Learning Outcomes Based Curriculum Framework (LOCF)

for

Mathematics

Undergraduate Programme

2022

Department of Mathematics

Cotton University

Panbazar, Guwahati
Assam

PART I

1.1 Introduction

Higher education plays a critical role in securing gainful work and/or offering further access to higher education. As a result, improving the quality of higher education should be given top priority in order to enable the next generation of students to acquire the skills, training, and knowledge they need to improve their thinking, comprehension, and application abilities and prepare them to compete, succeed, and excel globally.

The Cotton University envisions all of its programmes in the best interests of its students, and in this effort, it has given all of its Undergraduate courses a new perspective. For all of its Undergraduate programmes, it uses a Learning Outcome-based Curriculum Framework (LOCF).

At the undergraduate level, the LOCF approach is intended to provide a focused, outcome-based curriculum with an agenda to shape teaching-learning experiences in a more student centric manner. The LOCF strategy has been implemented to enhance students' experiences as they participate in their chosen programme. Students will be prepared for both academics and employment through the Undergraduate Programs.

The syllabus developed for B. Sc. (Honours) in Mathematics has the provision of ensuring the integrated personality of the students in terms of providing opportunity for exposure to the students towards Core Courses, Discipline Specific Courses, Generic Elective Courses, Ability Enhancement Courses and Skill Enhancement Courses with special focus on technical, communication and subject specific skills through practical and other innovative transactional modes to develop their employability skills.

1.2 Learning Outcomes-based Approach to Curriculum Planning and Development

The basic objective of the learning outcome based approach to curriculum planning and development is to focus on demonstrated achievement of outcomes (expressed in terms of knowledge, understanding, skills, attitudes and values) and academic standards expected of graduates of a programme of study. Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study.

The expected learning outcomes are used to set the benchmark to formulate the course outcomes, programme specific outcomes, programme outcomes and graduate attributes. These outcomes are essential for curriculum planning and development, and in the design, delivery and review of academic programmes. They provide general direction and guidance to the teaching-learning process and assessment of student learning levels under a specific programme.

The overall objectives of the learning outcomes-based curriculum framework are to:

- help formulate graduate attributes, qualification descriptors, programme learning outcomes and course learning outcomes that are expected to be demonstrated by the holder of a qualification;
- enable prospective students, parents, employers and others to understand the nature and level of learning outcomes (knowledge, skills, attitudes and values) or attributes a graduate of a programme should be capable of demonstrating on successful completion of the programme of study;
- maintain national standards and international comparability of learning outcomes and academic standards to ensure global competitiveness, and to facilitate student/graduate mobility; and
- provide higher education institutions an important point of reference for designing teaching-learning strategies, assessing student learning levels, and periodic review of programmes and academic standards.

1.3 Key outcomes underpinning curriculum planning and development

The learning outcomes-based curriculum framework is a framework based on the expected learning outcomes and academic standards that are expected to be attained by graduates of a programme of study. The key outcomes that underpin curriculum planning and development include Graduate Attributes, Programme Outcomes, Programme Specific Outcomes, and Course Outcomes.

1.3.1 Graduate Attributes

The disciplinary expertise or technical knowledge that has formed the core of the university courses. They are qualities that also prepare graduates as agents for social good in future. Some of the characteristic attributes that a graduate should demonstrate are as follows:

1. **Disciplinary knowledge**: Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines
2. **Research-related skills**: A sense of inquiry and capability for asking relevant/appropriate questions and articulating
3. **Analytical reasoning**: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others
4. **Critical thinking**: Capability to apply analytic thought to a body of knowledge
5. **Problem solving**: Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems
6. **Communication Skills**: Ability to express thoughts and ideas effectively in writing and orally
7. **Information/digital literacy**: Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
8. **Self-directed learning**: Ability to work independently, identify appropriate resources required for a project, and manage a project through to completion.
9. **Cooperation/Team work**: Ability to work effectively and respectfully with diverse teams
10. **Scientific reasoning**: Ability to analyze, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective

11. **Reflective thinking**: Critical sensibility to lived experiences, with self-awareness and reflexivity of both self and society.
12. **Multicultural competence**: Possess knowledge of the values and beliefs of multiple cultures and a global perspective
13. **Moral and ethical awareness/reasoning**: Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work
14. **Leadership readiness/qualities**: Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision, and using management skills to guide people to the right destination, in a smooth and efficient way.
15. **Lifelong learning**: Ability to acquire knowledge and skills, including 'learning how to learn', that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of work place through knowledge/skill development/reskilling.

1.3.2 Programme Outcomes (POs) for Undergraduate programme (Honours)

POs are statements that describe what the students graduating from any of the educational programmes should able to do. They are the indicators of what knowledge, skills and attitudes a graduate should have at the time of graduation.

1. **In-depth knowledge:** Understand the concepts and processes related to an academic field of study and demonstrate the applicability of their domain knowledge and its links to related disciplinary areas/subjects of study.
2. **Specialised knowledge and skills**: Demonstrate procedural knowledge and skills in areas related to one's specialization and current developments, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.
3. **Analytical and critical thinking:** Demonstrate independent learning, analytical and critical thinking of a wide range of ideas and complex problems and issues.
4. **Research and Innovation**: Demonstrate comprehensive knowledge about current research in the subject of specialization, critical observation to identify research problems and to collect relevant data from a wide range of sources, analysis and interpretation of data using methodologies as appropriate to the area of specialization for formulating evidence-based research output.
5. **Interdisciplinary Perspective:** Commitment to intellectual openness and developing understanding beyond subject domains.
6. **Communication Competence:** Demonstrate effective oral and written communicative skills to covey disciplinary knowledge and to communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study
7. **Career development:** Show proficiency in academic, professional, soft skills and employability required for higher education and placements.
8. **Teamwork:** Work in teams with enhanced interpersonal skills leadership qualities.

9. **Commitment to the society and the Nation**: Recognize the importance of social, environmental, human and other critical issues faced by humanity at the local, national and international level; appreciate the pluralistic national culture and the importance of national integration.

1.3.3 Programme Specific Outcomes (PSOs) in Mathematics

Programme specific outcomes include subject-specific skills and generic skills, including transferable global skills and competencies, the achievement of which the students of a specific programme of study should be able to demonstrate for the award of the degree. The programme specific outcomes would also focus on knowledge and skills that prepare students for further study, employment, and citizenship. They help ensure comparability of learning levels and academic standards across universities and provide a broad picture of the level of competence of graduates of a given programme of study. The attainment of PSOs for a programme is computed by accumulating PSO attainment in all the courses comprising the programme.

1. **Basic Concept**: Ability to interpret and analyze various concepts and theories
2. **Understanding real life application**: An understanding application of various methods and apply in real life problem.
3. **Research and Innovation**: Use of knowledge to identify a wide range of contemporary problems and issues and acquire research skills to produce a well-researched written work using geographical research tools.
4. **Critical thinking**: Able to identify critical problems.

1.3.4 Course Level Learning Outcome Matrix

Course Level Learning Outcomes Matrix – Core Course

Programme Specific Outcomes	101	102	201	202	301	302	303	401	402	403	501	502	601	602
Basic Concepts	x	x	x	X	X	x	x	x	x	X	x	x	x	X
Understand real life application	x	x	x	X	X	x	x	x	X	X	x	x	x	X
Research and innovations	x	x	x	X	X	x	x	x	X	X	x	x	x	X
Critical thinking	x	x	x	X	X	x	x	x	x	X	x	x	x	X

Course Level Learning Outcomes Matrix – Elective and Department Specific Elective Courses

Basic Concepts	x	x	x	X	X	x	x	x	x	X	x	x	x	X
Understand real life application	x	x	x	X	X	x	x	x	X	X	x	x	x	X
Research and innovations	x	x	x	X	X	x	x	x	X	X	x	x	x	X
Critical thinking	x	x	x	X	X	x	x	x	x	X	x	x	x	x

1.4 Teaching-learning process

The department of Mathematics, Cotton University has student-centric teaching-learning pedagogies to enhance the learning experiences of the students. All classroom lectures are interactive in nature, allowing the students to have meaningful discussions and question and answer sessions. Apart from the physical classes, lectures are also held in online mode where students can have doubt clearing and discussions with the teachers. Most of the teachers use ICT facilities with power-point presentations, e-learning platforms and other innovative e-content platforms for student-centric learning methods.

The department has adopted participative teaching-learning practices, which includes seminars, presentations and group discussions. These participative teaching-learning practices are included in the curricula of almost all the courses. Apart from these, exposure visits, special lectures by invited experts, workshops, and National/International seminars are held to augment knowledge, encourage innovative ideas and expose the students to global academic and research advancement.

The short-term projects, research projects, assignments and field works, which are the integral components of all the courses, enable the students to solve practical problems. Students are also being engaged in sample surveys, data collection and analysis works of the in-house and external research projects for acquiring experiential learning. The laboratories of the department offer hands-on learning experiences to the students.

1.5 Assessment methods

A variety of assessment methods that are appropriate to the discipline are used to assess progress towards the course/programme learning outcomes. Priority is accorded to formative assessment. Progress towards achievement of learning outcomes is assessed using the following: closed-book examinations; problem based assignments; practical assignment; laboratory reports; individual project reports (case-study reports); team project reports; oral presentations, including seminar presentation; viva voce interviews; computerised testing and any other pedagogic approaches as per the context.

PART II

Structure of Under-Graduate programme in Geography

Choice Based Credit System
B.Sc. Mathematics, Cotton University

Semester	Core Course (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (4)
1	MTH101C Calculus and Analytical Geometry MTH102C Algebra	AECC1			GE-1(MTH-103GE, Algebra and Analysis)
2.	MTH201C Analysis-I MTH202C Differential Equations-I	AECC2			GE-2 (MTH-203GE, Calculus and Differential Equation)
3.	MTH301C Analysis-II MTH302C Abstract Algebra-I MTH303C Multivariate Calculus		SEC1 (MTH001SEC)		GE-3 (MTH-304GE, Analytical Geometry and Vector)
4.	MTH401C Differential Equations-II MTH402C Linear Algebra MTH403C Abstract Algebra-II		SEC2 (MTH002SEC)		GE-4 (MTH-404GE, Abstract Algebra and Numerical Analysis)
5.	MTH501C Metric Spaces MTH502C Number Theory			DSE-1 (MTH503) DSE-2 (MTH504)	
6.	MTH601C Complex Analysis MTH602C Analysis-III			DSE-3 (MTH603) DSE-4/DPW (MTH604)	

C-Core, GE-Generic Elective, DSE-Discipline Specific Elective, SEC-Skill Enhancement Course

U.G. 1st Semester

Paper: MTH101C (Core)

Calculus and Analytical Geometry

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic concept of higher order derivatives, Leibniz rule, the first-derivative test for relative extrema, concavity and inflection points, second derivative test for relative extrema, curve sketching, limits to infinity, L'Hopitals rule, volumes by slicing, disks and washers methods, volumes by cylindrical shells, hyperbolic functions, reduction formulae, transformation of axes, classification of general second degree equations in two dimensions representing lines, parabola, ellipse and hyperbola, polar equations of conics, spheres, cylindrical and conical surfaces.

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

1. Apply Leibniz rule.
2. Curve sketching using first and second derivative tests.
3. Evaluate volumes by slicing, disks and washers methods.
4. Apply transformation of axes on parabola, ellipse and hyperbola.

Unit-I (25 lectures)

Higher order derivatives, Leibniz rule and its applications, The first-derivative test for relative extrema, Concavity and inflection points, Second derivative test for relative extrema, Curve sketching using first and second derivative tests; Limits to infinity and infinite limits, Graphs with asymptotes, L'Hopitals rule; Applications in business, economics and life sciences, curve tracing in Cartesian coordinates and polar coordinates of standard curves, Unit tangent, Normal and binormal vectors, Curvature.

Unit-II (18 lectures)

Volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Unit-III(9 lectures)

Hyperbolic functions, Reduction formulae, derivations and illustrations of reduction formulae.

Unit-IV (23 lectures)

Transformation of axes, classification of general second degree equations in two dimensions representing lines, parabola, ellipse and hyperbola, reflection properties of parabola, ellipse and hyperbola. Polar equations of conics. Spheres, cylindrical and conical surfaces.

Books Recommended

1. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd.(Pearson Education), Delhi, 2007:

2. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., JohnWiley and Sons (Asia) P. Ltd., Singapore, 2002:

Books for Reference

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

2. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

3. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London, 2016.

4. R.J.T. Bell, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994.

Paper: MTH102C (Core)

Algebra

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives:

The primary objective of this course is to introduce the basic concept of De Moivre's theorem for rational indices, expansion of cosx, sinx in positive integral powers of x, logarithm of acomplex number, exponential and trigonometric functions of a complex variable, Euler's expansion of cosine & sine, hyperbolic functions, inverse functions, Gregory's series, Equivalence class, partitions, one to one correspondence, cardinality of a set, general properties of polynomials, relation between the roots and the coefficients of equations, symmetric functions, applications of symmetric function of the roots, transformation of equations. Descarte's rule of signs, systems of linear equations, row reduction and echelon forms, vector equations, rank of a matrix, the matrix equation Ax=b, solution sets of linear systems.

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

1. Apply Descarte's rule of signs positive and negative rule.
2. Find Solutions of reciprocal and binomial equations.
3. Find algebraic solutions of the cubic and biquadratic.
4. Solve the matrix equation Ax=b, sets of linear systems and applications on linear systems.

Unit-I (19 lectures)

De Moivre's theorem for rational indices and its applications, expansion of cosx, sinx in positive integral powers of x, logarithm of a complex number, exponential and trigonometric functions of a complex variable, Euler's expansion of cosine & sine, hyperbolic functions, inverse functions, Gregory's series.

Unit-II (16 lectures)

Statements, Statements with quantifiers, compound statements, Implications, Proofs in Mathematics, Equivalence class, partitions, one to one correspondence, cardinality of a set: properties and examples.

Unit-III (10 lectures)

General properties of polynomials, graphical representation of a polynomial, maximum and minimum values of a polynomial.

Unit-IV (16 lectures)

Relation between the roots and the coefficients of equations.Symmetric functions, applications of symmetric function of the roots, transformation of equations. Descarte's rule of signs**.** Solutions of reciprocal andbinomial equations, solutions of the cubic equations by Cardon's method and biquadratic equations by Euler's method.

Unit-V (14 lectures)

Systems of linear equations, row reduction and echelon forms, vector equations, rank of a matrix, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. Subspaces of R^n, dimension of subspaces of R^n

Books Recommended:

1. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhauser, 2006:
2. D. C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

3. W.S. Burnside and A.W. Panton, The Theory of Equations, Dublin University Press, 1954.

4.C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.

5. A. Kumar, S. Kumaresan and B.K. Sarma, A Foundation Course in Mathematics, Narosa, 2018.

Books for Reference

1. S. K. Mappa,Higher Algebra (Classical), Ashoke Prakasam, Calcutta, 2014.

2. F. Ayers,Theory and Problems of Matrices, Schaum Outline Series, 1962.

3. S. Lipschutz, M. Lipson, Linear Algebra 4th Edition, Schaum's Outlines, 2008.

U.G. 2nd Semester

Paper: MTH201C (Core)

Analysis-I

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic concept of algebraic and order properties of R, δ-neighborhood of a point in R, idea of countable sets, uncountable sets, bounded and unbounded sets, suprema and infima, the completeness property of R, the Archimedean property, infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence, alternating series, Leibniz test.

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

1. Find Suprema and Infima of bonded sets.
2. Find Limit point, boundary points of a set etc.
3. Check the convergence of a sequence, also find limits of sequence etc.
4. Check the convergence of a infinite series by applying Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral.

Unit-I(12 lectures)

Algebraic and order properties of R, Absolute value of a real number,δ-neighborhood of a point in R, idea of countable sets, uncountable sets. Bounded and unbounded sets, suprema and infima, interior point, limit point, boundary points of a set, isolated points, open sets, closed sets, closure,

derived set, cantor set, compact sets, Heine-Borel theorem, Bolzano-Weierstrass theorem for sets,

Unit-II(09 lectures)

The completeness property of R, the Archimedean property, density of rational and irrational numbers in R, intervals, Nested intervals property.

Unit-III(14 lectures)

Interior point, limit point, boundary points of a set, isolated points, open sets, closed sets,closure, derived set, cantor set, compact sets, Heine-Borel theorem, Bolzano-Weierstrass theorem for sets.

Unit-IV(20 lectures)

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. Cauchy sequence, Cauchy's Convergence criterion.

Unit-V(20 lectures)

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

Books Recommended

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. G. G. Bilodeau , P. R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Denlinger, Charles G. (2011). Elements of Real Analysis. Jones & Bartlett India Pvt. Ltd. Student Edition. Reprinted 2015.

Books for Reference

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, McGraw Hill Education; 1st Edition, 2007.
2. B. S. Thomson, A. M. Bruckner and J. B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
3. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.
4. F. Ayres, E. Mendelson,Schaum's Outline of Calculus,Mcgraw Higher Ed, 6th Edition, 2012.

Paper: MTH202C (Core)

Differential Equations-I

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic concept of first order first degree, reducible second order differential, linear differential equations, exact differential equations, integrating factors, reducible second order differential, existence theorem and uniqueness theorem, general solution of homogeneous equation of second order, principle of superposition for a homogeneous equation, Wronskian, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients etc. Also basic idea of system of first order ordinary differential equations, total differential equation and simultaneous equations of the form dx/P=dy/Q=dz/R, solutions of differential equations.

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

1. Solving exact differential equation with the help of integrating factors.
2. Solving Bernoulli's differential equation.
3. Solving higher degree equations solvable for x, y and p.
4. Finding singular solution of first order ordinary differential equations.
5. Finding general solution of homogeneous equation of second order.
6. Applying transformation of the equation by changing the dependent variable, independent variable on linear differential equations of second order with variable coefficients.
7. Solving total differential equation and simultaneous equations.
8. Finding series solutions of differential equations, also Bessel and Legendre differential equations.

Unit– I: (11 lectures)

Review of first order first degree differential equations; linear and Bernoulli's differential equations. Exact differential equations and integrating factors of first order differential equations; Lipschitz condition; existence and uniqueness theorem (statement only).

Unit– II:(13 lectures)

Method of solving higher degree equations solvable for x, y and p. Clairaut's form and singular solutions, orthogonal trajectories. Singular solution of first order ordinary differential equations. Applications of first order differential equation.

Unit– III:(17 lectures)

General linear equation of second and higher order, principle of superposition for a homogeneous equation, Wronskian: its properties and applications, solutions of linear homogeneous and non-homogeneous equations of higher order with constant coefficients, method of variation of parameters, method of undetermined coefficients.

Unit– IV: (17 lectures)

Linear differential equations of second order with variable coefficients, standard methods, removal of first derivative, transformation of the equation by changing the independent variable, variation of parameter, applications of second order differential equations.

Unit– V: (17 lectures)

System of first order ordinary differential equations. Total differential equation of the form Pdx+Qdy+Rdz=0 and simultaneous equations of the form dx/P=dy/Q=dz/R. Exact differential equations including the special form $\frac{d^n y}{dx^n} = f(x)$.

Books Recommended

1. S. L. Ross, Differential Equations, John Wiley and Sons, India, 2004.

2.G. Simmons, Differentials Equations with Applications and Historical Notes 2nd Edition (International Series in Pure & Applied Mathematics), McGraw-Hill Higher Education, 1991

Books for Reference

1. B. Barnes and G. R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach Using Maple, Taylor and Francis, London and New York, 2002.

2. C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value Problems: Computing and Modeling, Pearson Education, India, 2005.

3. R. Bronson, Gabriel Costa, Differential Equations 3rd Edition, Schaum's Outline, 2009.

4. M.D. Raisinghania, Ordinary and partial differential Equation:. S.Chand and Co., India, 2017

U.G. 3rd Semester

Paper: MTH301C (Core)

Analysis-II

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic concept of limits of functions ($\varepsilon - \delta$approach), sequential criterion for limits, divergence criteria, limit theorems, Uniform continuity, uniform continuity criteria, uniform continuity theorem, monotone and inverse functions, differentiability of a function at a point and in an interval, Caratheodory's theorem, Interior extremum theorem, Rolle's theorem, Mean value theorems, intermediate value property of derivatives, Darboux's theorem, Taylor's theorem with Lagrange's form of remainder.

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

1. Check whether a function is continuous or discontinuous applying sequential criterion for continuity and discontinuity.
2. Apply intermediate value theorem to locate roots.
3. Check the uniform continuity and differentiability of a function.
4. Apply Darboux's theorem.
5. Apply Roll's theorem..
6. Apply mean value theorems to inequalities and approximation of polynomials.
7. Apply Taylor's theorem.

Unit-I(16 lectures)

Limits of functions ($\varepsilon - \delta$approach), sequential criterion for limits, divergence criteria. Limittheorems, one sided limits. Infinite limits and limits at infinity, continuous functions, sequential criterion for continuity and discontinuity,

Unit-II(17 lectures)

Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non uniform continuity criteria, uniform continuity theorem, monotone and inverse functions

Unit-III(12 lectures)

Review of differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema.

Unit-IV(14 lectures)

Interior extremum theorem, Rolle's theorem, Mean value theorems, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorems to inequalities and approximation of polynomials,

Unit-V(16 lectures)

Taylor's theorem with Lagrange's form of remainder, application of Taylor's theorem to convex functions and to inequality, relative extrema. Taylor's series expansions of exponential and trigonometric functions.

Books Recommended

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003

2. . K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.

Books for Reference

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, McGraw Hill Education; 1st Edition, 2007.

2. A. Mattuck, Introduction to Analysis, Prentice Hall, 1999.

3. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006

4. F. Ayres, Elliott Mendelson, Schaum's Outline of Calculus, Mcgraw Higher Ed, 6th Edition, 2012.

Paper: MTH302C (Core)

Abstract Algebra-I

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course objective: The primary objective of this course is to introduce the basic concept of Symmetries of a square, Dihedral groups, permutation groups and quaternion groups, subgroups, centralizer, normalizer, center of a group, product of two subgroups, cyclic groups, alternating

group, properties of cosets, normal subgroups, factor groups and related theorems. Also basic idea of group homomorphisms, isomorphisms, first, second and third isomorphism theorems and automorphism.

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

1. Understand of the concept of different types of groups e.g. symmetries of a square, dihedral groups, , cyclic groups, alternating group etc.
2. Familiarize with properties cyclic groups, classification of subgroups of cyclic groups, permutation groups, Lagrange's theorem and consequences normal subgroups.
3. Understand group homomorphism and its properties, Cayley's theorem, properties of isomorphisms, automorphism, automorphism groups, class equation.

Unit-I (28 lectures)

Symmetries of a square, dihedral groups, definition and examples of groups including quaternion groups (illustration through matrices), elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. Cyclic group and its properties.

Unit-II(27 lectures)

Permutation: Cycle notation for permutations, properties of permutations, even and odd permutations, symmetric group, alternating group, coset and its properties, Lagrange's theorem and consequences, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Unit-III(20 lectures)

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems. Automorphism, inner automorphism, automorphism groups, class equation. (18 lectures)

Books Recommended:

1. J. A. Gallian, Contemporary Abstract Algebra(4th Edition), Narosa Publishing House, New Delhi, 1999.(IX Edition 2010)

Books for Reference:

1.I. N. Herstein, Topics in Algebra , New Age Publications, 2006

2. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra, McGraw-Hill, 1997

3.J. B.Fraleigh, A first course in Abstract Algebra, 7th Edition, Pearson Education India, 2004.

4. P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul, Basic Abstract Algebra, Cambbridge University Press, 2nd Edition, 1994.

Paper: MTH303C (Core)

Multivariate Calculus

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course objective: The primary objective of this course is to introduce the basic concept of functions of several variables, limit and continuity, partial differentiation, differentiability, sufficient condition for differentiability, chain rule, extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, double and triple integration, volume by triple integrals, , line integrals, Green's theorem, Stokes' theorem, Divergence theorem.

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

1. To check continuity functions of several variables also find partial derivatives and check differentiability.
2. Apply chain rule on functions of one and two independent parameters, directional derivatives, the gradient, divergence and curl.
3. Find extrema of functions of two variables by applying method of Lagrange multipliers d.
4. Apply triple integral to find volumes.
5. Application of Green's theorem, Stokes' theorem, The Divergence theorem.

Unit-I(16 lectures)

Functions of several variables, limit and continuity of functions of two variables. Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters.

Unit-II(23 lectures)

Triple product, introduction of vector functions, operations with vector-valued functions, limitsand continuity of vector functions, differentiation and integration of vector functions, vector field, directional derivatives, gradient, maximal and normal property of the gradient, divergence and curl.

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

Unit-III(16 lectures)

Double integration over rectangular and nonrectangular regions. Triple integral over a parallelepiped and solid regions. Volume by triple integrals in cylindrical and spherical co-ordinates. Change of variables in double and triple integrals. (15 lectures)

Unit-IV(19 lectures)

Line integrals, Applications of line integrals: Mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path. Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes' theorem, divergence theorem.

Books Recommended:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

Books for Reference:

1. E. Marsden, A. J. Tromba and A. Weinstein, Basic multivariable calculus,Springer (SIE), Indian reprint, 2005

2. D. Spellman, M. Spiegel and S. Lipschutz,Vector analysis - Schaum's outline 2nd Edition, 2009.

3. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

4. J.Stewart, Multivariable Calculus: Concepts and Contexts, 2ndEd., Brooks /Cole,

Thomson Learning, USA, 2001.

U.G. 4th Semester

Paper: MTH401C (Core)

Differential Equation-II

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course objective: The primary objective of this course is to introduce the basic concept of partial differential equations(PDE), method of characteristic and general solution of first order PDE, canonical form of first order PDE, method of separation of variables, Non-linear PDE of first order, Cauchy's method of characteristic, Charpit's method, Jacobi's method, Bessel functions, Fourier series, Origin of second order PDE, Mathematical modelling of vibrating string etc.

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

1. Familiarize with classification of PDE
2. Apply method of characteristic and general solution of first order PDE
3. Apply method of separation of variables for first order PDE
4. Determination of integral surfaces of linear first order PDE
5. Solve non-linear PDE of first order by Cauchy's method of characteristic, Charpit's method, Jacobi's method.
6. Familiarize with Bessel functions, Fourier series, Half range Fourier sine series and cosine series.
7. Understand second order PDE and its application of mathematical modeling.
8. Solving linear second order PDE with constant coefficients, linear second order PDE with variable coefficients.

Unit– I(19 lectures)

Introduction to second order ordinary differential equations. Regular and singular points of differential equations. Series solutions of differential equations about ordinary and singular points. Bessel and Legendre differential equations. Bessel functions and their properties, Legendre polynomials and their properties.

Unit– II (20 lectures)

Introduction to partial differential equations, classification, construction and geometrical interpretation of first order partial differential equations (PDE), canonical form of first order PDE, method of separation of variables for first order PDE, method of characteristic and general solution of first order PDE. Determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces.

Unit– III(19 lectures)

Non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution.

Unit– IV(17 lectures)

Origin of second order PDE, classification of second order PDE, one dimensional wave and heat conduction equations, gravitational potential, linear second order PDE with constant coefficients.

Books Recommended:

1. T. Myint-U and L. Debnath, Linear Partial Differential Equation for Scientists and Engineers, Springer, Indian reprint, 2006.

2. I. N. Sneddon, Elements of Partial Differential Equation (3rd edition), McGraw Hill Book Company,1998.

Books for Reference:

1. I. P Stavroulakis and Stepan A Tersian, Partial Differential Equations: An Introduction with Mathematica and MAPLE, World Scientific, Second Edition, 2004.

2. G. Simmons, Differentials Equations with Applications and Historical Notes 2nd Edition, Mcgraw Higher Ed, 1991.

3. R. Bronson, Gabriel Costa, Differential Equations 3rd Edition, Schaum's Outline, 2009.

4. K. Sankara Rao, Introduction to Partial Differential Equations, PHI; 3rd edition edition, 2010

Paper: MTH402C (Core)

Linear Algebra

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of vector space, subspaces, linear span and linear independence, basis, dimension, dimension of sum of subspaces, quotient spaces and its dimension, Linear Maps, null space, range, rank and nullity of a linear map, invariant subspaces, eigen values and eigenvectors, Inner product, Norms, Cauchy-Scwarz Inequality, orthonormal basis, orthogonal projection, linear functional and adjoints.

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

1. Understand vector space, subspaces, sums and direct sum of subspaces, complementary subspaces, quotient spaces.
2. Familiarize with linear span and linear independence, basis, dimensions.
3. Understand linear Maps, null space, range, rank and nullity of a linear map, linear Isomorphism, matrix of a linear map.
4. Apply concept of eigenvalues and eigenvectors, polynomials to operators, upper triangular matrices, diagonal matrices.
5. Construct orthonormal basis of a vector space.
6. Familiarize with linear functional and adjoints.

Unit– I (25 lectures)

Vector space, subspaces, sums and direct sum of subspaces, linear span and linear independence, basis, dimensions, existence of complementary subspaces of a subspace of finite dimension, dimension of sum of subspaces, quotient spaces and its dimension.

Unit– II (16 lectures)

Linear maps, null space, range, rank and nullity of a linear map, linear isomorphism, matrix of a linear map, invertibility

Unit– III(18 lectures)

Invariant subspaces, eigen values and eigenvectors, polynomials applied to operators, upper triangular matrices, diagonal matrices, invariant subspaces on real vector spaces

Unit– IV(16 lectures)

Inner product, norms, Cauchy-Scwarz inequality, orthonormal basis, orthogonal projection and minimization problems, linear functional and adjoints.

Books Recommended:

1. S. Axler, Linear Algebra Done Right, Springer, 2015

Books for Reference:

1. K. M. Hoffman & R. Kunze, Linear Algebra, Prentice Hall of India, 1971.
2. P.K.Saikia, Linear Algebra, Pearson, 1st Edition, 2009.

3. S. Kumaresan, Linear Algebra A Geometric Approach, Prentice Hall of India, 2000.

Paper: MTH403C (Core)

Abstract Algebra-II

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course objective: The primary objective of this course is to introduce the basic concept of rings, subrings, ideals, fields, Integral domains, division rings, characteristic of a ring, ideals, sum of ideals, Product of ideals, homomorphisms of rings and imbeddings: maximal and prime ideals, principal ideal domain, unique factorization domain, polynomial rings, quotient rings, factorization of polynomials, irreducibles, primes.

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

1. Familiarize with definition and properties of rings, subrings, ideals, fields, Integral domains, division rings, characteristic of a ring, ideals, sum of ideals, Product of ideals
2. Understand homomorphisms of rings and imbeddings, maximal and prime ideals.
3. Understand principal ideal domain, unique factorization domain, etc. Also polynomial rings, ring of matrices-its ideals and quotients.
4. Familiarize with factorization of polynomials, reducibility tests, unique factorization in Z[x], divisibility in integral domains.

Unit I(17 lectures)

Definitions, examples and properties of rings, subrings, ideals,fields, integral domains, division rings, characteristic of a ring,sum of ideals, product of ideals

Unit II(17 lectures)

Homomorphisms of rings and imbeddings: maximal and prime ideals, idempotent & nilpotentelements and ideals, nil ideals in a ring, principal ideal, simple ring.

Unit III(14 lectures)

Principal ideal domain, unique factorization domain and Euclidean domain, quotient rings, field of quotients of an integral domain.

Unit IV(12 lectures)

Polynomial rings, its ideals and quotients, ring of matrices-its ideals and quotients.

Unit V(15 lectures)

Factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in Z[x]. Divisibility in integral domains, irreducibles, primes.

Books Recommended:

1.P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul, Basic Abstract Algebra, Cambbridge University Press, 2nd Edition, 1994.

2. J. A. Gallian, Contemporary Abstract Algebra(4th Edition), Narosa Publishing House, New Delhi, 1999.(IX Edition 2010)

Books for Reference:

1.I. N. Herstein, Topics in Algebra , New Age Publications, 2006.

2. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra, McGraw-Hill, 1997

3.J. B.Fraleigh, A first course in Abstract Algebra, 7th Edition, Pearson Education India, 2003

Paper: MTH501C (Core)

Metric Space

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of Metric space, Complete Metric space, open and closed balls, open set, interior of a set, Limit point of a set, closed set, diameter of a set, Cantor's Theorem, Subspaces, dense sets, separable spaces,

Continuous mappings, Uniform continuity, Homeomorphism, Banach Fixed point Theorem, Connectedness, Compactness etc.

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

1. Understand the properties of Metric space
2. Understand the concept of open and closed balls, neighbourhood, limit point etc.
3. Recognize Continuous mappings, Uniform continuity, Homeomorphism and apply Banach fixed point theorem.
4. Recognize Compactness, boundedness, Connectedness, connected subsets of R.

Unit-I(18 lectures)

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces.

Unit-II(23 lectures)

Open and closed balls, neighbourhood, open set, interior of a set, limit point of a set, closed set, diameter of a set, Cantor's theorem, subspaces, dense sets, separable spaces.

Unit-III(16 lectures)

Continuous mappings, sequential criterion and other characterizations of continuity, uniform continuity, Homeomorphism, contraction mappings, Banach fixed point theorem.

Unit-IV(09 lectures)

Connectedness: connected subsets of R, connectedness and continuous mappings.

Unit-V(09 lectures)

Compactness: compactness and boundedness, continuous functions on compact spaces.

Books Recommended:

1. S. Shirali & H. L. Vasudeva, Metric Spaces, Springer Verlag London (2006) (First Indian Reprint 2009).

Books for Reference:

1. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, Second Edition 2011.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, Mcgraw-Hill, Edition 2004.
3. S. Lipschutz, Schaum's Outline of General Topology, McGraw Higher ED, 2011
4. J. R. Munkres, Topology, Pearson Education India; 2nd edition, 2015.

Paper: MTH502C (Core)

Number Theory

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of Peano's axiom, well ordered principle, divisibility theory in the integers, Euclid's Lemma, Diophantine equation, fundamental theorem of arithmetic, sieve of Eratosthenes, Goldbach conjecture, theory of congruences, Chinese remainder theorem, Fermat's theorem, Wilson's theorem, Fermat-Kraitchik factorization method, mobius inversion formula, primitive roots and indices, Certain non-linear Diophantine equations, $x^2+y^2=z^2$, Fermat's last theorem.

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

1. Understanding Peano's axiom, Divisibility theory, division algorithm, Diophantine equation, An application to the calendar.
2. Familiarize with fundamental theorem of arithmetic, Goldbach conjecture, theory of congruences, Chinese remainder theorem and their application.
3. Understanding mobius inversion formula, greatest integer function and its application to the calendar.
4. Familiarize with primitive roots and indices, order of an integer modulo n, theory of indices.
5. Representation of integers as sums of squares, sum of two squares, sum of four squares.

Unit-I(14 lectures)

Peano's axiom, well ordered principle, principles of mathematical induction, divisibility theory of integers, division algorithm, GCD, Euclid's Lemma, Euclidean algorithm, diophantine equation, an application to the calendar.

Unit-II (17 lectures)

Fundamental theorem of arithmetic, sieve of Eratosthenes, Goldbach conjecture, Fermat and Mersenne primes, theory of congruences, basic of congruence, binary and decimal representations of integers, linear congruences and the Chinese remainder theorem

Unit-III(19 lectures)

Fermat's theorem, Wilson's theorem, Fermat-Kraitchik factorization method, number-theoretic functions, mobius inversion formula, greatest integer function, an application to the calendar, Euler's phi-function, Euler's theorem, properties of the phi-function

Unit-IV(14 lectures)

Primitive roots and indices, order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices

Unit-V (11 lectures)

Certain non-linear Diophantine equations, $x^2+y^2=z^2$, Fermat's last theorem, representation of integers as sums of squares, sum of two squares, sum of four squares

Books Recommended:

1. D. M. Burton, Elementary Number Theory (6th Edition), Tata McGraw-Hill Edition, Indian reprint, 2007.

Books for Reference:

1.I. Niven and H. S. Zuckerman,An Introduction to the Theory of Numbers (3rd edition) – Wiley Eastern Ltd., New Delhi, 1993

2. N. Robinns, Beginning Number Theory (2nd Edition), Narosa Publishing House Pvt. Limited, Delhi, 2007.
3.K.C. Chowdhury, A First Course in Theory Of Numbers, Asian Books Private Ltd, 2004.

U.G. 6th Semester

Paper: MTH601C (Core)

Complex Analysis

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of complex plane, functions of complex variable, mappings. Limits, Derivatives, differentiation formulas, Cauchy-Riemann equations, Analytic functions, examples of analytic functions, definite integrals of functions, Cauchy-Goursat theorem, Cauchy integral formula, Liouville's theorem etc. Also basic idea of Convergence of sequences and series, Taylor series and its examples, Laurent series and its examples, absolute and uniform convergence of power series,

Isolated singular points, residues, Cauchy's residue theorem, residue at infinity. Types of isolated singular points, residues at poles and its examples.

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

1. Understand many properties of complex plane, complex valued function.
2. Calculate derivatives, check sufficient conditions for differentiability.
3. Recognize analytic functions, evaluate definite integrals of functions and apply Cauchy-Goursat theorem, Cauchy integral formula etc.
4. Check convergence of sequences and series e.g. Taylor series, Laurent series. Recognize absolute and uniform convergence of power series.
5. Recognize Isolated singular points. Evaluate residues applying Cauchy's residue theorem.

Unit-I (16 lectures)

Limits, limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Unit-II (21 lectures)

Analytic functions, examples of analytic functions, exponential function, logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions, Contours, Contour integrals and its examples, Upper bounds for moduli of contour integrals.

Unit-III (16 lectures)

Anti-derivatives, proof of anti-derivative theorem, Cauchy-Goursat theorem, Cauchy integral formula. An extension of Cauchy integral formula, consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.

Unit-IV (11 lectures)

Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series, uniqueness of series representations of power series.

Unit-V (11 lectures)

Isolated singular points, residues, Cauchy's residue theorem, residue at infinity. Types of isolated singular points, residues at poles and its examples, definite integrals involving sines and cosines.

Books Recommended:

1. J. W. Brown and R. V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, 2009.

Books for Reference:

1. J. Bak and D. J. Newman, Complex analysis (2nd Edition),Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.
2. J. M. Howie , Complex Analysis , Springer Undergraduate Mathematics Series, 2003.

3. M. Spiegel, S. Lipschutz, John Schiller, Dennis Spellman, Complex Variable: Schaum's Outlines Series, McGraw Higher Ed, 2009.

Paper: MTH602C (Core)

Analysis-III

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of Riemann integration, inequalities of upper and lower sums, Riemann conditions of integrability, definition and integrability of piecewise continuous and monotone functions, intermediate value theorem for integrals, fundamental theorems of calculus, definition and integrability of piecewise continuous and monotone functions. Intermediate value theorem for integrals; fundamental theorems of calculus, differentiation under the sign of integration, Frullani's integrals, Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions, Power series, radius of convergence, Weierstrass approximation theorem..

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

1. Familiarize with Riemann conditions of integrability.
2. Understand pointwise and uniform convergence of sequence of functions.
3. Check convergence of improper integrals.
4. Apply Cauchy criterion for uniform convergence and Weierstrass M-Test on series of functions.
5. Familiarize with Power series, radius of convergence.

Unit-I(24 lectures)

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate value theorem for integrals, fundamental theorems of calculus, pointwise and uniform convergence of sequence of functions,

Unit-II(14 lectures)

Improper integrals: Convergence of improper integrals. Beta and Gamma functions and their properties. Differentiation under the sign of integration, Frullani's integrals.

Unit-III(13 lectures)

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.

Unit-IV(10 lectures)

Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

Unit-V(14 lectures)

Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard theorem, differentiation and integration of power series; Abel's theorem; Weierstrass approximation theorem.

Books Recommended:

1. K.A. Ross, Elementary Analysis: The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

2. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis (3rd edition), John Wiley and Sons (Asia) Pvt. Ltd.., Singapore, 2002.

Books for Reference:

1. G. Das and S. Pattanayak, Fundamentals of Mathematics Analysis, McGraw Hill Education; 1st Edition, 2007.

2. Charles G. Denlinger, Elements of Real Analysis, Jones and Bartlett (Student Edition),2011.

DSE- Discrete Mathematics

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of ordered sets, maps between ordered set, lattices as ordered sets, lattices as algebraic structures, sublattices, distributive lattices, Boolean algebras, Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, , pseudographs, complete graphs, bipartite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, Dijkstra's algorithm..

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

1. Understand basic properties of ordered sets, maps between ordered sets, duality principle, products and homomorphisms.
2. Familiarize with properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials.
3. Apply switching circuits.
4. Understand basic properties of graphs, pseudographs, complete graphs, bipartite graphs, isomorphism of graphs, paths and circuit, travelling salesman's problem, Dijkstra's algorithm, Floyd-Warshall algorithm.

Unit I: (11 lectures)

Definitions, Examples and basic properties of ordered sets, Order isomorphism, Hasse diagrams, Dual of an ordered set, Duality principle, Maximal and minimal elements, Building new ordered sets, Maps between ordered sets.

Unit II: (22 lectures)

Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms; Definitions, Examples and properties of modular and distributive lattices, The M3 – N5 theorem with applications, Complemented lattice, Relatively complemented lattice, Sectionally complemented lattice.

Unit III: (21 lectures)

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

Unit IV:(21 lectures)

Introduction to graphs, Königsberg bridge problem, Instant insanity game; Definition, examples and basic properties of graphs, 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, Dijkstra's algorithm.

Books Recommended:

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

2. E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory (2nd Edition), Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2003.

3. R. Lidl and G. Pilz, Applied Abstract Algebra (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

Books for Reference:

1. M. L. Lipson, S. Lipschutz, Discrete Mathematics, Mcgraw Higher Ed, 2017

2. F.Harary, Graph Theory, Narosa Publishing House, 2001.

DSE- Linear Programming and Theory of Games

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of linear programming problem(LPP), theory of simplex method, two-phase method, big-M method, duality, formulation of the dual problem, transportation problem, northwest-corner method least cost method and Vogel approximation method, Hungarian method, game theory, graphical solution procedure.

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

1. Apply simplex method on LPP.

2. Apply two-phase method, big-M method on LPP.
3. Understand formulation of the dual problem, primal-dual relationships,economic interpretation of the dual.
4. Apply Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem.
5. Apply Hungarian method for solving assignment problem.
6. Apply linear programming solution of games.

Unit 1 (16 lectures)

Linear programming problem: Standard, Canonical and matrix forms, Graphical solution; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic feasible solutions, Reduction of feasible solution to a basic feasible solution, Correspondence between basic feasible solutions and extreme points.

Unit 2 (26 lectures)

Simplex method: Optimal solution, Termination criteria for optimal solution of the linear programming problem, Unique and alternate optimal solutions, Unboundedness; Simplex algorithm and its tableau format; Artificial variables, Two-phase method, Big-M method.

Unit 3 (16 lectures)

Motivation and formulation of dual problem; Primal-Dual relationships; Fundamental theorem of duality; Complimentary slackness.

Unit 4 (17 lectures)

Transportation Problem: Definition and formulation; Methods of finding initial basic feasible solutions; Northwest-corner rule. Least- cost method; Vogel's approximation method; Algorithm for solving transportation problem. Assignment Problem: Mathematical formulation and Hungarian method of solving. Game Theory: Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear programming method of solving a game.

Books Recommended:

1. M. S. Bazaraa, J. J. Jarvis and H. D. Sherali, Linear Programming and Network Flows (2nd edition), John Wiley and Sons, India, 2004.
2. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.
3. H. A. Taha, Operations Research, An Introduction (9th edition), Prentice-Hall, 2010.

Books for Reference:

1. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research-Concepts and Cases (9th Edition), Tata McGraw Hill, 2010.

2. P. R Thie,G E Keough,An Introduction to Linear Programming and Game Theory, Wiley India Private Limited, 2008.

DSE-Mechanics

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of composition and resolution of forces, parallelogram of forces, triangle of forces, converse of triangle of forces, Lami's theorem, parallel forces, moment of a force about a point and an axis, couple and couple moment, conditions of equilibrium of a particle and of coplanar forces acting on a rigid body, friction, centre of gravity of an arc, plane area, virtual works, velocity and acceleration of a particle along a curve, simple harmonic motion, projectiles, central Forces, resisting medium, conservative force field, kinetic energy and work kinetic energy expression based on centre of mass, moment of inertia.

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

1. Understand composition and resolution of Forces, parallelogram of forces, triangle of forces, converse of triangle of forces, Lami's theorem, moment of a couple about a line.
2. Familiarize with resultant of a force system, conditions of equilibrium, friction, centre of gravity, virtual works.
3. Understand velocity, acceleration, simple harmonic motion, projectiles, central forces.
4. Understand conservative force field, work energy equation, kinetic energy and work kinetic energy expression based on centre of mass, translation and rotation of rigid bodies, moment of momentum equation.

Unit-I

Composition and resolution of forces, parallelogram of forces, triangle of forces, converse of triangle of forces, Lami's theorem, converse of Lami's theorem . Parallel forces, Moment of a force about a point and an axis, couple and couple moment, Moment of a couple.

Unit-II

Resultant of a force system of forces, conditions of equilibrium of a system of particles and of coplanar forces acting on a rigid body, friction and laws of friction and applications, centre of gravity of an arc, plane area,surface of revolution, solid of revolution. Virtual works.

Unit-III

Velocity and acceleration of a particle along a curve: tangential, normal, radial cross-radial components (plane curve), inverse square law, simple harmonic motion, and simple Pendulum, Projectiles. Central Forces, Kepler's Laws of planetary motion, Resisting medium.

Unit-IV

Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on centre of mass.

Books Recommended:

1. I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics (4th Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics (11th Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009
3. A.P. Roberts, Statics and Dynamics with Background in Mathematics, Cambridge University, 2003

Books for Reference:

1.B.C. Das, Statics, U.N. Dhur & Sons Private Ltd., 1947.
2. B.C. Das, Dynamics, U.N. Dhur & Sons Private Ltd., 1946.
3. M. R Spiegel,Theoretical Mechanics, McGraw Higher Ed, 1980.

DSE-Numerical Analysis

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of normalized floating point representation of real numbers, errors in arithmetic operations, absolute and relative error, calculus of finite difference, different interpolation formulae, numerical differentiation and integration, algebraic and transcendental equations and their roots, error analysis, rate of convergence and algorithm for each of these methods, systems of linear algebraic equations and their solutions.

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

1. Familiarize with absolute and relative error, truncation and round off errors.
2. Interpolate functions by applying Newton's formulae, Lagrange's formula, Gauss, Bessel and sterling's formula, Hermite interpolation.
3. Find numerical integration by applying general quadrature formula, trapezoidal rule, Simpson's one third and three eighth rule, Weddel's rule, Newton-Cote's formula, Gauss quadrature formula.
4. Determine roots of algebraic and transcendental equations by applying bisection method, secant method, Regula-Falsi method, Newton-Raphson method, fixed point iteration method.
5. Solve systems of linear algebraic equations by applying direct and iterative methods; forward and backward substitution method; Gauss elimination method; Gauss-Jordan elimination method, LU decomposition.

Unit– I (8 lectures)

Normalized floating point representation of real numbers and operations using it, normalization and its consequence, errors in arithmetic operations, absolute and relative error, truncation and round off errors, approximation and significant figures.

Unit– II(18 lectures)

Calculus of finite difference: different interpolation formulae with remainder terms, finite difference operators and their operations on function of a single variable, interpolation with equal and unequal intervals, Newton's formulae, Lagrange's formula, Gauss, Bessel and sterling's formula, Hermite interpolation.

Unit– III(17 lectures)

Numerical differentiation and integration: Numerical differentiation with the help of different interpolation formulae, general quadrature formula, trapezoidal rule, Simpson's one third and three eighth rule, Weddel's rule, Newton-Cote's formula, Gauss quadrature formula.

Unit– IV(16 lectures)

A brief introduction to algebraic and transcendental equations and their roots; direct and iterative methods for determination of roots of these equations; initial approximations;

bisection method, secant method, Regula-Falsi method, Newton-Raphson method, fixed point iteration method for determination of roots of algebraic and transcendental equations; error analysis, rate of convergence and algorithm for each of these methods

Unit– V(16 lectures)

A brief introduction to systems of linear algebraic equations and their solutions; direct and iterative methods; forward and backward substitution method; Gauss elimination method; Gauss-Jordan elimination method, LU decomposition

Books Recommended:

1. B. 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 Computation, New age International Publisher, India, 5th edition, 2007.

Books for Reference:

1. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008

2. R. L. Burden, J. D. Faires, Annette M. Burden, Numerical Analysis, Cengage Learning, 10 edition, 2015

3. K. Atkinson,An Introduction to Numerical Analysis, John Wiley & Sons; 2nd Revised edition, 1989.

DSE: Computer Programming in C Language

Credits: 6 = 4+0+2 (60 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of compiler, interpreter, assembler; algorithm and flowchart, elementary data types, syntax and semantics, reserved words, expression in C, operator, conditional statement, array, function, storage class and their application.

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

1. Understanding compiler, interpreter, assembler; algorithm and flowchart.
2. Familiarize with elementary data types e.g. variables, constants and identifiers; integer, character, floating point and string constants, variable declaration,

initialization of variables, constant data types; local and global variables.

3. Understand and apply conditional statements conditional Statement e.g. if, if-else, switch etc. and array: one dimensional array, two dimensional arrays.
4. Familiarize with user defined functions; recursive function, pointer variables.
5. Apply C-code to find square root of a number, roots of a quadratic equation, solution of transcendental equation (Bisection method, Newton-Raphson method, Regula-Falsi method) etc.

Unit-I

Brief introduction of compiler, interpreter, assembler; algorithm and flowchart.

Unit-II

Elementary data types; variables, constants and identifiers; integer, character, floating point and string constants, variable declaration, initialization of variables, constant data types; local and global variables; Syntax and semantics, reserved words, expression in C, operator precedence and associatively, unary, binary and ternary operators, C arithmetic operators, assignment operators, relational operators, logical and bitwise operators, expression statement; Header files and Library functions.

Unit-III

Conditional Statement: if, if-else, switch; go to statements; Loops: for, while and do-while loops; continue statement, nested control statement, Array: one dimensional array, two dimensional arrays.

Unit-IV

Function: user defined functions; recursive function, Pointer variables, calling a function by value and by reference; storage class (automatic, register, static, external).

Lab work:

To evaluate an arithmetic expression, to find gcd, factorial, Fibonacci number, prime number generation, reversing digits of an integer number, finding square root of a number, roots of a quadratic equation, sum of different algebraic and trigonometric series and logarithmic series, base conversion, test for Palindrome, addition subtraction and multiplication of matrices, to find the greatest and smallest of a finite number of numbers.

Books Recommended:

1. E. Balagurusamy, Programming in ANSI C, Tata McGraw Hill, 2010.

2. T. Jeyapoovan, A first course in programming with C, Vikas Publishing House, 2004.

Books for Reference:

1. B. W. Kernighan & Dennis M. Ritchie, C programming language, Prentice Hall, 1983.

2.Y. Kanetkar, Let us C, B.P. Publication, 2016.

DSE- Rigid Dynamics and Hydrostatics

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of moment of inertia and product of inertia, Moment of momentum equation for a system of particles, translation and rotation of rigid bodies, D'Alembert's principle, the general equation of motion of a rigid body, motion of the centre of inertia and motion relative to the centre of inertia. Chasles' theorem, Hydrostatic pressure equation, condition of equilibrium, lines of force, homogeneous and heterogeneous fluids, elastic fluids, surface of equal pressure and equal density, fluid at rest under action of gravity, rotating fluids, fluid pressure on plane surfaces, centre of pressure, equilibrium of a floating body, curves of buoyancy, meta centre,
Gas law, mixture of gases, internal energy.

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

1. Understand moment of inertia and product of inertia, moment of momentum equation for a system of particles etc.
2. Familiarize with D'Alembert's principle, the general equation of motion of a rigid body, Chasles' theorem, Hydrostatic pressure equation, condition of equilibrium etc.
3. Understand homogeneous and heterogeneous fluids, elastic fluids, surface of equal pressure and equal density, fluid at rest under action of gravity, rotating fluids etc.
4. Familiarize with Gas law.

Unit– I
Moment of inertia and product of inertia, six constant theorems, the momental ellipsoid, equimomental systems, principal axes.
Moment of momentum equation for a system of particles, translation and rotation of rigid bodies, D'Alembert's principle, the general equation of motion of a rigid body, motion of the centre of inertia and motion relative to the centre of inertia. Chasles' theorem, Motion about a fixed axis, the compound pendulum, centre of percussion.

Unit– II
Hydrostatic pressure equation, condition of equilibrium, lines of force, homogeneous and heterogeneous fluids, elastic fluids, surface of equal pressure and equal density, fluid at rest

under action of gravity, rotating fluids.Fluid pressure on plane surfaces, centre of pressure, resultant pressure on curved surfaces.

Unit– III

Equilibrium of a floating body, curves of buoyancy, surface of buoyancy, stability of equilibrium of floating bodies, meta centre, work done inproducing a displacement, vessel containing a liquid.

Unit– IV

Gas law, mixture of gases, internal energy, adiabatic expansion, work done incompressing a gas, isothermal atmosphere, convective equilibrium.

Books Recommended:

1. S. L. Loney, An elementary treatise on the Dynamics of a particle and of Rigid bodies, 2012.
2.F. Chorlton, Analytical Dynamics, CBS Publisher, 2002.
3.W. H. Besant, A Treatise on Hydromechanics :part-I : Hydrostatics ,Trieste Publishing Pty Limited, 11-Sep-2017

Books for Reference:

1. J. M. Kar , Hydrostatics, K. P. Basu Pub. Co. Calcutta, 2016

2. M. Ray& H.S.Sharma ,Hydrostatics, S.Chand, 2000.

3. A. S. Ramsey, Dynamics partI , Cambridge University Press, 1932.

4. M. R. Spiegel,Theoretical Mechanics, McGraw Higher Ed, 2017

DSE: Probability Theory and Statistics

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of sample space, probability set function, real random variables, probability mass/density functions, mathematical expectation, moments, moment generating function, discrete distributions, continuous distributions, joint cumulative distribution function and its properties, joint probability density function, marginal distributions, correlation coefficient, covariance, calculation of covariance from joint moment etc.

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

1. Understand sample space, probability set function, real random variables, probability

mass/density functions etc.
2. Familiarize with mathematical expectation, moments, moment generating function, characteristic function etc.
3. Familiarize with Uniform, Bernoulli, Binomial, Negative binomial, Geometric, Poisson, Uniform, Gamma, Exponential, Chi-square, Beta and normal distributions.
4. Understand joint cumulative distribution function and its properties.
5. Calculate covariance from joint moment generating function.
6. Familiarize with Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

Unit 1:(21 lectures)

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

Unit 2:(21 lectures)

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:(12 lectures)

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:(21 lectures)

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

Books Recommended:

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

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

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

Books for Reference:

1. Mood, A. M., Graybill, F. A. & Boes, D. C. (1974). Introduction to the Theory of Statistics (3rd ed.). McGraw-Hill Education Pvt. Ltd. Indian Edition (2017).

DSE-Biomathematics

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of population growth, administration of drugs, cell division, systems of linear ordinary differential equations, Predatorprey models, Stability and oscillations: Epidemics, Phase plane and Jacobian matrix, Local stability, Stability, Limit cycles, Forced oscillations; Mathematics of heart physiology: local model, threshold effect, Bifurcation, Bifurcation of a limit cycle, Modelling Molecular Evolution: Matrix models of base substitutions for DNA sequences, Jukes−Cantor model, Kimura models etc.

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

1. Understand population growth, nerve impulse transmission, predator-prey models.
2. Familiarize with A model of the cardiac pacemaker, mathematics of nerve impulse transmission, excitability and repetitive firing.
3. Understand bifurcation, bifurcation of a limit cycle, discrete bifurcation and period-doubling etc.
4. Familiarize with modelling molecular evolution: Matrix models of base substitutions for DNA sequences etc.

Unit 1: (16 lectures)

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

Unit 2:(27 lectures)

Stability and oscillations: Epidemics, Phase plane and Jacobian matrix, Local stability, Stability, Limit cycles, Forced oscillations; Mathematics of heart physiology: local model, threshold effect, phase plane analysis and heartbeat model, A model of the cardiac pacemaker; Mathematics of nerve impulse transmission: excitability and repetitive firing, travelling waves.

Unit 3: (16 lectures)

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

Unit 4:(16 lectures)

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

Books Recommended:

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

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

Books for Reference:

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

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

3. Simmons, George F., & Krantz, Steven G. (2015). Differential Equations. McGraw-Hill Education. Indian Reprint.

4. Strogatz, Steven H. (2009). onlinear Dynamics and Chaos (2nd ed.). Perseus Book Publishing. LLC. Sarat Publication, Kolkata, India.

GE-1

Paper: MTH103G (Generic Elective)

Algebra andAnalysis

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of well-ordering property of positive integers, divisibility and Euclidean algorithm, linear Diophantine equation, congruence relation between integers, inequalities, De Moivre's theorem for rational indices and its applications, relation between roots and coefficients, transformation of equations, Echelon forms and normal forms of matrix, rank of matrix, solution of system of linear homogeneous and non-homogeneous equations, sequence of real numbers, bounded, Cauchy's general principle of convergence, Cauchy sequence, sub sequences, convergence and divergence of monotonic sequences, Leibnitz test.

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

1. Understand mathematical induction, divisibility and euclidean algorithm and application application to the calendar.
2. Familiarize with inequalities involving A. M., G. M., H. M., Cauchy Schwarz inequality.
3. Apply De Moivre's theorem.
4. Solve cubic equation by Cardon's method.
5. Solve system of linear homogeneous and non-homogeneous equations.
6. Familiarize with sequence and infinite series.

Unit–I(8 lectures)

Inequalities: Inequalities involving A. M., G. M., H. M., Cauchy Schwarz Inequality.

Unit– II(17 lectures)

De Moivre's theorem for rational indices and its applications, logarithm of a complex number, exponential and trigonometric functions of a complex variable, Euler's expansion of cosine & sine, hyperbolic functions, inverse functions, Gregory's series.

Unit– III(12 lectures)

Relation between roots and coefficients: Symmetric functions of roots, Relation between roots and coefficients of a general polynomial equation in one variable, transformation of equations, solution of cubic equation by Cardon's method.

Unit– IV(12 lectures)

Well-ordering property of positive integers, Principles of Mathematical Induction, Division algorithm, Divisibility and Euclidean algorithm, GCD, Linear Diophantine equation, Congruence relation between integers.

Unit-V(8 lectures)

Echelon forms and normal forms of matrix, rank of matrix, solution of system of linear homogeneous and non-homogeneous equations.

Unit-VI(18 lectures)

Sequence of real numbers, bounded, convergent and non- convergent sequences, uniqueness of the limit and boundedness of a convergent sequence., Cauchy's general principle of convergence, Cauchy sequence, sub sequences, convergence and divergence of monotonic sequences, algebraic operations of limit, Sandwich theorem. Infinite series and the basic properties of infinite series. Absolute & conditional tests for convergence, comparison test, ratio test, Leibnitz test, Cauchy's root test.

Books Recommended:

1. T. Andreescu and Dorin Andrica, Complex Numbers from A to …. Z, Birkhauser, 2006.
2. D. M. Burton, Elementary Number Theory (6th Edition), Tata McGraw-Hill Edition, Indian reprint, 2007.
3. D. C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007.
4. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005

Books for Reference:

1.S. K. Mappa, Higher Algebra (Classical), Ashoke Prakasam, Calcutta, 2014
2. B. C. Das & B. N. Mukherjee, Higher Trigonometry –U N Dhur & Sons, 1932
3. S. Lipschutz, M. Lipson, Linear Algebra 3rd Edition, Mcgraw Higher Ed, 2005
4. S. Arora, S. C. Malik, Mathematical analysis, New Age Science Ltd, 2009

GE-2

Paper: MTH203G (Generic Elective)

Calculus and Differential Equation

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of Leibnit'z theorem, Rolle's theorem, Lagrange's Mean Value theorem, Cauchy's Mean Value theorem, Taylor's theorem, Maclaurin's theorem. Maclaurin's infinite power series for a given function, Functions of several variables, limit and continuity, partial derivatives, differentiability, Eulers theorem on homogeneous functions, order first degree differential equations, exact differential equations, integrating factors of first order differential equations, orthogonal trajectories, linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, basic concepts and definitions. First order equations: Classification, construction and geometrical interpretation. Method of separation of variables for solving first order partial differential equations. Lagrange's and Charpit's methods.

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

1. Understand Successive differentiation, standard results on nth order derivatives and Leibnit'z theorem.
2. Find infinite power series for a given function.
3. Familiarize with functions of several variables, limit and continuity, partial derivatives, chain rule.
4. Solve exact differential equations and find integrating factors of first order differential equations, orthogonal trajectories.
5. Find general solution of homogeneous equation of second order, linear homogeneous and non-homogeneous equations of higher order with constant coefficients.
6. Apply method of separation of variables, Lagrange's and Charpit's methods for solving first order partial differential equations.

Unit-1(30 lectures)

Successive differentiation, standard results on nth order derivatives and Leibnit'z theorem, Rolle's theorem, Lagrange's Mean Value theorem, Cauchy's Mean Value theorem, Taylor's theorem, Maclaurin's theorem. Maclaurin's infinite power series for a given function; expansion of exp(x),sinx, cosx, log(1+x) and allied functions. Indeterminate forms.

Functions of several variables, limit and continuity, partial derivatives, differentiability, Eulers theorem on homogeneous functions, chain rule, extreme values of functions of two variables.

Reduction formulae for integration.

Unit-2 (25 lectures)

Introduction to first order first degree differential equations, exact differential equations, integrating factors of first order differential equations, orthogonal trajectories. First order higher

degree differential equations. General solution of homogeneous equation of second order, linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation

Unit-3(20 lectures)

Partial differential equations: Basic concepts and definitions. First order equations: Classification, construction and geometrical interpretation. Method of separation of variables for solving first order partial differential equations. Lagrange's and Charpit's methods

Books Recommended:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005
2. S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.

Books for Reference:

1. M.D. Raisinghania, Ordinary and partial differential Equation:. S.Chand and Co., India, 2017
2. B. C. Das and B. N. Mukherjee, Differential Calculus, U. N. Dhur & sons, 1932.
3. B. C. Das and B. N. Mukherjee, Integral Calculus, U N Dhur & Sons, 1932.

GE-3

Paper: MTH304G (Generic Elective)

Coordinate Geometry and Vector

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of Transformation of axes, classification of general second degree equations in two dimensions representing lines, parabola, ellipse and hyperbola, polar equations of conics, spheres, cylindrical and conical surfaces, scalar triple product, vector triple product, product of four vectors, continuity and derivability of vector-point function, partial derivatives of vector point function, gradient, curl &divergence, identities, line integrals, Green's theorem, Stokes' theorem, Gauss divergence theorem.

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

1. Understand transformation of axes, classification of general second degree equations in two dimensions representing lines, parabola, ellipse and hyperbola, polar equations of conics.
2. Familiarize with scalar triple product, continuity and derivability of vector-point function, partial derivatives of vector point function, gradient, curl &divergence, identities.
3. Applications of line integrals on Mass and Work.
4. Evaluate area with the help of line integral.
5. Familiarize with surface integrals.

Unit-I(35 lectures)

Transformation of axes, classification of general second degree equations in two dimensions representing lines, parabola, ellipse and hyperbola, reflection properties of parabola, ellipse and hyperbola. Polar equations of conics. Spheres, cylindrical and conical surfaces.

Unit-II(20 lectures)

Scalar triple product, vector triple product, Product of four vectors, Continuity and derivability of vector-point function, partial derivatives of vector point function, gradient, curl &divergence, identities.

Unit-III(20 lectures)

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

Books Recommended

1. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London, 2016.

2. R.J.T. Bell, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994

3. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

Books for Reference

1. D. Spellman, M. Spiegel and S. Lipschutz, Vector analysis - Schaum's outline 2nd Edition, 2009.

2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

3. R.M. Khan, Analytical Geometry of two and three dimension and Vector analysis, New Central Book agency, 2010.

4. S. Narayan and P. K. Mittal, Vector Algebra:. S.Chand and Co., India, 2005.

GE-4

Paper: MTH404G (Generic Elective)

Abstract Algebra and Numerical Analysis

Credits: 6 = 5+1+0 (75 Lectures)

Total Marks: (Theory: 70, Internal Assessment: 30)
Workload: 5 Lectures, 1 Tutorial (per week) **Credits:** 6 (5+1)
Duration: 14 Weeks (84 Hrs.) **Examination:** 3 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of symmetries of a square, dihedral groups, definition of a group, subgroups, cosets, Lagrange's theorem on order of a subgroup of a finite group, cyclic groups, permutation: cycle notation for permutations, alternating group, normal subgroups, quotient groups, properties of rings, subrings, integral domains and fields, ring homomorphisms, properties of ring homomorphisms, finite

difference operators, Newton's formulae, Lagrange's formula, numerical differentiation and integration.

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

1. Familiarize with symmetries of a square, dihedral groups, definition of a group, subgroups, cosets, Lagrange's theorem on order of a subgroup of a finite group, cyclic groups, permutation.
2. Understandproperties of rings, subrings, integral domains and fields, ring homomorphisms, properties of ring homomorphisms.
3. Apply Newton's formulae, Lagrange's formula for interpolation of a function.
4. Apply general quadrature formula, trapezoidal rule, Simpson's one third and three eighth rule to evaluate integration.

Unit-I(28 lectures)

Symmetries of a square, dihedral groups, definition of a group, subgroups, cosets, Lagrange's theorem on order of a subgroup of a finite group, cyclic groups, Permutation: Cycle notation for permutations, properties of permutations, even and odd permutations, symmetric group, alternating group, normal subgroups, quotient groups, homomorphism and isomorphism of groups.

Unit-II(15 lectures)

Definition and examples of rings, properties of rings, subrings, integral domains and fields,Ring homomorphisms, properties of ring homomorphisms.

Unit– III(16 lectures)

Finite difference operators and their operations on function of a single variable, calculus of finite difference: different interpolation formulae with remainder terms, interpolation with equal and unequal intervals, Newton's formulae, Lagrange's formula.

Unit– IV(16 lectures)

Numerical differentiation and integration: Numerical differentiation with the help of different interpolation formulae, general quadrature formula, trapezoidal rule, Simpson's one third and three eighth rule,

Books Recommended

1.J. A. Gallian, Contemporary Abstract Algebra (4th Edition), Narosa Publishing House, New Delhi, 1999.(IX Edition 2010)

2. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

3. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 5th edition, 2007.

4. K. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons; 2nd Revised edition, 1989.

Books for Reference

1.J. B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

2. D.S. Malik, J. M. Mordeson and M.K. Sen, Fundamentals of abstract algebra, 1997.

3. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008

2. R. L. Burden, J. D. Faires, Annette M. Burden, Numerical Analysis, Cengage Learning, 10 edition, 2015

SEC: Logic and Sets

Credits 2=2+0+0 (30 lectures)

Total Marks: (Theory:50)
Workload: 2 Lectures (per week) **Credits:** 2
Duration: 14 Weeks (28 Hrs.) **Examination:** 2 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of operations on sets, family of sets, power sets, caertesian product of sets, functions, basic definitions, relations, relations on sets, types of relations, equivalence relations, equivalence classes and partitions of a set, countability of sets, sets with same cardinality, finite sets, countable sets, comparing countability, order relations, partial and total orders

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

1. Understand operations on sets, family of sets, power sets, caertesian product of sets.
2. Familiarize functions, basic definitions.
3. Understand relations on sets, types of relations, equivalence relations, equivalence classes and partitions of a set.
4. Familiarize with countability of sets, sets with same cardinality, finite sets etc.

Unit-I (18 lectures)

Sets, basic terminologies, operations on sets, family of sets, power sets, caertesian product of sets.

Functions, basic definitions, one-one, onto functions and bijections, composition of funcions, inverse of a function, image and inverse image of subset under functions.

Relations, relations on sets, types of relations, equivalence relations, equivalence classes and partitions of a set

Unit-II(12 lectures)

Countability of sets, sets with same cardinality, finite sets, countable sets, comparing countability.

Order relations, partial and total orders, chains, bounds and maximal elements, axiom of choice and its equivalents

Books Recommended

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education,

1998.

2. P.R. Halmos, Naive Set Theory, Springer, 1974.

3. E. Kamke, Theory of Sets, Dover Publishers, 1950.

4. A. Kumar, S. Kumaresan, B. K. Sarma, A Foundation Course in Mathematics, Narosa Publishing House, 2018

SEC: Probability and Statistics

Credits 2=2+0+0 (30 lectures)

Total Marks: (Theory: 50)
Workload: 2 Lectures (per week) **Credits:** 2
Duration: 14 Weeks (28 Hrs.) **Examination:** 2 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of Sample space, probability axioms, real random variables, cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions.

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

1. Familiarize with sample space, random variables, probability mass/density functions, mathematical expectation etc.
2. Understand discrete distributions: uniform, binomial, Poisson and continuous distributions: uniform, normal, exponential.
3. Understand joint cumulative distribution function and its properties.
4. Familiarize with independent random variables.

Unit-I(17 lectures)

Sample space, probability axioms, real random variables (discrete and continuous), cumulativedistribution function, probability mass/density functions, mathematical expectation, moments,moment generating function, characteristic function, discrete distributions: uniform, binomial,Poisson, continuous distributions: uniform, normal, exponential.

Unit-II(13 lectures)

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables.

Books Recommended

1. R. V. Hogg, J. W. McKean and A. T. Craig, Introduction to Mathematical

Statistics, Pearson Education, Asia, 2007.

2. I. Miller and M. Miller, J. E. Freund, Mathematical Statistics with Application,

7th Ed., Pearson Education, Asia, 2006.

3. S. Ross, Introduction to Probability Model, 9th Ed., Academic Press, Indian Reprint,

2007.

SEC: Graph Theory

Credits 2=2+0+0 (30 lectures)

Total Marks: (Theory: 50)
Workload: 2 Lectures (per week) **Credits:** 2
Duration: 14 Weeks (28 Hrs.) **Examination:** 2 Hrs

Course Objectives: The primary objective of this course is to introduce the basic idea of basic properties of graphs, pseudographs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's5algorithm, Floyd-Warshall algorithm

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

1. Understand basic idea of basic properties of graphs, pseudographs.
2. Familiarize with Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph.
3. Apply Dijkstra's5algorithm, Floyd-Warshall algorithm

Unit-I(15 lectures)

Definition, examples and basic properties of graphs, pseudographs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits.

Unit-II(15 lectures)

Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's5algorithm, Floyd-Warshall algorithm.

Books Recommended:

1. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory 2nd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2003.

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