

References:

1. S. L. Loney (2006). An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies. Read Books.
2. P. L. Srivatava (1964). Elementary Dynamics. Ram Narin Lal, Beni Prasad Publishers Allahabad.
3. J. L. Synge & B. A. Griffith (1949). Principles of Mechanics. McGraw-Hill.
4. A. S. Ramsey (2009). Statics. Cambridge University Press.
5. A. S. Ramsey (2009). Dynamics. Cambridge University Press.
6. R. S. Varma (1962). A Text Book of Statics. Pothishala Pvt. Ltd.
7. Gregory I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, 2006. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
8. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2010.
9. Chorlton, F., Textbook of Dynamics CBS Publishers & Distributors, 2005.
10. Loney, S. L., Elements of Statics and Dynamics I and II, 2004
11. Nayak, P.K., A Text Book of Mechanics, Alpha-Science.
12. Ghosh, M. C, Analytical Statics.
13. Matiur Rahman, Md., Statics, New Central Book Agancy (P) Ltd, 2004.
14. Rana and Joag, Classical Mechanics, McGraw Hill Edu(India) Private Ltd.
15. S.A. Mollah, Analytical Statics, Books and Allied (P)Ltd
16. Ganguly and Saha, Analytical Dynamics of a particle including Elementary statics, New Central Book Agency (P) Ltd.
17. M.D.Raisinghania, Dynamics, S Chan and company Ltd.

CORE COURSE-9

Course Name: Linear Algebra

Course Code: BSCHMTMC402

Course Type: **C**	Course Details: **CC-9**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

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

- Understand the concepts of vector spaces, subspaces, bases, dimension and their properties.
- Relate matrices and linear transformations, compute eigen values and eigen vectors of linear transformations.
- Learn properties of inner product spaces and determine orthogonality in inner product spaces.
- Realise the importance of adjoint of a linear transformation and its canonical form.

Unit-I: Vector Spaces

Definition and examples, Subspace, Linear span, Quotient space and direct sum of subspaces,Linearly independent and dependent sets, Bases and dimension.

Unit-II: Linear Transformations
Algebra of linear transformations, Matrix of a composite & inverse linear transformation, Change of coordinates, Rank and nullity of a linear transformation and rank-nullity theorem.

Unit-III: Further Properties of Linear Transformations
Isomorphism of vector spaces, Isomorphism theorems, Dual and second dual of a vector space, Transpose of a linear transformation, Eigen vectors and eigen values of a linear transformation, Characteristic polynomial and Cayley-Hamilton theorem, Minimal polynomial.

Unit-IV: Inner Product Spaces
Inner product spaces and orthogonality, Cauchy-Schwarz inequality, Gram-Schmidt orthogonalisation, Diagonalisation of symmetric matrices.

Unit-V: Adjoint of a Linear Transformation and Canonical Forms
Adjoint of a linear operator; Hermitian, unitary and normal linear transformations; Jordan canonical form, Triangular form, Trace and transpose, Invariant subspaces.

References :

1. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003). Linear Algebra (4thedition). Prentice-Hall of India Pvt. Ltd.

2. Serge Lang (2005). *Introduction to Linear Algebra* (2nd edition). Springer India.

3. Gilbert Strang (2014). *Linear Algebra and its Applications* (2nd edition). Elsevier.

4. Kenneth Hoffman & Ray Kunze (2015). *Linear Algebra* (2nd edition). Prentice-Hall.

5. Nathan Jacobson (2009). *Basic Algebra* I & II (2nd edition). Dover Publications.

6. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.

7. Vivek Sahai & Vikas Bist (2013). *Linear Algebra* (2nd Edition). Narosa Publishing House.

8. Mapa, Higher Algebra(Abstract and linear), Sarat Book Distributors.

CORE COURSE-10

Course Name: Partial Differential Equations and Calculus of Variations

Course Code: BSCHMTMC403

Course Type: **C**	Course Details: **CC-10**		L-T-P: **5-1-0**	
		CA Marks	ESE Marks	
Credit: **6**	Full Marks: **50**	Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the geometric and physical nature of Partial Differential Equations and classify them accordingly.
- Apply a range of techniques to solve first & second order partial differential equations.
- Model physical phenomena using partial differential equations such as the heat and wave equations.
- Understand problems, methods and techniques of calculus of variations.

First Order Partial Differential Equations

Unit-1: Partial Differential Equations (PDEs) – Basic concepts and Definitions, Order and Degree. First-Order Equations: Classification, Construction and Geometrical Interpretation. The Cauchy Problem for a First-Order PDEs and the statement of Kowalewski theorem. Lagrange method of characteristics for obtaining general solution of quasi-linear PDEs. Integral surfaces passing through a given curve. Surfaces orthogonal to a given system of surfaces.

Unit-2: Geometric Interpretation of First order non-linear PDEs and Cauchy's Method of Characteristics. Compatible system of First order PDEs (statement) and problems. Canonical Forms of First-order Linear Equations. Solution of first order partial differential equations by Charpit's general method. Some special type of equation which can be solved easily by methods other than the general method. Method of Separation of Variables for solving first order PDEs.

Second and Higher Order Partial Differential Equations

Unit-3: Origin and applications of second and higher order PDEs. Classification of second order PDE. Reduction of Second order PDE with constant or variable coefficients to canonical/normal form. Methods to find the general solution of homogeneous and non-homogeneous linear PDEs with constant coefficients.

Unit-4: Derivation of Wave Equation and Heat Equation in One-dimension. Method of separation of variables: Solving the Wave equation and Heat Equation in One-dimension. D'Alembert's Solution of the Wave Equation and its Physical Interpretation

Unit-5: Calculus of Variations-Variational Problems with Fixed Boundaries

Euler's equation for functional containing first order and higher order total derivatives, Functionals containing first order partial derivatives, Variational problems in parametric form, Invariance of Euler's equation under coordinates transformation.

Unit-6: Calculus of Variations-Variational Problems with Moving Boundaries

Variational problems with moving boundaries, Functionals dependent on one and two variables, One sided variations. Sufficient conditions for an extremum-Jacobi and Legendre conditions, Second variation.

Graphical Demonstration

1. Solution of Cauchy problem for first order PDE.
2. Finding the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of the equation $\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

a) $u(x, 0) = \emptyset(x), u_t(x, 0) = \psi(x), x \in R, t > 0.$

b) $u(x, 0) = \emptyset(x), u_t(x, 0) = \psi(x), u(0, t) = 0\ x \in (0, \infty), t > 0$

5. Solution of the equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

a) $u(x, 0) = \emptyset(x), u_t(0, t) = a, u(l, t) = b, 0 < x < l,\ t > 0.$

b) $u(x, 0) = \emptyset(x), x \in R, 0 < t < T.$

References:

1. Ian N. Sneddon (2006). *Elements of Partial Differential Equations*. Dover Publications.
2. A. S. Gupta (2004). *Calculus of Variations with Applications*. PHI Learning.
3. TynMyint-U & Lokenath Debnath (2013). *Linear Partial Differential Equation for Scientists and Engineers* (4th edition). Springer India.
4. S. J. Farlow (1993). *Partial differential equations for scientists and engineers*. Courier Corporation.
5. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
6. M. D. Raisinghania (2018). *Advanced Differential Equations*. S. Chand Publishing.

SKILL ENHANCEMENT COURSE-2

(Choose any one from the following)

Course Name: Graph Theory

Course Code: BSCHMTMSE401

Course Type: **SE**	Course Details: **SEC-2**			L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Appreciate the definition and basics of graphs along with types and their examples.
- Understand the Eulerian circuits, Eulerian graphs, Hamiltonian cycles, representation of a graph by matrix.
- Relate the graph theory to the real-world problems

Unit –1: Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs isomorphism of graphs.

Unit –2: Eulerian circuits, Eulerian graph, semi-Eulerian graph and theorems, Hamiltonian cycles and theorems. Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph,

Unit –3: Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm.

References:

1. J. Clark and D. A. Holton: A First Look at Graph Theory, Allied Publishers Ltd., 1995.
2. D. S. Malik, M. K. Sen and S. Ghosh: Introduction to Graph Theory, Cengage Learning Asia, 2014.
3. Nar Sing Deo : *Graph Theory*, Prentice-Hall, 1974.
4. J. A. Bondy and U.S.R. Murty: Graph Theory with Applications, Macmillan, 1976.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003..
6. D.N.Ghosh, Discrete Mathematics, Academic Publishers
7. D.K.Ghosh, Introduction to Graph Theory, New Central Book Agency(P) Ltd.

Course Name: Object Oriented Programming in C++

Course Code: BSCHMTMSE402

Course Type: **SE**	Course Details: **SEC-2**		L-T-P: **4-0-0**	
Credit: **4**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand the basic characteristics of object oriented programming languages, different components and structures in C++ programming language.
- Understand and apply the programming concepts of C++ which is important for mathematical investigation and problem solving.
- Use mathematical libraries for computational objectives.
- Represent the outputs of programs visually in terms of well formatted text and plots.

Unit 1: Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.

Unit 2: Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

Unit 3: Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

References:

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997.
2. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
3. Bruce Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall, 2000.
4. D. Parasons, Object Oriented Programming with C++, BPB Publication, 2008.
5. Bjarne Stroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley, 1997.
6. E. Balaguruswami, Object Oriented Programming In C++, Tata McGrawHill, 2011.
7. Herbert Scildt, C++, The Complete Reference, Tata McGrawHill, 2003.

SEMESTER V

CORE COURSE-11

Course Name: Set Theory &Metric Spaces

Course Code: BSCHMTMC501

<table>
<tr><td>Course Type: C</td><td colspan="3">Course Details: CC-11</td><td colspan="2">L-T-P: 5-1-0</td></tr>
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<tr><td>……</td><td>10</td><td>.......</td><td>40</td></tr>
</table>

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

- Learn basic facts about the cardinality of a set.
- Learn abstract formulation of the notion “distance” on an arbitrary set and learn how known concepts like continuity, convergence of sequences etc behave in such abstract setting.
- Understand several standard concepts of metric spaces and their properties like openness, closeness, completeness, compactness, Bolzano-Weierstrass property, and connectedness.
- Identify the continuity of a function defined on metric spaces and homeomorphisms.

Unit-I: Theory of Sets

Finite and infinite sets, Countable and uncountable sets, Cardinality of sets, Schröder-Bernstein theorem, Cantor’s theorem, Order relation in cardinal numbers Arithmetic of cardinal numbers, Partially ordered set, Zorn’s lemma and Axiom of choice, Various set theoretic paradoxes.

Unit-II: Concepts in Metric Spaces

Definition and examples of metric spaces, Open ball/sphere and closed ball/sphere, Neighbourhoods, Hausdorff property, Interior points, Open sets, exterior and boundary points, Limit points and isolated points, Closed sets, metric topology, Interior and closure of a set, Boundary of a set, Bounded sets, Distance between two sets, Diameter of a set, Subspace of a metric space.

Unit-III: Complete Metric Spaces and Continuous Functions

Cauchy sequence and Convergent sequence, properties of a Cauchy sequence, Completeness of metric spaces, examples of some standard complete metric spaces

$(\mathbb{R}^n, \mathbb{C}^n, l_p, C[a,b])$, Cantor's intersection theorem, Dense sets and separable spaces, first countable and second countable metric spaces, relation between separable and second countable metric spaces, Nowhere dense sets and Baire's category theorem, Continuous and uniformly continuous functions, sequential criteria and other characterizations of continuity, Homeomorphism, Banach Fixed point Theorem and its application to ordinary differential equations.

Unit-IV: Compactness

Compact spaces, Sequential compactness, Bolzano-Weierstrass property, compactness and finite intersection property, Heine-Borel theorem, Totally bounded sets, Equivalence of compactness and sequential compactness, Continuous functions on compact spaces.

Unit-V: Connectedness

Separated sets, Disconnected and connected sets, Components, Connected subsets of $\mathbb{R}$, Continuous functions on connected sets.

References:
1. P. R. Halmos (1974). Naive Set Theory. Springer.
2. E. T. Copson (1988). Metric Spaces. Cambridge University Press.
3. P. K. Jain & Khalil Ahmad (2019). Metric Spaces. Narosa.
4. S. Kumaresan (2011). Topology of Metric Spaces (2nd edition). Narosa.
5. M.N. Mukherjee (2014), Elements of metric spaces (4th edition), Academic publishers.
6. Satish Shirali & Harikishan L. Vasudeva (2006). Metric Spaces. Springer-Verlag.
7. Micheál O'Searcoid (2009). Metric Spaces. Springer-Verlag.
8. G. F. Simmons (2004). Introduction to Topology and Modern Analysis. McGraw-Hill.
9. Q.H. Ansari (2010). Metric spaces. Narosa.

CORE COURSE-12

Course Name: Advanced Algebra

Course Code: BSCHMTMC502

Course Type: **C**	Course Details: **CC-12**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Understand the automorphism, inner automorphism and the fundamental concepts of Group Actions and their applications

- Understand the application of Sylow theorems to characterize certain Finite Groups.
- Be acquainted with the basic concepts of Ring Theory such as the concepts of ideals, quotient rings, Integral domains and Fields.
- Know in detail about Polynomial Rings, Fundamental properties of Finite Field extensions and classification of Finite Fields.

Unit -1: Automorphism, inner automorphism, Characteristic subgroups, Commutator subgroup and its properties. Group actions, orbits, stabilizers and kernels, Orbit-stabilizer Theorem, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem.

Unit -2: Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Finite Simple Groups, Simplicity of An for $n \geq 5$, non-simplicity tests.

Unit -3: Definition, examples and elementary properties of rings, Commutative rings, Integral domain, Division rings and fields, Characteristic of a ring, Ring homomorphisms and isomorphisms, Ideals and quotient rings. Prime, principal and maximal ideals, Relation between integral domain and field, Euclidean rings and their properties, Wilson and Fermat'stheorems.

Unit -4: Polynomial rings over commutative ring and their basic properties, The division algorithm; Polynomial rings over rational field, Gauss lemma and Eisenstein's criterion, Euclidean domain, principal ideal domain, and unique factorization domain.

Unit -5: Extension of a field, Algebraic element of a field, Algebraic and transcendental numbers, Perfect field, Classification of finite fields.

References:

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., 1999.
4. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998
7. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, Tata McGrawHill,1997.
8. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
9. P.B.Bhattacharya, S.K.Jain & S.R. Nagpaul, Basic Abstract Algebra, 2nd Ed., Cambridge University Press, 2003
10. Serge Lang, Algebra, 3rd Ed, Springer-Verlag, 2002

DESCIPLINE SPECIFIC ELECTIVE (DSE-1 &DSE-2)

(Choose any Two from the following)

Course Name: Tensors & Differential Geometry

Course Code: BSCHMTMDSE501

<table>
<tr><td>Course Type: DSE</td><td colspan="2">Course Details: DSE-1 /DSE-2</td><td colspan="2">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>10</td><td>…….</td><td>40</td></tr>
</table>

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Explain the basic concepts of tensors.
- Understand role of tensors in differential geometry.
- Learn various properties of curves including Frenet-Serret formulae and their applications.
- Know the Interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae.
- Understand the role of Gauss's Theorema Egregium and its consequences.
- Apply problem-solving with differential geometry to diverse situations in physics, engineering and in other mathematical contexts.

Unit -1: Tensor: Contravariant and Covariant vectors, Different transformation laws, Tensor product of two vector spaces, Properties of tensors, Symmetric and Skew symmetric Tensors, Contraction of Tensors, Quotient law, Inner product of vectors

Unit -2: Metric tensor, Associated Covariant and Contravariant vectors, Christoffel Symbols and their laws of transformation, Riemannian space, Covariant Differentiation of Covariant and Contravariant vectors and of Tensors, Curvature Tensors, Ricci Tensor, Einstein space.

Unit -3: Theory of Space Curves: Space curves, Planer curves, Arc length, Curvature, torsion and Serret-Frenet formula. Fundamental existence and uniqueness Theorem for curves, Non-unit Speed curves, Osculating circles, Osculating circles and spheres, Existence of space curves. Evolutes and involutes of curves.

Unit -4: Theory of Surfaces: Parametric curves on surfaces, Direction coefficients, First and second Fundamental forms, Principal, Gaussian and Mean curvatures, Gauss and Weingarten Formulae, The Fundamental Theorem of Surfaces, Surfaces of constant Gauss Curvature, Gauss-Bonnet theorem, Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines.

Unit -5: Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces. Geodesics: Canonical geodesic equations, Nature of geodesics on a surface of revolution. Clairaut's theorem, Normal property of geodesics, Torsion of a geodesic, Geodesic curvature. Parallel vector field along a curve and Parallelism, Exponential map, Gauss Lemma, Geodesic Co-ordinates.

References:

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
3. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
4. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
6. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003
7. P. K. Nayak, Textbook of Tensor Calculus and Differential Geometry, PHI Learning Private Limited, 2012.
8. Christian Bär, Elementary Differential Geometry, Cambridge University Press, 2010
9. R. S. Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt Ltd., 1965

Course Name: Integral Transforms and Fourier Analysis

Course Code: BSCHMTMDSE502

Course Type: **DSE**	Course Details: **DSE-1 / DSE-2**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Learn Fourier series, Bessel's inequality, term by term differentiation and integration of Fourier series.
- Know about Fourier Transform and its relation with Fourier Series, Laplace Transform and its relation with Fourier Transform and the sufficient conditions for their existence.
- Familiarise with the properties of Fourier and Laplace Transforms.
- Learn to apply Fourier and Laplace Transforms to well-known functions.
- Learn to find inverse Laplace Transform and inverse Fourier Transform.
- To be able to solve real world initial value, boundary value and initial-boundary problems using Integral Transforms or Fourier Series.

UNIT-1: Fourier Series

Periodic functions. Definition of Fourier Series. Dirichlet's conditions of convergence and statement for sufficient condition for a trigonometric series to be a Fourier series. Derivation of Fourier Coefficients. Examples of Fourier expansions and summation results for series. Gibbs phenomenon. Use of odd & even functions in evaluating Fourier coefficients– Half range sine & cosine series, Differentiation and integration of Fourier series. Statements of absolute and uniform convergence of Fourier series, Riemann- Lebesgue lemma, Bessel's inequality and Parseval's identity. The complex form of Fourier series.

Unit-2: Fourier Transforms

Fourier Transforms as a limit of Fourier Series. Fourier Integral Theorem (statement only). Determination of Fourier Transform Pairs from Fourier Integral. Definition and properties of Fourier Transforms: Linearity, Change of Scale Property, Shifting Property, Modulation theorem. Fourier Transforms of Derivatives, Fourier Transforms of some useful functions. Fourier sine and cosine transforms.

Inverse Fourier Transform and examples. Statements of Convolution Theorem, Plancherel's identity, Reimann-Lebesgue Lemma and examples.

Unit-3: Laplace Transforms

Definition of Laplace Transform. Derivation of Laplace Transform from Fourier Integral and its relation with Fourier Transform. Laplace Transform of some elementary functions. Suffcient conditions for the existence of Laplace Transform (statement only) with counter examples. Properties of Laplace transforms: Linearity, First Shifting Property, Change of Scale Property, Laplace transforms of periodic functions, Second Shifting Property, Laplace transforms of derivatives and integrals. Laplace transform of Dirac’s delta function, Statements of Initial and final value theorems.

Inverse Laplace Transform: Definition and examples. Lerch’s theorem (statement only). Statement and applications of Convolution theorem and Heaviside expansion theorem.

Unit 4: Applications of Integral Transforms and Fourier Analysis

Application of Fourier series in the solution of heat equation, wave equation and Laplace equation. Application of Integral Transforms in the solution of initial value and boundary value problems in ODEs. Solution of heat equation and wave equation using Integral Transforms.

References:

1. I. N. Sneddon (1969) *Fourier Series*. Dover.
2. L. C. Andrews and B. K. Shivamoggi (1999). *Integral Transforms for Engineers* (Vol. 66). SPIE Press.
3. A. Pinkus and S. Zafrany (1997). *Fourier Series and Integral Transforms*. Cambridge University Press.
4. L. Debnath and D. Bhatta (2016). *Integral Transforms and their Applications*. Chapman and Hall/CRC.
5. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley.
6. A. K. Vasishtha and R. K. Gupta (2016): *Integral Transforms*. Krishna
7. Murray R. Spiegel (1974). *Fourier Analysis with Applications to Boundary Value Problems*. Schaum's Outline Series.

Course Name: Linear Programming and Game Theory

Course Code: BSCHMTMDSE503

Course Type: **DSE**	Course Details: **DSE-1 / DSE-2**		L-T-P: **5-1-0**		
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Analyze and solve linear programming models of real life situations.
- Provide graphical solution of linear programming problems with two variables, and illustrate the concept of convex set and extreme points.
- Solve linear programming problems using simplex method.
- Learn techniques to solve transportation and assignment problems.
- Solve two-person zero sum game problems.

Unit -1: Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, theorems on convex sets, optimality and unboundedness, Unique and alternative solutions, the simplex algorithm, simplex method in tableau format, Artificial variables, two-phase method. Big-M method and their comparison.

Unit -2: Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual, Dual Simplex method.

Unit -3: Transportation problem and its mathematical formulation, northwest corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, Optimal solution, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, Travelling salesman problem.

Unit -4: Game theory: Formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, Rectangular and Square games, Concept of Dominance, graphical solution procedure, Algebraic method of solution, linear programming solution of games.

References:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
5. J.G.Chakravorty and P.R.Ghosh, Linear Programming and Game Theory, Moulik Library.

6. A.Mukherjee and N.K.Bej, Advance Linear Programming and Game Theory, Books and Allied (P) Ltd.
7. J.K.Sharma, Operations Research, TRINITY.

Course Name: Special Theory and Relativity

Course Code: BSCHMTMDSE504

Course Type: **DSE**	Course Details:**DSE-1 / DSE-2**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes: This course will enable the students to

- Understand the basic concepts of Special Relativity including Michelson-Morley experiment and geometrical interpretations of Lorentz transformation equations.
- Learn about length contraction, time dilation and relativity of simultaneity.
- Study 4-dimensional Minkowskian space-time and its properties.
- Understand the concepts of 4-vectors, mass-energy equivalence and equations of motion as a part of relativistic mechanics.
- Imbibe connections between relativistic mechanics and electromagnetism.

Unit-I: Review of Newtonian Mechanics and Introduction to Special Relativity
Inertial frames, Speed of light and Galilean relativity, Michelson-Morley experiment, Lorentz-Fitzgerald contraction hypothesis, Relative character of space and time, Concepts of Simultaneity, Postulates of special theory of relativity, Lorentz transformation equations and its geometrical interpretation, Group properties of Lorentz transformations.

Unit-II: Relativistic Kinematics
Consequences of Lorentz transformation - Composition of parallel velocities, Length contraction, Time dilation, Transformation equations for components of velocity and acceleration of a particle and Lorentz contraction factor, Relativistic Doppler effect.

Unit-III: Geometrical Representation of Space-time
Four dimensional Minkowskian space-time of special relativity, Time-like, light-like and space-like intervals, Null cone, Proper time, World line of a particle, Four vectors and tensors in Minkowskian space-time.

Unit-IV: Relativistic Mechanics
Variation of mass with velocity, Equivalence of mass and energy, Energy-momentum four vector, Transformation equations for momentum and energy, Relativistic mass-energy relation, Relativistic force and Transformation equations for its components, Relativistic equations of motion of a particle in covariant form, Longitudinal and transverse mass, Relativistic Lagrangian and Hamiltonian for a particle.

Unit-V: Electromagnetism

Energy-momentum tensor of a continuous material distribution, Transformation equations for the densities of electric charge and current, electric and magnetic field strengths under Lorentz transformation, The Field of a uniformly moving point charge, Forces and fields near a current carrying wire, Forces between moving charges, The invariance of Maxwell`s equations, Maxwell's equations in tensor form.

References:

1. James L. Anderson (1973), *Principles of Relativity Physics*, Academic Press.
2. Peter Gabriel Bergmann (1976), *Introduction to the Theory of Relativity*, Dover Publications.
3. C. Moller (1972), *The Theory of Relativity* (2nd edition), Oxford University Press.
4. Robert Resnick (2007), *Introduction to Special Relativity*, Wiley.
5. Wolfgang Rindler (1977), *Essential Relativity: Special, General, and Cosmological,* Springer-Verlag.
6. V. A. Ugarov (1979), *Special Theory of Relativity*, Mir Publishers, Moscow.
7. S. Banerji & A. Banerjee (2012), *The Special Theory of Relativity*, Prentice Hall India Learning Private Limited.

SEMESTER VI

CORE COURSE-13

Course Name: Complex Analysis

Course Code: BSCHMTMC601

Course Type: **C**	Course Details: **CC-13**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

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

- Visualize complex numbers as points of $\mathbb{R}^2$ and stereographic projection of complex plane on the Riemann sphere.
- Understand the significance of differentiability and analyticity of complex functions leading to the Cauchy-Riemann equations.
- Learn the role of Cauchy-Goursat theorem and Cauchy integral formula in evaluation of contour integrals.
- Apply Liouville's theorem in fundamental theorem of algebra.
- Understand the convergence, term by term integration and differentiation of a power

series.
- Learn Taylor and Laurent series expansions of analytic functions, classify the nature of singularity, poles and residues and application of Cauchy Residue theorem.

Unit-1: Complex Plane and functions: Complex numbers and their representations, algebra of complex numbers; Complex plane, Open set, Domain and region in complex plane; Stereographic projection; functions, limits & continuity.

Unit-2: Analytic functions and Cauchy-Riemann equations:
Differentiability of a complex valued function, Cauchy-Riemann equations, Harmonic functions, Analytic functions, necessary and sufficient conditions for analyticity.

Unit-3: Power Series: Power series, radius of convergence, Cauchy-Hadamard theorem, analyticity of the sum function of a power series .

Unit-4: Conformal and Bilinear Transformations: Transformations, Examples of isogonal and conformal transformations, Some general transformations: translation, rotation, magnification, inversion ; Bilinear transformation , fixed points of a bilinear transformation , cross ratio .

Unit-5: Cauchy's theorem: Complex line integrals, Cauchy's theorem on line integral , evaluations of line integrals using Cauchy's integral formula, Morera's theorem, Cauchy's inequality, Lioville's theorem, Taylor's theorem and Laurent's theorem on analytic functions.

Unit-5: Singularities and Contour integration: Zeros of an analytic function, singularities and their natures, residues at pole, residues at infinity , Cauchy's residue theorem , Jordan's lemma, evaluation of proper and improper integrals.

References:
1. Lars V. Ahlfors (2017). Complex Analysis (3rd edition). McGraw-Hill Education.
2. Joseph Bak & Donald J. Newman (2010). Complex Analysis (3rd edition). Springer.
3. James Ward Brown & Ruel V. Churchill (2009). Complex Variables and Applications (9th edition). McGraw-Hill Education.
4. John B. Conway (1973). Functions of One Complex Variable. Springer-Verlag.
5. E.T. Copson (1970). Introduction to Theory of Functions of Complex Variable. Oxford University Press.
6. Theodore W. Gamelin (2001). Complex Analysis. Springer-Verlag.
7. George Polya & Gordon Latta (1974). Complex Variables. Wiley.
8. H. A. Priestley (2003). Introduction to Complex Analysis. Oxford University Press.
9. E. C. Titchmarsh (1976). Theory of Functions (2nd edition). Oxford University Press.

CORE COURSE-14

Course Name: Numerical Methods & Numerical Lab

Course Code: BSCHMTMC602

Course Type: **C** (Theoretical+Practical)	Course Details: **CC-14**		L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks
		Practical	Theoretical	Practical	Theoretical
		30	**10**	**20**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the problem solving skills using numerical methods,
- Handle large system of equations, non-linearity and and that are often impossible to solve analytically,
- Solve differential equations by numerical methods,
- Develop problem solving skills using computer programming,
- Acquire knowledge of C programming language,
- Solve different numerical problems using algorithm, flowchart, C language programming.

Numerical Methods(50 marks)

Unit-1: Algorithms, Convergence, Errors: Relative, Absolute. Round off, Truncation.

Unit-2: Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Error and Rate of convergence of these methods.

Unit -3: System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU Decomposition.

Unit-4: Interpolation: Lagrange and Newton's methods, Error bounds, Finite difference operators. Gregory forward and backward difference interpolations.
Numerical differentiation: Methods based on interpolations, methods based on finite differences.

Unit–5: Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpsons $3/8^{th}$ rule, Weddle's rule, Boole's rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's $1/3^{rd}$ rule, Gauss quadrature formula.
The algebraic eigen value problem: Power method.

Unit -6: Numerical solution of Ordinary Differential Equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Numerical Methods Lab (using C programming) (Total Marks: 50)

- ***Continuous assessment (internal): Total 30 marks.***

Students have to prepare a practical note book containing working formula, algorithm, flowchart and program with input and output of all practical problem listed below.

- ***End Semester Examination (External): Total 20 marks.***

Lab notebook & Viva Voce: 5 marks
One practical problem: 15 marks (Working formula: 2, Algorithm: 3, Program: 8, Result: 2)

List of practical problems (using C programming)

1. Solution of transcendental and algebraic equations by
(a) Newton Raphson method.
(b) Regula Falsi method.

2. Solution of system of linear equations
(a) Gaussian elimination method
(b) Gauss-Seidel method

3. Interpolation: Lagrange Interpolation

4. Numerical Integration
(a) Trapezoidal Rule
(b) Simpson's one third rule

5. Solution of 1st order ordinary differential equations: Fourth order Runge Kutta method

Reference:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering, 2012.
3. Nayak, P.K., Numerical Analysis: Theory & Applications, Asian Books Pvt. Ltd.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co, 1966.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978. Yashavant Kanetkar, Let Us C, BPB Publications, 2016.
9. S.A. Molla, Numerical Analysis and computational Procedures, Books and Allied (P) Ltd., 2005.

DESCIPLINE SPECIFIC ELECTIVE (DSE)

(Choose any two from the following)

Course Name: Discrete Mathematics

Course Code: BSCHMTMDSE601

Course Type: **DSE**	Course Details: **DSE-3/DSE-4**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

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

- Learn about partially ordered sets, lattices and their types.

- Understand Boolean algebra and Boolean functions, logic gates, switching circuits and their applications.
- Solve real-life problems using finite-state and Turing machines.
- Assimilate various graph theoretic concepts and familiarize with their applications.

Unit-I: Partially Ordered Sets
Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.

Unit-II: Lattices
Lattices as posets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.

Unit-III:Boolean Algebras and Switching Circuits
Boolean algebras, De Morgan's laws, Boolean homomorphism, Representation theorem; Boolean polynomials, Boolean polynomial functions, Disjunctive and conjunctive normal forms, Minimal forms of Boolean polynomials, Quine-McCluskey method, Karnaugh diagrams, Switching circuits and applications.

Unit-IV: Finite-State and Turing Machines
Finite-state machines with outputs, and with no output; Deterministic and nondeterministic finite-state automaton; Turing machines: Definition, examples, and computations.

Unit-V: Graphs
Definition, examples and basic properties of graphs, Königsberg bridge problem; Subgraphs, Pseudographs, Complete graphs, Bipartite graphs, Isomorphism of graphs, Paths and circuits, Eulerian circuits, Hamiltonian cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, Shortest path and Dijkstra's algorithm.

References :
1. B. A. Davey & H. A. Priestley (2002). *Introduction to Lattices and Order* (2nd edition). Cambridge University Press.

2. Edgar G. Goodaire & Michael M. Parmenter (2018). *Discrete Mathematics with Graph Theory* (3rd edition). Pearson Education.

3. Rudolf Lidl & Günter Pilz (1998). *Applied Abstract Algebra* (2nd edition). Springer.

4. Kenneth H. Rosen (2012). *Discrete Mathematics and its Applications*: *With Combinatorics and Graph Theory* (7th edition). McGraw-Hill.

5. D. S. Malik and M. K. Sen (2004), *Discrete Mathematical Structures: Theory and Applications*. THOMSON (COURSE TECHNOLOGY).

6. C. L. Liu (1985). *Elements of Discrete Mathematics* (2nd edition). McGraw-Hill.

Course Name: Number Theory

Course Code: BSCHMTMDSE602

Course Type: **DSE**	Course Details: **DSE-3/DSE-4**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

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

- Learn about some important results in the theory of numbers including the prime number theorem, Chinese remainder theorem, Euler's theorem, Wilson's theorem and their consequences.
- Learn about number theoretic functions, modular arithmetic and their applications.
- Familiarise with modular arithmetic and find primitive roots of prime and composite numbers.
- Know about open problems in number theory, namely, the Goldbach conjecture and Twin-prime conjecture.
- Apply public crypto systems, in particular, RSA.

Unit-I: Distribution of Primes and Theory of Congruencies
Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Twin-prime conjecture, Odd perfect numbers 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
Number theoretic functions for sum and number of divisors, Multiplicative function, The Möbius inversion formula, Greatest integer function, Euler's phi-function and properties, Euler's theorem.

Unit-III: Primitive Roots
Order of an integer modulo *n*, Primitive roots for primes, Composite numbers having primitive roots; Definition of quadratic residue of an odd prime, Euler's criterion.

Unit-IV: Quadratic Reciprocity Law
The Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli.

Unit-V: Applications
Public key encryption, RSA encryption and decryption with applications in security systems.

References :

1. David M. Burton (2007). *Elementary Number Theory* (7th edition). McGraw-Hill.
2. I. Niven (2012). *An Introduction to the Theory of Numbers* (5th edition). John Wiley & Sons.
3. Neville Robbins (2007). *Beginning Number Theory* (2nd edition). Narosa.
4. Gareth A. Jones & J. Mary Jones (2005). *Elementary Number Theo*ry. Springer.
5. Neal Koblitz (1994). *A Course in Number Theory and Cryptography* (2nd edition). Springer-Verlag.

Course Name: Advanced Mechanics

Course Code: BSCHMTMDSE603

Course Type: **DSE**	Course Details: **DSE-3 / DSE-4**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

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

- Understand the reduction of force system in three dimensions to a resultant force acting at a base point and a resultant couple.
- Learn about a nul point, a nul line, and a nul plane with respect to a system of forces acting on a rigid body together with the idea of central axis.
- Know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia to derive Euler's dynamical equations.
- Study the kinematics and kinetics of fluid motions to understand the equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates which are used to derive Euler's equations and Bernoulli's equation.
- Deal with two-dimensional fluid motion using the complex potential and also to understand the concepts of sources, sinks, doublets and the image systems of these with regard to a line and a circle.

Unit-I: Statics in Space: Forces in three dimensions, Reduction to a force and a couple, Equilibrium of a system of particles, Central axis and Wrench, Equation of the central axis.

Unit-II: Motion of a Rigid Body : Definition of rigid body as a system of particles and condition of rigidity, Moments and products of inertia of standard bodies, Momental ellipsoid, Principal axes and principal moments of inertia; The momentum of a rigid body in terms of linear momentum and angular momentum about any point, Equations of motion in terms of linear and angular momenta, Motion of a rigid body with a fixed point, Existence of an angular velocity, Kinetic energy and angular momentum of a rigid body in terms of inertia constants, Euler's dynamical equations and the motion under no forces.

Unit-III: Kinematics of Fluid Motion : Lagrangian and Eulerian approaches, Acceleration of fluid at a point, Equation of continuity in Cartesian, cylindrical polar and spherical polar coordinates, Boundary surface, Streamlines and path lines, Velocity potential, Rotational and irrotational motion, Vorticity vector and vortex lines.

Unit-IV: Kinetics of Fluid Motion: Euler's equations of motion in Cartesian, cylindrical polar and spherical polar coordinates, Bernoulli's equation, Impulsive motion.

Unit-V: Motion in Two-Dimensions: Stream function, Complex potential, Basic singularities: Sources, sinks, doublets and complex potentials due to these basic singularities; Image system of a simple source and a simple doublet with regard to a line and a circle.

References:

1. A. S. Ramsay (1960). A Treatise on Hydromechanics, Part-II Hydrodynamics G. Bell & Sons.
2. F. Chorlton (1967). A Textbook of Fluid Dynamics. CBS Publishers.

3. Michel Rieutord (2015). Fluid Dynamics An Introduction. Springer.
4. E. A. Milne (1965). Vectorial Mechanics,Methuen & Co.Limited.London.
5. F. Chorlton (1969). A Text Book of Dynamics, D Van Nosterand Co. Ltd.London.
6. Shanti Swarup, Fluid dynamics, Krishna Prakashan, Meerut.
7. M.D.Raisinghania, Fluid Dynamics, S.Chand
8. Ghosh, M. C, Analytical Statics.
9. Matiur Rahman, Md., Statics, New Central Book Agancy (P) Ltd, 2004.
10. S.A. Mollah, Analytical Statics, Books and Allied (P)Ltd
11. S.A. Mollah, Dynamics of Rigid Bodies, Books and Allied (P)Ltd
12. A. Mukherjee and N.K.Bej, Advanced Mechanics,Shreedhar Prakashani.

Course Name: Bio Mathematics

Course Code: BSCHMTMDSE604

Course Type: **DSE**	Course Details:**DSE-3/ DSE-4**			L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**.......**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Grasp the idea of various bio-mathematical models and techniques which will help them to tackle physical world problems.

Unit -1: Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC)

Unit -2: Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario Spatial Models: One species model with diffusion, Two species model with diffusion. Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population.

Unit -3: Discrete Models: Overview of difference equations, steady state solution and linear stability analysis. Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson- Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Graphical Demonstration (Teaching Aid)

1. Growth model （exponential case only）.
2. Decay model （exponential case only）.

3. Lake pollution model (with constant/seasonal flow and pollution concentration).
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of infuenza (basic epidemic model, contagious for life, disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).

References:

1. L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
2. J. D. Murray, Mathematical Biology, Springer, 1993.
3. Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008
5. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Pool of Generic elective Calculus

[Students of a Particular Honours department will choose one Generic Elective Paper of any other existing Honours Department except his/her Department from the pool provided below]

Semester I

GENERIC ELECTIVES [GE-1(1)]

Course Name: Differential Calculus

Course Code: BSCHMTMGE101

Course Type: **GE**	Course Details: **GE-1**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	**…….**	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Assimilate the notions of limit of a sequence and convergence of a series of real numbers.
- Calculate the limit and examine the continuity of a function at a point.
- Understand the consequences of various mean value theorems for differentiable functions.
- Sketch curves in Cartesian and polar coordinate systems.

Limit of functions, Algebra of limits, Continuous functions, Properties of continuous functions, Monotone functions, Inverse function. Differentiability of functions, Successive differentiation, Leibnitz's theorem, Rolle's theorem, Mean value theorem of Lagrange and of Cauchy with geometrical interpretations. Taylor's theorem and Maclaurin's theorem with remainder in Lagrange's and Cauchy's form and application of mean value theorem, Darboux's theorem. Series expansion of $\sin x, \cos x, \log(1+x), (1+x)^n, a^x$ with domain of convergence.

Partial differentiation, Euler's theorem on homogeneous functions.

Determination of maxima and minima, Indeterminate forms.

Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates.

References:

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2002.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education, 2007.
3. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH, 2012.
4. Shanti Naryayn and P. K. Mittal, *Differential Calculus*, S Chand.
5. K.C.Maity and R.K.Ghosh, *Differential Calculus*, Books and Allied (P) Ltd.

Semester II

GENERIC ELECTIVES [GE-1(2)]

Course Name: Differential Equations and Vector Calculus

Course Code: BSCHMTMGE201

Course Type: **GE**	Course Details: **GE-2**			L-T-P: **5-1-0**	
		CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical

Credit: **6**	Full Marks: **50**	……	**10**	**…….**	**40**

Course Learning Outcomes:
(After the completion of course, the students will have ability to):

- Learn various methods to find the solutions of ordinary differential equations.
- Understand the central concepts in multivariable analysis, including space curves; directional derivative; gradient; multiple integrals; line and surface integrals; vector fields; divergence, curl and flux;

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.

Definition of vector, Resolution of vectors into components along three directions. Scalar and vector products of two and three vectors. Applications to geometry and mechanics**.**

Continuity and differentiability of vector-valued function of one variable. Velocity and acceleration. Vector-valued functions of two and three variables, Gradient of scalar function, Divergence, Curl and their properties.

References:

1. S. L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. B. Spain, *Vector Analysis*, D.Van Nostrand Company Ltd.
3. L. Brand, *Vector Analysis*, Dover Publications Inc.
4. Shanti Narayan**,** *A Text Book of Vector Analysis*, 19th Edn, S.Chand publishing.
5. M. Spiegel, S.Lipschutz , D. Spellman, *Vector Analysis*, McGraw-Hill.

Semester III

GENERIC ELECTIVES [GE-1(3)]

Course Name: Linear and Modern Algebra

Course Code: BSCHMTMGE301

Course Type: **GE**	Course Details: **GE-3**		L-T-P: **5-1-0**	
Credit: **6**	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		……	**10**	....	**40**

Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand the concepts of different types of groups, rings and field.
- Understand the basic concepts of group actions and their applications.
- Understand the concepts of vector spaces, sub-spaces, linear dependence and linear independence of a finite set of vectors.

Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn of integers under addition modulo n and the group U(n) of units under multiplication modulo n. Cyclic groups from number systems, complex roots of unity, circle group, the general linear group GLn(n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions. group of permutation, Normal subgroups: their definition, examples, and characterizations, Quotient groups. Divisor of zeros, Rings, Integral domain, fields.

Solution of non-homogeneous system of three linear equations by matrix inversion method. Elementary row and column operations, rank of a matrix, row reduced echelon form and fully reduced normal form.

Vector spaces over reals, simple examples, linear dependence and independence of a finite set of vectors, sub-spaces, definition and examples.

References:

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, 1999.
4. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.
5. S. K. Mapa, *Higher Algebra (Abstract and Linear)*, Sarat Book House.
6. Promode Kumar Saikia, *Linear Algebra With Applications*, Pearson.
7. U. M. Swamy & A. V. S. N. Murthy, *Algebra: Abstract and Modern*, Pearson.
8. Ghosh & Chakravorty, *Higher Algebra (Classical & Modern)*, U. N. Dhur & Sons Pvt. Ltd.

Semester IV

GENERIC ELECTIVES [GE-1(4)]

Course Name: Basics in Real Analysis

Course Code: BSCHMTMGE401

<table>
<tr><td>Course Type: GE</td><td colspan="2">Course Details: GE-4</td><td colspan="3">L-T-P: 5-1-0</td></tr>
<tr><td rowspan="3">Credit: 6</td><td rowspan="3">Full Marks: 50</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>……</td><td>10</td><td>.......</td><td>40</td></tr>
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Course Learning Outcomes:

(After the completion of course, the students will have ability to):

- Understand about sets in R, sequences, series of functions and infinite series.

Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).
Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz's test(Tests of Convergence without proof). Definition and examples of absolute and
conditional convergence.

Sequences and series of functions, Pointwise and uniform convergence. Mn-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

References:

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis*, John Wiley and Sons (Asia) P.Ltd.,2000.
3. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
4. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series*- Undergraduate Texts In Mathematics, Springer Verlag, 2003.
5. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH , 2012.
6. S. N. Mukhopadhyay and A. Layek – *Mathematical Analysis – Vol-I* , U. N. Dhar & Sons Pvt. Ltd.
7. S. N. Mukhopadhyay and S. Mitra – *Mathematical Analysis – Vol-II,* (U. N. Dhar & Sons. Pvt. Ltd.

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