**Mathematics**

**Curriculum**

**B.Sc Honours**

Session 2021-2022 and Onwards

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Department of Mathematics

Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj

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**1. About the University**

Bangabandhu Sheikh Mujibur Rahman University (BSMRU), Kishoreganj has been established in Kishoreganj district in the name of Father of the Nation Bangabandhu Sheikh Mujibur Rahman with the special initiative of His Excellency the President of the People's Republic of Bangladesh, Advocate Md. Abdul Hamid. Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj Act 2020 (Act No. 17 of 2020, September 15, 2020) was enacted to establish the University. The Act was passed by the Parliament of Bangladesh in the year 2020. According to the provisions of this Act the University will be established at Boulai Union of Sadar Upazila of Kishoreganj District. The University will be placed on 103.87 acres of land at Patdha and Raghunandanpur mouzas of Boulai union under Kishoreganj Sadar Upazila of Kishoreganj District. It is located approximately 8.9 km from Kishoreganj city towards Mithamoin road.

The first academic activity of the university has been started from the academic session 2021-2022 along with the four departments (Computer Science and Engineering, Mathematics, English, and Accounting) and the initial enrolment of thirty students in each department. Total forty departments, five institutes, three centers, and eight Interdisciplinary Research Centers (IRCs) are proposed in the academic plan. The forty departments are operated under the six faculties. The name of the faculties are Faculty of Science, Faculty of Engineering, Faculty of Arts, Faculty of Social Science, Faculty of Biological Science, and Faculty of Business Studies.

**Mission of the University**

The mission of Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj is

* To create and disseminate knowledge for the sustainable development of next generation.
* To maintain and achieve equality of higher education with the advanced world in various fields.
* To create and expand opportunities for higher education and research at the national level especially in various fields of modern knowledge practice and reading.
* To provide undergraduate, postgraduate, and doctoral levels of education and research that create knowledge, excellence and distribution in science, engineering, arts, humanities, social sciences, law, business administration and management, including new branches of science and knowledge.
* To conduct online and campus based short and long courses side by side with the graduate and undergraduate levels.

**Vision of the University**

The vision of Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj is

* To create efficient manpower related to industry, business, society, and economics using modern teaching method and technology according to the criterions of higher education, profession, and economical requirement.
* To create the university into a world class university in the quality of higher education and research.
* To develop world-class laboratories and to engage in research jointly with various universities and industries by inviting and collaborating with world-class researchers of different fields of research.

**2. About the Department of Mathematics**

The department of Mathematics offers four years undergraduate program at the very beginning to earn B. Sc Honours (B.Sc (Hons.).) degree and subsequently will offer the graduate and doctoral programs under the Faculty of Science. This Curriculum is for the undergraduate students in the Department of Mathematics. The department of Mathematics at BSMRU, Kishoreganj is committed to produce graduate with the solid foundation to pursue a higher degree in science and engineering. The Curriculum is so designed as to contain all the necessary study materials so that a graduate can solve the real science and engineering problems successfully after graduation. This program will help to students to develop wide-ranging skills, such as real and functional analysis, group theory, linear algebra, number theory, calculus and geometry, numerical computing, mathematical modelling and dynamical system, financial mathematics, and so on. This program will also help student to develop logical thinking and solving complex problems. The Curriculum and curriculum committee of the Department will periodically review the courses and their contents to meet the current demand and trends all over the world.

**3. Major Research Areas**

Major research areas include Group Theory, Number Theory, Topology and Geometry, Ring Theory, Differential Geometry, Analysis and its Applications, Dynamical Systems, Functional Analysis, Complex Analysis, Mathematical Physics, Computational Science and Numerical Analysis, Computational Fluids Dynamics, Mechanics, Mathematical Biology, Mathematical Hydrology, Operations Research, Fuzzy Mathematics, Financial Mathematics, Ordinary and Partial Differential Equations etc.

**4. Courses requirements for Undergraduate students**

|  |  |  |
| --- | --- | --- |
| **Year** | **Courses** | |
| **Semester I** | **Semester II** |
| First Year | Theory = 5 Courses | Theory = 4 Courses  Lab = 1 Courses |
| Total : 15 Credits | Total : 15 Credits |
| Second Year | Theory = 5 Courses  Lab = 1 Courses | Theory = 4 Courses  Lab = 1 Courses |
| Total : 18 Credits | Total : 15 Credits |
| Third Year | Theory = 5 Courses  Lab = 1 Courses | Theory = 4 Courses  Lab = 1 Courses |
| Total : 18 Credits | Total : 15 Credits |
| Fourth Year | Theory = 6 Courses  Lab = 1 Courses | Theory = 5 Courses  Viva-Voce = 2 Courses  Project work of 3 Credits |
| Total : 21 Credits | Total : 20 Credits |
| Grand Total 137 Credits | | |

**5. Details outlines of the courses**

**First Year (Semester-I)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 1101 | Fundamentals of Mathematics | 3 |
| MAT 1103 | Differential Calculus | 3 |
| MAT 1105 | Analytic Geometry | 3 |
| STA 1107 | Basic Statistics | 3 |
| PHY 1109 | Mechanics and Waves | 3 |
| Total Credit in 1st Year 1st Semester | | 15 |

**First Year (Semester-II)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 1201 | Linear Algebra-I | 3 |
| MAT 1203 | Integral Calculus | 3 |
| STA 1205 | Introduction to Probability | 3 |
| PHY 1207 | Electricity and Magnetism | 3 |
| MAT 1202 | MATHEMATICA Lab | 3 |
| Total Credit in 1st Year 2nd Semester | | 15 |

**Second Year (Semester-I)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 2101 | Real Analysis | 3 |
| MAT 2103 | Differential Calculus of Several Variables | 3 |
| MAT 2105 | Ordinary Differential Equations-I | 3 |
| MAT 2107 | Mathematical Statistics | 3 |
| MAT 2109 | Introduction to Financial Mathematics | 3 |
| MAT 2111 | FORTRAN Programming | 3 |
| Total Credit in 2nd Year 1st Semester | | 18 |

**Second Year (Semester-II)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 2201 | Linear Algebra-II | 3 |
| MAT 2203 | Integral and Vector Calculus | 3 |
| MAT 2205 | Numerical Methods-I | 3 |
| MAT 2207 | Discrete Mathematics | 3 |
| MAT 2202 | FORTRAN Programming Lab | 3 |
| Total Credit in 2nd Year 2nd Semester | | 15 |

**Third Year (Semester-I)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 3101 | Function Analysis | 3 |
| MAT 3103 | Complex Analysis | 3 |
| MAT 3105 | Ordinary Differential Equations-II | 3 |
| MAT 3107 | Linear Programming | 3 |
| MAT 3109 | Mechanics | 3 |
| MAT 3111 | C++ Programming | 3 |
| Total Credit in 3rd Year 1st Semester | | 18 |

**Third Year (Semester-II)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 3201 | Abstract Algebra | 3 |
| MAT 3203 | Theory of Numbers | 3 |
| MAT 3205 | Numerical Analysis-II | 3 |
| MAT 3207 | Mathematical Methods | 3 |
| MAT 3209 | MATLAB Programming | 3 |
| Total Credit in 3rd Year 2nd Semester | | 15 |

**Fourth Year (Semester-I)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 4101 | Partial Differential Equations | 3 |
| MAT 4103 | Tensor Analysis | 3 |
| MAT 41XX | Hydrology | 3 |
| MAT 41XX | Stochastic Calculus | 3 |
| MAT 4102 | Mathematical Biology | 3 |
| MAT 4104 | Industrial Mathematics | 3 |
| MAT 4106 | Simulation Lab | 3 |
| Total Credit in 4th Year 1st Semester | | 21 |

**Fourth Year (Semester-II)**

|  |  |  |
| --- | --- | --- |
| **Course Code** | **Course Title** | **Credits** |
| MAT 4201 | Fundamentals of Topology | 3 |
| MAT 4203 | Differential Geometry | 3 |
| MAT 4205 | Optimization | 3 |
| MAT 4207 | Introduction to Actuarial Mathematics | 3 |
| MAT 4209 | Fuzzy Mathematics | 3 |
| MAT 4202 | Viva Voce | 2 |
| MAT 4200 | Project | 3 |
| Total Credit in 4th Year 2nd Semester | | 20 |

**6. Details Curriculum for B.Sc (Hons.) in Mathematics**

**First Year Semester-I**

**MAT 1101:** **Fundamentals of Mathematics 3 Credits**

**Introduction and Specific Objectives**

This course aims to provide learning of fundamental concepts of mathematics which are essential for mathematical thinking. The course includes concepts and theories such as elementary set theory, graph and relation, logic, number systems, sequences, series, inequalities, polynomials, voting system and apportionment. A unique emphasis on applied problems throughout the course utilizes each new technique and develops the conceptual aspects of algebra.

**Learning Outcomes**

On successful completion of this course students will be able to

* to understand set theory in detail and apply this concept to solve real world problems
* to understand mathematical concepts and definitions of functions and relations
* to apply precise, logical reasoning to problem solving
* to understand number systems, sequences, series and inequalities
* to apply the knowledge of this course to solve problems in business/ natural science/ economics.

**Course Contents**

1. **Set Theory:** Set concepts, subsets, Venn Diagrams & Set operations, Venn Diagrams with three sets & verification of equality of sets, Applications of sets in the Management, Natural & Social Sciences.
2. **Relations and Functions:** Cartesian product of sets; Relations; Order relation; Equivalence relations; Functions; Images and inverse images of sets.
3. **Logic:** Statements and Logical Connectives, Truth Tables for Negation, Conjunction, and Disjunction, Truth Tables for the Conditional and Biconditional, Equivalent Statements, Symbolic arguments, Euler Diagrams and Syllogistic Arguments, Switching Circuits, applications and models.
4. **Real and Complex number system** Number Theory, The Integers, The Rational Numbers, The Irrational Numbers and the Real Number System, Real Numbers and Their Properties, Field of complex numbers; Geometrical representations; Polar form; De Moivre’s theorem and its applications.
5. **Sequences and Series:** Arithmetic and Geometric Sequences & Series, Fibonacci Sequence, Applications and problem solving situations in business/ natural Science/ Economics.
6. **Inequalities:** Basic inequalities, Inequalities involving means, powers; inequalities of Cauchy, Chebyshev and applications.
7. **Polynomials:** Polynomial Functions and Modeling (The leading term test, finding zeros of polynomial functions, polynomial models) , Polynomial Division; The Remainder and Factor Theorems ( Division and Factors, The remainder theorem, Synthetic division, finding factors of polynomials), Theorems about zeros of polynomial functions (The fundamental theorem of Algebra, finding polynomials with given zeros, zeros of Polynomial Functions with real coefficients, rational coefficient, integer coefficients and the rational zeros theorem, Descartes' rule of signs), Polynomial models and applications.
8. **Voting and Apportionment:** Voting Methods, Flaws of Voting, Apportionment Methods, Flaws of the Apportionment Methods.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Angel, Abbott and Runde, A survey of Mathematics with applications, 10th edition, Pearson.
2. Blitzer, Thinking Mathematically, 6th edition, Pearson.
3. Beecher, Penna and Bittinger, College Algebra, 5th edition, Pearson.
4. S. Lipschutz, Set Theory, Schaum’s Outline Series.
5. S. Barnard & J. M. Child, Higher Algebra.

**MAT 1103: Differential Calculus 3 Credits**

**Introduction and Specific Objectives**

Calculus is one of the most fundamental courses in Mathematics which majorly contains two parts (Differential and Integral). The course Differential calculus I mainly contains the initial part of Differential calculus (Single variable function). Understanding this course will lead everyone to learn the other mathematical courses which needs the fundamentals of differentiation. After completing this course students will learn the basic idea of function, limits and continuity of functions, graphical representation of different functions, analysis of functions, basics of differentiation and the applications involving differentiation in different sectors of real life.

**Learning Outcomes**

At the end of the course the students will be able to:

1. Understand function both in mathematically and graphically

2. Understand the basic concepts of limit and continuity of function

3. Understand the basics of differentiation and techniques of differentiation

4. Understand some physical phenomena of differentiation

5. Solve some real life problems involving differentiation

6. Apply differentiation to analyze some properties of functions

7. Use differentiation to generate the idea of infinite series

**Course Content**

**1. Functions:** Notion, representation and transformation of graphs of functions; Different kinds of functions (polynomial, rational, logarithmic, exponential, trigonometric, hyperbolic functions), their inverses and graphs; Combination of functions; Even and odd functions; Symmetricity of functions; Functional model.

**2. Limit and Continuity:** Limit of a function; Basic limit theorems with proofs; Limit at infinity and infinite limit; Sandwich (Squeezing) theorem (without proof);Continuous and discontinuous functions; Algebra of continuous functions; Properties of continuous functions on closed, and bounded intervals; Horizontal and vertical asymptotes; Intermediate Value Theorem (statement and illustration with applications).

**3. Differentiation:** Tangent lines and rates of change; Derivative of a function, One sided derivatives; Techniques of differentiation; Chain rule theorem (without proof); Successive differentiation; Leibnitz theorem; Rates of change in Natural and Social Sciences; Related rates; Marginal analysis and approximations with increments; Linear approximations and differentials; Indeterminate forms; L’Hospital’s rules.



**4. Applications of Differentiation:** Concavity and extrema of functions; Curve sketching techniques; Rolle’s theorem: Lagrange’s and Cauchy’s mean value theorems; Exponential models; Optimization problems; Newton’s method; Applications to Business, Economics, Biology, Physics and Engineering sciences.

**5. Expansion of Functions:** Taylor’s theorem with general form of the remainder; Lagrange’s and Cauchy’s forms of the remainder; Taylor’s series; Maclaurin’s series; Convergence of series and validity regions; Differentiation and integration of series; Validity of Taylor expansions and computation of series.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. H. Anton, I. C. Bivens, S. Davis, Calculus.
2. E.W. Swokowski, Calculus.
3. James Stewart, Calculus: Early Transcendentals.
4. Deborah Hughes-Hallett, Applied Calculus.
5. Stefan Waner and Steven Costenoble, Applied Calculus.

**MAT 1105: Analytic Geometry 3 Credits**

**Introduction and Specific Objectives**

The Geometry course includes an in-depth analysis of plane, solid, and coordinate geometry as they relate to both abstract mathematical concepts as well as real-world problem situations. Topics include logic and proof, parallel lines and polygons, perimeter and area analysis, volume and surface area analysis, similarity and congruence, trigonometry, and analytic geometry. Emphasis will be placed on developing critical thinking skills as they relate to logical reasoning and argument. Students will be required to use different technological tools and manipulatives to discover and explain much of the course content.

**Learning Outcomes**

Students that successfully complete this course will be able to

* sketch graphs of and discuss relevant features of lines, circles, and other conic sections and determine equations of curves when given information that determines the curves
* perform translations and rotations of the coordinate axes to eliminate certain terms from equations and use the polar coordinate system, relate it to the rectangular coordinate system, and graph equations using polar coordinates
* compute the distance between points, the distance from a point to a line, and the distance from a point to a plane in the three-dimensional coordinate system
* sketch and describe regions in space and perform algebraic operations with vectors in two and three dimensions computing dot and cross product of vectors, finding scalar and vector projections of a vector onto another, determining if vectors are parallel and orthogonal, etc
* find equations of lines and planes in space and identify and describe quadratic surfaces.

**Course Contents**

Group-A: Two-dimensional geometry

1. **Coordinates in two dimensions:** Oblique and rectangular coordinate systems; Polar coordinates.
2. **Transformation of Coordinates:** Translation and rotation of axes; Transformed coordinates; Effect of translation and rotation on an equation.
3. **Standard form of second degree equation Pair of straight lines:** Existence and identification of pair of straight lines; Technique to compute pair of straight lines; Angle between two lines; Bisectors of angles between two lines; Homogeneous equation of second degree; Equation of pair of perpendicular straight lines to other pair.

**Conic sections:** Identification of conics using rotation of axes; Standard equations and properties of parabola, ellipse, and hyperbola; Tangent; Chord of contact; Pole and polar; Conjugate points and lines; Equation of chord in terms of its middle point; Pair of tangents; Reduction of equation of conics; Equations of conics in polar coordinates with applications; Parametric equations of conics.

*Group-B: Three-dimensional geometry*

1. **Coordinates in three dimensions:** Rectangular coordinates system in 3-space; Direction cosines and direction ratios; Projection of a line segment; Distance of a point from a line; Angle between two lines with given direction cosines and direction ratios.
2. **Plane in 3-space:** Equations of planes; Coplanarity; Transformation of the general equation of a plane to the normal form; Angle between two intersecting planes; Plane parallel to a given plane; Length of perpendicular; Bisectors of the angles between two planes; Plane through the intersection of two planes;
3. **Line in 3-space:** Symmetrical form of equation of a line; Equation of a line of intersection of two planes; Equation and shortest distance between two skew lines; Coplanar lines; Distance and angle between a straight line and a plane.
4. **Standard forms of Conicoids:** Sphere, paraboloid, ellipsoid, hyperboloid (of one-sheet and two sheets) with sketches.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Khosh Mohammad, Analytic Geometry and Vector Analysis.
2. H. Anton et al, Calculus with Analytic Geometry.
3. D. G. Zill and J. M. Dewar, Pre-calculus with calculus previews.
4. Michael Sullivan, Pre-calculus.
5. Howard Anton, IriBivens and S. Davis, Calculus Early Transcendental.

**STA 1107: Basic Statistics 3 Credits**

**Introduction and Specific Objectives**

This course is intended to provide the basic foundations of statistics with applications in real life. The class will cover topics on descriptive statistics, correlation, regression. The students will discuss the theory and how to apply and use the theory for real life problem-solving and inquiry. A central objective is to provide students with hands on experience in using the statistical theory and methods to perform the different statistical analyses and to interpret results.

**Learning Outcomes**

After successfully completing this course, a student will be able to: Demonstrate the ability to apply fundamental concepts in exploratory data analysis, Construct and analyze graphical displays to summarize data, Compute and interpret measures of center and spread of data, Calculate, interpret and communicate the correlation coefficient and simple linear regression model.

**Course contents**

1. **Definition and Scope:** Definitions of statistics- past and present, its nature and characteristics, Methods of statistics, Scope and application of statistics, Abuse of statistics. Sources of statistical data, Primary and secondary sources of data.
2. **Processing and Presentation of Data:** Measurement scales; Variables, Attributes, Classification, Characteristic and basis of classification, Array formation. Tabulation, Different types of tables, Frequency distribution. Graphical presentation of data, Details of different types of graphs and charts with their relative merits and demerits.
3. **Characteristics of Statistical Data:** Measures of Location, Dispersion, Skewness, Kurtosis and their properties, Moments. Schematic plots.
4. **Correlation and Regression:** Bivariate data. Scattered diagram, Simple correlation, Rank correlation, Correlation ratio, Intra-class and bi-serial correlation, Multiple and partial correlations. Simple regression analysis, Principles of least squares, Lines of best fit, Standard error of estimators of regression coefficients, their properties, and their applications.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Islam, M.N. (2006). An Introduction to Statistics & Probability, Book World, Dhaka.
2. Sheldon Ross; Introductory Statistics, Third Edition.
3. Larson, R. and Farber, B. (2003), Elementary Statistics.
4. Yule and Kendall, M.G. An Introduction to the Theory of Statistics, Charles Griffin, London.

**PHY 1109: Mechanics, Waves and Properties of Matters 3 Credits**

**Introduction and Specific Objectives**

This course is an introduction to the fundamental principles of economics. Main objective of the course is to explain one dimensional motion and dependence of force on position, velocity and time. Explain the two-dimensional motion like that of projectile motion. Also explain important properties of matter.

**Learning Outcomes**

* Apply the equation of motion to one or two dimensions of the system in order to understand kinematics of the body under the various conditions of applied force.
* Apply the knowledge in construction of beams, bridges etc,
* Apply knowledge in understanding the flow of liquid and surface tension applied on the surface of liquid.

**Course Contents**

**1. Mechanics:** Different Co-ordinate systems, Projectile motion, Newton’s laws of motion, Conservation theorems, Collisions, Rotational motion, Angular momentum and Torque, Moment of inertia, Parallel and Perpendicular axes theorems, Gravitation, Gravitational potential escape velocity, Kepler’s laws.

**2. Waves:** Simple harmonic motion, Simple and compound pendulum, Traveling waves, Interference, Stationary waves, Vibrations in strings, Sound, Beats, Doppler effect.

**3. Properties of matter:** Books law, Elastic modulli and their interrelations bending of beams, cantilever, surface tension, capillarity, concepts of fluid flow, Bernoulli’s equation and its applications, viscosity.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Halliday and Resnick, Physics (part I).

2. D.S. Mathur, Elements of properties of Matter

3. Introduction to Classical Mechanics, R. G. Takawale and P. S. Puranik, Tata McGraw-Hill (1997)

4. Properties of Matter, Brijlal and N. Subrahmanyam S. Chand (1999)

**First Year Semester-II**

**MAT 1201: Linear Algebra I 3 Credits**

**Introduction and Specific Objectives**

Linear algebra is an essential part of the curriculum of majors such as: Computer science, Engineering, Economics, Physics, and Mathematics. It has a broad range of applications in those areas. For most students, Linear Algebra is the first course that blends computational and conceptual aspects of mathematics. The study of linear algebra is motivated by the geometry of problems in two and three dimensions. A clear understanding of the concepts of linear algebra is essential for the proper description and representation of all physical and mathematical phenomena in higher dimensions. The algorithms of linear algebra are also central to the theory of scientific computing and numerical analysis.

**Learning Outcomes**

By the end of MTH 104: Linear Algebra I, students should be able to:

1. Solve systems of linear equations and homogeneous systems of linear equations by elementary row operations.

2. Use matrix operations to solve systems of equations and be able to determine the nature of the solutions.

4. Understand some applications of systems of linear equations.

5. Perform operations with matrices and find the transpose and inverse of a matrix.

6. Calculate determinants using row operations, column operations and expansion down any column and across any row.

7. Interpret vectors in two and three-dimensional space both algebraically and geometrically.

8. Recognize the concepts of the terms span, linear independence, basis, and dimension, and apply these concepts to various vector spaces and subspaces,

9. Find the kernel, range, rank, and nullity of a linear transformation.

10. Calculate eigenvalues and their corresponding eigenspaces.

11. Understand the concept of a linear transformation as a mapping from one vector space to another and be able to calculate its matrix representation with respect to standard and nonstandard bases.

12. Determine if a matrix is diagonalizable, and if it is, how to diagonalize it.

**Course Content**

1. **Matrices and Determinants:** Review of matrices and determinant; Elementary row and column operations; Row-reduced echelon matrices; Invertible matrices; Block matrices. Application to Leontief input-output Economic models, Markov chains and Computer graphics.
2. **System of Linear Equations:** Linear equations; System of linear equations (homogeneous and non-homogeneous); Solutions of system of linear equations using different method; Application to Network Flow and Electrical Networks, Balancing chemical equations; Polynomial interpolation.
3. **Vectors in and :** Review of geometric vectors in and space. Vectors in and , Inner product. Norm and distance in and, respectively.
4. **Vector Spaces:** Vector space; Subspace; Linear dependence of vectors; basis and dimension of vector spaces; Change of bases; Row space and Column space of a matrix; rank of matrices; Solution spaces of systems of linear equations; Application to Polynomials.
5. **Linear Transformations:** Linear transformations; Examples and illustrations with applications; Kernel and image of a linear transformation and their properties.
6. **Eigenvalues and Eigenvectors of Matrices:** Eigenvalues and eigenvectors; Diagonalization; Cayley-Hamilton theorem; Application to Least square approximation.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. H. Anton, and C. Rorres, Linear Algebra with Applications, 10th Edition.

2. S. Lipshutz, Linear Algebra, Schaum’s Outline Series.

3. David C. Lay, Linear Algebra and its Applications, 4th Edition.

4. W. K. Nicholson, Linear Algebra with Applications, 3th Edition.

5. G. Strang, Linear Algebra and its Applications, 4th Edition.

6. B. Kolman & D. R. Hill, Elementary Linear Algebra with Applications, 9th Edition.

**MAT 1203: Integral Calculus 3 Credits**

**Introduction and Specific Objectives**

In mathematics, an integral assigns numbers to functions in a way that describes displacement, area, volume, and other concepts that arise by combining infinitesimal data. The process of finding integrals is called integration. Along with differentiation, integration is a fundamental operation of calculus, and serves as a tool to solve problems in mathematics and physics involving the area of an arbitrary shape, the length of a curve, and the volume of a solid, among others.

**Learning Outcomes**

1. Compute integrals of basic functions by using antiderivative formulas and techniques such as substitution, integration by parts, trigonometric identities, trigonometric substitutions, partial fraction decomposition and rationalizing substitutions. Be able to simplify and manipulate the integrand and choose an effective technique or combination of techniques based on the form of the integrand.

2. Compute definite integrals by using the fundamental theorem of calculus. Be able to recognize functions that are given as definite integrals with variable upper and lower limits and find their derivatives, relate antiderivatives to definite and indefinite integrals, and the net change as the definite integral of a rate of change.

3. Approximate the area between a curve and the x-axis by using the left, right or midpoint sums. Interpret a definite integral in terms of the area between a curve and the x-axis. Compute definite integrals by using the Riemann sum, the definition of a definite integral. Use the comparison properties to estimate the value of a definite integral.

4. Construct an integral or a sum of integrals that can be used to find the volume of a solid by considering its cross-sectional areas. For solids that are obtained by revolving a region about an axis of rotation, find the volume by considering cross-sectional discs or washers.

5. Determine whether an improper integral (which either has infinite lower or upper limits of integration, or has a integrand with infinite discontinuities within or at the boundary of the interval of integration) diverges or converges, by evaluating the improper integral or by using the comparison theorem.

**Course Content**

**1. Introduction:** Antiderivatives and indefinite integrals; Techniques of integration; Definite integration using antiderivatives; Definite integration using Riemann sums.

**2. Properties of Integration:** Basic properties; Fundamental theorems of calculus; Mean Value Theorem for integrals; Integration by reduction; Walli’s formulae with geometrical interpretation.

**3. Applications of Integration:** Area between curves; Volumes of solid by slicing, disks and washers; Volumes by cylindrical shells; Average value of a function; Arc length; Area of a surface of revolution; Applications to Business, Economics, Social Sciences, Biology and Physical Engineering sciences.

**4. Improper Integrals:** Different types of improper integrals; Test for convergence (comparison, ratio, absolute and conditional); Application to probability distribution; Gamma and beta functions.

**5. Parametric and Polar curves:** Arc length for parametric curves; Graphing in polar coordinates; Tangent lines, arc length and area for Polar Curves; Area and volume of surface by revolving in Polar coordinates.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. H. Anton, I. C. Bivens and S. Davis, **Calculus: Early Transcendentals**, Wiley.

2. E.W. Swokowski, **Calculus with Analytic Geometry**, Brooks/ Cole.

3. G. B. Thomas and R. L. Finney, **Calculus and Analytic Geometry**.

4. J. Stewart, **Single Variable Calculus: Early Transcendentals**.

5. R. Larson, R. P. Hostetler, F. H. Edwards and D. E. Heyd, **Calculus with Analytic Geometry**, Houghton Mifflin College Div.

**STA 1205: Introduction to Probability 3 Credits**

**Introduction and Specific Objectives**

This course is intended to provide the basic foundations of statistics with applications in real life. The class will cover topics on probability, and probability distributions for both continuous and discrete random variables. A central objective is to provide students with hands on experience in using the statistical theory and methods to perform the different statistical analyses and to interpret results.

**Learning Outcomes**

After successfully completing this course, a student will be able to: Utilize basic concepts of probability including independence and conditional probability to calculate, interpret and communicate event probabilities both for discrete and continuous random variables, Determine the appropriate probability distribution based on experiment conditions and assumptions.

**Course Contents**

1. **Basic concepts of probability:** Meaning of probability, Scope of probability, Definition of probability, Different types of probability definitions: classical, axiomatic empirical and subjective. Difference between probability and possibility. Laws of probability, Conditional probability, Theorem of total probabilities.
2. **Bayes theorem:** Uses and importance of Bayes theorem in statistics.
3. **Random variables:** Discrete and continuous random variables, probability mass function, probability density function, Distribution function, function of random variable and its distribution, joint distribution, marginal and conditional distributions, independence of random variables, Mathematical expectation, expectations of sum and products of random variables. Moments and moment generating functions, Cumulants and cumulant generating functions, Relation between moments and cumulants.
4. **Probability Distributions:** Detail study of Binomial, Poisson & Normal distributions.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Islam, M.N. (2006). An Introduction to Statistics & Probability, Book World, Dhaka.
2. Mosteller, Rourket Thomas, Probability with Statistical Application.

**PHY 1207 Electricity and Magnetism 3 Credits**

**Introduction and Specific Objectives**

This course provides the foundations of electromagnetic theory, with applications in electrical and electronic engineering, deeply covering the basic mathematical concepts of electrostatics, Gauss’s law, Coulomb’s law, Maxwell’s equation, magnetostatics, Biot–Savart’s law, Ampere’s law, electric and magnetic fields in materials, magnetic boundary conditions, electromagnetic waves, propagation of electromagnetic waves, and other applications.

**Learning Outcomes**

The students will be able to learn the basic mathematical concepts related to electromagnetic vector fields. They can apply the principles of electrostatics to the solutions of problems relating to electrostatic and magnetostatic fields, magnetic scalar and vector potentials, magnetic torque, moment, dipole, and boundary conditions. They will also be familiar with the concepts related to Biot – Savart’s law, Ampere’s circuit law, Maxwell’s equations in magnetostatic and electrostatics and electrodynamics.

**Couse Contents:**

1. Point charges and Coulomb’s law. Definition of the electric field. Superposition principle. Electric field lines. Field due to a dipole. Torque on a dipole in uniform E-field.
2. Gauss’ law. Coulomb’s law from Gauss’ law. Cases with planar, spherical and cylindrical symmetry. Gauss’ law in differential form.
3. Static electric field as a conservative vector field (∇×E=0). Notion of a potential Equipotential; surfaces. Potential and potential energy for a system of charges.
4. Capacitance and capacitors. Analogy with springs. Parallel plate capacitors and spherical Capacitors. Energy stored in a capacitor. Capacitors in parallel and in series, Capacitors used as charge accelerators. Concept of electron-volts. Eelectric field as the carrier of electrical evergy and electrical energy density in terms of electric field.
5. Dielectric media. Polarization vector and Displacement vector. Capacitor with a dielectric, Gauss’s law with dielectrics.
6. Motion of charge carriers in matter. Current density, drift velocity, the Durde model. Ohmic conductors and Ohm’s law. (The laws of resistivity). Resistance and resistivity. Addition of resistances.
7. Electromotive force and potential drop. Kirchoff’s laws : Junction and Loop rules. Their physical basis. Problems involving Multiloop circuits with resistors and batteries, ammeter. Voltmeter and their use.
8. Single loop RC circuit. Charge, Charging and discharging of a capacitor and the Time constant. Energy transformation in the RC circuit.
9. Definition of magnetic field : Lorentz Force. Properties of static magnetic field. Gauss’ law for magnetic fields. Absence of magnetic monopoles. Motion of charged particles in magnetic field : Hall effect.
10. Magnetic fields due to currents : Biot-Savart law. Magnetic fields due to current carrying areas and straight lines. Ring current as a magnetic dipole. Ampere’s law comparison between Biot-savart and Ampere law. Field due to an infinite straight wire, ideal solenoid and a toroid.
11. Magnetic properties of matter. paramagnet, diamagnet and ferromagnet. Magnetization vector. Hysteriesis.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Elements of Electromagnetics; Mathew N.O. Sadiku, 3rd Edition, Oxford University Press.

2. Electricity and Magnetism for Advanced Students; Sydney G. Starling.

3. Introduction to Electrodynamics; David J Griffiths, fourth Edition.

4. Foundations of Electromagnetic Theory-J. Reitz, F. Milford and R. Christy, Addison Wesley.

**MAT 1202: Mathematica Lab 3 Credits**

Problem solving in concurrent courses (e.g. Calculus, Linear Algebra and Geometry) using MATHEMATICA Programming.

**Lab Assignments:** There are at least 07 assignments.

**Evaluation:** Internal assessment (Laboratory works) 40 Marks. Final examination (Lab: 3 hours) 60 Marks.

**Second Year Semester-I**

**MAT 2101: Mathematical Analysis** **3 Credits**

**Introduction and Specific Objectives**

Mathematics has become an indispensable tool in many areas including the physical sciences, engineering and computer sciences as well as economics and management science and mathematical analysis is one of the main pillars of mathematics. The study of mathematical analysis has great value for the students who wish to go beyond the routine manipulations of formulas to solve standard problems, for ability to think deductively and analyze complicated examples to modifying and extending concepts to new contexts.

The objective of the course is to introduce the basic ideas of real analysis with particular emphasis on metric spaces.

**Learning Outcomes**

* A sound knowledge of the sets of real numbers, boundary of a set, supremum, infimum, limit, interior, exterior of a set and when a set close or open.
* Understanding the idea of infinite sequences of real numbers and their convergences.
* Working knowledge of the convergence of infinite series of real numbers.
* Understanding the concept of limit, continuity, differentiability of real valued functions.
* Be familiar with the Riemann integral in R and Rn and able to calculate the values of integrals.
* Ability to deal with various examples of metric spaces, open and closed sets in metric spaces.
* Implementations of the convergence of infinite sequence of metric in many real life problems.

**Course Contents**

1. **Real number system:** Supremum and infimum of a set, cluster (limit) points; the completeness axiom, Dedekind’s theorem and Bolzano-Weierstrass theorem (No proof), Open and closed sets, interior, exterior and boundary of a set, cluster point and derived set.
2. **Infinite sequences:** Sequences of real number, Convergence, Monotone sequences, subsequences, Cauchy’s general principle of convergence, some important sequences.
3. **Infinite series of real numbers:** convergence and absolute convergence, Tests for convergence; Power series, Uniform convergence, differentiation and integration of power series.
4. **Limit, continuity and differentiability:** Limit, continuity and differentiability of functions, properties, Intermediate value theorem (no proof), Uniform continuity, Differentiation in , Implicit and inverse function theorems (Statements and verifications, and applications only, no proof).
5. **The Riemann integral:** definitions via Riemann’s sums and Darboux’s sums,Darboux’s theorem, (equivalence of the two definitions) Necessary and sufficient conditions for integrability and integration in .
6. **Metric Spaces:** Definition and examples. ϵ- neighborhood, open and closed sets in metric spaces, Interior, exterior and boundary of a set.. Cluster points of sets in metric spaces, Derived set, closure of a set. Bounded sets, Equivalent metrics.
7. **Infinite sequences in metric spaces:** Infinite sequences in metric spaces and their convergence, Cauchy sequences, Complete metric spaces, Continuity and uniform continuity of functions on metric spaces, Sequences and series of functions and their convergence.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. W. Rudin, Principles of Mathematical Analysis.
2. R. G. Bartle, Introduction to Real Analysis.
3. W F Trench, Introduction to Real Analysis.
4. Malik Arora, Mathematical Analysis.
5. FatemaChowdhury and Munibur Rahman Chowdhury, Essentials of Real Analysis.

**MAT 2103: Differential Calculus of Several Variables 3 credits**

**Introduction and Specific Objectives**

Calculus, the branch of mathematics concerned with the calculation of instantaneous rates of change (differential calculus) and the summation of infinitely many small factors to determine some whole (integral calculus). Calculus is considered to be one of the greatest achievements of the human intellect and it is now the basic entry point for anyone wishing to study physics, chemistry, biology, economics, finance, or actuarial science. The development of calculus in the seventeenth and eighteenth centuries was motivated by the need to understand physical phenomena such as the tides, the phases of the moon, the nature of light, gravity etc.

**Learning Outcomes**

Upon successful completion of the course, students should be able to

1. developed a clear understanding of the fundamental concepts of vector calculus and partial derivatives

2. solve various problems using the basic concepts of vector calculus

3. visualize graphs of curve in 3D, surface and analyze various properties of them

4. apply ideas of partial derivatives in many real life problems

5. find extreme values of multivariable functions using different approaches and apply them to solve practical problems

6. develop a clear idea of physical significance of gradient, divergence and curl and learn some physical applications of them.

**Course Contents**

1. **Vector-valued functions:** Introduction to Vector-Valued Functions, Limits, continuity and derivatives of vector valued functions. Tangent lines to graphs of vector-valued functions. Arc length from vector view point. Arc length parameterization.
2. **Curvature:** Unit Tangent, Normal and Binormal Vectors, Curvature of plane and space curves: Curvature from intrinsic, Cartesian, Parametric and Polar equations. Radius of curvature. Centre of curvature.
3. **Partial Differentiation:** Functions of several variables, Graphs of functions of two variables, Limits and continuity, Partial derivatives, Differentiability, linearization and differentials. The Chain rule. Partial derivatives with constrained variables, Directional Derivatives and Gradients, Tangent Planes and Normal Vectors, Extrema of functions of several variables, Lagrange multipliers. Taylor’s formula for functions of two variables.
4. **Vector:** Differentiation of Vectors, Gradient, Divergence and curl and their physical meanings.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. H. Anton, IrlBivens, Stephen Davis, Calculus: Early Transcendentals, 10th Edition.
2. J. Stewart, Calculus: Early Transcendentals, 6th Edition.
3. E. Swokowski, Calculus with Analytic Geometry.
4. R. T. Smith and R. B. Minton, Calculus: Early Transcendental Functions 4th Edition.

**MAT 2105: Ordinary Differential Equations 3 Credits**

**Introduction and Specific Objectives**

This course provides an introduction to ordinary differential equations and modeling with them. Formulation and solution of ordinary differential equations play a vital role in modeling physical and biological phenomena. This course focuses on how to find the analytical solutions of linear and nonlinear ODE, in particular, of first and second order using different methods.

The objective of this course is to introduce the basics of ordinary differential equations and terminologies. It focuses on the ability of the students to solve different types of ordinary differential equations analytically using well known techniques. Exploring the utility of ordinary differential equations in modeling physical and biological systems.

**Learning Outcomes**

The students will be able to

* know the basic idea about differential equations, order, degree, classifications and modeling approach, initial value problems and autonomous differential equations
* formulate differential equations by removing arbitrary constants from algebraic relations and draw solutions curves using direction field
* find whether an initial value problem (IVP) has solution and whether the solution is unique by using the Existence and Uniqueness theorem
* classify first-order DE’s as separable, homogeneous, linear, exact, Bernoulli’s and solve them using appropriate methods
* know about higher order, mostly second order ODE’s and their classifications such as Homogeneous and Nonhomogeneous
* solve them using reduction of order, method of undetermined coefficients, variation of parameters
* learn about Cauchy Euler equations and their solution process; several linear and nonlinear models using higher order ODE’s, systems of linear differential equations using matrices, and applications of linear systems
* know about autonomous systems, stability and linearization of systems of nonlinear differential equation and some well-known mathematical models.

**Course Contents**

1. **Introduction to Differential Equations:** Definition of Differential Equation, Order and Degree; Classification of Differential Equations; Formulation; Modeling Approach, Models and Initial Value Problems, Solution Curves without a solution: Direction fields, Autonomous first order DEs. The Modeling Process: Differential Systems.
2. **First-Order Differential Equations:** Existence and Uniqueness theorem (without proof), Solution of First-order DE’s: Separable, Homogeneous, Linear, Exact, Solutions by substitutions, Linear models, Nonlinear models. Modeling with systems of first order DEs: Population models, Models of growth and decay, Acceleration velocity models: Motion of a falling body, Compartmental analysis, heating and cooling of buildings, Newtonian mechanics, Electrical circuits.
3. **Higher-Order Differential Equations:** Homogeneous and Nonhomogeneous equations, Reduction of order, Homogeneous linear equations with constant coefficients, Undetermined coefficients, Variation of parameters, Cauchy Euler equations, Mass spring oscillator, Coupled Spring/Mass systems: Free damped motion, free undamped motion, Driven motion, Series circuit Analogue. Electrical Networks and Mechanical Systems, Linear models: BVP, Nonlinear models.
4. **Systems of Linear Differential Equations:** Matrix form of a linear system, Homogeneous and Nonhomogeneous linear systems, Second order systems and Mechanical applications. Metapopulations, Natural killer cells and Immunity, Transport of Environmental pollutants, Solution by Diagonalization.
5. **Systems of Nonlinear Differential Equations:** Chemical Kinetics: The Fundamental Theorem, Autonomous systems, Stability of linear systems, Ecological models: Predators and competitors, linearization and local stability.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Robert L. Borrelli and Courtney S. Coleman, Differential equations: A Modeling Perspective.
2. D. G. Zill and Warren S. Wright, Differential Equations with Boundary-Value Problems.
3. C. Henry Edwards, David E. Penney and David T. Calvis, Differential Equations and Boundary Value Problems: Computing and Modeling.
4. Nagle, Saff and Snider, Fundamentals of Differential Equations and Boundary Value Problems.

**MAT 2107: Mathematical Statistics 3 Credits**

**Introduction and Specific Objectives**

The course contents are designed to give students a clear idea about random variables and methods of finding the distribution of a function of random variables, Central limit theorem and Chebyshev’s inequality with applications and sampling distributions. Moreover, this course is also designed to give fundamental concept of estimation theory and hypothesis testing, to obtain approximate values and confidence intervals for the unknown parameters, constructing different hypothesis testing procedures related to parametric, goodness of fit and analysis of variance tests using appropriate statistical methods and theories.

**Learning outcomes**

On successful completion of this course, students will be able to: understand the basic concept of random variables, methods of finding the distribution of a function of random variables, Central limit theorem and Chebyshev’s inequality with applications, Sampling distributions, basic terms of estimation theory and test of hypothesis, obtain point estimators and construct confidence intervals of parameters with applications of estimation methods and hypothesis testing.

**Course Contents**

1. **Population and Sample:** Concept of population, sample, parameter, statistic, random sample, probability distribution, Standard errors of statistics and their large sample approximations. Transformation of variables including square root, log, sin-inverse etc.
2. **Random Variables:** Basic concept of random variable and its types, Distribution of sum, difference, product and quotient of random variables, functions of random vectors of continuous and discrete type, Central limit theorem, other limit laws and their applications.
3. **Expectations and Generating Functions:** Conditional expectations, Chebyshev’s inequality, probability generating function, characteristic function, inversion theorem.
4. **Sampling distributions:** Definition, Different sampling distributions: Chi-square , Snedecor-Fisher’s F and Student’s t distribution, Different methods of finding sampling distribution: Analytical method, inductive method, geometrical method, method of using characteristic function, etc. Sampling from the normal distributions, Distribution of sample mean and variance and their independence for normal population, Sampling distribution of correlation and regression coefficients, frequency and their uses.
5. **Basics of Estimations:** Methods of estimation and criteria of estimations. Preliminaries of tests: Hypothesis, Types of hypotheses, concept of test of significance, procedures of a test, errors in testing of hypothesis, level of significance, one tailed and two-tailed tests, p-value. Tests based on different statistic.
6. **Tests:** Testing the significance of a single mean, single variance, single proportion, difference of two means and proportions, ratio of two variances and their confidence intervals. Tests and confidence intervals concerning simple correlation coefficient and regression coefficient for single and double sample. Paired t-test.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Hoog, R.V.& Craig, A.T., An introduction to mathematical statistics.
2. Prem S. Mann, Introductory Statistics, 8th Edition John Wiley & Sons.
3. Gupta, S.C. and Kapoor, V.K., Fundamental of Mathematical Statistics.
4. Richard A. Johnson and Gouri K. Bhattacharyya, Statistics: Principles and Methods.
5. John E. Freund, Miller and Miller, Mathematical Statistics with Applications.

**MAT 2109: Introduction to Financial Mathematics 3 Credits**

**Introduction and Specific Objectives**

This course is a basic introduction to finance. It starts by making an introduction to the value of money, interest rates and financial contracts, in particular, what are fair prices for contracts and why no-one uses fair prices in real life. Then, there is a review of probability theory followed by an introduction to financial markets in discrete time. In discrete time, one will see how the ideas of fair pricing apply to price contracts commonly found in stock exchanges. The next block focuses on continuous time finance and contains an introduction to the basic ideas of Stochastic calculus. There is an overview of Actuarial Finance also. This course is a great introduction to finance theory and its purpose is to give students a broad perspective on the topic.”The course unit aims to enable students to acquire active knowledge and understanding of some basic concepts in financial mathematics including stochastic models for stocks and pricing of contingent claims.

**Learning Outcomes**

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

* gain knowledge of basic financial concepts and financial derivative instruments
* use the fundaments of no-Arbitrage pricing concept
* apply basic probability theory to option pricing in discrete time in the context of simple financial

models

* understand fundamental knowledge of Stochastic analysis (Ito Formula and Ito Integration)
* understand Black-Scholes formula and get the concept of Introduction to actuarial mathematics
* learnprice financial derivatives such as options.

**Course Contents**

1. **Introduction to Finance:** Definition of finance, types of finance, major financial decisions, goals of finance, functions of financial institutions and financial Market, difference between the capital markets and the money markets.
2. **Time Value of Money:** Definition and concepts-cash flow, discounting and compounding, present value, future value, annuities, mixed streams, effective annual interest rate, amortization.
3. **Interest rates, Bond and Stock Valuation:** Interest rates and required returns, Term structure of interest rates, important bond features, different types of bond, valuation fundamentals and bond valuation; Difference between debt and equity, features of both common and preferred stock, basic stock valuation using zero-growth, constant-growth, and variable growth models.
4. **Overview of basic concepts in securities markets:** Exchange-traded markets; Over-the-counter markets; Forward contracts; Future contracts; Options; Types o f traders, etc.
5. **Stochastic models for stock prices:** Continuous-time stochastic processes; Wiener processes; The process for a stock price; The parameters; Itˆo’s lemma; The lognormal property of stock prices.
6. **Hedging strategies and managing market risk using derivatives:** Financial derivatives; European call and put options; Payoff diagrams, short selling and profits; Trading strategies: Straddle, Bull Spread, etc; Bond and risk-free interest rate; No arbitrage principle; Put-call parity; Upper and lower bounds on call options.
7. **Binomial option pricing model:** One-step binomial model and a no-arbitrage argument; Risk-neutral valuation; Two-steps binomial trees; Binomial model for stock price; Option pricing on binomial tree; Matching volatility σ with u and d; American put option pricing on binomial tree.
8. **Risk-neutral Portfolio:** Risk-neutral valuation, replication and pricing of contingent claims.
9. **Black-Scholes analysis:** Black-Scholes model; Black-Scholes Equation; Boundary conditions for call and put options; Exact solution to Black-Scholes equation; Delta-hedging; the Greek letters; Black-Scholes equation and replicating portfolio; Static and dynamic risk-free portfolio; Option on dividend-paying stock; American put option.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. L J Gitman, Principles of Managerial Finance 12th Edition.

2. J. Hull,Options, Futures and Other Derivatives, 8th Edition, Prentice-Hall, 2012.

1. P. Wilmott, S. Howison and J. Dewynne, The Mathematics of Financial Derivatives: A Student Introduction, Cambridge University Press, 1995.

**MAT 2111: FORTRAN Programming 3 Credits**

**Introduction and Specific Objectives**

Fortran was developed for general scientific computing and is a very popular language for this purpose. This course provides an introduction, the structure and contents of the Fortran programming language. It will provide the students with enough knowledge to write Fortran programs and the students will gain general experience that can usually be applied when using any programming language. The main objective of this course is to expose students to algorithmic-problem solving and to develop fundamental skills in Fortran programming, with emphasis on a transparent and disciplined programming style, code modularity and reusability of the components.

**Learning Outcomes**

After successful completion of this course, the students will be able to understand the basic components of the digital computer, the basic characteristics of several operating systems, several number systems, and the conversion of numbers from one system to others. They will know the evolution, development and standard solving techniques of Fortran programming language. The students will also learn several loops, decision statements, several external and internal procedures of Fortran programming in detail. They will be able to use arrays, allocate memory for arrays and use files efficiently in Fortran programming language.

**Course Contents**

1. **Introduction to Computing:** Introduction to Digital Computers; Operating Systems; Programming and Problem Solving.
2. **Number System:** Binary; Octal; Decimal and Hexadecimal number systems. Conversion of numbers from one system to others.
3. **Fundamentals of Computer Programming:** Programming basics; High-level programming languages; Introduction to FORTRAN; Fortran Evolution; Basic difference of FORTRAN 77 and Fortran 90; Problem-Solving Techniques: Flowcharts; Algorithms; Pseudo code.
4. **Programming in Fortran:** Syntax and semantics; Constants; and Variables; Data Types; Arithmetic; Relational and Logical operations; Operator Precedence; Single and Mixed Mode Arithmetic; Expressions and Assignment Statements; Fortran Input/Output.
5. **Control Constructs and Arrays:** IF Constructs; Nested and Named IF Constructs; SELECT CASE Construct; Do Loops; Named and Nested Loops; Do While Loops; Declarations and construction of Arrays; Memory allocation for Arrays; Problems solving using Arrays.
6. **Programming Units:** Types of Programming Units; Main Program; External Procedures; Internal Procedures; Modules; Function subprograms; Subroutines; subprogram for recursion.
7. **Use of Files:** Necessity of using files; opening and closing of files; reading from files; writing into files; Construction and implementation of Fortran programs for solving problems in Mathematics using Files.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Stephen J. Chapman, Introduction to FORTRAN 90/95.
2. Michael Metcalf, John Reid, Malcolm Cohen, Modern Fortran explained, Oxford University Press.
3. Gordon B. Davis & Thomas R. Hoffmann, FORTRAN 77: A Structured, Disciplined Style.

**Second Year Semester-II**

**MAT 2201: Linear Algebra II 3 Credits**

**Introduction and Specific Objectives**

Linear algebra II is the study of vector spaces and linear mappings between them. In this course, we will begin by reviewing topics you learned in Linear Algebra I, starting with vectors, matrices and linear mappings. The review will refresh the student's knowledge of the fundamentals of vectors and of matrix theory, and how to perform operations on matrices. After the review, we can extend this idea to Similar Matrices. Next, we will focus on Linear Functional and dual Space. We will then introduce a new structure on vector spaces: an inner product. Inner products allow us to introduce geometric aspects, such as length of a vector, and to define the notion of orthogonality between vectors. In this context, we will study the applications in Linear Models and Fourier Approximation, and more. We will end this chapter with the spectral theorem, which provides a decomposition of the vector space on which operators act, and singular-value decomposition, which is a generalization of the spectral theorem to arbitrary matrices. Then, we will study Bilinear, quadratic & hermitian forms. Symmetric Matrices and Quadratic Forms, Positive Definite Matrices will be studied at the end of this course with their applications in diverse fields. The subject material is of vital importance in all fields of mathematics and in science in general.

**Learning Outcomes**

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

1. know and use the properties of similar matrices. Also, explain the concepts of canonical forms of matrices, Symmetric, orthogonal and Hermitian matrices

2. get familiar with the Linear Functional, dual Space, Second dual space, Annihilators, Transpose of a linear transformation and their properties

3. understand the concept of a linear transformation as a mapping from one vector space to another and be able to calculate its matrix representation with respect to standard and nonstandard bases

4. describe the basic terminologies appeared in inner product spaces and the Gram-Schmidt process and gather knowledge about operator theory and apply them into the spectral theorem

5. formulate the concept and properties of Bilinear, Quadratic & Hermitian forms and demonstrate them into canonical forms and identify the definite, semi-definite forms and minors

6. deal with the Diagonalization process, and to recognize their applications

7. learn several ways of testing for positive definiteness and also how to find Minima, Maxima, and Saddle Points by the entries of *A*

8. apply linear algebra to such real world phenomena as to Image Processing and Statistics, and linear Models and Fourier Approximation.

**Course Contents**

1. **Similar Matrices:** Canonical forms of matrices, Symmetric, orthogonal and Hermitian matrices

2. **Linear Functional and Dual Space:** Linear transformation and their properties. Matrix representation of linear transformations. Change of bases. Linear functional and the dual space; Dual basis, Second dual space; Annihilators; Transpose of a linear transformation

3. **Orthogonality:** Inner product, Length and Orthogonality; Projections and Least Squares; The Gram-Schmidt process; Orthonormal sets; Inner product spaces; Linear functions and adjoints; Positive operators; unitary operators and normal operators; The spectral theorem; Application to Linear Models and Fourier Approximation

4. **Bilinear, Quadratic & Hermitian forms:** Matrix form; transformations; canonical forms; reduction form; definite and semi-definite forms; principal minors; and factorable forms

5. **Symmetric Matrices and Quadratic Forms:** Diagonalization of Symmetric Matrices; Quadratic Forms; The Singular Value Decomposition; Applications to Image Processing and Statistics

6. **Positive Definite Matrices:** Minima, Maxima, and Saddle Points; Tests for Positive Definiteness; Minimum Principles.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Howard Anton and Chris Rorres, Elementary Linear Algebra Applications Version.
2. W. Greub, Linear Algebra.
3. Bernard Kolman, Linear Algebra.
4. WK Nicholson, Introduction to Abstract Algebra.

**MAT 2203: Integral and Vector Calculus 3 Credits**

**Introduction and Specific Objectives**

Calculus is a branch of mathematics concerned with the calculation of instantaneous rates of change (differential calculus) and the summation of infinitely many small factors to determine some whole (integral calculus). Calculus is considered to be one of the greatest achievements of the human intellect and it is now the basic entry point for anyone wishing to study physics, chemistry, biology, economics, finance, or actuarial science. The development of calculus in the seventeenth and eighteenth centuries was motivated by the need to understand physical phenomena such as the tides, the phases of the moon, the nature of light, gravity etc.

**Learning Outcomes**

1. The ability to work with different types of coordinate systems like rectangular coordinates, cylindrical coordinates and spherical coordinates.

2. The ability to understand and to sketch, roughly, different types of cylindrical and quadric surfaces.

3. The ability to set up and compute multiple integrals in rectangular, polar, cylindrical and spherical coordinates.

4. The ability to change variables in multiple integrals.

5. An understanding of physical significance of gradient, divergence and curl.

6. An understanding of line integrals for work and flux, surface integrals for flux, general surface integrals and volume integrals. Also, an understanding of the physical interpretation of these integrals.

7. An understanding of the major theorems (Green's, Stokes', Gauss') of the course and of some physical applications of these theorems.

**Course Contents**

1. **Multiple Integrals:** Double Integrals and iterated integrals, Area as a double integral, Double integrals in polar form.

2. **Triple integrals and iterated integrals:** Volume as a triple integral, Triple integral in cylindrical and spherical coordinates.

3. General multiple integrals, Change of Variables in Multiple Integrals; Jacobians.

4. **Vector Integration:** Line and Surface integrals, Green’s theorem, Gauss’s theorem, Stokes’ theorem.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. H. Anton, I. C. Bivens and S. Davis, Calculus: Early Transcendentals, Wiley.

2. E. W. Swokowski, Calculus with Analytic Geometry, Brooks/Cole.

3. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Addison Wesley.

4. J. Stewart, Multi Variable Calculus: Early Transcendentals, Cengaga Learning.

5. W. Rudin, Principle of Mathematical Analysis.

**MAT 2205: Numerical Methods I 3 Credits**

**Introduction and Specific Objectives**

It may be considered to be a preparatory course in numerical analysis. While mathematical in nature, emphasis is also given to programming techniques for numerical methods. Introduction and application of numerical methods to the solution of physical and engineering problems. Techniques include iterative solution techniques, methods of solving systems of equations, and numerical integration and differentiation.

The goal is to cover a wide range of numerical methods to obtain an approximate solution of problems of physics where an exact solution is not available. A broad knowledge is often decisive to choose the right method when developing a new code.

**Learning Outcomes**

At the conclusion of the course, students should be able to

* find numerical approximations to the roots of an equation by Newton method, Bisection Method, Secant Method, etc
* find numerical solution to a system of linear equations by Gaussian Elimination, Jacobi and Gauss-Siedel Iterative methods
* demonstrate the use of interpolation methods to find intermediate values for any given set of points
* apply several methods of numerical integration, including Romberg integration.

**Course Contents**

1. **Preliminaries of Computing:** Basic concepts, Floating point arithmetic, Types of errors and their computation, Convergence.
2. **Numerical solution of non-linear and transcendental equations:** Bisection method, Method of false position. Fixed point iteration, Newton-Raphson method, Iterative method and Error Analysis.
3. **Interpolation and polynomial approximation:** Polynomial interpolation theory, Finite differences and their table, Taylor polynomials, Newton's Interpolation, Lagrange polynomial, Divided differences, Extrapolation.
4. **Numerical Differentiation and Integration:** Numerical differentiation, Richardson’s extrapolation, Elements of Numerical Integration, Trapezoidal, Simpson's, Weddle's etc., Adaptive quadrature method, Romberg’s integration.
5. **Numerical Solutions of linear systems:** Direct methods for solving linear systems, Gaussian elimination and backward substitution, pivoting strategies, numerical factorizations, Iterative methods: Jacobi method, Gauss Seidel method, SOR method and their convergence analysis.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. R.L. Burden and J. D. Faires – Numerical Analysis.
2. K. Atkinson – Introduction to Numerical Analysis
3. M. A. Celia and W. G. Gray – Numerical Methods for Differential Equations.
4. L.W. Johson& R. D. Riess, Numerical Analysis.

**MAT 2207: Discrete Mathematics 3 Credits**

**Introduction and Specific Objectives**

This course is an introduction to the study of Discrete Mathematics, a branch of contemporary mathematics that develops reasoning and problem-solving abilities, with an emphasis on proof. Topics include logic, Boolean algebra, mathematical reasoning and proof, combinatorics and graph theory. The subject enhances one’s ability to reason and ability to present a coherent and mathematically accurate argument. This course is intended for students of Applied Mathematics capable of and interested in progressing through the concepts of discrete mathematics in more depth and at an accelerated rate. The objectives of this course are to develop logical thinking with the emphasis of proving statements correctly and the correctness of an argument, to solve the circuit designing problems using Boolean algebra, and to develop skills to solve problems using graph theory. The main objective of this course is to provide basic ideas to identify and apply concepts of logic, Boolean algebra, proof techniques, combinatorics, graphs and trees.

**Learning Outcomes**

After successful completion of this course, the students will be able to understand logical arguments and logical constructs, have a better understanding of logic and mathematical proofs and apply Boolean Algebra to construct gates and to minimize the circuits. The learners will understand the basics of Induction, Recursion, Recurrence relations and Generating functions, and be able to apply the methods from these topics in solving problems. The students will be able to understand the terminologies, definitions, concepts and methods of graphs and trees. They will have complete knowledge to solve realistic problems using the graphs and/or trees.

**Course Contents**

1. **Logic and Mathematical Proofs:** Propositional logic and Equivalences; Rules of Inferences and Quantifiers; Various Quantified Statements; Methods of proof.
2. **Boolean Algebra:** Boolean Functions; Representing Boolean Functions; Logic Gates; Minimization of Circuits using Karnaugh maps.
3. **Induction and Recursion:** Mathematical induction; Well ordering; Recursive Definitions.
4. **Combinatorics:** The principle of Inclusion and Exclusion; Pigeonhole Principle. Recurrence relations; Applications to computer operations; Solving Linear Homogeneous and Nonhomogeneous Recurrence Relations; Generating Functions.
5. **Graph Theory and Applications:** Graphs; Graph Terminology; Special Types of Graphs; Representing graphs; Adjacency Matrices; Incidence Matrices; Graph Isomorphism; Paths; Circuits; Eulerian and Hamiltonian Paths; Shortest-Path problems; Dijkstra’s Algorithm; Traveling Salesperson Problem, Planar Graphs.
6. **Trees:** Tree Terminology; Properties of Trees; Spanning Trees; Minimum Spanning Trees; Algorithms (Prim’s and Kruskal’s) for Minimum Spanning Trees and their comparison.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. K. H. Rosen, Discrete Mathematics and its Applications.
2. RP Grimaldi and BV Ramana, Discrete and Combinatorial Mathematics.
3. Bernard Kolman, Robert C. Busby, Sharon Cutler Ross, Discrete Mathematical Structures, Pearson Education.

**MAT 2202: FORTRAN Lab 3 Credits**

Problem solving in concurrent courses (e.g. Calculus, Linear Algebra, Differential Equations, Numerical Analysis and Discrete Mathematics) using FORTRAN.

**Lab Assignments:** There are at least 07 assignments.

**Evaluation:** Internal assessment (Laboratory works) 40 Marks. Final examination (Lab: 3 hours) 60 Marks.

**Third Year Semester-I**

**MAT 3101: Functional Analysis** **3 Credits**

**Introduction and Specific Objectives**

This course will cover the foundations of functional analysis in the context of topological linear spaces and normed linear spaces. It will start with a review of the theory of general linear spaces. The linear analysis on Hilbert spaces with its rich geometrical structures will be studied with normed linear spaces. Uniform Boundedness Principle, Open Mapping Theorem and Closed Graph Theorem will be presented and several applications will be analyzed. The important notion of duality will be developed in Banach and Hilbert spaces. Bounded and unbounded self-adjoint operators in Hilbert spaces will be analyzed. Further, Banach Fixed point theorem with applications, Schauder fixed point theorem, Frechet derivative and Newton’s method for nonlinear operators will be introduced.

This course introduces students to the basic knowledge of linear functional analysis, an important branch of modern analysis. This is a course on functional analysis for mathematics students. It aims to study normed linear spaces and some of the linear operators between them and give some applications of their use. The normed linear spaces which are complete metric spaces are especially important.

**Learning Outcomes**

Upon completion of this course, students will explore the followings:

1. Familiarity with the main, big theorems of functional analysis.
2. Learn the fundamental concepts of Topological Linear Spaces and study of the properties of bounded linear maps between topological linear spaces of various kinds.
3. Ability to use duality in various contexts and theoretical results from the course in concrete situations.
4. Capacity to work with families of applications appearing in the course, particularly specific calculations needed in the context of famous theorem.
5. Be able to produce examples and counter examples illustrating the mathematical concepts presented in the course.
6. Understand the statements and proofs of important theorems and be able to explain the key steps in proofs, sometimes with variation.

**Course Content**

1. Review of General Linear (Vector) spaces: Linear mappings, linear operators, elementary properties of linear operators, linear operators in finite dimensional spaces, linear functional, basis and its dual on finite dimensional space, Zorn’s lemma, extension of linear functions, sublinear functional.
2. Inner product and norm (on a vector space over ): Definitions and examples, Cauchy-Schwarz inequality, norm derived from inner product, Parallelogram law, metric derived from a norm, inner product space, orthogonality, Bessel’s inequality.
3. Normed linear spaces: Sequence space, separability, Riesz’s lemma, boundedness and continuity, Quotient space, spaces of bounded linear operators.
4. Banach spaces: Open mapping theorem, closed graph theorem, and their applications, Baire’s category theorem, Uniform boundedness principle, normed conjugate of a NLS (Hahn-Banach theorem). Fixed point theorems: Contraction mapping, Banach fixed point theorem, Schauder fixed point theorem and applications of fixed-point theorems.
5. Hilbert spaces: Basic properties, Riesz representation theorem, adjoint of a linear operator.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. E. Taylor, Introduction to Functional Analysis, Wiley
2. E. Kreyszig, Introduction to Functional Analysis with Applications, Wiley
3. J. Maddox, Elements of Functional Analysis, Cambridge University Press
4. B, Rynne, M. A. Youngson, Linear Functional Analysis, Springer
5. M. Schechter, Principles of Functional Analysis, American Mathematical Society.

**MAT 3103 Complex Analysis** **3 Credits**

**Introduction and Specific Objectives**

Complex analysis, which is mainly the theory of complex functions of a complex variable. The course is introduced to the basic idea of the complex plane, along with the algebra and geometry of complex numbers, and then move on to differentiation, integration, complex dynamics, power series representation and Laurent series. Majorly this course contains the integration of a complex function and theorems related to complex integration. Also the course contains the general representation of complex numbers and functions with the special idea of different complex mappings too. After completing the course, students will gain the basic ideas of complex numbers, complex functions and theorems related to complex differentiation, integration and applications of these theorems to solve different mathematical problems.

1. To develop the basic ideas complex numbers and functions.

2. To learn the ideas of limit, continuity and differentiability of complex functions, theorems related to differentiation of complex function.

3. Understanding the Harmonic function, Analytic function and Cauchy-Riemann equation.

4. Learning the basic properties of integration of complex functions, theorems on complex integration and use of these theorems to solving mathematical problems.

5. Understanding the ideas of Taylor and Laurent series and the singularities.

6. Understanding the basics of Conformal mapping and Bilinear transformation.

**Learning Outcomes**

1. Understand complex numbers and complex functions.

2. Understand the basic concepts of limit, continuity and differentiability of complex function.

3. Understand the analytic function and Cauchy-Riemann equation.

4. Understand the integration of complex functions and theorems related to complex integration.

5. Solve some difficult integration using the theorems involving complex function.

6. Understand the infinite series and singularities.

7. Understand the ideas of Conformal mapping and Bilinear transformation.

**Course Content**

1. Complex plane: Metric properties and geometry of the complex plane. The point at infinity. Stereographic projection.
2. Functions of a complex variable: Limit, continuity and differentiability of a complex function. Analytic functions and their properties. Harmonic functions.
3. Complex integration: Line integration over rectifiable curves. Winding number. Cauchy’s theorem. Cauchy’s integral formula. Liouville’s theorem. Fundamental theorem of Algebra. Rouche’s theorem. The maximum and the minimum modulus principle.
4. Singularities: Power series of complex terms. Residues, Taylor’s and Laurent’s expansion. Cauchy’s residue theorem. Evaluation of integrals by contour integration. Branch points and cuts.
5. Bilinear transformations and mappings: Basic mapping. Linear fractional transformations. Other mappings. Conformal mappings.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. R.V. Churchill & J.W. Brown, Complex Variables and Applications.
2. L.V. Ahlfors, Complex Analysis, McGraw-Hill.
3. D G Zill, Complex Variables.
4. Murray R. Spigel, Complex Variables, Schaums Outline Series.
5. S Ponnusamy & Herb Silverman, Complex Variable with Applications.
6. H. S. Kasana, Complex Variables, Theory and Applications.

**MAT 3105 Ordinary Differential Equations II** **3 Credits**

**Introduction and Specific Objectives**

The course blends classical ODE material with more modern qualitative methods. Designed to solve various Mathematical problems using analytical methods and establish a relationship between mathematics and application to other disciplines such as physical science and engineering students.

**Course Objectives**

1. To introduce Special types of differential equations in physical and engineering fields used by Physicists and engineers from which special functions such as Bessel’s function, Legendre function, Hermite function, Laguerre function, hypergeometric and confluent hypergeometric functions with their applications
2. Give an account of and apply the theorems concerning existence and uniqueness;
3. Analyze equilibrium points and periodic orbits with respect to stability;
4. To introduce the Students to understand to solve linear/nonlinear problems of Mathematical models of different physical/ engineering areas with constant coefficients and/or variable coefficients.

**Learning Outcomes**

This course is aligned with the following Mathematics program learning outcomes:

Students will be able to solve mathematical problems using analytical methods and recognize the relationships between different areas of mathematics and the connections between mathematics and application to other disciplines.

1. Students will be able to apply series solution method about ordinary and singular points to solve various physical and engineering problems arises as models in terms of ordinary and partial differential equations.
2. Students will understand special functions such as Bessel’s function, Legendre function, Hermite function, Laguerre function, hypergeometric and confluent hypergeometric functions with their applications.

**Course Content**

1. Existence and uniqueness theory: Fundamental existence and uniqueness theorem. Dependence of solutions on initial conditions and equation parameters. Existence and uniqueness theorems for systems of equations and higher-order equations.
2. Series solutions of second order linear equations: Taylor series solutions about an ordinary point. Frobenius series solutions about regular singular points.
3. Legendre functions (Generating function, recurrence relations and other properties of Legendre polynomials, Expansion theorem, Legendre differential equation, Legendre function of first kind, Legendre function of second kind, associated Legendre functions).
4. Bessel functions (Generating function, recurrence relations, Bessel differential equation, Integral representations Orthogonality relations, Modified Bessel functions).
5. Hermite polynomials, Laguerre polynomials (Generating function, Rodrigue’s formula, orthogonal properties, Hermite and Laguerre differential equation, recurrence relations, expansion theorems).
6. Special functions: Gamma and Beta functions. Error function. Hyper geometric equations.
7. Systems of linear first order differential equations: Elimination method. Matrix method for homogeneous linear systems with constant coefficients. Variation of parameters. Matrix exponential.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. S. L. Ross, Differential Equations
2. D. G. Zill, A First Course in Differential Equations with Applcations.
3. F. Brauer & J. A. Nohel, Differential Equations.
4. H.J.H. Piaggio, An Elementary Treatise on Differential Equations
5. W.N. Lebedev & R.A. Silverman, Special Functions and their Applications.

**MAT 3107 Linear Programming 3 Credits**

**Introduction and Specific Objectives**

Optimization is one of the greatest successes to emerge from operations research and management science. It is an art of finding minima or maxima of some objective function, and to some extend an art of defining the objective functions. This course will focus on the optimization techniques such as linear programming (LP), nonlinear programming (NLP) and quadratic programming (QP). This is an interdisciplinary branch of applied mathematics and formal science that uses methods like mathematical modeling, statistics, and algorithms to arrive at optimal or near optimal solutions to real life problems and closely relates to Industrial Engineering. It is a tool for solving optimization problems. In 1947, George Dantzig developed an efficient method, the simplex algorithm, for solving linear programming problems. Since the development of the simplex algorithm, LP, NLP and QP have been used to solve optimization problems in industries as diverse as banking, education, forestry, petroleum, and trucking.

1. To give knowledge on mathematical formulations of real life problems.

2. Students will know different ways to solve the formulated mathematical models.

3. This course will help the students to learn the sensitivity analysis of real life problems.

**Learning Outcomes**

* + - 1. describe the basic properties such as convex sets and related theorems;
      2. gather knowledge about LP, standard form, canonical form, slack variables, surplus variables, basic solutions, non-basic solutions, feasible solutions optimal solutions etc.;
      3. know the ways to formulate a real life problem into a mathematical problem;
      4. Solve 2-dimensional problems by using graphical method;
      5. solve general LP problems by using simplex method (usual simplex method, 2-phase simplex method and Big-M simplex method);
      6. solve special type of LP by Dual simplex method;
      7. use sensitivity analysis to study the changes in availability, conditions etc.

**Course Content**

1. Introduction: Convex sets and related theorems, introduction to linear programming (LP)
2. Formulation: Formulation of LP problems.
3. Solution Techniques: Graphical solutions, Simplex method, Two -phase and Big-M simplex methods.
4. Duality and Sensitivity: Duality and related theorems, Dual simplex method, shadow prices and Sensitivity analysis of LP.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. S.I. Gass, Linear Programming.
2. W. Winston, Operations Research.
3. G. Hadley, Linear Programming.
4. N.S. Kambo, Mathematical Programming Techniques.
5. Ravindran, Phillips & Solberg, Operations Research.
6. Hiller and Liberman, Operations Research

**MAT 3109 Mechanics** **3 Credits**

**Introduction and Specific Objectives**

Mechanics describes the behavior of a body, in either a beginning state of rest or of motion, subjected to the action of forces. Applied mechanics, bridges the gap between physical theory and its application to technology. It is used in many fields of engineering, especially mechanical engineering and civil engineering. In this context, it is commonly referred to as Engineering Mechanics. Much of modern engineering mechanics is based on Isaac Newton's laws of motion while the modern practice of their application can be traced back to Stephen Timoshenko, who is said to be the father of modern engineering mechanics.

Resultant force and couple corresponding to any base point of a system of coplanar forces with general conditions of equilibrium of a system of coplanar forces. Centre of gravity and formulate for the centre of gravity by integration. Stable and unstable equilibriums with examples.

S.H.M.(Periodic time, Amplitude & Frequency) as well as compounding of two simple harmonic motions of the same period and in the same straight line. Motion where the accelerations are parallel to fixed axes with tangential and normal accelerations. About apse, apsidal distance and apsidal angle and some important theorems related to the central force. Accelerations of a particle in terms of polar coordinates and accelerations of a particle in terms of cylindrical coordinates.

**Learning Outcomes**

1. Students have to learn resultant force and couple corresponding to any base point of a system of coplanar forces with general conditions of equilibrium of a system of coplanar forces.
2. Further, general formulae for the determination of the centre of gravity and formulate for the centre of gravity by integration.
3. Definitions of stable and unstable equilibriums with examples.
4. They have to learn some important theorems related to S.H.M.(Periodic time, Amplitude & Frequency) as well as compounding of two simple harmonic motions of the same period and in the same straight line.
5. Therefore, motion where the accelerations are parallel to fixed axes with tangential and normal accelerations.
6. Learning about apse, apsidal distance and apsidal angle and some important theorems related to the central force.
7. Accelerations of a particle in terms of polar coordinates and accelerations of a particle in terms of cylindrical coordinates.

**Course Content**

*Group A: Statics*

1. Reduction and Equilibrium of coplanar forces: Reduction of coplanar forces, Equilibrium of three coplanar forces, Resultant force and couple, General condition of equilibrium and related topics.
2. The Centre of Gravity of a Body: Definition of the Centre of gravity, General formulae for the determination of the Centre of gravity, Formulae for the Centre of gravity of an Arc and any plane area,
3. Stable and Unstable Equilibriums: Definitions of stable and unstable equilibriums with examples, some important theorems involving stable and unstable equilibriums.

*Group B: Dynamics*

1. Motion of a Particle in a Straight line: Some Important theorems related to Simple Harmonic Motion (Periodic time, Amplitude and Frequency), Motion of a particle towards the earth from a point outside of it.
2. Motion of a Particle in a Plane: Motion where the accelerations are parallel to fixed axe, Motion in a plane referred to polar coordinates, Velocities and accelerations of a particle along and perpendicular to the radius vector to it from a fixed origin, Tangential and normal accelerations.
3. Central Forces: Definitions of central force and central orbit, Apse, Apsidal distance and apsidal angle, Some important theorems related to the central force, Kepler’s Laws.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. S. L. Loney : Statics and Analytical Dynamics of a Particle, Publisher Arihant Publications
2. L.A. Pars: Introduction to Dynamics, Publisher, New Age lnternational

**MAT 3111: Programming in C++ 3 Credits**

**Introduction and Specific Objectives**

Programming skill represents a generic problem solving ability, and is considered essential for any science background student. The course is designed to provide complete knowledge of C++ language. Students will be able to develop logics which will help them to create programs and applications in C++. Also by learning the basic programming constructs they can easily switch over to any other language in future. The objective of this course is to impart adequate knowledge on the need of programming languages and problem solving techniques, to develop programming skills using the fundamentals and basics of C++ Language, to enable effective usage of arrays, structures, functions and pointers. It provides in-depth coverage of object-oriented programming principles and techniques. Topics include classes, overloading, data abstraction, information hiding, encapsulation, inheritance, polymorphism etc.

**Learning Outcomes**

The students will be able to understand

* basic idea of programming language and object oriented programming language, properties of object oriented programming language, how C++ improves C with object-oriented features, syntax and semantics of C++ programming language
* different data types, conditional logics, different arithmetic, relational and basic I/O operations. writing programs with different types of loops and to write programs using different types of arrays and Strings
* different types of functions, difference between call by value and call by reference, recursion. They will understand about code reusability with the help of various user defined functions.
* the basics of structures, pointers and various types of file operations
* design C++ programs with objects, classes, constructors, destructors, function overloading and operator overloading
* inheritance and virtual functions implement dynamic binding with polymorphism and how inheritance promote code reuse in C++.

**Course Contents**

1. **Basic Concepts:** Introduction to Computer Programming, Problem Solving Techniques, Programming Style, Debugging and Testing, Documentation.
2. **Object Oriented Programming Concepts:** Object Oriented Programming Overview, Encapsulation, Inheritance and Polymorphism. Object Oriented vs. Procedural Programming, Basics of Object Oriented Programming Language.
3. **Data Types, Conditional Logics and Operators:** Basic I/O, Data Types, Conditional Logics such as If, If-Else, Switch. Arithmetic, Relational, Logical and Bitwise Operators, Precedence and Associativity, Arithmetic Expression Evaluation.
4. **Loops, Arrays and Strings:** Looping Basic, Necessity of Loops, While Loop, For Loop, Do While Loop, Nested Loop. Basics of Array, Accessing through Indices, Accessing using Loops, Two Dimensional Arrays. Basics, I/O Operations using String, Basic String Operations.
5. **Functions and Structures:** Basic Functions, Different Types of Functions, Local and Global Variables, Call by Value, Call by Reference, Passing Arrays in a Function as Parameter, Recursive Function. Structures, Pointers and File Operation: Basics of Structures, Pointer Operation, Call by Reference using Pointers, Basic File Operations.
6. **Objects and Classes:** Attributes and Functions, Constructors and Destructors, Operator Overloading, Function Overloading.
7. **Inheritance and Virtual Functions:** Derived Class and Base Class, Derived Class Constructors, Overriding Member Functions, Abstract Base Class, Virtual Functions: Virtual Functions, Pure Virtual Functions, Friend Functions, Friend Class.
8. **Exception and Exception Handling:** Exception Handling Fundamentals, Exception Types.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Robert Lafore, Object-Oriented Programming in C++.
2. Herbert Schildt, Teach Yourself C++.
3. E Balagurusamy, Object Oriented Programming with C.
4. P. J. Deitel, H. M. Deitel, C++ How to Program.
5. Joyce Farrell, Object Oriented Programming using C++.

**Third Year Semester-II**

**MAT 3201 Abstract Algebra 3 Credits**

**Introduction and Specific Objectives**

Abstract algebra is the set of advanced topics of Algebra that deal with abstract algebraic structures rather than the usual number systems. It aims to find general underlying principles common to the usual operations (addition, multiplication, etc.) on diverse sets such as integers, polynomials, matrices, permutations, and much more. Students will learn in particular about the most important abstract algebraic structures which are groups, rings, and fields. It gives to student a good mathematical maturity and enables to build mathematical thinking and skill. Important branches of abstract algebra are commutative algebra, representation theory, and homological algebra.

1. Introduce students to the basic concepts of algebraic structures embedded in Group and Ring Theories;
2. Explain to students the role commutativity plays in Abstract Algebra;
3. Demonstrate to students that there is a partial converse of Lagrange theorem;
4. Capture the canonical homomorphism via normality leading to isomorphism of two groups.
5. Demonstrate to students that this is a branch of pure mathematics whose applications to real life situations is still employable;
6. Emphasize the fact that abstract concepts arise from the analysis of concrete situations;
7. Develop student’s power to think for himself in terms of concepts, include a variety of examples on each topic;
8. Demonstrate to students that there is a partial converse of Lagrange theorem;
9. Capture the canonical homomorphism via normality leading to isomorphism of two groups.
10. Upon completion of this course, students may take Advanced Abstract Algebra or Graph Theory with Applications.

**Learning Outcomes**

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

1. Define equivalence relation and equivalence class and determine, with complete justification, whether or not a given relation is an equivalence relation and, if so, identify equivalence classes.
2. State the Well-Ordering Principle of the positive integers and use it in a proof.
3. Define left-inverse, right-inverse and inverse of a function; and identify examples and non-examples of each, and prove the equivalence of one-to-one and existence of a left-inverse, and the equivalence of onto with existence of a right inverse.
4. Demonstrate familiarity with the definition of a group and be able to test a set with binary operation to determine if it is a group.
5. Construct a Cayley table for a group.
6. Demonstrate familiarity with the common groups.
7. Compute the order of a group, the order of a subgroup, and the order of an element.
8. Identify subgroups of a given group.
9. Identify cyclic groups and apply the fundamental theorem of cyclic groups.
10. Demonstrate familiarity with permutation groups and be able to decompose permutations into 2-cycles.
11. Define the concepts of homomorphism, isomorphism, and automorphism and check whether a given function defines one of these.
12. Prove the common properties of homomorphism.
13. Define the external direct product and be able to compute the direct product of groups.
14. Apply Lagrange’s theorem.
15. Define normal subgroups and be able to prove that given subgroups are normal.
16. State and apply the fundamental theorem of finite Abelian groups.
17. Give a definition of ring and cite a variety of common examples and non-examples (finite and infinite, polynomials,and matrices).

**Course Content**

1. Groups and subgroups. Groups of symmery. Permutation groups. The symmetric group on *n* letters. Cyclic groups.
2. Left and right congruence modulo a sub group. Cosets. Lagrange’s theorem, Product of cosets. Frobenius’s counting formula.
3. Normal subgroups, quotient (factor) groups. Homomorphisms and automorphisms. The isomorphism theorems. Conjugacy: the class equation. Direct product. Groups of small orders.
4. Rings, ideals and quotient rings, prime and maximal ideals.
5. Integral domain. Field of fractions.
6. Principal ideal domains. Euclidean domains. Unique factorization domains.
7. Polynomial rings. Primitive polynomials (Gauss’s theorem). Eisenstein’s irreducibility criterion.
8. Characteristic of a ring or integral domain. Prime Fields; structure of prime fields.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. P.B. Bhattarcharya, S.K. Jain & S.R. Nagpaul, Basic Abstract Algebra.
2. W.K. Nicholson, Introduction to Abstract Algebra.
3. J.B. Fraleigh, Introduction to Abstract Algebra.
4. M.Artin, Algebra.

**MAT 3203: Theory of Numbers** **3 Credits**

**Introduction and Specific Objectives**

According to Karl Friedrich Gauss, “Mathematics is the queen of sciences and the theory of numbers is the queen of mathematics." Number theory is arguably one of the oldest and most fascinating branches of mathematics. This fascination stems from the fact that there are a great many theorems concerning the integers, which are extremely simple to state, but turn out to be rather hard to prove.

The objective of this course is to introduce continued fraction of rational and irrational numbers, Linear Diophantine equation, Quadratic Residues, Congruence with its application in different fields like Scheduling Round-Robin tournament, checking ISBN as well as Cryptography.

**Learning Outcomes**

* Ability to describe and use the continued fraction algorithm to find representations of rational and quadratic irrational numbers.
* Familiar with linear Diophantine equation and Linear Congruencies, Chinese remainder theorem.
* Get proper knowledge of congruence and can apply in different real life problems.

**Course Content**

1. Continued fractions: Simple continued fraction, Convergent of continued fraction, Infinite Continued fraction- Periodic and Non-Periodic.
2. Linear Diophantine equations and Congruence: Linear Congruence, Solution of System of Linear Congruencies with single variable but different moduli and different variables but single modulus, Chinese remainder theorem.
3. Application of congruence: Divisibility test, Round Robin tournament schedule, ISBN Check Digits, Pseudorandom Generators etc.
4. Arithmetic of quadratic fields: Quadratic Integers, Quadratic Congruence, Quadratic Residue and Euclidean quadratic Fields, Representation by sum of two and four squares only statements (No Proof).
5. Application of Number theory in Cryptography: Encryption Schemes, Digital Signatures, Fault-Tolerant Protocols and Zero-Knowledge Proofs, RSA encryption method.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Kenneth H. Rosen, Elementary Number Theory.
2. S. G. Telang , Number Theory.
3. G.H. Hardy & E.M. Wright, An Introduction to Theory of Number.
4. Oded Goldreich, Foundations of Cryptography.

**MAT 3205 Numerical Analysis-II**  **3 Credits**

**Introduction and Specific Objectives**

This course is a study of mathematical techniques used to model physical phenomena arising from different branches of science and engineering. It involves the development of mathematical models and the application of the computer to solve engineering problems using the following computational techniques: curve fitting, Spline Interpolation, solution methods for nonlinear system of equations, numerical solution of differential equations. ordinary Differential Equations, with applications to engineering problems.

The objective of this course is to provide students with the skills, knowledge and attitudes required to determine approximate numerical solutions to mathematical problems which cannot always be solved by conventional analytical techniques, and to demonstrate the importance of selecting the right numerical technique for a particular application, and carefully analyzing and interpreting the results obtained.

**Learning Outcomes**

At the conclusion of the course the student should be able to:

1. Use least squares approximation to find the best fit curve for a given set of data points.

2. Choose an appropriate numerical solution method based on the properties of the given non linear system.

3. Find numerical solution of a initial value problems (IVP) by different single and multistep methods.

4. Construct numerical methods for the numerical solution of boundary-value problems and accuracy properties of these methods.

**Course Content**

1. Curve fitting and Approximation : Spline Interpolation and Cubic Splines, Least Squares Approximation.
2. Approximating Eigenvalues : Eigenvalues and eigenvectors, the power method, Convergence of Power method, Inverse Power method, Rayleigh Quotient Method, Householder’s method, Q-R method.
3. Nonlinear system of equations : Fixed point for functions of several variables, Newton’s method, Quasi-Newton’s method, Conjugate Gradient Method, Steepest Descent techniques.
4. Initial value problems for ODE (Single-step methods) : Euler’s and modified Euler’s method, Higher order Taylor’s method, Runge-Kutta methods.
5. Multi-step methods : Adams-Bashforth, Adams-Moulton, Predictor-Corrector and Hybrid methods, variable step-size multi-step methods, error and stability analysis.
6. Boundary value problem for ODE (8 hours): Shooting method for linear and nonlinear problems, Finite difference methods for linear and nonlinear problems.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. R.L. Burden and J.D. Faires – Numerical Analysis.
2. K. Atkinson – Introduction to Numerical Analysis.
3. M.A. Celia and W.G. Gray – Numerical Methods for Differential Equations.
4. L.W. Johson & R.D. Riess –Numerical Analysis.
5. John H. Mathews –Numerical Methods for Mathematics, Science and Engineering.

**MAT 3207 Mathematical Methods 3 Credits**

**Introduction and Specific Objectives**

This is an advanced mathematics course which is proposed to give an overview of mathematical methods widely used in physical sciences. Fourier series, Laplace transforms, Fourier transforms, Eigenvalue problems and Strum-Liouvile boundary value problems will be studied. Here we focus on the application to solve real life problems. After taking this course, students will become familiar with new mathematical skills.

1. To understand the concept of Fourier series, its real form and complex form and enhance the real-life problem-solving skill.

2. To learn the Laplace transform, Inverse Laplace transform of various functions and its application.

3. To learn the Fourier transform of various functions and its application to solve real life boundary value problems and integral equation.

4. To learn the finding of eigenvalues and eigenfunctions by solving Strum-Liouvile boundary value problem (S-LBVP), formation of Green’s function from S-LBVP and hence the solving of S-LBVP.

**Learning Outcomes**

1. Expand the periodic function of one variable by using Fourier series of real and complex forms.

2. Apply Fourier series expansion of periodic function of one variable to selected physical problems.

3. Understand the concept of Laplace transform and inverse Laplace transform of various function.

4. Solve initial value problems and boundary value problems using Laplace transform.

5. Calculate the Fourier transforms of simple functions and apply them to selected physical problems.

6. Find the solution of the wave, heat flow and Laplace equations using the Fourier transforms.

7. Find the eigenvalues and the corresponding eigenfunctions by solving Strum-Liouvil boundary value problems.

8. Define the term “orthogonality” as applied to functions and recognize sets of orthogonal functions which are important in physics.

9. Find the Green’s function from Strum-Liouvile boundary value problems.

10. Solve Strum-Liouvile boundary value problems by finding the Green’s function from Strum-Liouvile boundary value problems.

**Course Content**

1. Fourier Series: Fourier series and its convergence. Fourier sine and cosine series. Properties of Fourier series. Operations on Fourier series. Complex from. Applications of Fourier series.
2. Laplace transforms: Basic definitions and properties, Existence theorem. Transforms of derivatives. Relations involving integrals. Laplace transforms of periodic functions. Transforms of convolutions. Inverse transform. Calculation of inverse transforms. Use of contour integration. Applications to boundary differential equations.
3. Fourier transforms: Fourier transforms. Inversion theorem. Sine and cosine transforms. Transform of derivatives. Transforms of rational function. Convolution theorem. Parseval’s theorem. Applications to boundary value problems and integral equation.
4. Eigenvalue problems and Strum-Liouvile boundary value problems: Regular Strum-Liouville boundary value problems. Non-homogeneous boundary value problems and the Fredholm alternative. Solution by eigenfunction expansion. Green’s functions. Singular Strum Liouville boundary value problems/Oscillation and comparison theory.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. R.V. Churchill & J. W. Brown, Fourier Series and Boundary value problems.
2. W.N. Lebedev & R.A. Silverman, Special Functions and their Applications.
3. E. Kreuszig, Advanced Engineering Mathematics.
4. M. R. Spiegel, Laplace Transforms, Schaum’s Outline Series.

**MAT 3202: MATLAB** **3 Credits**

Problem Solving in concurrent courses (Complex Analysis, Numerical Analysis and Applied Mathematics, Linear Programming) using MATLAB. Lab Assignments: There shall be at least 5 lab assignments

**Fourth Year Semester-I**

**MAT 4101: Partial Differential Equations 3 Credits**

**Introduction and Specific Objectives**

Partial differential equations (PDE) is an important branch of Science. It has many applications in various physical and engineering problems. The idea of the course is to give a solid introduction to PDE for advanced undergraduate students. We require only advanced calculus. The course goes quite rapidly through a lot of material, but our focus is linear second order uniformly elliptic, parabolic and hyperbolic equations. In this course mainly we attempt to give some ideas about first order and second order linear PDEs. A few Nonlinear PDE is discussed shortly. The method of solving first-order and second order equations are illustrated taking many examples.

The main objective of the course is for students to

1. State the heat, wave, Laplace, and Poisson equations and explain their physical origins, basic existence, uniqueness and continuous dependence of initial and boundary conditions.
2. Identify and classify linear PDEs.
3. Solve simple first order equations using the method of characteristics;
4. Identify homogeneous PDEs and evolution equations.
5. Solve the wave equation using d’Alembert’s formula.
6. Solve wave equation by separating variables and Fourier series.
7. Solve the heat, wave, Laplace, and Poisson equations using separation of variables and apply boundary conditions.
8. Solve PDEs using Fourier integrals and transforms.

**Learning Outcomes**

On completion of the course, the student will be able to:

1. Describe the most common partial differential equations that appear in problems concerning e.g. heat conduction, flow, elasticity and wave propagation;
2. Give an account of basic questions concerning the existence and uniqueness of solutions, and continuous dependence of initial and boundary data;
3. Solve simple first order equations using the method of characteristics; classify second order equations;
4. Solve simple initial and boundary value problems using e.g. D'Alembert's solution; formula, separation of variables, Fourier series expansion, Fourier transform methods;
5. Describe, compute and analyse wave propagation and heat conduction in mathematical terms;
6. Formulate maximum principles for various equations and derive consequences.

**Course Content**

1. **Introduction**: Preliminaries, Classification, Differential operators and the superposition principle, Differential equations as mathematical models, Associated conditions, Simple examples.
2. **First order equations**: Definition of PDEs of First Order Quasi-linear PDEs; Solving PDEs of First Order: The method of characteristics; The existence and uniqueness theorem; The Lagrange method; Conservation laws and shock waves; The eikonal equation; General nonlinear equations.
3. **Second order equations**: Definition of General PDE, Classifications of Second Order PDEs as Parabolic, Hyperbolic, and Elliptic Equations; Canonical form of hyperbolic/ parabolic / elliptic equations.
4. **The one dimensional wave equation**: Introduction, Canonical form and general solution, The Cauchy problem and d’Alembert’s formula, Fourier Transform methods, Domain of dependence and region of influence, The Cauchy problem for the nonhomogeneous wave equation, Two-Dimensional Wave Equation.
5. **The Heat equation**: The Cauchy Problem and initial conditions, The weak maximum principle, solutions on bounded intervals, on the real line and on the half line, the nonhomogeneous heat equation, The energy method and uniqueness.
6. **Elliptic equations**: Introduction, The maximum principle, Green’s identities, Separation of variables for elliptic problems, Poisson’s formula, Dirichlet and Neumann Problems, Green’s functions and integral representations in a plane.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Peter V. O’Neil , Beginning Partial Differential Equations, second edition, John Wiley & Sons.
2. [Walter A. Strauss](https://www.bookdepository.com/author/Walter-A-Strauss), Partial Differential Equations : An Introduction, second edition,John Wiley & Sons.
3. T. Hillen, I E Leonard and H. Van Roessel, Partial Differential Equations: Theory and Completely Solved Problems, FriesenPress.
4. Nakhle H. Asmar, Partial Differential Equations and Boundary Value Problems with Fourier Series ,third edition, [Dover Books on Mathematics](https://www.amazon.com/gp/product/B08B3PDY3W?ref_=dbs_dp_rwt_sb_tkin&binding=kindle_edition).

**MAT 4103: Tensor Analysis 3 Credits**

**Introduction and Specific Objectives**

This course deals with the analysis of coordinates, vectors and tensors. It will also focus on Riemannian metric and its tensor. Covarient differentiations of tensor and its application will also be discussed.

**Course Content**

1. Coordinates, Vectors and tensors: Curvilinear coordinates, Kronecker delta, summation convention, space of ***N*** dimensions, Euclidean and Riemannian space, coordinate transformation, Contravariant and covariant vectors, the tensor concept, symmetric and skew-symmetric tensors.
2. Riemannian metric and metric tensors: Basis and reciprocal basis vectors, Euclidean metric in three dimensions, reciprocal or conjugate tensors, Conjugate metric tensor, associated vectors and tensor’s length and angle between two vector’s, The Christoffel symbols.
3. Covariant Differentiation of tensors and applications: Covariant derivatives and its higher rank tensor and covariant curvature tensor, Ricci tensor, zero tensor, Intrinsic derivative, Bianchi identity, Flat Space.
4. Applications of tensor analysis to elasticity theory and electromagnetic theory.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

* 1. B. Spain, Tensor Calculus
  2. I.S. Sokolnikoff, Tensor Analysis
  3. L.P. Lebedev & M. J. Cloud, Tensor Analysis
  4. A.J. McConnell, Applications of Tensor Analysis

**MAT 4105: Hydrodynamics 3 Credits**

**Introduction and Specific Objectives**

The course deals with theoretical and practical aspects of hydrodynamics and fluid dynamics. The various topics covered are: Reynolds Transport Theorem, conservation of mass, momentum and energy, the development of the Navier-Stokes' equation, ideal and potential flows, vorticity, hydrodynamic forces in potential flow. Some of the vital topics covered are boundary layer concept, governing equations, incompressible flows, compressible flows, high speed flows, internal flow, external flow, dimensional analysis, and introduction to computational fluid dynamics.

1. To understand the concept of fluid and to be able to explain the properties of fluid.
2. To understand the hydrostatic forces acting on a solid surface immersed in liquid and to be able to calculate them in a specific situation.
3. To understand the basic equations of the conservation laws (continuity equation, Euler’s equation and Bernoulli’s theorem, momentum theorem) and to be able to apply them in a specific problem.
4. To understand the concept of dimensional analysis and to be able to apply it in a specific situation.
5. To understand about the Navier-Stokes equation, steady and unsteady laminar flow.

**Learning Outcomes**

Upon completion of this course, students will explore the followings:

1. To learn the basic knowledge on fluid properties (continuity, density, viscosity, and surface tension).
2. Describe the fundamental principles of the motion of ideal (inviscid) and real (viscous) fluid flows.
3. Apply analytical concepts to analyse a range of two-dimensional fluid flows, with appropriate choice of simplifying assumptions and boundary conditions.
4. To learn the dimensional analysis (basic/derived quantities, Buckingham’s pi-theorem, similarity parameters).
5. To learn the fundamentals of fluid dynamics (different types of flows (steady/unsteady, viscous/inviscid, laminar), stream/path/streak lines), flowrate and hydrodynamic conservation laws (continuity equation, Euler’s equation of motion, Bernoulli’s theorem.
6. Investigate the physics/dynamics of a particular fluid flow giving a critical evaluation of the effect of significant flow and geometric parameters applying both hydrodynamic theory and knowledge from other disciples relevant to the problem.

**Course Content**

1. **Preliminaries:** Velocity and acceleration of fluid particles; relation between local and individual rates; steady and unsteady flows; uniform and non-uniform flows; stream lines; path lines; vortex lines; velocity potential; Rotational and irrotational flows.
2. **Continuous motion:** Equations of continuity; equations of continuity in spherical and cylindrical polar coordintes; boundary surfaces. Euler’s equation of motion, conservative field of force; motion under conservative body force; vorticity equations (Helmholtz’s vorticity equation); Bernoulli’s equations and its application.
3. **Two-dimensional flow:** Motion in two-dimensions; stream function, physical meaning of stream function; velocity in polar-coordinates; relation between stream function and velocity; circulation and vorticity; relation between circulation and vorticity; Kelvin’s circulation theorem.
4. **Circle theorem and complex dynamics:** The circle’s theorem; motion of a circular cylinder; pressure at points on a circular cylinder; application of circle theorem. Blasius theorem; Sources, sinks and doublets; complex potential and complex velocity; stagnation points.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. L.M. Mine Thomosn, Theoretical Hydrodynamics, Dover Publication.
2. F.M. White, Fluid Mechanics, McGraw-Hill
3. H. Schlichting, Boundary Layer Theory, McGraw-Hill, New York.
4. F. Chorlton, A Text Book of Fluid dynamics, CBS Publication.

**MAT- 4107: Stochastic calculus 3 Credits**

**Introduction and Specific Objectives**

First course in stochastic area; moving from distribution to stochastic process. Brownian motion and its properties have been discussed and how these properties characterize a stochastic process in Black and Scholes world have been considered. Cricaial for students delving into Mathematical Finance, Acturial Science and stochastic area of Mathematical Biology for further studies. Fundamental differences between classical calculus and stochastic calculus have been exploed through Ito's formula. Firsthand stochastic differential equations have been studied with stock price modelling in view; filtration and sigma-algebra structures, and information flow in stochastic world, are introduced. Foundational course for research development in stochastic environment.

**Course Content**

1. Sigma algebra, filtration, conditional expectation and structure of stochastic process.
2. Martingale and Brownian motion stochastic process; construction of random walk, Brownian motion as a limit of random walk stochastic process. Distributional properties, correlation and covariance of Brownian motion stochastic process. First variation and quadratic variation of Brownian motion stochastic process. Simulation of Brownian motion paths. Martingale property of some useful Brownian motion functionals.
3. Ito’s formula (with intuitive illustrations), stochastic integral and stochastic calculus.
4. Stochastic differential equations (SDE); details of basic SDE’s; different numerical schemes (Euler, Milstein etc.) for simulating basic SDE’s.
5. Calibrating parameters of some basic SDE’s using real life (or simulated) data.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Lawrence C. Evans -An introduction to stochastic differential equations.
2. Ubbo F. Wiersema -Brownian motion Calculus.
3. Nigel Byott -Lectures on and illustrations of SDEs.

**MAT 4109: MATHEMATICAL BIOLOGY 3 Credits**

**Introduction and Specific Objectives**

To provide students with the mathematical tools used to study and solve a variety of problems in biology at different scales. Mathematical Biology is one of the most rapidly growing and exciting areas of Applied Mathematics. This is because recently developed experimental techniques in the biological sciences, are generating an unprecedented amount of quantitative data.

By the end of the module the student should be able to:

* to analyze simple models of biological phenomena using mathematics
* to reproduce models and fundamental results of biological systems
* introduce the student to advanced mathematical modeling in the Life Sciences
* apply methods in the module to new problems inside the scope of Mathematical Biology
* explore methods for solving the models and discuss the implications of the predictions.

**Learning Outcomes**

After completing this course, the students will be able to understand:

* the applications of ODE models in a variety of biological systems,
* making the student aware how to choose and use different modeling techniques in different areas
* reaction-diffusion equations and their applications in biology
* introduce the connections between biological questions and mathematical concepts
* develop the mathematics of dynamical systems, linear algebra, differential equations and difference equations through modeling biological systems.
* explore the utility of using mathematical tools to understand the properties and behavior of biological systems.

**Course Content**

1. **Single Species Continuous Models:**  Introduction to linear and nonlinear population models, Sharpe-Lotka age-dependent population model, Gurtin-MaCamy age-dependent population model, stability.
2. **Multi Species Continuous Models:**  Two species linear and nonlinear population models, multi-species models, stability.
3. **Microbial Population Models**: Microbial population, chemostat, growth of microbial populations, dynamics of microbial competition, stability.
4. **Dynamics of Infectious Diseases:**  Virus, immunity, cells, epidemic models, dynamics of infectious diseases, AIDS/HIV models, dynamics of hepatitis B virus, age-dependent epidemic model, control of an epidemic, drug therapy, vaccination effects, treatment of HIV, CTL responses, immune response dynamics.
5. **Dynamics with diffusion**: Diffusion equation, single and multi-species diffusion models, competition model with diffusion, epidemic model with diffusion.
6. **Stochastic Model**: Concepts in probability, stochastic Processes, Brownian motion, martingales, stochastic linear and nonlinear models of population.
7. **Applications**: Glucose concentration in blood, heart beat model, tumor growth model, blood cell growth etc.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. F Brauer& C Castillo-Chavez, *Mathematical models in population biology and epidemiology*, Springer-Verlag, New York, 2001.
2. J.D. Murray, *Mathematical Biology*, Springer, 1993.
3. Leah Edelstein-Keshet, *Mathematical Models in Biology*, 1988.
4. H. L. Smith & P. Waltman, *Theory of Chemostat*, CUP, 1995.
5. M. A. Nowak & R. M. May, *Virus Dynamics, Mathematical Principles of Immunology and Virology*, 2000.

**MAT 4111: Industrial Mathematics 3 Credits**

**Introduction and Specific Objectives**

Operations activities, such as forecasting, choosing a location for an office or plant, allocating resources, designing products and services, scheduling activities, and assuring and improving quality are core activities and often strategic issues in Industrial Mathematics. Industrial Mathematics helps the business organizations to manage systems or processes that create goods and/or services. The material in this course is intended as an introduction to the field of industrial mathematics. The field of industrial mathematics is dynamic, and very much a part of the good things that are happening in business organizations. Much of what the students learn will have practical application.

1. To give knowledge on the ways to manage the business organization efficiently.

2. Students will be able to learn the mathematical formulating procedure of different types of management tools.

3. It will help the students to apply the knowledge gather from this course in real life problems.

**Learning Outcomes**

After completing this course, the students will be able to an expert in the following areas: in product and service design, process selection, technology selection, design of work systems, location planning, facility planning, quality improvement of goods and services, forecasting, capacity planning, scheduling, managing inventory, assuring quality, motivating employees, and deciding where to locate facilities.

**Course Content**

**1. Introduction:** Introduction to Industrial mathematics (IM), The scope of IM, IM and decision making, Productivity, Product mix, Strategy, Competitiveness.

**2. Capacity Planning:** Strategic capacity decision, Strategy formulation, Defining and measuring capacity, Evaluating capacity alternatives.

**3. Quality Control:** Management of quality, Statistical process control, Variations and control, Control charts, Process capability, Improving process capability, Capability analysis.

**4. Forecasting:** Features common to all forecasts, Elements of good forecast, Steps in the forecasting process, Accuracy and control of forecasting, Applications, Forecasting models.

**5. Inventory Control:** Nature and importance of inventories, Introduction to basic inventory models (Economic order quantity (EOQ) model, EPQ model, Fixed order interval model, Single period model.

**6. Scheduling:** Scheduling in high-volume systems, intermediate-volume systems, low-volume systems, Scheduling methods of Linear Programming, Scheduling jobs through two work centers, Minimizing scheduling difficulties, Scheduling the work force.

**7. Simulation:** Basic terminology of simulation, Steps in simulation process, Application of simulation, Simulations with random variables, Advantage and limitations of using simulations.

**8. Project Management:** Behavioral aspect of project management, Key decisions in project management, PERT (program evaluation and review technique), CPM (critical path method), Deterministic time estimates, Probabilistic time estimates, Applications.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. William J. Stevenson – Operations Management.
2. Wayne L. Winston- Operations Research
3. Hillier and Lieberman - Introduction to OR
4. Hira & Gupta-Problems in OR
5. Turban & Merideth -Fundamentals of Management Science.

**MAT 4102: Simulation Lab 3 Credits**

Problem solving in concurrent courses (e.g. Calculus, Linear Algebra and Geometry) using Simulation Programming.

**Lab Assignments:** There are at least 07 assignments.

**Evaluation:** Internal assessment (Laboratory works) 40 Marks. Final examination (Lab: 3 hours) 60 Marks.

**Fourth Year Semester-II**

**MAT 4201: Fundamentals of Topology 3 Credits**

**Introduction and Specific Objectives**

This course is about the study of elementary properties of topological spaces. Topological spaces turn up naturally in mathematical analysis, abstract algebra and geometry. A topological space is a structure that allows one to generalize concepts such as convergence, connectedness and continuity.

The objectives of this course are to:

* introduce students to the concepts of open and closed sets abstractly, not necessarily only on the real line approach.
* introduce student to elementary properties of topological spaces and structures defined on them.
* introduce students how to generate new topologies from a given set with bases.
* introduce student to maps between topological spaces and Homeomorphisms.
* introduce concepts of topological spaces such as connectedness and compactness.
* develop the student’s ability to handle abstract ideas in topology to understand real world applications.

**Learning Outcomes**

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

* distinguish among open and closed sets on different topological spaces;
* identify precisely when a collection of subsets of a given set equipped with a topology forms a topological space;
* construct maps between topological spaces to understand when two topological spaces are homeomorphic;
* state and prove standard results regarding compact and/or connected topological spaces, and decide whether a simple unseen statement about them is true, providing a proof or counterexample as appropriate
* determine that a given point in a topological space is either a limit point or not for a given subset of a topological space;
* apply and use fixed point theorems to understand modern day applications apply theoretical concepts in topology to understand real world applications.

**Course Content**

1. Topological Spaces : Definitions and examples (discrete, indiscrete, cofinite, cocountable topologies). Metiric topology. Cluster point of a set. Neighbourhood system. Base and subbase. Subspace. Topological properties.
2. Continuous functions in topological spaces: Countinuity . Squential continuity. Uniform continuity. Homeomorphisms.
3. Separation axioms: Properties of spaces. Some related theorems. Completely regular spaces. Completely normal spaces.
4. Countability of topological spaces: First and and second countable spaces. Separable space. Lindelof ‘s theorems.
5. Compactness: Compact spaces. Concept of product spaces. Tychonoff’s theorem. Locally compact spaces. Compactness in metric spaces. Totally boundedness, Lebesgue number. Equivalence of compactness, sequential compactness and Bolzano-Weierstrass property.

**6.** Connectedness: Connected spaces, totally disconnected spaces, components of space, locally and pathwise connected spaces.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. G.F. Simmons, Introduction to Topology and Modern Analysis, Krieger Publishing Company
2. S.Lipschutz, General Topology, McGraw-Hill
3. J. Kelly, General Topology, Springer-Verlag
4. Munkres. James, Topology, Prentice Hall, Inc

**MAT 4203: Differential Geometry Credit: 3**

**Introduction and Specific Objectives**

Differential geometry is based on three dimensional basic vectors geometry with calculus. Tensor calculus forms an essential part of the mathematical background required to applied mathematicians, physicists, space scientists and engineers. It’s widely used in many branches of pure and applied mathematics. Indeed the algebraic properties of tensors form the subject matter of linear algebra, while their differential properties that of differential geometry. Understanding of this Course will precede students to learn other areas of mathematics such as Geometry of Differential Manifolds, General Theory of Relativity, Cosmology, Riemannian Geometry etc.

1. To give knowledge on mathematical concepts of space curve and surfaces, this course is very much useful.
2. Students will know the concepts of helices, tangent, normal, bi-normal, involutes and evolutes.
3. Students will learn about the fundamental forms, Gaussian and normal Curvature, Geodesics etc. on mathematical concepts of surface.
4. Student will have knowledge on Christoffel’s symbols and their applications, Riemann-Christoffel tenser and the Ricci tensor.

**Learning Outcomes**

Upon the successful completion of this course students will able to

1. Apply Serret-Frenet’s Formulae to solve various types of problems.
2. Earn basic knowledge about tangent, normal, binormal and different types of planes, Curvature, Torsion.
3. Solve to find tangent, normal, bi-normal and their lines, Curvature and Torsion of a space curve.
4. Gather knowledge about Spherical indicatrix of Tangent, Normal, Binormal, Curvature and Torsion.
5. Illustrate curves of involutes and evolutes and Bertrand curves.
6. Know how to find different types of fundamental forms of surfaces.
7. Know how to find the angle of two directions of surfaces.
8. Apply the concepts of fundamental magnitudes to find Mean Curvature and Gaussian Curvature.
9. Apply the concepts of tensor calculus to do various types of problem solution in Relativity, Cosmology and Geometry of Manifolds.
10. Apply the concepts of space curve to learn in future the spherical indicatrix of the tangent, tangent space and tangent bundle , smooth map and the knowledge of Manifolds in field of n-dimensional Geometry and theory of Relativity etc.

**Course Content**

1. Curves in space : Vector functions of one variable, Analytic representation of curves, Arc length, Space curves, unit tangent to a space curve, equation of a tangent, normal and binormal line to a curve, Osculating plane (or Plane of curvature).
2. Serret-Frenet’sformulae : Curvature, Torsion, Helices, Spherical Indicatrix of tangent, etc. Involutes, Evolutes, Bertrand curves.
3. Vector functions of two variables : Tangent and normal plane to the surface. Principal normal, binormal and Fundamental planes, theorems on curvature and torsion.
4. Elementary Theory of Surfaces : Analytic representation of surfaces, Monge’s form of the surface, First fundamental form or metric, geometrical interpretation of metric, properties of metric, angle between any two directions and parametric curves, condition of orthogonality of parametric curves, elements of area, unit surface normal, Normal, tangent plane.
5. Second fundamental form : Meusnier's theorem, principal direction and curvature, Rodrigues's formula, Euler’s theorem, A geometrical interpretation of asymptotic and curvature lines, Mean and Gaussian Curvature, Elliptic, hyperbolic and parabolic points, DupinIndicatrix, Third Fundamental form, Theorem of Beltrami-Ennerper. The equation of Gauss-Weingarten.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. C. E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press, London.
2. D. J. Struik, Lectures on Classical Differential Geometry, Addison-Wesley Publishing Company, Inc. USA.
3. M. M. Lispchutz, Theory and Problems of Differential Geometry, McGraw-Hill Book Company, New York.
4. N. Srivastava, Tensor Calculus Theory and Problems, University Press Limited, India.
5. Barry Spain, Tensor Calculus a Concise Course, Dover Publications Inc. Mineola New York.

**MAT 4205: Optimizations 3 Credits**

**Introduction and Specific Objectives**

Optimization is one of the greatest successes to emerge from operations research and management science. It is an art of finding minima or maxima of some objective function, and to some extend an art of defining the objective functions. This course will focus on the optimization techniques such as linear programming (LP), nonlinear programming (NLP) and quadratic programming (QP). This is an interdisciplinary branch of applied mathematics and formal science that uses methods like mathematical modeling, statistics, and algorithms to arrive at optimal or near optimal solutions to real life problems and closely relates to Industrial Engineering. It is a tool for solving optimization problems. In 1947, George Dantzig developed an efficient method, the simplex algorithm, for solving linear programming problems. Since the development of the simplex algorithm, LP, NLP and QP have been used to solve optimization problems in industries as diverse as banking, education, forestry, petroleum, and trucking.

1. To give knowledge on mathematical formulations of real life problems.

2. Students will know different ways to solve the formulated mathematical models.

3. This course will help the students to learn the sensitivity analysis of real life problems.

**Learning Outcomes**

* + - 1. Describe the basic properties such as convex sets and related theorems;
      2. Gather knowledge about LP, standard form, canonical form, slack variables, surplus variables, basic solutions, non-basic solutions, feasible solutions optimal solutions etc.;
      3. Know the ways to formulate a real life problem into a mathematical problem;
      4. Solve 2-dimensional problems by using graphical method;
      5. Solve general LP problems by using simplex method (usual simplex method, 2-phase simplex method and Big-M simplex method);
      6. Solve special type of LP by Dual simplex method;
      7. Use sensitivity analysis to study the changes in availability, conditions etc.
      8. Solve NLP problems by different optimization methods
      9. Solve QP problems by different methods

**Course Content**

1. Introduction: Convex sets and related theorems, introduction to linear programming (LP)
2. Formulation: Formulation of LP problems.
3. Solution Techniques: Graphical solutions, Simplex method, Two -phase and Big-M simplex methods.
4. Duality and Sensitivity: Duality and related theorems, Dual simplex method, shadow prices and Sensitivity analysis of LP.
5. Introductory concepts of Nonlinear programming (NLP): Classification of NLP problems, Convexity of Nonlinear functions, Gradient and Hessian matrix and related theorems.
6. Solution Techniques of constrained NLPs: Lagrange’s Multiplier method, Kuhn-Tucker method.
7. Solution of Quadratic programming (QP): Complementary pivot method, Wolfe’s method etc.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. S.I. Gass, Linear Programming.
2. W. Winston, Operations Research.
3. G. Hadley, Linear Programming.
4. N.S. Kambo, Mathematical Programming Techniques.
5. Ravindran, Phillips & Solberg, Operations Research.
6. Hiller and Liberman, Operations Research.

**MAT 4207: Introduction to Actuarial Mathematics 3 credits**

**Introduction and Specific Objectives**

Actuaries are the back bone for the insurance company. Without them, there is no concept of insurance company. They work for insurance companies and predict the profitability of various customers by using the mathematical and statistical formulas. Actuaries estimate the present value cost for future uncertainty like accidents, deaths, natural disaster, disability and lawsuits. Actuaries are engaged in life insurance, retirement benefit consultancies, asset management, postretirement medical benefit, the cost of retirement benefit plans. They also involved in periodic valuation of life insurance business, pensions and other investment benefits liabilities.

At the end of the course students will:

1. Have sufficient exposure to actuarial and financial mathematics
2. Be familiar with the role of insurance in society, basic economic theory, and the basics of how insurance and financial markets operate.
3. Have familiarity with several of the technical tools, computer languages or software packages used by actuaries.
4. Develop communication, leadership and teamwork skills, and understand their importance in the actuarial industry.
5. Be able to apply this knowledge and these skills in new combinations and to new problems.

**Learning Outcome**

* Compute different types of interests which is the most important learning for a business student.
* Will calculate annuities and their application in life insurance.
* Different types of risk model will give clear idea about the formulation of policy.
* Learn how to use mortality tables to calculate commutation function.
* Net premium calculation will give advantage to find out the benefit of both the company and the policy owner.

**Course Content**

**1. Theory of Interest :** Interest, Simple Interest, Compound Interest, Accumulated Value, Present Value, Rate of Discount: *d,*  Constant Force of Interest: *δ,* Varying Force of Interest,

**2. Annuities and its Applications:** Annuity-Immediate, Annuity–Due, Deferred Annuities, Continuously Payable Annuities, Perpetuities, Equations of Value. Amortization of a Debt, Outstanding Principal, Mortgages, Refinancing a Loan, Sinking Funds, Comparison of Amortization and Sinking-Fund Methods.

**3. Individual Risk Models:** Models for Individual Claim Random Variables, Sums of Independent Random Variables, Approximations for the Distribution of the Sum, Applications to Insurance.

**4. Survival Distributions:** Probability for the Age-at-Death, The Survival Function, Time-Until-Death for a Person Aged *x*, Curtate-Future-Lifetime, Force of Mortality.

**5. Life Tables:** Relation of Life Table Functions to the Survival Function, Life Table Example, The Deterministic Survivorship Group, Other Life Table Functions, Assumptions for Fractional Ages, Some Analytical Laws of Mortality, Select and Ultimate Tables.

**6. Life Insurance:** Introduction, Insurance payable at the moment of death, Insurance payable at the end of the year of death, Recursion equations, Commutation Functions.

**7.** **Life Annuities:** Introduction, Mortality Tables, Pure Endowments, Continuous Life Annuities, Discrete Life Annuities, Life Annuities with mthly payments. Commutation Functions formula for annuities with level payments, Varying Annuities.

**8. Net Premium:** Fully continuous premiums, Fully discrete premiums, True mthly Payment Premiums, commutation functions, Apportionable premiums.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. Bowers, Gerber, Hickman, Jones Nesbitt: Actuarial Mathematics
2. Mohammad Soharab Uddin: Introduction to Actuarial and Financial Mathematics
3. Petr Zima Robert L. Brown : Mathematics of Finance, Schaum’s outlines
4. CHRIS RUCKMAN, JOE FRANCIS: FINANCIAL MATHEMATICS A Practical Guide for Actuaries and other Business Professionals

**MAT 4209: Fuzzy Mathematics 3 Credits**

**Introduction and Specific Objectives**

Fuzzy Mathematics is based on fuzzy set theory. Fuzzy set theory is the study on fuzzy logic which is based on fuzzy sets, introduced by L. A. Zadeh in 1965, and symbolic logic. Fuzzy set theory is generalization of abstract set theory. Because of the generalization, it has a much wider scope of applicability than abstract set theory in solving various kinds of real physical world problems, particularly in the fields of pattern classification, information processing, control, system identification, artificial intelligence, and, more generally, decision processes involving uncertainty, impreciseness, vagueness, and doubtful data.

The notation, terminology, and concept of Fuzzy Mathematics are helpful for students to obtain primary idea in studying and solving various kinds of real physical world problems.

1. To give the idea of fuzzy sets, operations on them, and notion of fuzzy logic.
2. To understand the difference between classical set theory and fuzzy set theory.
3. To give the idea of relationship between classical set and fuzzy set via alpha-cut and strong alpha- cut representation, convexity of fuzzy sets, and Extension Principle for fuzzy sets.
4. To give the notion of fuzzy numbers, arithmetic operations on them, and Lattice of fuzzy Numbers.
5. To give the idea of linear fuzzy equations.
6. To give the concept of fuzzy relations and operations, similarity fuzzy relation, fuzzy morphism, and fuzzy relation equation.
7. To give the idea of the applications of fuzzy set theory.

**Learning Outcomes**

Students who successfully complete this course will:

1. Gather knowledge about fuzzy logic, fuzzy set theory and understand the difference between classical set and fuzzy set.
2. Achieve knowledge of conversion of fuzzy set to classical set and vice versa via alpha-cut and strong alpha-cut representation, and some additional properties of via alpha-cut and strong alpha-cut.
3. Gather knowledge about necessary and sufficient condition of a fuzzy set to be a fuzzy number.
4. Be able to do arithmetic operations of two fuzzy numbers and be also able to calculate their maximum and minimum.
5. Achieve knowledge of the concept of the procedure to get a solution of fuzzy equations.
6. Obtain the concept of binary fuzzy relation, domain, range, and inverse, composition of two binary fuzzy relations, some definitions, and theorems with proofs.
7. Achieve the idea of applications of fuzzy set theory and learn the methodology of using fuzzy sets in a real-life problem.

**Course Content**

1. **Crisp sets and fuzzy sets :** An overview of crisps sets; the notion of fuzzy sets; basic
2. concepts of fuzzy sets. An overview of classical logic; fuzzy logic.
3. **Operations of fuzzy sets :** General discussion; fuzzy complement; fuzzy union; fuzzy intersection combinations of operations; general aggregation operations.
4. **Fuzzy arithmetic :** fuzzy numbers, linguistic variables, arithmetic operations on intervals and fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.
5. **Fuzzy relations :** Crisp and fuzzy relations ; binary relations on a set; equivalence and similarity relations; compatibility or tolerance relations; orderings; morphisms; fuzzy relational equations.
6. **Applications of Fuzzy Set Theory**.

**Evaluation:** Incourse Assessment 25 marks, Attendance 5 marks, Final examination (Theory: 3 hours) 70 Marks. **Eight** questions of equal value will be set of which any **five** are to be answered.

**References**

1. G. J. Klir& U. Clair, Fuzzy Set Theory: Foundations and Applications, Prentice Hall
2. G. J. Klir& Bo Yuan, Fuzzy Sets & Fuzzy Logic Theory and Applications, Pearson
3. R. Lowen, Fuzzy Set Theory: Basic Concepts, Techniques and Bibliography, Springer
4. H.J. Zimmermann, Fuzzy Sets Theory and Its Applications, Springer

###### **MAT 4202 Viva Voce IV (Comprehensive) 2 Credits**

Viva Voce on all the courses taught from First Year to Fourth Year.

###### **MAT 4200 Project 3 Credits**

Each student is required to work on a project and present a project report for evaluation. Such projects should be extensions or applications of materials included in different honours courses and may involve field work and use of technology. There may be group projects as well as individual projects.

**Evaluation:** Project implementation and evaluation rules are given in the appendix.

N.B. In the grading system the evaluation of any course (irrespective of its credit hours) should be carried out of 100 marks. In each theoretical course 30% will be reserved for internal assessment.

**7. Rules and Guidelines for B.Sc Honours Program**

The rules and guidelines for the B.Sc. honours programs (B.Sc honours in Math) will be applicable from the Session 2021-2022 and onward.

**7.1 The B.Sc Honours Program**

The B.Sc honours program under the Faculty of Science is a four academic year program. The program comprises eight semesters, each having duration of six academic calendar months to be distributed as follows:

* Classes : Fifteen active weeks
* Preparatory Leave : Maximum two weeks
* Semester Final Exam : Two-three weeks
* Vacation : Only the usual vacation of the University will be applicable
* Result publication : Within one months from the end of the theory course examination.

**7.2 Admission**

* Students will be admitted to the respective department as per the University rules.
* Each year application requirements will be defined by the Central Admission Committee of the University.
* Departments can define specific requirements of subject-wise score in admission test with the approval of the Central Admission Committee.

**7.3 Definition of Credit**

* Fifteen class-hour of fifty minutes each is defined as one credit for theoretical courses
* Thirty lab hours work is defined as one credit for practical or lab courses

**7.4 Credit Requirements for the B.Sc Engineering Program**

* Total credits : 137
* Credits for core courses (theory) : 102
* Credits for practical courses : 09
* Credits for programming : 09
* Credit for physics and statistics : 12
* Viva voce : 02
* Credits or projects : 03

**7.5. Course Identification**

The undergraduate students of different years of this department have to follow the course schedule given. The letter prefix in any course number indicates the department offering the courses or the discipline viz. MAT for Mathematics, PHY for Physics and STA for Statistics.

Each course is designated by a three letters word identifying the department (details described earlier) which offers it followed by a four digit number with the following criteria:

The first digit corresponds to the year in which the course is taken by the student.

The second digit represents the semester in which the course is taken by the student.

The last two digits are ‘odd’ for a theoretical course and ‘even’ for a laboratory course.

The minimum credits to be completed for obtaining the degree of B.Sc. honours in Mathematics are 137

**7.6 Teaching of the courses**

For each credit of a theory course, there will be 1 class per week of 1 hour duration.

Total classes in a semester for each credit of a theory course will be 15 (15×1).

Total Contact Hours in a semester for each 1.0 credit theory course: 15×1=15.

For each 1.0 credit lab course, there will be 1 class per week of 2 hours duration.

Total classes in a semester for each 1.0 credit lab course in 15 weeks: 15×1=15.

Total Contact Hours in a semester for each 1.0 credit lab course: 15×2=30.

**7.7 Grades and Grade Points**

The UGC (of Bangladesh) approved grading system applies to calculate grade and grade points. Grades and grade points will be awarded on the basis of marks obtained in the written, oral and practical Exam according to the following table:

|  |  |  |
| --- | --- | --- |
| **Marks** | **Letter Grade** | **Grade Point** |
| 80% and Above | A+ | 4.00 |
| 75% to < 80% | A | 3.75 |
| 70% to < 75% | A- | 3.50 |
| 65% to < 70% | B+ | 3.25 |
| 60% to < 65% | B | 3.00 |
| 55% to < 60% | B- | 2.75 |
| 50% to < 55% | C+ | 2.50 |
| 45% to < 50% | C | 2.25 |
| 40% to < 45% | D | 2.00 |
| Less Than 40% | F | 0.00 |
|  | I | Incomplete |
|  | W | Withdrawn |

* Only “D” or higher grade will be counted as credits earned by a student.
* A student obtaining “F” grade in any course will not be awarded degree.
* In the tabulation process, only the total marks of a student in any course will be rounded-up to next number and the published result of the program will show only the grades earned and the Cumulative Grade Point Average (CGPA) at the end of each semester.

## 7.8 Calculation of GPA and CGPA

Grade Point Average (GPA) is the weighted average of the grade points obtained of all the courses passed/completed by a student. For example, if a student passes/completes *n* courses in a term having credits of *C*1*, C*2*, . . . , Cn* and his grade points in these courses are *G*1*, G*2*, . . . , Gn* respectively then,



The Cumulative Grade Point Average (CGPA) is the weighted average of the GPA obtained in all the terms passed/completed by a student. For example, if a student passes/completes n terms having total credits of *TC*1*, TC*2*, . . . , TCn* and his GPA in these terms are GPA1*,* GPA2*, . . . ,* GPA*n* respectively then,



**7.9 Marks Distribution for a Course:**

**(a.) Theory Course**

i. Attendance : 05%

ii. In-course exam, quiz/assignment/presentation : 25%

iii. Final exam : 70%

**Total Marks 100%**

**(b) Lab Course**

(i) Lab attendance : 10%

(ii) Continuous evaluation : 50%

(iii) Final exam : 40%

**(c) Project**

(i). Defense : 60%

(ii) Report : 40%

**7.10 Guideline for Attendance Mark**

|  |  |
| --- | --- |
| **Attendance (%)** | **Marks (05)** |
| 90 and above | 05 |
| 85 to 89 | 04 |
| 80 to 84 | 03 |
| 75 to 79 | 02 |
| 60 to 74 | 01 |
| Less than 60 | 00 |

**7.11 Exam Committee Formation**

* At the beginning of each academic semester/session, an exam committee shall be formed for that semester/session by the academic committee of respective department. Chairman of the exam committee will act as a course coordinator for that semester/session. The role of a course coordinator is to monitor the academic activities. He/She will report to the respective chairman of the department to ensure class conduction properly for the theory and lab courses.
* The exam committee will consist of four members proposed by the academic committee of the respective department.
* The committee members are a chairman, two internal members from the respective department and one external member outside of the department.
* The exam committee will be responsible for all exam related activities as per university rules.

**7.12 Evaluation of the Courses**

The performance of a student in a course will be evaluated in the following ways:

(a) For a theory course the evaluation will be made on the basis of attendance, quiz/assignment/ presentation, in-course exam and final exam.

(b) For any courses attendance, quiz/assignment/presentation, in-course exam will be evaluated by the course teacher/s and the result must be submitted to the exam committee and controller of exam before commencement to the semester final examination.

(c) The percentage of attendance of students for each course (according to the format supplied by the chairman) along with the attendance sheet must be submitted to the chairman of the department before commence to the semester final examination.

(d) The in-course exam scripts must be shown to students before the last class of a semester.

(e) If more than one in-course exam is taken final mark will be calculated by averaging all of them.

(f) For theory course final exams, generally there will be two examiners: course teacher will be the first examiner and the second examiner will be within the department or from a relevant department of the University. If a suitable examiner is not found from the University, a second examiner may be appointed from other universities with prior permission from the Vice Chancellor.

(g) (i) The answer scripts of final exam will be evaluated by two examiners and the average mark will be considered as the mark obtained, if the difference of two examiner marks not exceeded 20%.

(ii) In case of a difference of marks between the two examiners is more than 20% then the script will be evaluated by a third examiner. Marks of nearest two examiners will be taken for average.

(iii) If the differences of marks of third examiner from the first and second examiner become equal then average of three examiners marks will be obtained mark.

(h) The assessment of laboratory /practical /field course will be made by observing overall performance of a student during practical (continuous evaluation), attendance, viva-voce, assignments and evaluation of lab final exam (set by the department).

(i) For fourth year project evaluation will be made on the basis of presentation on project defense and project report.

(j) For field study evaluation will be made on the basis written examination or presentation on that field study and field study report.

**7.13 Requirement to Sit for Course Final Exam**

1. Students having 70% or more attendance on average is eligible to appear in the semester final Exam.
2. Student having average 60-69% attendance will be allowed to sit for the exam with a fine Tk. 1000.00 (one thousand) in the University central account.
3. Student having average attendance below 60% will not be allowed to sit for the semester final Exam but may seek re-admission in the program.
4. The semester final exam will be arranged centrally by the controller of examination of the University.
5. The duration of theory course final exams will be as follows:

|  |  |
| --- | --- |
| **Credit** | **Duration of Exam** |
| 3 Credits Course | 3 Hours |

1. Duration of lab exam will be defined by the respective department.

**7.14 Promotion to the Next Academic Year**

A student has to attend courses required for a particular semester, appeared at the annual exams and scored a minimum specified CGPA for promotion to the next year.

Promotion to the next year will be given if a student scores minimum CGPA as follows:

|  |  |
| --- | --- |
| **Year Description** | **CGPA** |
| 1st Year to 2nd Year | CGPA: 2.00 |
| 2nd Year to 3rd Year | CGPA: 2.25 |
| 3rd Year to 4th Year | CGPA: 2.50 |

**7.15 Requirements for the Award of the B.Sc Honours Degree**

(a) The student must earn required credits in a maximum period of six academic years starting from the date of admission at 1st year 1st semester.

(b) The student must obtain CGPA of at least 2.5 out of 4.00 to achieve the B.Sc Honours degree without “F” grade in any course.

**7.16 Tabulations**

(a) Examiners will upload their course marks directly through online in the result processing system.

(b) The examiners will submit the hard copy of the marks sheet to the chairman of the Exam committee and the Controller of Examination.

(c) The exam committee will appoint two tabulators.

(d) Tabulators will receive marks of all courses from the chairman of the Exam committee.

(e) The two tabulators will independently check the tabulation sheets according to the examiners’ mark sheets through online and then submit to the office of the Controller of Examination through the Chairman of Exam committee.

(f) The Controller of Exam will publish the results and students will get their result through email and SMS.

**7.17 Improvement Examination**

1. A student will be allowed a single earliest available chance to clear “F” grade/grades complying with the time requirement for the degree. A student will not be allowed for grade improvement if he or she passes and the final semester result is published.
2. A student may sit for improvement exam for courses where grade obtained is less than or equal to “C+” (C plus) and the best grade that a student can be awarded is B+ (B plus). However, if the grade is not improved the previous grade will remain valid.
3. Improvement exam for all odd semesters will always be held with immediate next even semester and the same exam committee will conduct the improvement exam (for example, 1st semester improvement exam will be held on immediate 2nd semester, 3rd semester in improvement exam will be held on immediate 4th semester, 5th semester improvement exam will be held on immediate 6th semester, 7th semester improvement exam will be held on immediate 8th semester. Improvement exam for all even semesters will always be held with immediate next academic session or batch.
4. In case of improvement exam in addition to usual fees a fine will be charged by the department through their Academic Committee.

(e) A student will be allowed to seat both for the final and in-course/others exam for the course.

**7.18 Re-admission and Dropout**

(a) A student may be allowed re-admission for a maximum of two times to complete the B.Sc. Honours program.

(b) A student may seek re-admission provided he or she has at least 30% (thirty percent) attendance in the previous semester or year.

(c) A student who is unable to get minimum required CGPA even after taking re-admission twice will be dropped out from the academic program.

**7.19 Dean’s Award**

In recognition of excellent academic performance students may be given Dean’s Merit Award for every batch after completion of the B.Sc Honours program as per following criteria.

1. An awardee must not have appeared in any improvement exam during his or her study period.
2. An awardee must have CGPA 3.75 or above.
3. However, the number of awardees of each department will not exceed two. In case of equal CGPA the final semester CGPA will be considered to break the tie.

**7.20 Other General Regulations**

(a) The existing rules of Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj will be applicable if any matter does not cover in the above guidelines.

(b) Disciplinary and punishable actions will be applied according to the existing rules of the university.