Curriculum for Four Years (Eight Semesters)
B Sc (Hons) Program
Department of Mathematics and Data Science
Military Institute of Science and Technology

Total Credits: 140

List of Departmental and Non-Departmental Courses for First Year (17+17= 34 Credits)

Level-1, Term-I

Sl	Course No.	Course Title	Credit Hour	Contact Hour
1.	MATH 101	Fundamentals of Mathematics	3.00	3.00
2.	MATH 102	Differential Calculus	3.00	3.00
3.	MATH 103	Integral Calculus	3.00	3.00
4.	STAT 101	Basic Statistics and Probability	3.00	3.00
5.	PHY 101	Physics-I	2.00	2.00
6.	MATH 150	Math Lab I: MATHEMATICA	0.75	1.50
7.	MATH 151	Math Lab II: MS Excel for Statistics	0.75	1.50
8.	MATH 152	Math Lab III: Introduction to Programming C++	1.50	3.00
	Total		**17.00**	**20.00**

Level-1, Term-II

Sl	Course No.	Course Title	Credit Hour	Contact Hour
1.	MATH 104	Linear Algebra	3.00	3.00
2.	MATH 105	Analytic Geometry and Vector Analysis	3.00	3.00
3.	MATH 106	Introduction to Number Theory	3.00	3.00
4.	DS 101	Data Structures and Algorithms	2.00	2.00
5.	GES 101	Fundamental of Sociology	2.00	2.00
6.	ENG 111	English for Communication and Scientific Writing	1.50	3.00
7.	MATH 153	Math Lab IV: Data Structures and Algorithms	1.50	3.00
8.	MATH 199	Presentation on Modern Trends in Mathematics and Data Science	1.00	1.00
	Total		**17.00**	**20.00**

List of Departmental & Non-Departmental Courses for Second Year (18.5+18.5 = 37 Credits)

Level-2, Term-I

Sl	Course No.	Course Title	Credit Hour	Contact Hour
1.	**MATH 201**	Differential Equations	3.00	3.00
2.	**MATH 202**	Numerical Analysis I	2.00	2.00
3.	**STAT 201**	Mathematical Statistics	3.00	3.00
4.	**DS 201**	Introduction to Data Science	2.00	2.00
5.	**PHY 201**	Physics-II	2.00	2.00
6.	**ECO 201**	Mathematical Economics	2.00	2.00
7.	**MATH 250**	Math Lab V:(MATLAB: Numerical Analysis)	1.50	3.00
8.	**MATH 251**	Math Lab VI: Introduction to Data Science	1.50	3.00
9.	**MATH 252**	Math Lab VII: Python for Statistics & Data Science	1.50	3.00
	Total		**18.50**	**23.00**

Level-2, Term-II

Sl	Course No.	Course Title	Credit Hour	Contact Hour
1.	**MATH 203**	Real Analysis	3.00	3.00
2.	**MATH 204**	Discrete Mathematics	3.00	3.00
3.	**MATH 205**	Multivariate Calculus	3.00	3.00
4.	**DS 202**	Database Management System	2.00	2.00
5.	**GERM 201**	Research Methodology	2.00	2.00
6.	**MATH 253**	Math Lab VIII: Database Management System	1.50	3.00
7.	**MATH 254**	Math Lab IX: SQL	1.50	3.00
8.	**MATH 255**	Math Lab X: R for Statistics & Data Science	1.50	3.00
9.	**MATH 299**	Presentation on Modern Trends in Mathematics and Data Science	1.00	1.00
	Total		**18.50**	**23.00**

List of Departmental & Non-Departmental Courses for Third Year (19+17 = 36 Credits)

Level-3, Term-I

Sl	Course No.	Course Title	Credit Hour	Contact Hour
1.	**MATH 301**	Complex Analysis	3.00	3.00
2.	**MATH 302**	Fundamentals of Topology	3.00	3.00
3.	**MATH 303**	Mathematical Methods	3.00	3.00
4.	**MATH 304**	Stochastic Calculus	3.00	3.00
5.	**DS 301**	Introduction to Machine Learning	2.00	2.00
6.	**DS 302**	Time Series Analysis and Forecasting	2.00	2.00
7.	**MATH 350**	Math Lab XI: Introduction to Machine Learning	0.75	1.50
8.	**MATH 351**	Math Lab XII: Data Visualization	1.50	3.00
9.	**MATH 352**	Math Lab XIII: Time Series Analysis and Forecasting	0.75	1.50
	Total		**19.00**	**22.00**

Level-3, Term-II

Sl	Course No.	Course Title	Credit Hour	Contact Hour
1.	**MATH 305**	Abstract Algebra	3.00	3.00
2.	**MATH 306**	Numerical Analysis II	2.00	2.00
3.	**B MATH 301**	Introduction to Mathematical Finance	2.00	2.00
4.	**DS 303**	Data Mining	2.00	2.00
5.	**DS 304**	Big Data Analytics	2.00	2.00
6.	**GELM 301**	Leadership Management	2.00	2.00
7.	**MATH 353**	Math Lab XIV: (MATLAB/PYTHON: Numerical Analysis)	1.50	3.00
8.	**MATH 354**	Math Lab XV: Data Mining	0.75	1.50
9.	**MATH 355**	Math Lab XVI: Big Data Analytics	0.75	1.50
10.	**MATH 299**	Presentation on Modern Trends in Mathematics and Data Science	1.00	1.00
	Total		**17.00**	**20.00**

List of Departmental and Non-Departmental Courses for Fourth Year (17.5+15.5 = 33 Credits)

Level-4, Term-I

Sl	Course No.	Course Name	Credit Hour	Contact Hour
1.	**MATH 401**	Introduction to Functional Analysis	3.00	3.00
2.	**MATH 402**	Industrial Mathematics	3.00	3.00
3.	**MATH 403**	Mechanics	3.00	3.00
4.	**MATH 404**	Optimization Techniques	3.00	3.00
5.	**MATH 405**	Introduction to Actuarial Mathematics	3.00	3.00
6.	**MATH 406**	Combinatorics	3.00	3.00
7.	**MATH 407**	Meteorology	3.00	3.00
Courses MATH 401–MATH 407 to be offered by the Academic Committee (Four courses has to be taken: 12 Credits)				
8.	**DS 401**	Deep Learning and Neural Networks	2.00	2.00
9.	**GESE 401**	Data privacy and Ethics	2.00	2.00
10.	**MATH 450**	Math Lab XVII: Deep Learning and Neural Networks	1.50	3.00
	Total		**17.50**	**19.00**

Level-4, Term-II

Sl	Course No.	Course Name	Credit Hour	Contact Hour
1.	**MATH 408**	Differential Geometry and Tensor Calculus	3.00	3.00
2.	**MATH 409**	Hydrodynamics and Fluid Dynamics	3.00	3.00
3.	**MATH 410**	Scientific Computing and simulations	3.00	3.00
4.	**MATH 411**	Mathematical Biology	3.00	3.00
5.	**MATH 412**	Fuzzy Mathematics	3.00	3.00
Courses MATH 408–MATH 412 to be offered by the Academic Committee (Two courses has to be taken: 06 Credits)				
6.	**DS 402**	Data Security	2.00	2.00
7.	**DS 403**	AI Model Deployment & MLOps	2.00	2.00
8.	**MATH 451**	Math Lab XVIII: AI Model Deployment & MLOps	1.50	3.00
9.	**MATH 490**	Project Work/ Thesis	3.00	6.00
10.	**MATH 499**	Presentation on Modern Trends in Mathematics and Data Science	1.00	1.00
	Total		**15.50**	**20.00**

Course Code	MATH 101		Course Type	Core (Theory)		Level 1 Term I	
Course Title	Fundamentals of Mathematics					Credit Hr	3
Prerequisite	None					Contact Hr	3
Rationale	Fundamentals of mathematics are the base of all mathematics courses. After completion of this course, students will get some useful and applicable ideas on mathematical logic, methods of proofs, set theory, relations and functions with graphs, real and complex number system, inequality, summation of series, some very important theories on roots of polynomials.						

Course Objective

- Introduce fundamental concepts of mathematical reasoning, including logic and set theory.
- Develop skills in constructing and understanding rigorous mathematical proofs.
- Cover number systems (real and complex) and algebraic fundamentals such as polynomial equations.
- Enhance problem-solving ability with sequences, series, and inequalities.

Contents

1. **Elements of Logic:** Mathematical statements; Logical connectives; Conditional and biconditional statements; Truth tables and tautologies; Quantifications; Logical implication and equivalence; Deductive reasoning; Methods of proof (direct, indirect); method of induction.
2. **Set Theory:** Sets and subsets; Set operations; Family of Sets; Cardinality of sets; De Morgan's laws; Applications of Set Theory.
3. **Relations and Functions:** Cartesian product of sets; Relations; Order relation; Equivalence relations; Functions; Images and inverse images of sets.
4. **Real Number System:** Field and order properties; Natural numbers, integers and rational numbers; Absolute value; Basic inequalities including inequalities involving means, powers; Inequalities of Weierstrass, Cauchy, Chebyshev.
5. **Complex Number System:** Field of complex numbers; Geometrical representations; Polar form; De Moivre's theorem and its applications.
6. **Summation of Finite Series:** Arithmetic and geometric series; Method of difference; Successive differences; Summation of trigonometric series.
7. **Theory of Equations:** Synthetic division; Number of roots of polynomial equations; Relations between roots and coefficients; Sum of power of roots; Descartes rule of signs: number of real and imaginary roots; Multiplicity of roots; Symmetric functions of roots; Transformation of equations; Fundamental theorem of algebra (without proof).

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Explain** the foundations of mathematics.	L, D, QA	T, ASG, F
CO2	**Interpret** the basic concepts of Logic and the ideas of the	L, D, QA	T, ASG, F

	Summation of algebraic and trigonometric series.		
CO3	**Evaluate** equations and inequalities, both algebraically and graphically.	L, D, QA	T, ASG, F
CO4	**Formulate** the Weierstrass, Cauchy's and Chebychief's inequalities.	L, D, QA	T, ASG, F
CO5	**Calculate** different mathematical problems of complex number and the different problems of Theory of equations.	L, D, QA	T, ASG, F
CO6	**Distinguish** among Arithmetic, Geometric and Harmonic Series.	L, D, QA	T, ASG, F
CO7	**Identify** the idea about of De-Moiver's Theorem.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		3							2
CO2	3		3		2	2				2
CO3	3		3		2					2
CO4	3		3							2
CO5	3	2	3		2					3
CO6	3		3		2					3
CO7	3		3		2					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. S. Lipschutz, Set Theory, Schaum’s Outline Series. 2. S. Barnard & J. M. Child, Higher Algebra. 3. P.R. Halmos, Naive Set Theory. 4. H. S. Hall and S. R. Knight, Higher Algebra.

Course Code	MATH 102		Course Type	Core (Theory)		Level 1 Term I
Course Title	**Differential Calculus**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rationale	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.					

Course Objective

- Introduce the fundamental concepts of functions, limits, continuity, and differentiation.
- Develop the ability to compute derivatives using various techniques and interpret their geometric and physical meanings.
- Build conceptual understanding of theorems related to continuity, differentiability, and mean value concepts.
- Enable students to apply differentiation to solve real-life problems in sciences, engineering, economics, and optimization.
- Provide foundations for advanced mathematical courses involving calculus, analysis, and modeling.

Contents

1. **Functions:** Concept of functions; Different types of functions (polynomial, rational, logarithmic, exponential, trigonometric, hyperbolic functions), inverses and graphs; transformation of graphs; Composite functions; Even, odd and symmetric functions; Applications of functions.
2. **Limit and Continuity:** Limit of a function; Basic limit theorems with proofs; Limit at infinity and infinite limit; Sandwich (Squeezing) theorem; Continuous and discontinuous functions; Properties of continuous functions on closed and bounded intervals; Horizontal and vertical asymptotes; Intermediate Value Theorem.
3. **Differentiation:** Tangent lines and rates of change; Derivative of a function; One sided derivative; Techniques of differentiation; Chain rule theorem; 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; 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.		
Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	**Understand** function both in mathematically and graphically, the basic concepts of limit and continuity of function, the basics of differentiation and techniques of differentiation, some physical phenomena of differentiation, the fundamental concepts of calculus and partial derivatives.	L, D, QA	T, ASG, F
CO2	**Evaluate** various problems using the basic concepts of calculus.	L, D, QA	T, ASG, F
CO3	**Visualize** graphs of curve in 3D, surface and analyze various properties of them..	L, D, QA	T, ASG, F
CO4	**Find** extreme values of multivariable functions using different approaches and apply them to solve practical problems.	L, D, QA	T, ASG, F
CO5	**Solve** some real-life problems involving differentiation.	L, D, QA	T, ASG, F
CO6	**Apply** differentiation to analyze some properties of functions, ideas of partial derivatives in many real-life problems.	L, D, QA	T, ASG, F
CO7	**Use** differentiation to generate the idea of infinite series	L, D, QA	T, ASG, F

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CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		3							2
CO2	3		3							2
CO3	3	2	3	2	2	2				2
CO4	3		3							3
CO5	3		3		3					3
CO6	3		3		3					3
CO7	3	2	3		3					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. H. Anton, I.C. Bivens and S. Davis, Calculus: Early Transcendentals, Wiley (10th Edition). 30 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.

Course Code	**MATH 103**		**Course Type**	**Core (Theory)**		**Level 1 Term I**	
Course Title	**Integral Calculus**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rationale	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 19 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.						

Course Objective

- Understanding of Integral Calculus and its applications.
- Interpret definite integrals geometrically as areas under curves and construct them as limits of Riemann sums.
- Understand differentiation and anti-differentiation as inverse operations, as outlined in the Fundamental Theorem of Calculus
- Proficient in evaluating integrals using various techniques.
- Recognize and solve different types of improper integrals, calculate areas between curves, volumes of solids of revolution, surface areas, and arc lengths using integration.
- Solve problems involving multiple integrations in rectangular, cylindrical, and spherical coordinate systems, and apply appropriate models.

Contents

1. **Various Techniques of Integration:** 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:** Areas; 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 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.
6. **Improper Integrals:** Different types of improper integrals; Test for convergence.
7. **Integrals Depending upon a Parameter:** Differentiation and integration under the integral sign.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**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.	L, D, QA	T, ASG, F
CO2	**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 20 find their derivatives, relate antiderivatives to definite and indefinite integrals, and the net change as the definite integral of a rate of change.	L, D, QA	T, ASG, F
CO3	**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.	L, D, QA	T, ASG, F
CO4	**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.	L, D, QA	T, ASG, F
CO5	**Determine** whether an improper integral (which either has infinite lower or upper limits of integration, or has an 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.	L, D, QA	T, ASG, F
CO6	**Know** about rectangular coordinates, cylindrical coordinates and spherical coordinates	L, D, QA	T, ASG, F
CO7	**Sketch** of different types of cylindrical and quadric surfaces	L, D, QA	T, ASG, F
CO8	**Compute** multiple integrals in rectangular, polar, cylindrical and spherical coordinates	L, D, QA	T, ASG, F
CO9	**Test** the convergence of improper integrals	L, D, QA	T, ASG, F
CO10	**Understand** differentiation and integration under the integral sign	L, D, QA	T, ASG, F
(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO1	3	2	3							2
CO2	3	2	3		2					2
CO3	3		3		2					2
CO4	3		3		2					3
CO5	3	2	3							3
CO6	3		3		2					3
CO7	3	2	3							3
CO8	3	2	3							3
CO9	3		3		2					3
CO10	3	2	3		2					3
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	**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.

Course Code	**STAT 101**		**Course Type**	**Core (Theory)**		**Level 1 Term I**
Course Title	**Basic Statistics and Probability**					**Credit Hr** | **3**
Prerequisite	**None**					**Contact Hr** | **3**
Rationale	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, probability, and probability distributions for both continuous and discrete random variables. 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.

Course Objective

- Provide the basic foundations of statistics with applications in real life. The
- Cover topics on descriptive statistics, correlation, regression, probability, and probability distributions for both continuous and discrete random variables.
- Apply and use the theory for real life problem-solving and inquiry.
- Provide students with hands on experience in using the statistical theory and methods
- Perform the different statistical analyses and to interpret results.

Contents

1. **Introductory Statistics:** data, statistics, discrete and continuous variables, population and sample, frequency distribution, graphical representations of data.
2. **Numerical Descriptive Measures:** Mean media, mode, geometric mean, harmonic mean.
3. **Measures of Dispersion:** Variance, standard deviation, coefficient of variation, mean deviation.
4. **Correlation and Regression Analysis:** Moments, skewness and kurtosis. Simple regression and correlation, regression coefficients, method of least squares, correlation co-efficient, rank correlation, correlation ratio, multiple correlation and regression.
5. **Probability:** Sample space and events, probabilities defined on events, conditional probabilities, etc.
6. **Probability theory:** Independent events, discrete and continuous random variables, expectation of a random variable, jointly distributed random variables, moment generating functions central limit theorems, conditional probability and conditional expectation.
7. **Discrete Probability Distributions:** Discrete random variables and their probability distributions, elementary study of binomial, Poisson and hypergeometric distribution.
8. **Continuous Probability Distributions:** Basic concepts of population distribution and sampling distribution, normal distribution and other continuous distributions.
9. **Combinatorial analysis:** basic principles of counting, permutations, combinations; axioms of probability: sample space and events, axioms of probability, sample spaces having equally likely outcomes, probability as a measure of belief; conditional probability and independence: conditional probabilities, Bayes formula, independent events.
10. **Random variables:** introduction, discrete random variables, expectation, expectation of a function of a random variable, variance, Bernoulli and binomial random variables, Poisson random variable, other discrete random variables (geometric, negative binomial, hypergeometric); expected value of a sums of random variables; properties of cumulative distribution function; continuous random variables: expectation and variance of continuous random variable, normal random variable, normal approximation to binomial distribution, exponential random variables.
11. **Jointly distributed random variables:** joint distribution functions, independent random variables, sums of independent random variables, conditional distributions (discrete and continuous cases); properties of expectation: expectation of sums of random variables, covariance, variance of sums, correlations, conditional expectation, moment generating functions, probability generating function.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Demonstrate** the ability to apply fundamental concepts in exploratory data analysis	L, D, QA	T, ASG, F
CO2	**Construct** and analyze graphical displays to summarize data	L, D, QA	T, ASG, F
CO3	**Compute and interpret** measures of center and spread of data	L, D, QA	T, ASG, F
CO4	**Calculate** the correlation coefficient and simple linear regression model	L, D, QA	T, ASG, F
CO5	**Utilize** basic concepts of probability including independence and conditional probability to calculate, interpret and communicate event probabilities both for discrete and continuous random variables.	L, D, QA	T, ASG, F
CO6	**Determine** the appropriate probability distribution based on experiment conditions and assumptions.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		3	2						2
CO2	3		3	2						2
CO3	3	2	3	2	2					3
CO4	3	2	3	3	2					3
CO5	3		3	3	2	2				3
CO6	3	2	3	3	2					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings

1. Yule and Kendal., An Introduction to the Theory of Statistics (14th Edition), Charles Griffin, 1965.
2. Weatherburn, C.E., A First Course in Mathematical Statistics (2nd Edition), Cambridge University Press, 1949.
3. Kenney and Keeping, Mathematics of Statistics, Vol. I (3rd Edition), 1962
4. Gupta and Kapoor, Fundamental of Mathematical Statistics (10th Edition), Sultan Chand & Sons, 2000.
5. Mosteller, Robert and Thomas, Probability with Statistical Application (2nd Edition), Addison Wiseley, 1961.
6. S.M. Ross , Introduction to Probability Models (10th Edition), Academic Press, 2009.

Course Code	PHY 101		Course Type	Theory		Level 1 Term I
Course Title	Physics-I				Credit Hr	2
Prerequisite	None				Contact Hr	2
Rationale	After finishing this course, students will able to explain the elasticity, surface tension, interference, and diffraction. Also, students will relate the theory with the real world phenomena.					

Course Objective

- Understand fundamentals of elasticity, surface tension, interference, and diffraction.
- Comprehend wave phenomena, electric and magnetic fields, and electromagnetic induction.
- Analyze practical applications of physical principles in mechanics and electromagnetism.

Contents

Part A: Properties of matter and optics:

1. **Elasticity:** Stress, strain, Hooke's law, elastic hysteresis, elastic modulus, Poisson's ratio, internal P.E and relation between elastic constants.
2. **Surface tension:** Surface tension, Surface energy, pressure difference across a surface film, contact angle and capillarity, Determination of angle of contact, Velocity of wave on the surface of a liquid**.**
3. **Interference:** Huygen's principle, superposition of waves, coherent source, Young's experiments, Michaelson's interferometer, Newton's rings.
4. **Diffraction (Fraunhofer class):** Diffraction by a single slit, resolving power, Rayleigh's criterion for resolution, plane diffraction grating.

Part B: Waves, Electricity and Magnetism:

5. **Travelling, stationery and sound waves:** Equation of a traveling wave, transmission of energy by a traveling wave, normal modes and proper frequencies of a stretched string, damped and forced vibrations of a string, Sound waves: Intensity, loudness and pitch, Doppler effect.
6. **Electric field and potential:** Electric charge and Coulomb's law, electric field and field strength, point charge in a electric field, dipole in a electric field, electric flux Gauss's law and some applications, Coulomb's law from Gauss's law, potential and field strength, potential due to a point charge, a group of point charges and a dipole, electric potential energy.
7. **Steady current and magneto statics:** current and current density, resistance, resistivity and conductivity, Ohm's law, electromotive force, potential difference, Kirchhoff's law, Magnetic field: Magnetic field and field strength, magnetic force on a current, torque on a current loop, Amperes law.
8. **Electromagnetic induction:** Faraday's experiment on electromagnetism, Faraday's law, Lenz's law, Self-induction and mutual induction, Self-inductance of a solenoid, Eddy currents, Energy stored in magnetic field, Energy stored in solenoid, Generator or Dynamo.

Course Learning Outcomes (CO)	Teaching Strategy	Assessment Methods

CO1	**Explain** physical principles underlying elasticity and surface tension.	L, D, QA	T, ASG, F
CO2	**Analyze** wave behavior and electromagnetic phenomena through theoretical and practical problems.	L, D, QA	T, ASG, F
CO3	**Solve** problems related to electric and magnetic fields and induction.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3							1
CO2	3		3		2					1
CO3	3		3		2					1

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings

1. Jenkins and White, Fundamentals of Optics (4th Edition), McGraw-Hill Education, 2001.
2. Longhurst, Geometrical and Physical Optics (2nd Edition), Longmans, Green and Co. Ltd., 1967.
3. Morgan , Introduction to Geometrical and Physical optics, R. E. Krieger Pub. Co., 1978.
4. Born and Wolf, Principles of Optics (7th Edition), Cambridge University Press, 1999.
5. Halliday D. and Resnick R, H.S , Physics, Estern limited, 1960.
6. Duckworth, H. E, Electricity and Magnetism, Holt, Rinehart and Winston, 1960.

Course Code	**MATH 150**	**Course Type**	**Lab**	**Level 1 Term I**	
Course Title	**Math Lab I: MATHEMATICA**			**Credit Hr**	**0.75**
Prerequisite	**None**			**Contact Hr**	**1.5**
Rationale	MATHEMATICA is a robust tool for professionals and researchers who require advanced mathematical capabilities and are willing to invest in a comprehensive software solution. However, its cost, learning curve, and resource requirements may make it less suitable for casual users or those with simpler needs. MATHEMATICA				

	uses controlled high-precision numbers and symbolic analysis to solve problems that are intractable with traditional numerical methods and limited-precision numbers.

Course Objective

- Apply computational tools to solve mathematical problems from first-year courses.
- Develop proficiency in MATHEMATICA for mathematical and statistical computations.
- Complete lab assignments to demonstrate computational skills.

Contents

1. Problems Solving: Problems in the courses of First Year B Sc Honor's will be solved using Computer Algebra System (CAS) MATHEMATICA.
2. Lab Assessment: Take Class Test.
3. Lab Assignments: Course instructors will provide a list of Lab assignments.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Solve** mathematical problems using MATHEMATICA.	L, D, QA	T, ASG, F
CO2	**Demonstrate** computational proficiency in lab assessments.	L, D, QA	T, ASG, F
CO3	**Integrate** software tools with theoretical knowledge for problem-solving.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3	3	2		2			2
CO2	3		3	3	2	2	2			2
CO3	3	2	3	3	2		2			2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Introduction to Mathematica, Springer Computational Geoscience with Matematica. 2. Programming with Mathematica: An Introduction By Paul Wellin. 3. Schaum's Outline of Mathematica and the Wolfram Language, Third Edition (Schaum's Outlines).

Course Code	MATH 151		Course Type	Lab		Level 1 Term I
Course Title	Math Lab II: MS Excel for Statistics				Credit Hr	0.75
Prerequisite	None				Contact Hr	1.5
Rationale	This course is designed to provide a practical, hands-on approach to understanding and applying statistical analysis techniques. This course emphasizes the importance of data analysis in various fields, aiming to bridge the gap between theoretical statistical concepts and their real-world applications using a familiar software platform.					

Course Objective

- Apply computational tools to solve mathematical problems from first-year courses.
- Develop proficiency in MS Excel for mathematical and statistical computations.
- Complete lab assignments to demonstrate computational skills.

Contents

As per the theoretical course 'DS 101: Basic Statistics and Probability'.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Solve** mathematical problems using Excel.	L, D, QA	T, ASG, F
CO2	**Demonstrate** computational proficiency in lab assessments.	L, D, QA	T, ASG, F
CO3	**Integrate** software tools with theoretical knowledge for problem-solving.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3	2	2		2			3
CO2	3		3	3	3	2	2			3
CO3	3	2	3	3	3		2			3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings

1. Introduction to Mathematica, Springer Computational Geoscience with Matematica.
2. Programming with Mathematica: An Introduction By Paul Wellin.
3. Schaum's Outline of Mathematica and the Wolfram Language, Third

	Edition (Schaum's Outlines).

Course Code	**MATH 152**		**Course Type**	**Lab**		**Level 1 Term I**	
Course Title	**Math Lab III: Introduction to Programming C++**					**Credit Hr**	**1.5**
Prerequisite	**None**					**Contact Hr**	**3**
Rationale	This module covers introductory ideas to connect C programming with statistics through programming code execution. To understand how to analyze descriptive mathematics and data analysis using C programming.						

Course Objective

- 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.

Contents

Basic Concepts
Introduction to Computer Programming, Problem Solving Techniques, Programming Style, Debugging and Testing, Documentation.

Object Oriented Programming Concepts
Object Oriented Programming Overview, Encapsulation, Inheritance and Polymorphism. Object Oriented vs. Procedural Programming, Basics of Object-Oriented Programming Language.

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.

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, Dimensional Arrays. Basics, I/O Operations using String, Basic String Operations.

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.

Objects and Classes
Attributes and Functions, Constructors and Destructors, Operator Overloading, Function Overloading.

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.

Exception and Exception Handling
Exception Handling Fundamentals, Exception Types.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	Be introduced with the C programming language.	L, D, QA	T, Q, ASG, F
CO2	Know techniques that facilitate the development of structured computer programs, such as algorithms, pseudocode, flowchart, etc. Understand how to control C programs, write C functions, use arrays.	L, D, QA	T, Q, ASG, F
CO3	How to connect C programming with mathematics through programming code execution.	L, D, QA	T, Q, ASG, F
CO4	Understand how to analyze descriptive statistics and data analysis using C programming.	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1		3								2
CO2		3								2
CO3		2								2
CO4		3								2

Learning Materials

Recommended Readings	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++.
Supplementary Readings	
Others	-

Course Code	MATH 104		Course Type	Core (Theory)		Level 1 Term II	
Course Title	**Linear Algebra**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rationale	A first course in linear algebra serves as an introduction to the development of logical structure, deductive reasoning and mathematics as a language. For students, the tools developed from a course in linear algebra will be as fundamental in their professional work as the basic tools of calculus. For these reasons, this course is a core course for students pursuing a major in Mathematics and Data Science.						

Course Objective

- Solve systems of linear equations using various methods, including Gaussian and Gauss Jordan elimination and inverse matrices.
- Perform matrix algebra, determinants, and their properties.
- Understand and apply properties of real vector spaces and subspaces, including linear independence and dependence.
- Find eigenvalues and eigenvectors and use them in applications.

Contents

1. **System of Linear Equations and Matrices:** System of linear equations; Elementary row operations; Gaussian elimination; Algebra on Matrices; Invertible matrices; Determinant and its properties; Applications to Leontief input-output Economic models, Markov chains, Computer graphics, Network Flow and Electrical Networks, Balancing chemical equations.
2. **Euclidean Vector Spaces**: Vectors in $\mathbb{R}\boldsymbol{n}$, Inner product. Norm and distance; Orthogonality.
3. **General 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.
4. **Linear Transformations:** Matrix transformations; Linear transformations; Examples and illustrations with applications; Kernel and image of a linear transformation and their properties.
5. **Eigenvalues and Eigenvectors of Matrices:** Eigenvalues and eigenvectors; Diagonalization; Cayley-Hamilton theorem; Complex Vector Spaces; Application to Least square approximation.
6. **Similar Matrices:** Canonical forms of matrices, Symmetric, orthogonal and Hermitian matrices
7. **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
8. **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
9. **Bilinear, Quadratic & Hermitian Forms**: Matrix form; transformations; canonical forms; reduction form; definite and semi-definite forms; principal minors; and factorable forms

10. **Symmetric Matrices and Quadratic Forms:** Diagonalization of Symmetric Matrices; Quadratic Forms; The Singular Value Decomposition; Applications to Image Processing and Statistics
11. **Positive Definite Matrices:** Minima, Maxima, and Saddle Points; Tests for Positive Definiteness; Minimum Principles.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Solve** systems of linear equations and homogeneous systems of linear equations by Gaussian elimination and Gauss-Jordan elimination, Row-reduce a matrix to either row-echelon or reduced row-echelon form.	L, D, QA	T, ASG, F
CO2	**Understand** some applications of systems of linear equations.	L, D, QA	T, ASG, F
CO3	**Perform** operations with matrices and find the transpose and inverse of a matrix. Use matrix operations to solve systems of equations and be able to determine the nature of the solutions.	L, D, QA	T, ASG, F
CO4	**Calculate** determinants using row operations, column operations and expansion down any column and across any row.	L, D, QA	T, ASG, F
CO5	**Interpret** vectors in two and three-dimensional space both algebraically and geometrically.	L, D, QA	T, ASG, F
CO6	**Recognize** the concepts of the terms span, linear independence, basis, and dimension, and apply these concepts to various vector spaces and subspaces.	L, D, QA	T, ASG, F
CO7	**Find** the kernel, range, rank, and nullity of a linear transformation.	L, D, QA	T, ASG, F
CO8	**Calculate** eigenvalues and their corresponding eigenspaces.	L, D, QA	T, ASG, F
CO9	**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.	L, D, QA	T, ASG, F
CO10	**Determine** if a matrix is diagonalizable, and if it is, how to diagonalize it.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3							2
CO2	3		3		2					2
CO3	3		3							2

CO4	3	2	3							2
CO5	3		3							2
CO6	3		3		2					3
CO7	3	2	3							3
CO8	3	2	3							3
CO9	3		3		2					3
CO10	3	2	3							3
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										
Learning Materials										
Recommended Readings	**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.** B. Kolman & D. R. Hill, Elementary Linear Algebra with Applications, 9th Edition. S.M. Ross, Introduction to Probability Models (10th Edition), Academic Press, 2009.									

Course Code	**MATH 105**		**Course Type**	**Core (Theory)**		**Level 1 Term II**
Course Title	**Analytic Geometry and Vector Analysis**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rationale	After finishing this course, students will able to explain the physical meaning of 115 graphs, geometrical formula and equations. Also, students will relate the theory with the real world phenomena.					
Course Objective						

- Understand coordinate systems in two and three dimensions and transformations between them.
- Analyze and classify conic sections and second-degree equations.
- Apply vector algebra and vector operations in geometric contexts.
- Be able to acquire knowledge on vector analysis and geometry.
- Achieve ability to solve problems with straight lines, pair of straight lines, circles, conics in 2D and 3D co-ordinate systems.
- Be able to find the length, volume and area of objects related to engineering study by using vector, Laplace transform to ordinary differential equation sandal so be able to solve the problems of the pair of straight lines, circles, system of circles, parabola, ellipse etc.

Contents

Part A: Analytic 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**
   (a) 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.
   (b) 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.
4. **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.
5. **Plane in 3-Space:** Equations of planes; Co-planarity; 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;
6. **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.
7. **Standard Forms of Conicoid:** Sphere, paraboloid, ellipsoid, hyperboloid (of one-sheet and two sheets) with sketches.

Part B: Vector Analysis

1. **Vectors and scalars:** Vectors, scalars, vector algebra, laws of vector algebra, unit vectors,

rectangular unit vectors, components of a vector, scalar fields, vector fields.

2. **Combination of Vectors:** Linear Dependence and independence of vectors.
3. **Product of Vectors**: Scalar or dot products, cross or vector products, geometrical interpretation, physical interpretation, scalar triple products, vector triple product, reciprocal sets of vectors.
4. **Curvilinear coordinates:** Transformation of coordinates, orthogonal curvilinear coordinates, unit vectors in curvilinear systems, arc length and volume elements, gradient, divergence and curl in orthogonal curvilinear coordinate systems, cylindrical coordinates, spherical coordinates.
5. **Vector Equations:** Straight line and plane, Angle between two planes, Angle between a line and a plane, Intercept on the axes of co-ordinates (rectangular) by plane.
6. **Equation of the shortest distance:** Distance (Perpendicular) of a point from a line, conditions of coplanarity of two straight lines, shortest distance between two non-intersecting straight lines or two skew lines
7. **Vector equations of sphere:** Tangent plane, orthogonality of two intersecting spheres, diametral plane, polar plane, radical plane.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Identify** isometries like reflections, rotations and translations and use them to categorize conics. Define reflections, rotations and translations, conics and draw the graph of conics. Define circle, ellipse, hyperbola and parabola, ellipsoid and express hyperboloid of one and two sheets.	L, D, QA	T, ASG, F
CO2	**Apply** these notions to curves. Use isometries to transform conics to canonic forms,	L, D, QA	T, ASG, F
CO3	**Express** equations of line in the space. Express equation of the line a point and direction of which are given, equation of the line that passes through a point and perpendicular to two lines, equations of planes in the space, equation of the plane that passes through a point and perpendicular to the line given,	L, D, QA	T, ASG, F
CO4	**Describe** equation of the line two points of which are given. Identify condition of perpendicular or parallel of two the lines, equation of the plane determined by three points.	L, D, QA	T, ASG, F
CO5	**Calculate** distance from a point to a line, distance from a line to a line, distance from a point to a plane and define surfaces.	L, D, QA	T, ASG, F
CO6	**Formulate** equation of surfaces on Cartesian coordinates and locate any surface.	L, D, QA	T, ASG, F
CO7	**Express** intersection curve of two surfaces, explain a sphere and express a cylinder.	L, D, QA	T, ASG, F
CO8	**Develop** a clear idea of physical significance of gradient, divergence and curl and learn some physical applications of them, analyses and demonstrate the technique in real life problems which is taught in vector and geometry.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3							2
CO2	3		3							2
CO3	3	2	3							2
CO4	3	2	3							2
CO5	3	2	3							3
CO6	3		3		2					3
CO7	3	3	3		2					3
CO8	3	3	3		2					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings

1. H. Anton, I. C. Bivens and S. Davis, Calculus: Early Transcendental, Wiley.
2. E.W. Swokowski, Calculus with Analytic Geometry, Brooks/Cole; Alternate.
3. Khosh Mohammad, Analytic Geometry and Vector Analysis.
4. J. A. Hummel, Vector Geometry.
5. S. Lang, A First Course in Calculus.
6. Murray R Spiegel, Vector Analysis, Schaum’s Outline Series.
7. James A. Hummel, Vector Geometry, Wesley Publishing Company – 1965.
8. Md. Ali Ashraf, Md. A.K. Hazra, Vector Analysis with Applications (3rd edition), New Age International (P) Limited, Publisher.

Course Code	**MATH 106**		**Course Type**	**Core (Theory)**		**Level 1 Term II**

Course Title	**Introduction to Number Theory**	**Credit Hr**	**3**
Prerequisite	**None**	**Contact Hr**	**3**
Rationale	Elementary Number Theory is the study of the basic structure and properties of natural numbers. Learning Number Theory helps improving one's ability of mathematical thinking. After completion of this course, students will prove results involving divisibility and greatest common divisors; solve systems of linear congruence’s; find integral solutions to specified linear Diophantine Equations; apply Euler-Fermat’s Theorem to prove relations involving prime numbers; apply the Wilson’s theorem.		

Course Objective

- Identify and apply various properties of and relating to the natural numbers including the well-ordering principle, primes, unique factorization, the division algorithm, and greatest common divisors.
- Identify certain number theoretic functions and their properties.
- Understand the concept of congruences and use various results related to congruences including the Chinese Remainder Theorem.
- Solve certain types of Diophantine equations.

Contents

1. **Divisibility:** Definition; properties; division algorithm; greatest integer function.
2. **Primes**: Definition, Euclid's Theorem; Prime Number Theorem (statement only); Goldbachand Twin Primes conjectures; Fermat primes; Fermat's Theorem; Mersenne primes.
3. **Prime Factorizations:** Definition and properties of greatest common divisor (GCD) and least common multiple (LCM); Euclid's algorithm; Fundamental Theorem of Arithmetic; Linear Diophantine equations; Continued Fractions; Euclid's Lemma; Canonical prime factorization; divisibility; GCD; and LCM in terms of prime factorizations.
4. **Congruences:** Definitions and basic properties; residue classes; complete residue systems; reduced residue systems; Linear congruences in one variable; Euclid's algorithm; Simultaneous linear congruences; Chinese Remainder Theorem; Wilson's Theorem; Euler's Theorem; Pseudoprimes and Carmichael; Application of congruences (Divisibility test, Round robin tournaments, ISBN Check Digits).
5. **Arithmetic Functions:** Arithmetic function and Multiplicative functions (definitions and basic examples); The Moebius function; The Euler phi function; Carmichael conjecture; Number of divisors and sum of divisors functions; Perfect numbers; Characterization of even perfect numbers, Representation of numbers by sum of two and four squares; Application of Number theory in Cryptography; Encryption Schemes, Ceaser cipher algorithm, Rivest-Shamir-Adleman (RSA) Algorithm.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	**Effectively** express the concepts and results of Number Theory.	L, D, QA	T, ASG, F

CO2	**Understand** the logic and methods behind the major theorems and their proofs in Number Theory.	L, D, QA	T, ASG, F
CO3	**Construct** mathematical proofs of statements and look for counter examples to establish falsity of some the statements.	L, D, QA	T, ASG, F
CO4	**Understand and verify** the conjectures about the natural numbers.	L, D, QA	T, ASG, F
CO5	**Use** concepts of number theory to solve huge number of real-life problems.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		3		2					2
CO2	3		3		2					2
CO3	3	2	3		2					3
CO4	3	2	3		2					3
CO5	3	2	3		2					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** S. G Telang, Number Theory. **2.** James Strayer, Elementary Number Theory. **3.** G H. Hardy and E. M. Wright, An Introduction to Theory of Number. **4.** Kenneth Rosen, Elementary Number Theory and its Applications. **5.** Fatema Chowdhury and Munibur Rahman Choudhury, Essentials of Number Theory.

Course Code	DS 101		Course Type	Core (Theory)		Level 1 Term II	
Course Title	Data Structures and Algorithms					Credit Hr	2
Prerequisite						Contact Hr	2
Rationale	This course is designed to provide a clear concept on the essential parts of the data structures and algorithms related to computer science. This course begins with the introduction of basic concepts of some commonly used data structures and algorithms and then covers. The course is also designed to focus on basic and essential topics in data structures and algorithms, including different types of trees, heap, trie, disjoint set, greedy algorithms, dynamic programming, sorting algorithms, flow networks, string matching algorithms, graph sorting, backtracking, algorithm analysis and approximation algorithms						

Course Objective

- To develop a general understanding of basic data structures and algorithms
- To develop Programming skills for data structures and algorithms
- To implement data structures such as linear lists, hash tables, binary trees, heaps, binary search trees, and graphs and writing programs for these solutions.
- To employ the different data structures to find the solutions for specific problems
- Choose the appropriate data structure for modeling a given problem

Contents

Introduction to Data Structures

Introduction to data structures and algorithms, array representation in memory, array mapping function, asymptotic notation; Overview of data structures, why data structures matter, Types of data structures, Role of data structures in data science

Array searching

Linear search, Binary search; Sorting: Bubble sort, Insertion sort, Count sort; Linked list: Single linked list, double linked list; FIFOLIFO: Stack, Queue;

Graph Theory

Introduction, classification of graph, representation of graph, breadth first search, depth first search;

Trees

Classification of trees, tree traversal, Binary search tree, Segment tree; Heap, Priority Queue, AVL Tree, TRIE;

List and Hashing

Skip list, Hash table, Hashing; String matching algorithm: Knuth–Morris–Pratt (KMP) algorithm, Set-List: Disjoint set, Skip List; Greedy Strategy: Dijkstra‘s algorithm;

Dynamic Programming

Bellman Ford‘s algorithm, Matrix chain multiplication, 0-1 knapsack, longest common subsequence finding; Mergesort, Quicksort; Flow network: Maximum flow problem;

Graph Sorting

Directed Acyclic Graph, Topological sorting; Backtracking: Map coloring problem, 0-1 Knapsack by branch and bound; Solving Recurrences: Algorithm analysis, Master theorem; Approximation Algorithms: NP Completeness

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Express the fundamentals of static and dynamic data structures and relevant standard algorithms.	L, D, QA	T, Q, ASG, F
CO2	Demonstrate advantages and disadvantages of specific algorithms and data structures, apply required modification and optimization in any data structure and algorithm in common engineering design.	L, D, QA	T, Q, ASG, F
CO3	Select basic data structures and algorithms and illustrate important algorithmic design paradigms and methods of analysis.	L, D, QA	T, Q, ASG, F
CO4	Analyze the running time complexity and determine bugs in the program, recognize needed basic operations with algorithms and data structures.	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3		3							
CO3	3	3								
CO4	3	3								

Learning Materials

Recommended Readings	1. Michael, T., Goodrich, Roberto, T., and Michael H. G. (2013). Data Structures and Algorithms in Python, Wiley. 2. Introduction to Algorithms (Third Edition), Thomas H. Cormen 3. Data Structures and Algorithm Analysis in C++ (2014) - Mark Allen Weiss 4. Data Structures and Algorithm Analysis in Cpp (4th Edition) – Michael T. Goodrich, Roberto Tamassia.
Supplementary Readings	
Others	-

Course Code	GES 101		Course Type	Core (Theory)		Level I Term II
Course Title	**Fundamental of Sociology**					**Credit Hr** 2
Prerequisite						**Contact Hr** 2
Rationale	The subject **Fundamentals of Sociology** provides students with a basic understanding of society, social relationships, and social institutions. It explains how social norms, values, and culture influence human behavior and shape social life. Through this subject, students learn to analyze social issues such as inequality, stratification, and social change. This subject also develops critical thinking and a scientific approach to understanding social problems. Therefore, **Fundamentals of Sociology** is important for building social awareness and serves as a foundation for advanced studies in sociology and related social sciences.					

Course Objective

The main objective of this course is to introduce students to the basic concepts, nature, and scope of sociology. It aims to help learners understand society, social relationships, culture, and social institutions, and how these elements influence human behavior. The course also seeks to develop students' ability to analyze social problems such as inequality, stratification, and social change using a scientific and critical approach. Furthermore, it provides a strong foundation for advanced studies in sociology and related social sciences and promotes social awareness and responsible citizenship.

Contents

Introduction to Sociology
Meaning, nature, scope, and importance of sociology; sociology as a social science.

Society and Culture
Concept of society and culture; elements of culture; norms, values, customs, and traditions.

Socialization and Social Interaction
Meaning and process of socialization; agents of socialization; forms of social interaction.

Social Groups and Social Institutions
Types of social groups; family, education, religion, economy, and political institutions. Social Stratification and Inequality**,** Meaning and forms of social stratification; class, caste, gender inequality**.**

Social Change
Meaning, causes, and factors of social change; modernization and globalization.

Social Problems
Concept and types of social problems; poverty, unemployment, crime, and population problems.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the basic concepts, nature, and scope of sociology and society.	L, D, QA	T, ASG, F

CO2	**Explain** the role of culture, socialization, and social institutions in shaping human behavior.	L, D, QA	T, ASG, F
CO3	**Analyze** social issues such as inequality, stratification, and social change using sociological perspectives.	L, D, QA	T, ASG, F
CO4	**Apply** sociological concepts and theories to understand and address real-life social problems.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2							
CO2	3		2		1	1		2		
CO3	2	2	3	1	2	1				1
CO4	2	1	2	1	3	1			2	1

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	5. Applebaum, Richard. Chambliss J William. Sociology: A brief introduction. Delhi: Longman Publisher. 1997 6. Abraham, M Francis. Contemporary Sociology: An introduction to Concepts and Theory, India: Oxford University Press, 2006. 7. Gisbert, P. Fundamentals of Sociology. Bombay: Orient Longman, 1990. Print.
Supplementary Readings	1. Kornblum, Willam. Sociology in a Changing World. New York: Holt Rine Hart and Winston INVC, 2011.Print. 2. Maclver & Page, Society. London: Macmillan & Co, 1950. 3. Teevan, James J (ed), Introduction to Sociology A Canadian Focus. Canada: Prentice Hall, 1992. Print.

Course Code	ENG 111		Course Type	Theory		Level 1 Term II	
Course Title	English for Communication and Scientific Writing					Credit Hr	1.5
Prerequisite	None					Contact Hr	3
Rationale	After finishing this course, students will able to expand vocabulary, increase proficiency in reading, writing and listening in English.						

Course Objective

- Use English effectively for the purpose of practical communication.
- Expand vocabulary, increase proficiency in reading, writing and listening
- Develop greater understanding of grammatical rules and usage.

Contents

1. **Clauses:** Structure, function, variation, and expansion of clause, Noun in the clause (number, determiners), Pronoun in the clause (number, case, agreement, and reference), Verb in the clause (form, tense, voice, mood, subject-verb agreement), Modifiers in the clause (adjective, adverb, infinitive, participles)
2. **Advanced Grammar:** Transformation of sentences, WH Questions, Punctuation, parallel structure
3. **Advanced Vocabulary:** Confusing Words - Synonyms, Antonyms, Homonyms.
4. **Listening:** Listening monologue, phonemes, situational dialogues, conversations Reading: Fractions of various modern fictions written in easy language, short stories, unseen comprehensions.
5. **Inference and Impressions:** Making inference, understanding how impressions are created, examining impact of words, examining points of view and reaching a conclusion. Summarizing and Comparison: Summarizing a text, understanding use of words and their effects, comparing the style of fiction and non-fiction texts.
6. **Newspaper Reading and Prose:** Newspaper (general news, cultural news, sports news, domestic and international news, entertainment news, advertisement, employment notice, editorial and articles), Prose relating to history, geography, science and technology
7. **Pronunciation:** Introduction to pronunciation, places and manners of articulation, phonetic symbols, the most common mistakes in pronunciation, etc.
8. **Professional writing:** Memorandum – Different types of Letters and Applications, e.g., Job application - Cover letter - CV - Complaint letter - Letter of Apology, etc. - Report
9. **Academic writing:** Summarizing- Paraphrasing - Essay writing - Writing film reviews Technical Writing: Practicing writing skills, Introduction to writing tools (ChatGPT, Grammarly, plagiarism checker)

8\. **Speaking:** Making requests, giving commands, inviting people, giving advice, giving suggestions, Agreeing and disagreeing, Asking questions, Giving opinion, Making comments, Presenting a paper, Addressing an audience, etc.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Develop** critical reading abilities to identify, retrieve, and understand relevant information and implied meanings.	L, D, QA	T, ASG, F
CO2	**Communicate** clearly and accurately, summarizing,	L, D, QA	T, ASG, F

	paraphrasing, and applying logical reasoning with proper grammar and vocabulary.		
CO3	Convey information and opinions effectively, using appropriate grammar, vocabulary, and pronunciation.	L, D, QA, Pr	T, ASG, F
(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)			

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	1							3		3
CO2	1							3		3
CO3	1							3		3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** P.C. Das (2022). Applied English Grammar & Composition, Edition 2021-2022. **2.** Devlin, J. (2013). How to Speak and Write Correctly, 2nd edition, McGraw-Hill. **3.** Educational Testing Service (2020). The Official Guide to the TOEFL iBT test, 6th edition. **4.** Raymond Murphy (2019). English Grammar in Use, 5th edition, Cambridge.

Course Code : MATH 153 **Course Name : Math Lab IV** (Data Structures and Algorithms)	**Credit Hour: 1.50** **Contact Hour: 3.00**

Course Contents

As per the theoretical course DS 102

Course Code	MATH 199		Course Type			Level 1 Term II

Course Title	**Presentation on Modern Trends in Mathematics and Data Science**	**Credit Hr**	**1**
Prerequisite	**All courses taught in the First Year**	**Contact Hr**	**1**
Rationale	This course aims to provide students with understanding of first-year courses through presentation.		

Course Objective

- Assess understanding of first-year courses through presentation.

Contents

Presentation on courses taught in the First Year.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Demonstrate** comprehensive knowledge and application skills from first-year subjects.	LQA	Pr, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3		2	2	2			3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

<table>
<tr><td>Course Code</td><td>MATH 201</td><td></td><td>Course type</td><td>Core (theory)</td><td></td><td colspan="2">Level 2 Term I</td></tr>
<tr><td>Course Name</td><td colspan="5">Differential Equations</td><td>Credit Hr</td><td>3.0</td></tr>
<tr><td>Prerequisite</td><td colspan="5">Differential and Integral Calculus</td><td>Contact Hr</td><td>3.0</td></tr>
<tr><td>Rationale</td><td colspan="7">The construction of mathematical models to address real life problems has been one of the most important aspects of each of the branches of science. These mathematical models are formulated in terms of equations involving functions and their derivatives. Such equations are called differential equations. This course emphasizes classical methods for finding solution formulas. After completion of this course, the students will get some useful and applicable ideas for modeling physical and other phenomena.</td></tr>
</table>

Learning Objective

The learning objectives of this course are to

- Understand the concepts of initial value problem and solution.
- Learn to solve differential equations with constant and variable coefficients.
- State the heat, wave, Laplace, and Poisson equations and explain their physical origins, basic existence, uniqueness and continuous dependence of initial and boundary conditions.
- Solve simple first order equations using the method of characteristics
- Identify homogeneous PDEs and evolution equations.
- Solve the wave equation using d’Alembert’s formula.
- Solve wave equation by separating variables and Fourier series.
- Solve PDEs using Fourier integrals and transforms.
- Learn to solve real-world problems in fields such as Biology, Chemistry, Economics, Engineering, and Physics modeled by first and second order differential equations.
- Gather experience to solve system of equations with constant coefficients.

Contents

Part A: ODE

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.

Part B: PDE

1. **Mathematical formulation** and modeling of physical systems in PDE, well-posed problems, usual operators and classes of equations, boundary conditions, IVP, BVP, EVP, IBVP.
2. **First order equations**: Methods for finding general solutions, constant-coefficient advection equation, linear and quasi-linear equations, methods of characteristics, IVP for conservation laws and applications. Shocks and expansion fans. Charpit's method, Solution by ODE method and separation variables.
3. **Second order PDE**: General equations and classifications, canonical forms, constant coefficient equations. Methods of solutions: separation of variables and eigenfunction expansion methods for one dimensional heat (heat flow in a rod) and wave equations, d'Alembert's formula, nonhomogeneous problems. Initial BVPs. Two dimensional heat and wave equations.
4. **The potential equation**: Method of separation variables for Laplace and Poisson equations, Dirichlet and Neumann problems in rectangular, circular (disk), partially bounded and unbounded domains, Properties of Harmonic functions. Maximum-Minimum principles, Mixed BVPs, Eigenvalue problem, Helmholtz equation, Nonhomogeneous boundary conditions.

Course Learning Outcomes (CO)		Teaching Strategies	Assessment Methods
CO1	**Solve** first/higher order linear differential equations with and without initial conditions	L, D, QA	T, ASG, F

CO2	**Determine** regions of the plane over which a given order differential equation will have a unique solution	L, D, QA	T, ASG, F
CO3	**Use** methods for obtaining exact solutions of linear homogeneous and nonhomogeneous differential equation	L, D, QA	T, ASG, F
CO4	**Compare** the methods of solutions developed in higher order and solution in 2nd /1st order equations	L, D, QA	T, ASG, F
CO5	**Solve** first-order partial differential equations, solve simple first order equations using the method of characteristics; classify second order equations	L, D, QA	T, ASG, F
CO6	**Explain** Conservation laws and shock waves; The eikonal equation; General nonlinear equations	L, D, QA	T, ASG, F
CO7	**Reduce** second order partial differential equations to standard form and solve the problems using present techniques	L, D, QA	T, ASG, F
CO8	**Analyze** real-world problems modeled by Ordinary/Partial differential equations	L, D, QA, CS	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO Mapping

Course Outcome (CO)	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2		3							3
CO2	3	3	3							2
CO3	3	2	3							3
CO4	3		3							
CO5	3	3	3							2
CO6	3	3	3							
CO7	3		3							
CO8	2	3	3				2			3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

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.
5. Larry C. Andrews, Elementary Partial Differential Equations with Boundary Value Problems, Academic Press College.
6. Paul DuChateau and David Zachmann , Applied Partial Differential Equations.
7. Richard Haberman, Elementary Partial Differential Equations with Fourier series and BVPs, Prentice-Hall International Editions.
8. Yehuda Pinchover and Jacob Rubinstein, An Introduction to Partial Differential Equations, (Cambridge University Press).

Course Code	**MATH 202**		**Course type**	**Core (theory)**		**Level 2 Term I**	
Course Name	**Numerical Analysis I**					**Credit Hr**	**2.0**
Prerequisite	**Differential and Integral calculus**					**Contact Hr**	**2.0**
Rationale	Numerical analysis, area of mathematics and computer science that creates, analyzes, and implements algorithms for obtaining numerical solutions to problems involving continuous variables. Such problems arise throughout the natural sciences, social sciences, engineering, medicine, and business. Numerical analysis is concerned with all aspects of the numerical solution of a problem, from the theoretical development and understanding of numerical methods to their practical implementation as reliable and efficient computer programs. Most numerical analysts specialize in small subfields, but they share some common concerns, perspectives, and mathematical methods of analysis.						

Learning Objective

The learning objectives of this course are to

- To gain the knowledge on several traditional but popular and effective numerical methods for solving nonlinear equations of one variable.
- Students will know the basic properties and operations for matrices and vectors, and then presents some most fundamental numerical algorithms for linear systems.
- Students will learn a simple and often efficient methodology to extract a good approximation to some given function or data by interpolation.
- The course comes closer to our aforementioned aim, when we discuss numerical integration and differentiation.

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.

Course Learning Outcomes		Teaching Strategies	Assessment Methods
CO1	**Knowledge** about floating point, types of error, algorithm and convergence	L, D, QA	T, ASG, F
CO2	**Use** different root finding methods to find roots of an equation.	L, D, QA	T, ASG, F
CO3	**Apply** various techniques to solve the system of linear equations using various numerical methods	L, D, QA, CS	T, ASG, F
CO4	**Explain** and understand how to use Newton's divided difference technique	L, D, QA	T, ASG, F
CO5	**Solve** real-life problems using Spine quadrature and adaptive quadrature	L, D, QA, CS	T, ASG, F
CO6	**Capture** the knowledge of how to integrate numerically by using integral methods	L, D, QA	T, ASG, F
CO7	**Learn** the concept of first order differential equations and will be able to solve the differential equations using different numerical methods of ODE.	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping										
Course Outcomes (CO)	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									2
CO2	3		3							2
CO3	3		3							2
CO4	3		3							2
CO5	2	3	3				2			3
CO6	3		3							2
CO7	3	3	3							2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Material

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

Course Code	**STAT 201**	**Course Type**	**Core (theory)**	**Level 2 Term I**	
Course Name	**Mathematical Statistics**			**Credit Hr**	**3.0**
Prerequisite	**Basic Statistics and Probability**			**Contact Hr**	**3.0**
Rationale	This course will provide knowledge of sampling theory and different tests in which giving concept about practical situation.				

Learning Objective

The learning objectives of this course are to

- 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.
- 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.

Contents

Part A: Sampling Distributions

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 ($\chi 2$), 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.

Part B: Inference

1. **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.

2. **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.

3. **Attributes and Contingency Tables:** Association of attributes, Association & disassociation, Measure of association, Attribute, contingency tables, General test of independence in an r x c contingency table. Fisher's exact test for a 2×2 contingency table.

4. **Goodness of fit:** Test of goodness of fit, Analysis of Variance (ANOVA): One-way, two-way classification etc.

Course Learning Outcome (CO)		Teaching Strategies	Assessment Methods
CO1	**Understand** the basic concept of random variables, methods of finding the distribution of a function of random variables	L, D, QA	T, ASG, F
CO2	**Know** central limit theorem and Chebyshev's inequality with applications	L, D, QA, CS	T, ASG, F

CO3	**Learn** Sampling distributions, basic terms of estimation theory and test of hypothesis	L, D, QA	T, ASG, F
CO4	**Obtain** point estimators and construct confidence intervals of parameters with applications of estimation methods and hypothesis testing	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes (CO)	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3	3	3	3		2		3
CO2	3		3	3	3		2		3	3
CO3	3			2	3					3
CO4	3		3	3	3					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

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.

Course Code	**DS 201**	**Course Type**	**Core (Theory)**	**Level 2 Term I**	
Course Title	**Introduction to Data Science**			**Credit Hr**	**2**
Prerequisite	**DS 101**			**Contact Hr**	**2**
Rationale	This course deals with fundamental concepts and methods of statistics as a whole. The impact that statistics has made and will continue to make in Data Science and virtually in all elds of scientific and human endeavors will be illustrated. A brief discussion on the introductory definitions and meaning of terms and terminologies used in Applied Statistics and Data Science will be given. The basic topics in data, variables, their measurements, storage, management and methods for analyzing them will be presented.				

Course Objective

- To develop Skills in Data Summarization and Visualization
- To know how to calculate different measures of central tendency, dispersion, and correlation analysis with clear interpretations.
- To learn exploratory data analysis (EDA) methods.

Contents

1. **Introduction to Data Science:** Data Science, Importance in various fields. Basic concepts of Population, Sample, Variable, Types of Data, Level of Measurement.
2. **Data Summarization and Organization**: Understanding the dataset, Raw Data. Organizing Data, Construction of Frequency tables, Concept of Relative Frequency and its uses.
3. **Data Visualization:** Graphing Qualitative Data, Shapes of Histograms, Frequency Polygon, Ogive, Stem-and-Leaf Display, Dot Plots, Time series plot.
4. **Association of Attributes**: Association of Attributes, Types of Association, Methods of Measures of Association, Contingency Table.
5. **Data Science Tools and Techniques:** Introductory Concepts of Machine Learning, Big Data, Spark, Hadoop, Python, R and their uses in Data Science.
6. **Introduction:** Machine learning, Scopes and limitations, Supervised and unsupervised learning.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Apply** appropriate techniques to organize, summarize, and visualize data with interpretation.	L, D, QA	T, ASG, F
CO2	**Compute** appropriate measures of central tendency, dispersion, and correlation analysis with interpretation.	L, D, QA	T, ASG, F
CO3	**Understand** the shape of the data to adopt appropriate statistical analysis tools.	L, D, QA	T, ASG, F
CO4	**Apply** various measures of attributes in real-life problems.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3	2	2					2
CO2	3		3	2	2					2
CO3	3		3	2	2					3
CO4	3	2	3	2	2					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)	
Learning Materials	
Recommended Readings	**1.** Kotu, V. and Deshpande, B. (2019). Data Science Concepts and Practice, 2nd Edition, Elsevier. **2.** Saltz, J. S., and Stanton, J. M. (2017). An introduction to data science. Sage Publications. **3.** Lind, A. D., Marchal, W. and Wathen, S. (2020). Statistical Techniques in Business and Economics, 18th Edition, McGraw Hill Inc. **4.** Devore, J. L. (2020). Probability and Statistics for Engineering and the Science, 9th Edition, Cengage Learning. **5.** Ou, G., Zhu, Z., Dong, B., and Weinan, E. (2023). Introduction to Data Science. World Scientific. **6.** Shah, C. (2020). A hands-on introduction to data science. Cambridge University Press.

Course Code	**PHY 201**		**Course Type**	**Theory**		**Level 2 Term I**
Course Name	**Physics-II**				**Credit Hr**	**2.0**
Prerequisite	**N/A**				**Contact Hr**	**2.0**
Rationale	This course will provide the knowledge about modern physics and the concept behind many natural phenomena.					
Learning Objective						
The learning objectives of this course are to • Understand modern physics concepts including relativity, quantum mechanics, atomic and nuclear physics. • Study statistical mechanics, solid-state physics, and elementary particles.						
Contents						
1. **Relativity:** Special relativity, Time dilation, Length contraction, Relativity of mass, Mass and Energy relationship, Doppler effect, General relativity 2. **Wave-Particle Duality:** Electromagnetic waves, Blackbody radiation, Photoelectric effect, light concept, X-Rays, X-Ray diffraction, Compton effect, Pair production, De-Broglie waves, Phase and Group velocities, Particle in a box, Uncertainty principle 3. **Atomic and Molecular Physics:** Alpha particle scattering experiment, Rutherford model, Electron orbits, Bohr model, Atomic spectra, Sommerfeld model, Vector atom model, Pauli exclusion principle, Correspondence principle, Rotational and Vibrational energy levels, Electronic spectra of molecules 4. **Quantum Mechanics:** Postulates of Quantum mechanics, Schrodinger's equation (Time dependent and independent), Operators, Eigenvalue equation, Basis vectors, Expectation						

values, Potential well, Tunnel effect, Harmonic oscillator

5. **Statistical Mechanics:** Statistical distributions, Rayleigh-Jeans Formula, Wien's displacement law, Planck's Radiation law, Specific heats of solids, Free electrons in metal
6. **The Solid state physics:** Crystalline and Amorphous Solids, Different types of bonds in solids, Band theory of solids, different crystal systems, Crystal defects, Semiconductor devices (Junction diode and Junction transistor)
7. **Nuclear structure and transformations:** Nuclear composition, Nuclear force, Properties of Nucleus, Binding energy, Meson theory of nuclear forces, Radioactive Decay (Alpha, Beta, Gamma Decays), Nuclear reactions
8. **Elementary particles:** Interactions and particles, Leptons, Hadrons, Matter and Anti-matter, Elementary particle quantum numbers, Quarks, The Higgs Boson

Course Learning Outcome (CO)		Teaching Strategies	Assessment Strategies
CO1	**Explain** and apply principles of modern physics	L, D, QA	T, ASG, F
CO2	**Analyze** atomic and nuclear phenomena	L, D, QA	T, ASG, F
CO3	**Understand** particle physics fundamentals.	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes (CO)	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									2
CO2	3									2
CO3	3									2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

1. Concepts of modern physics, Arthur Beiser, McGraw-Hill International
2. Semat, H.; Introduction to Atomic and Nuclear Physics.
3. Weidner, R.T. and Sells R.L.; Elementary Modern Physics; Allyn and Bacon Inc.
4. H. D Young, R A Freedman, University Physics with Modern Physics, Pearson, 14th Ed., 2015

Course Code	ECO 201		Course Type	Theory		Level 2 Term I
Course Name	**Mathematical Economics**				**Credit Hr**	**2.0**
Prerequisite	**Differential Calculus**				**Contact Hr**	**2.0**
Rationale	This course will provide the fundamental knowledge of economics, many economic models and mathematical relations in market strategy etc.					

Learning Objective

The learning objectives of this course are to

- Introduce economic concepts, demand-supply analysis, elasticity, consumer behavior, and production theory.
- Study market structures, macroeconomic indicators, and investment decisions.
- Learn how to interpret economic models, diagrams and tables and use them to analyze di erent economic phenomena
- Illustrate how government policies microeconomic choices and macroeconomic upshots.

Contents

1. **Basic Concepts**: Definition and scope of economics, basic economic problems and their sources, choice, tradeoff and opportunity cost, economic systems - command economy, market economy and mixed economy; microeconomics and macroeconomics.
2. **Demand and supply:** definition, factors influencing them, demand and supply schedules & curves, law of demand, market demand and market supply, movements along and shifts in demand curve, shifts in supply curve, market equilibrium: price theory in the market, its implications, effects of a shift in demand or supply on equilibrium position, special cases.
3. **Elasticity**: Elasticity of demand and supply - concepts, definitions and problems associated with calculations, price elasticity, income elasticity and cross elasticity of demand, consumer's expenditure pattern and total revenue in relation to elasticity of demand, computation of elasticity from demand function and family budget data.
4. **Consumer Behavior and Utility**: basic concepts, ordinal and cardinal measurements of utility, consumer's preference ordering. Total utility and marginal utility, relationship between them, law of diminishing marginal utility, Equi marginal principle. Substitution and income effects and the law of demand. Slutsky equation, computation of elasticity from Slutsky equation. consumer's surplus and its applications.
5. **The Indifference Curve Analysis**: Indifference curve analysis as an improvement over Marshallian analysis, consumer's indifference curve: properties, rate of commodity substitution. The equilibriums position of tangency: consumer's equilibrium, effects of income and price change on equilibrium.
6. **Production and Cost**: Concept of a Production Function, factors of production-fixed and variable, Total, Average and Marginal Product, the Law of Diminishing Returns, Returns to

Scale; Costs: Fixed and Variable Cost, Total, Average and Marginal cost, Short Run and Long Run Costs.

7. **Decision of firm and Revenue**: Isoquants, Isocosts and the Least Cost Combination, Total, Average and Marginal Revenue; Equating Marginal Revenue with Marginal Cost, Market Structure, Perfectly Competitive Markets, Monopoly, Oligopoly (Game Theory), Monopolistic Competition.

8. **Macroeconomics**: key concept of macroeconomics: GDP, GNP, Real vs. Nominal GDP, Price Deflators; Saving, consumption, investment; National income analysis; Inflation, Unemployment; Fiscal and monetary policy, Investment Decision, Cost benefit analysis, NPV, IRR, Payback period.

Course Learning Outcome (CO)		Teaching Strategies	Assessment Strategies
CO1	**Analyze** economic models mathematically	L, D, QA, CS	T, ASG, F
CO2	**Interpret** market behaviors and consumer choices	L, D, QA	T, ASG, F
CO3	**Apply** mathematical tools to macroeconomic and investment problems	L, D, QA, CS	T, ASG, F
CO4	**Understand** fiscal and monetary policies of Bangladesh and how they are related to relevant SDG goals.	L, D, QA,	T, ASG, F
CO5	**Demonstrate** the skills to apply and explain macroeconomic and microeconomic principles to analyses different individual, firm or state-level economic issues	L, D, QA, CS	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes	Program Learning Outcomes (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3				3			2	3
CO2	3	3							2	
CO3	3	3	3		3	2			2	
CO4		3	3					2	2	
CO5	3	3	3		3				2	3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
1.	Samuelson, P. A. and W. D. Nordhaus (2004). Economics, 18th Edition, McGraw-Hill/Irwin.
2.	Pindyck, R. S. and D. L. Rubinfeld (2012). Microeconomics, 8th Edition, Pearson Education.
3.	Mankiw, G. N. (2012). Macroeconomics, 8h Edition, Worth Publishers, Inc.

Course Code	**MATH 250**		**Course Type**	**Lab**		**Level 2 Term I**	
Course Name	**Math Lab III (MATLAB: Numerical Analysis I)**					**Credit Hr**	**1.5**
Prerequisite	**Numerical Analysis I**					**Contact Hr**	**3**
Rationale	This course will provide the knowledge of programming skills for solving many numerical problems.						

Learning Objective

The learning objectives of this course are to

- Use programming operations to calculate solutions
- Determine better and more accurate solutions
- Perform and evaluate algebraic and trigonometric operations using built-in functions
- Assign and manage variables
- Manipulate vectors and matrices, use matrix indexing, and determine matrix dimensions
- Generate linearly spaced vectors
- Create and execute a script
- Create and evaluate x-y plots and subplots suitable for technical presentation
- Create, test, and execute user-defined functions and sub-functions
- Create function input validation
- Distinguish between the different MATLAB ‘data types’
- Create and manipulate Structures and Arrays
- Perform and evaluate relational and logical operations
- Load, analyze, and manipulate images
- Obtain and utilize user input
- Manage and format text output
- Import and export numeric data using other filetypes (e.g. .csv, .xls, and .txt)
- Perform polynomial curve-fitting, general curve fitting, and interpolation
- Perform numeric and symbolic differentiation and integration
- Solve non-linear systems of equations
- Solve numeric ODE’s
- Build a block diagram in Simulink to perform an operation
- Perform numerical optimization
- Analyze Signals

Contents

1. **Problems Solving**: Problems in the courses of Second Year BS Honours will be solved using Computer Algebra System (CAS) MATLAB.
2. **Lab Assessment**: Take Class Test.
3. **Lab Assignments**: Course instructors will provide a list of Lab assignments.

Course Learning Outcome (CO)		Teaching Strategies	Assessment Strategies
CO1	**Understanding** MATLAB	L, D, QA, CS	T, ASG, F
CO2	**Apply** programming language in higher study	L, D, QA, CS	T, ASG, F
CO3	**Solve** real life problems using programming language	L, D, QA, CS	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcome	Program Learning Outcomes (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	3	2	2	1	2	3
CO2		3	3	3	3					3
CO3		3	3	3	3	3			3	3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

1. MATLAB for Engineers, 6th edition, Holly Moore, Salt Lake Community College, Pearson Education Inc, 2022
2. Introduction to Scientific Computing by Charles F. Van Loan
3. Numerical Computing with Matlab" by Cleve Moler
4. MATLAB Handbook with Applications to Mathematics, Science, Engineering, and Finance by Jose Miguel David Baez-Lopez, David Alfredo Baez Villegas, Copyright 2019
5. Mathematical Modeling and Simulation with MATLAB, Sheldon Lee, La Crosse, WI Megan Buzby, Juneau, AK, Copyright Year: 2021
6. Advanced Engineering Mathematics with MATLAB, 5th edition, Dean G. Duffy, USNA, CRC Press, Inc., 2021

Course Code : MATH 251 Course Name : Math Lab VI: (Introduction to Data Science)	Credit Hour: 1.50 Contact Hour: 3.00
Course Contents	
As per the theoretical course DS 201	

Course Code	MATH 252		Course Type	Lab		Level 2 Term I	
Course Title	**Math Lab VII: Python for Statistics and Data Science**					**Credit Hr**	**1.5**
Prerequisite						**Contact Hr**	**3**
Rationale	This course aims to provide students with practical experience in creating and analyzing simulated models, fostering a comprehensive understanding of the application of simulation techniques in diverse fields for decision-making, analysis, and problem-solving purposes.						

Course Objective

- To give students a working knowledge of Python programming.
- To teach programming fundamentals, basic data structures, writing functions, and importing and exporting data in different formats.

Contents

1. **Fundamentals of Python:** Installing Python, Anaconda, Spyder, Jupyter Notebook, Colab; Python Editors, Essential Python Libraries.
2. **Basic Python Programming:** the basic syntax of a Python program, Python data types; expressions and variables; lists, tuples, sets, and dictionaries; writing conditions, loops, and functions.
3. **NumPy Basics - Arrays and Vectorized Computation:** The NumPy ndarray-A Multidimensional Array Object-Creating ndarrays and Data Types for ndarrays, Basic **Indexing and Slicing, Universal Functions**: Fast Element-wise Array Functions, Data Processing Using Arrays, File Input and Output with Arrays, Linear Algebra.
4. **Getting Started with pandas:** Introduction to pandas Data Structures, Essential Functionality, Summarizing and Computing Descriptive Statistics, Handling Missing Data, Hierarchical Indexing, Other pandas Topics-Integer Indexing and Panel Data.
5. **Data Loading, Storage, and File Formats:** Reading and Writing Data in Text Format, Binary Data Formats, Interacting with HTML and Web APIs, Interacting with Databases-Storing and Loading Data in Mongo DB.
6. **Data Wrangling- Clean, Transform, Merge, Reshape:** Combining and Merging Data Sets, Reshaping and Pivoting, Data Transformation, String Manipulation
7. **Plotting and Visualization:** A Brief matplotlib API Primer, Plotting Functions in pandas, **Plotting Maps:** Visualizing Haiti Earthquake Crisis Data, Python Visualization Tool Ecosystem

8. **Data Aggregation and Group Operations:** Group By Mechanics, Data Aggregation, Group-wise Operations and Transformations, Pivot Tables and Cross-Tabulation
9. **Time Series:** Date and Time Data Types and Tools, Time Series Basics, Date Ranges, Frequencies, and Shifting, Time Zone Handling, Periods and Period Arithmetic, Resampling and Frequency Conversion, Time Series Plotting, Moving Window Functions

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Develop** a comprehensive understanding of various data structures, along with the proficiency to implement efficient data management techniques and create effective visual representations of data using Python, enabling them to analyze and communicate complex information for diverse applications.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2			3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. McKinney W. (2022). Python for data analysis: Data wrangling with Pandas, NumPy, and Jupyter, 3rd edition. OReilly. 2. VanderPlas J. (2016). Python data science handbook: Essential tools for working with data. OReilly. Reference Books 1. Grus, J. (2019). Data science from scratch: First principles with python. OReilly.

Course Code	**MATH 203**		**Course Type**	**Core (theory)**		**Level 2 Term II**	
Course Name	**Real Analysis**					**Credit Hr**	**3.0**
Prerequisite	**Calculus**					**Contact Hr**	**3.0**
Rationale	This course is a continuation of the elementary analysis of functions of single real variables to the elementary analysis of functions of several variables. To facilitate the analysis, the required topological ideas of metric spaces. Their elementary properties and the basics of functions defined on a metric space are the objects of study at the beginning of the course. The course provides the main background needed in modern Advanced Mathematical Analysis.						

Learning Objective

The learning objectives of this course are to

- Elaborate introduction of calculus, alluring complex structure of the real number set, fineness of convergence of limit and series, stimulating paradoxical mirages in infinite.
- Expose the students to a level of understanding the short comings of informal treatment in dealing with objects in calculus
- Along with the study of the properties of functions defined on a metric space the prime objectives of the course are the study of the properties of Differentiation and Integration of functions of several real variables.
- The study of the properties of limit, Continuity, Differentiability, Chain rule of differentiation, Jacobian, implicit and inverse function theorems, Riemann integrals of functions of several variables, Fubini's theorem and change of variables, etc.

Contents

1. **Real Numbers:** Bounded sets of real numbers. Supremum and infimum. The completeness axiom and its consequences. Dedekind's theorems. Cluster (limit) points; Bolzano-Weierstrass theorem.
2. **Sequence and Series:** Infinite sequences. Convergence. Theorems on limits. Monotone sequences, subsequences. Cauchy's general principle of convergence. Cauchy's first and second theorems on limits, Infinite series of real numbers, convergence and absolute convergence. Tests for convergence; Gauss's tests (simplified form). Alternating series (Leibnitz's test). Product of infinite series. Pointwise and Uniform convergence. Interchangeability of limiting processes. Power series. Differentiation and integration of power series. Abel's continuity theorem.
3. **Continuity:** Properties of continuous functions. Intermediate value theorem.
4. **Differentiation:** Derivatives and its properties, Mean Value theorem, Taylor's theorem, Darboux's theorem. Definition and properties of derivative a function of several variables, implicit, and inverse function theorems with some applications.
5. **Integration:** The Riemann Stieltjes integral; definitions via Riemann's sums and Darboux's sums. Darboux's theorem. Necessary and sufficient conditions for integrability. Classes of integrable functions. Fundamental theorems of calculus. Definition and properties of the integral of functions of several variables, Fubini's theorem, and change of variables.
6. **Metric Space:** Definition and examples. Open and closed sets, Equivalent metrics, Cauchy sequence and completeness, compactness.

Course Learning Outcomes (CO)		Teaching Strategies	Assessment Strategies
CO1	**Understand** the concept of limit, ideas of convergence of real	L, D, QA	T, ASG, F

	sequence and series		
CO2	**Test** the convergence of series	L, D, QA	T, ASG, F
CO3	**Learn** elementary analysis of functions of several variables. Limit, continuity, differentiability of a function, for example	L, D, QA	T, ASG, F
CO4	**Apply** partial derivatives in optimization of a function. And learn applications of inverse and implicit function theorem	L, D, QA	T, ASG, F
CO5	**Evaluate** multiple integrals using Fubini's theorem.	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcome	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									
CO2	3									3
CO3	3		3							3
CO4	3	2	3		2		2			3
CO5	3		3							3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

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. Fatema Chowdhury and Munibur Rahman Chowdhury, Essentials of Real Analysis.

Course Code	**MATH 204**	**Course Type**	**Core (theory)**	**Level 2 Term II**	
Course Name	**Discrete Mathematics**			**Credit Hr**	**3.0**
Prerequisite	**N/A**			**Contact Hr**	**3.0**
Rationale	Discrete mathematics deals with fundamental ideas of reasoning, counting, recurrence relations and graph theory. Understanding of this course will help students to learn the bridging of mathematics with computer science. After completion of this course, students will get some useful and applicable ideas on mathematical logic, recurrence relations, generating functions, different graphs. It will enable them to use algorithms on graphs to solve some well-known problems.				

Learning Objective

The learning objectives of this course are to

- To give knowledge on some basic mathematical concepts in discrete mathematics and their applications.
- To provide brief knowledge of use of logical inferences, different methods of proofs.
- To introduce elementary graph theory and some algorithms of computational mathematics.
- Students will learn about the bridging of discrete mathematics with computer science.

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.

Course Learning Outcomes (CO)		Teaching Strategies	Assessment Strategies
CO1	**Analyze** logical propositions via truth tables.	L, D, QA	T, ASG, F
CO2	**Prove** mathematical theorems using mathematical induction.	L, D, QA	T, ASG, F
CO3	**Understand** sets and perform operations and algebra on sets	L, D, QA	T, ASG, F
CO4	**Determine** properties of relations, identify equivalence and partial order relations, sketch relations	L, D, QA	T, ASG, F
CO5	**Identify** functions and determine their properties.	L, D, QA	T, ASG, F
CO6	**Define** graphs, digraphs and trees, and identify their main properties with shortest path	L, D, QA	T, ASG, F

	algorithm		
CO7	**Learn** combinatorics with recurrence relations.	L, D, QA	T, ASG, F
(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)			

CO-PO mapping

Course Outcome	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3							3
CO2	3		3							
CO3	3		3							3
CO4	3	2	3							3
CO5	3		3							
CO6	3	2	3				2			2
CO7	3	3	3							3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

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.

Course Code	**MATH 205**		**Course Type**	**Core (theory)**		**Level 2 Term II**	
Course Name	**Multivariate Calculus**					**Credit Hr**	**3.0**
Prerequisite	**Differential and Integral Calculus, Analytical Geometry and Vector Analysis**					**Contact Hr**	**3.0**
Rationale	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 Objective

The learning objectives of this course are to

- Fluency with vector operations and the various ways to describe vector valued functions.
- An understanding of a parametric curve described by a position vector; the ability to find parametric equations of a curve and to compute its velocity and acceleration vectors.
- A comprehensive understanding of the gradient, including its relationship to level curves (or surfaces), directional derivatives, and linear approximation.
- The ability to compute derivatives using the chain rule or total differentials.
- The ability to set up and solve optimization problems involving several variables, with or without constraints.
- 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.
- The ability to set up and compute multiple integrals in rectangular, polar, cylindrical and spherical coordinates.
- The ability to change variables in multiple integrals.
- An understanding of the major theorems (Green's, Stokes', Gauss') of the course and of some physical applications of these theorems.

Contents

Part A: Differential Calculus

1. **Vector-valued functions:** Introduction to Vector-Valued Functions, Calculus 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.

Part B: Integral Calculus

1. **Double Integrals:** Double Integrals over Nonrectangular Regions, Double Integrals in Polar Coordinates, Surface Area; Parametric Surfaces and Applications of Double Integrals.
2. **Triple integrals:** Volume as a triple integral, Triple Integrals in Cylindrical and Spherical Coordinates, Centers of Gravity Using Multiple Integrals and Applications of Triple Integrals, Change of Variables in Multiple Integrals; Jacobians.
3. **Topics in vector calculus:** Vector Fields, Gradient, Divergence, curl and their physical meanings Line Integrals, Green’s Theorem, Surface Integrals, The Divergence Theorem, Stokes’ Theorem, Applications of Surface Integrals; Flux.

Course Learning Outcome (CO)	Teaching Strategies	Assessment Strategies

CO1	**Sketch** the graphs of functions of double variables, especially quadric surfaces.	L, D, QA	T, ASG, F
CO2	**Gain** knowledge on the basic analysis of functions of several variables (limit, continuity, partial differentiation, and differentiability)	L, D, QA	T, ASG, F
CO3	**Compute** the dynamical properties of vector valued functions and their geometric properties like length, curvature, and torsion	L, D, QA	T, ASG, F
CO4	**Change** the parameter for a parametric curve to a different parameter and investigate issues associated with changes of parameter	L, D, QA	T, ASG, F
CO5	**Compute** the extreme values of a function/model of several variables defined on compact domain using the ideas of partial derivatives	L, D, QA	T, ASG, F
CO6	**Compute** integrals of several variable functions to compute area and volume of irregular shapes bounded by the graphs of functions and interprets them in the context of different branches of natural sciences.	L, D, QA, CS	T, ASG, F
CO7	**Evaluate** triple integrals using Cartesian, cylindrical and spherical coordinate system and will be able to change a problem from one coordinate system to another	L, D, QA	T, ASG, F
CO8	**Calculate** the Jacobian of a function of multiple variables and will be able to evaluate double and triple integrals applying changes of variables	L, D, QA	T, ASG, F
CO9	**Compute** the integral of the tangential components of a	L, D, QA	T, ASG, F

	vector field along a curve especially in ℝ2 and ℝ3, to compute the flux density, flux across a closed surface, circulation density, and circulation of a vector field along the boundary of a surface for vector fields		

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcome	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		2							
CO2	3		2							
CO3	3		2							
CO4	3		2							
CO5	3		2							
CO6	3		2	3						2
CO7	3		2							
CO8	3		2							
CO9	3		2							

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

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

Course Code	**DS 202**		**Course Type**	**Core (theory)**		**Level 2 Term II**	
Course Name	**Database Management System**					**Credit Hr**	**2.0**
Prerequisite	**Introduction to data science**					**Contact Hr**	**2.0**
Rationale	Database Management Systems (DBMS) are vital components of modern information systems. Database applications are pervasive and range in size from small in-memory databases to terra bytes or even larger in various applications domains. This course introduces database design and creation using a DBMS product. Students should be able to design and implement normalized database structures by creating simple database tables, queries, reports, and forms.						

Learning Objective

The learning objectives of this course are to

- To describe the fundamental elements of relational database management systems.
- To explain the basic concepts of relational data model, entity relationship model,
- To know about relational database design, relational algebra, and SQL.
- To design ER-models to represent simple database application scenarios.
- To improve the database design by normalization.
- To be familiar with basic database storage structures and access techniques.

Contents

1. **Introduction:** Database, Purpose of Database, Database Languages, Database Design, Database.

2. **Relational Database:** Structure of Relational Database, Database Schema, Schema Diagrams, Relational Query Languages.

3. **Introductions to SQL:** Overview of the SQL Query Language, SQL Data Definition, Basic Structure of SQL Queries, Set Operations, Joint Expressions, Integrity Constraints, SQL Data Types and Schemas.

4. **Advanced SQL:** Accessing SQL from a Programming Language. Functions and Procedures, Triggers, and Recursive Queries.

5. **Database Design Using the E-R Model:** Overview of the Design Process, ER Model, Complex Attributes, Mapping Cardinalities, Primary Key, Removing Redundant Attributes in Entity Sets, Extended ER Features.

6. **Relational Database Design:** Features of Good Relational Designs, Decomposition Using Functional Dependencies, Normal Forms, Functional Dependency Theory, Algorithms for Decomposition, More Normal Forms, Database-Design Process

7. **Complex Data Types:** Semi-structured Data, Object Orientation, Textual Data, Spatial Data.

8. **Application Development:** Application Programs and User Interfaces, Web Fundamentals, Serlets, Alternative Server-Slide Frameworks, Application Architectures, Application Performance and Securities.

Course Learning Outcome (CO)		Teaching Strategies	Assessment Strategies
CO1	**Describe** the fundamental elements of a relational database management system (RDBMS).	L, D, QA	T, ASG, F
CO2	**Explain** the basic concepts of the relational data model, entity-relationship (ER) model, relational database design, relational algebra, and SQL.	L, D, QA	T, ASG, F

CO3	**Design** ER-models to represent simple database application scenarios.	L, D, QA, CS	T, ASG, F
CO4	**Apply** normalization techniques to improve database design.	L, D, QA, CS	T, ASG, F
CO5	**Identify** and describe basic database storage structures and access techniques.	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3		3	3		3				2
CO2	3	2	3	3		3			2	3
CO3	3		3	3	2			2	3	3
CO4	3	3	3	3		3			3	3
CO5	3	3		3	2	3				3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

1. Silberschatz A., Korth H. F., and Sudarshan S. (2022). Database System Concepts, 7th Edition, McGraw-Hill Education.
2. Ramakrishnan R. and Gehrke J. (2008). Database Management Systems, 3rd Edition, New York: McGraw-Hill
3. Hernandez, Michael James. (2013). Database design for mere mortals: a hands-on guide to relational database design. Pearson Education.

Course Code	**GERM 201**		**Course Type**	**Theory**		**Level 2 Term II**	
Course Name	**Research Methodology**					**Credit Hr**	**2.0**
Prerequisite	**N/A**					**Contact Hr**	**2.0**
Rationale	The research methodology course is fundamental to teaching students the theoretical and practical skills required to conduct research in various elds. The course introduces students to the fundamental principles of research design, data collection, data analysis, and report writing. It will cover a range of research approaches, including quantitative, qualitative, and mixed methods.						

Learning Objective

The learning objectives of this course are to

- To provide students with hands-on experience in designing and conducting research studies, particularly to develop student's knowledge
- To understand of how to formulate research questions, develop hypotheses, choose appropriate research methods, and collect and analyze data and write a report for scientific publication.
- To provide students with the knowledge and skills necessary to conduct valid, reliable, and ethical research

Contents

1. **Foundations of Research**: Meaning, concept, motivation, and objectives of the research; Types of research descriptive vs. analytical, applied vs. fundamental, quantitative vs. qualitative, conceptual vs. empirical, concept of the applied and basic research process. Criteria and steps of good research. Language of research: Variables and attributes; concepts and constructs; theory and models; proposition and hypotheses: relational terminologies: independent and dependent variables, intervening variables, extraneous variables, moderating variables confounder variables.
2. **Problem Identification and Formulation:** Defining and formulating the research problem, the importance of literature review in defining a problem, identifying gap areas from literature and research database, research question, and formulation of research hypothesis.
3. **Research Design and Methods**: Research methods vs. methodology; features of a good research design, concept, types, and uses of exploratory, descriptive, and experimental research designs. Qualitative and quantitative research approach, mixed methods design. Concept of measurement, problems in measurement in research- validity, and reliability. Sampling: use of sampling techniques in research design; brief review of sampling and sample size determination.
4. **Techniques of data collection**: Qualitative approaches focus group discussion (FGD), in depth interview (IDI), key informant interview (KII) and their guidelines and checklist; concepts of ethnography, content analysis, and discourse analysis, Quantitative approach the concept of a survey, mode of a survey face-to-face interview, telephone interview, online/email, etc. Survey tools Questionnaire, schedule, structured, semi-structured, open ended, and close-ended questions. Data collection apps: survey CTO, Kobo Toolbox, etc.; Field Implementation a pilot study, monitoring the data collection, quality control, and data validity.
5. **Monitoring and Evaluation (M&E)**: Concept of monitoring and evaluation, objectives of M&E; performance monitoring versus performance evaluation. Key steps of M&E; M&E design: Baseline, ongoing, and end-line evaluation; evaluation criteria relevance, effectiveness, efficiency, impact, and sustainability.
6. **Human resources and budget in research**: allocation of human resources, preparing a budget for research work.
7. **Data Analysis**: Steps of data preparation and analysis; Guidelines for using secondary data for research: when, how, and why;
8. **Dissemination of Research findings**: Different Steps in Writing Report, Layout of the Research Report; Effective presentation, preparing articles for peer review.
9. **Research Ethics and Scholarly Publishing**: Ethics-ethical issues, ethical committees (human and animal); IPR- intellectual property rights and patent law, commercialization, copyright, royalty; scholarly publishing concept and research paper design, citation, acknowledgment, plagiarism, reproducibility, and accountability.
10. **Experiential Learning Project**: Group project and field work writing a research proposal, developing and implementing field data collection, data analysis, and report writing and presentation.

Course Learning Outcome (CO)		Teaching Strategies	Assessment Strategies
CO1	**Formulate** research questions, develop hypotheses, choose appropriate research methods, and collect and analyze data	L, D, QA	T, ASG, F
CO2	**Learn** about the various data collection techniques, such as surveys, interviews, observations, and statistical techniques for analyzing data	L, D, QA	T, ASG, F
CO3	**Apply** their knowledge through practical exercises	L, D, QA, CS	T, ASG, F
CO4	**Become** competent in planning, conducting, evaluating, and presenting a research project	L, D, QA	T, ASG, F
CO5	**Learn** ethics-ethical issues, citation, acknowledgment, plagiarism, reproducibility, and accountability	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG-Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	1		1	3	3	1	2			3
CO2	1		1	3	3	1	1			3
CO3				3	1		2	3	2	2
CO4	1		1	3	3	1	3			2
CO5		2		2	3	1	3	3	2	3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

1. Kothari CR and Garg G (2019). Research Methodology: Methods & Techniques. New Age.
2. Gertler PJ, Martinez S, Premand P, Rawlings LB and Vermeersch CMJ (2017) . Impact Evaluation in Practice, 2nd edition. World Bank Group, Washinngton DC.
3. Coninck JD, Chaturvedi K, Haagsma B, Gri oen H and Glas MVD (2008). Planning, monitoring and evaluation in development organizations: sharing training and facilita tion experiences. Sage.

Course Code : MATH 253 Course Name : Math Lab VIII: (Database Management System)	Credit Hour: 1.50 Contact Hour: 3.00
Course Contents	
As per the theoretical course DS 202 (Without SQL part)	

Course Code : MATH 254 Course Name : Math Lab IX: (SQL)	Credit Hour: 1.50 Contact Hour: 3.00
Course Contents	
As per the theoretical course DS 202 (Only SQL part)	

Course Code	**MATH 255**		**Course Type**	**Lab (Theory)**		**Level 2 Term II**	
Course Title	**Math Lab X: R for Statistics and Data Science**					**Credit Hr**	**1.5**
Prerequisite	**None**					**Contact Hr**	**3**
Rationale	This course is designed to equip students with the essential skills to efficiently manage and visualize complex data sets in R, enabling them to analyze and present data effectively for various research and analytical purposes.						

Course Objective

- To give students a working knowledge of R programming.
- To teach programming fundamentals, basic data structures, writing functions, and importing and exporting data in different formats.
- To equip students with the ability to apply R programming for effective data manipulation, visualization, and analysis.
- To develop skills in control structures (loops, conditionals) to implement precise logic and flow control in R scripts, enhancing code efficiency.
- To learn how to write and use R functions to create modular and reusable code that facilitates efficient processes for data analysis.

Contents

1. **Introduction to R:** History and overview of R programming language, R objects, data structure (e.g. lists, data frames, etc.), reading and writing data les, sub setting R objects, vectorized operations, control structures, functions (both in-built and custom), simulation, and calling C function from R.
2. **Exploratory data analysis with R:** managing data with different tidy verse packages (e.g. dplyr, ggplot2, etc.), exploratory graphs (grammar of graphics), and generating summary statistics. Application of R in optimizing non-linear functions using Newton-Raphson iterative procedure, numerical integration and differentiation.

Course Learning Outcomes (CO)		**Teaching Strategy**	**Assessment Methods**
CO1	**Develop** a comprehensive understanding of various data structures, along with the proficiency to implement efficient data management techniques and create effective visual representations of data using R, enabling them to analyze and communicate complex information for diverse applications.	L, D, QA	T, ASG, F

(L– Lecture, D– Discussion, QA– Question & Answer Session, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2			3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** Wickham H and Grolemund G (2017). R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. OReilly. **2.** Wickham H (2019). Advanced R, Second Edition. Chapman & Hall/CRC.

Course Code	**MATH 299**	**Course Type**	**Oral**	**Level 2 Term II**
Course Name	**Presentation on Modern Trends in Mathematics and Data Science**		**Credit Hr**	**1.0**

Learning Objective

The learning objectives of this course are to Oral assessment of second-year course knowledge and applications.

Contents

Presentation on any topic (or selected by academic committee) taught in the Second Year.

Course Learning Outcome (CO)

Demonstrate comprehensive understanding of second-year subjects.

Course Code	MATH 301		Course Type	Core (Theory)		Level 3 Term I	
Course Title	Complex Analysis					Credit Hr	3
Prerequisite	Differential and Integral Calculus, Multivariate Calculus					Contact Hr	3
Rationale	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.						

Course Objective

- To develop the basic ideas complex numbers and functions.
- To learn the ideas of limit, continuity and differentiability of complex functions, theorems related to differentiation of complex function.
- Understanding the Harmonic function, Analytic function and Cauchy-Riemann equation.
- Learning the basic properties of integration of complex functions, theorems on complex integration and use of these theorems to solving mathematical problems.
- Understanding the ideas of Taylor and Laurent series and the singularities.
- Understanding the basics of Conformal mapping and Bilinear transformation

Contents

Complex Plane
Metric properties and geometry of the complex plane. The point at infinity. Stereographic projection.

Functions of a Complex Variable
Limit, continuity and differentiability of a complex function. Analytic functions and their properties. Harmonic functions.

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.

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.

Bilinear Transformations and Mappings
Basic mapping. Linear fractional transformations. Other mappings. Conformal mappings.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain the structure, geometry, and metric properties of the complex plane including stereographic projection.	L, D, QA	T, Q, ASG, F

CO2	Analyze complex functions in terms of limit, continuity, differentiability, analyticity, and harmonicity.	L, D, QA	T, Q, ASG, F
CO3	Evaluate complex integrals using Cauchy's theorem, Cauchy integral formula, and related major results.	L, D, QA	T, Q, ASG, F
CO4	Identify singularities, compute residues, and evaluate integrals via contour integration and series expansions.	L, D, CS, QA	T, Q, ASG, F
CO5	Apply bilinear transformations and conformal mappings to solve mapping problems in the complex plane.	L, D, CS, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	2							
CO2	3	3	3							
CO3	3	3	3		2					
CO4	3	3	3		2					
CO5	3	3	2		2					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	8. R.V. Churchill & J.W. Brown, Complex Variables and Applications. 9. L. Penniri, Elements of Complex Variables. 10. L.V. Ahlfors, Complex Analysis, McGraw-Hill 11. D G Zill, Complex Variables. 12. Murray R. Spigel, Complex Variables, Schaums Outline Series.
Supplementary Readings	1. Real and Complex Analysis – Walter Rudin, McGraw-Hill. 2. The Elements of Complex Analysis – B. Choudhary, Wiley 3. Elementary Linear Algebra Application Version- Howard Anton & Chris Rorres
Others	-

Course Code	MATH 302		Course Type	Core (Theory)		Level 3 Term I	
Course Title	**Fundamentals of Topology**					**Credit Hr**	**3**
Prerequisite	**Real Analysis**					**Contact Hr**	**3**
Rationale	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.						

Course Objective

- 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

Contents

Topological Spaces
Definitions and examples (discrete, indiscrete, cofinite, cocountable topologies). Metric topology. Cluster point of a set. Neighbourhood system. Base and subbase. Subspace. Topological properties.

Continuity
Continuity, Sequential continuity, Uniform continuity, Homeomorphisms.

Separation Axioms
Properties of T_0 , T_1 , T_2, T_3 , T_4 spaces. Some related theorems. Completely regular spaces. Completely normal spaces.

Countability of Topological Spaces
First and second countable spaces. Separable space. Lindelof 's theorems.

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.

Connectedness
Connected spaces, totally disconnected spaces, components of space, locally and path-wise connected spaces.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Distinguish among open and closed sets on different topological spaces.	L, D, QA	T, Q, ASG, F

CO2	Identify precisely when a collection of subsets of a given set equipped with a topology forms a topological space	L, D, QA	T, Q, ASG, F
CO3	Construct maps between topological spaces to understand when two topological spaces are homeomorphic	L, D, QA	T, Q, ASG, F
CO4	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	L, D, CS, QA	T, Q, ASG, F
CO5	Determine that a given point in a topological space is either a limit point or not for a given subset of a topological space.	L, D, CS, QA	T, Q, ASG, F
CO6	Apply and use fixed point theorems to understand modern day applications apply theoretical concepts in topology to understand real world applications.	L, D, CS, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	2							
CO2	3	2	3		2					
CO3	3	3	3		2					
CO4	3	3	3		3					
CO5	3	3	3		2					
CO6	2	2	3		3				2	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	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. J. Munkres, Topology, Prentice Hall, Inc
Supplementary Readings	1. Colin, A., and Robert, F. (2007). Introduction to Topology. Pearson, India
Others	-

Course Code	MATH 303		Course Type	Core (Theory)		Level 3 Term I
Course Title	**Mathematical Methods**				**Credit Hr**	**3**
Prerequisite	**None**				**Contact Hr**	**3**
Rationale	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.					

Course Objective

- To understand the concept of Fourier series, its real form and complex form and enhance the real-life problem-solving skill.
- To learn the Laplace transform, Inverse Laplace transform of various functions and its application.
- To learn the Fourier transform of various functions and its application to solve real life boundary value problems and integral equation.
- To learn discrete Fourier transform (DFT) and fast Fourier transform (FFT) and its applications
- 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

Contents

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.

Laplace Transforms

Basic definitions and properties, Existence theorem. Transforms of derivatives. Relations involving integrals. Laplace transforms of periodic functions. Convolution theorem (Transforms of convolutions). Inverse transform. Calculation of inverse transforms. Use of contour integration. Applications to boundary differential equations.

Fourier Transforms

Fourier transforms. Inversion theorem. Sine and cosine transform. Transform of derivatives, Parseval's theorem, Uncertainty principle, Transforms of rational function. Convolution theorem, circular convolutions, discrete Fourier Transform, Fast Fourier Transform, Radon transform, Applications to boundary value problems and integral equation.

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.

Bessel Functions
Solution of Bessel's Equation, Generating function Recurrence relation, values of Bessel function, orthogonality, Modified Bessel function.

Legendre Polynomials
Solution of Legendre equation, Generating function, Recurrence relation, Rodrigues' formula and orthogonality of Legendre polynomials.

Leguerre Polynomials
Solution of Leguerre's equations, Integral and recurrence formula, Differential forms, orthogonality.

Hermite Polynomials
Solution of Hermite equation, Integral and recurrence formula, orthogonality.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Introduce the basic concept of the Fourier series, Fourier Transform, Laplace Transform, Legendre's differential equation, Bessel's differential equation, Laguerre's differential equation, Hermite's differential equation and their series solution and discuss their various properties	L, D, QA	T, Q, ASG, F
CO2	Represent a real signal into different types of orthogonal functions.	L, D, QA	T, Q, ASG, F
CO3	Analyze a non-periodic function by Fourier integral.	L, D, QA	T, Q, ASG, F
CO4	Apply the Fourier series, Fourier transform and Laplace transform in the different fields particularly in the signals and systems and in the solution of ODE and PDE's.	L, D, CS, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	2	2	2		2					
CO2	3	2								2
CO3	3	3	2		2				2	2
CO4	3	3			3					2
CO5	3	3	3		2					
CO6	2	2	3		3				2	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)	
Learning Materials	
Recommended Readings	1. R.V. Churchill & J. W. Brown, Fourier Series and Boundary value problems. 2. E. Kreuszig, Advanced Engineering Mathematics. 3. M. R. Spiegel, Laplace Transforms, Schaum's Outline Series. 4. Boyce, Di Prima, Elementary Differential Equations. 5. Jeffreys, Methods of Mathematical Physics (3rd Edition) 6. Lokenath Debnath & Dambaru Bhatta, Integral Transforms and Their Applications (3rd Edition), Chapman and Hall/CRC
Supplementary Readings	1. Hsu, H. P. (1995). Signals and Systems. McGraw-Hill. 2. Osgood, B. G. (2019). Lecture notes for the Fourier Transform and its Applications. AMS
Others	-

Course Code	**MATH 304**		**Course Type**	**Core (Theory)**		**Level 3 Term I**	
Course Title	**Stochastic Calculus**					**Credit Hr**	**3**
Prerequisite	**None**					**Contact Hr**	**3**
Rationale	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. Crucial for students developing into Mathematical Finance, Actuarial Science and stochastic area of Mathematical Biology for further studies. Fundamental differences between classical calculus and stochastic calculus have been explored 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 Objective

- This course will mainly emphasize on the study of stochastic calculus, departing from the deterministic one. It will help understand probability foundations, such as, measure theory concepts (σ −algebra), random variables, stochastic process, conditional expectations, etc.
- Students will obtain a rigorous probabilistic understanding of Brownian motion, Ito calculus, and stochastic differential equations (SDEs).
- Special focus will be given to the numerical solution procedures for SDEs.

Contents
Introduction Sigma algebra, filtration, conditional expectation and structure of stochastic process. **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. **Ito's Formula and Stochastic Calculus** Ito's formula (with intuitive illustrations), stochastic integral and stochastic calculus. **Stochastic Differential Equations (SDEs)** Details of basic SDEs; different numerical schemes (Euler, Milstein etc.) for simulating basic SDEs. **SDEs and Calibration** Calibrating parameters of some basic SDEs using real life (or simulated) data.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Understand the concepts of sigma algebra, expectation with respect to sigma algebra, filtration, Brownian motion, martingale, Ito stochastic integral, etc. with related properties	L, D, QA	T, Q, ASG, F
CO2	Learn Ito's formula and its implications.	L, D, QA	T, Q, ASG, F
CO3	Be able to analytically solve some specific SDEs.	L, D, QA	T, Q, ASG, F
CO4	Learn numerical methods for solving SDEs.	L, D, CS, QA	T, Q, ASG, F
CO5	Get the idea of calibrating parameters for some basic SDEs.	L, D, CS, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	3		3					2
CO2	3	3	3		3					2
CO3	3	3	3		3					2
CO4	2	3	2	3	2					2

CO5	2	3	2	3	3				2	2
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										
Learning Materials										
Recommended Readings	1. Lawrence C. Evans, An introduction to stochastic differential equations, Lecture note, University of California, Berkeley. 2. Ubbo F. Wiersema, Brownian Motion Calculus, John, Wiley & Sons. 3. Fima C. Klebaner, Introduction to Stochastic Calculus with Applications, Imperial College Press. 4. Ovidiu Calin, An Informal Introduction to Stochastic Calculus with Applications, World Scientific. 5. Gregory F. Lawler, Stochastic Calculus: An Introduction with Applications, Lecture note.									
Supplementary Readings										
Others	-									

Course Code	**DS 301**	**Course type**	**Core (theory)**	**Level 3 Term I**	
Course Name	**Introduction to Machine Learning**			**Credit Hr**	**2.0**
Prerequisite	**Introduction to Data Science, Statistics**			**Contact Hr**	**2.0**
Rationale	This course will provide the fundamental knowledge about machine learning, types of various algorithm to predict the pattern of a dataset etc.				

Learning Objective

The learning objectives of this course are to

- Introduce Machine learning which is the fundamental block for Artificial Intelligence (AI).
- Variety of problems, such as prediction, estimation, classification and parameterization that convey formulates link between the human understandings and the automation for machines.
- Introduce statistical learning concepts for supervised and unsupervised learning.
- Study regression, classification, model selection, and regularization techniques.
- Explore tree-based models, boosting, and clustering algorithms.

Contents

1. **An Introduction to Statistics for Machine Learning**: What Is Statistical Learning; Supervised Versus Unsupervised Learning; Regression Versus Classification Problems; Assessing Model Accuracy; Measuring the Quality of Fit; The Bias-Variance Trade-Off; The Classification Setting.
2. **Statistical Learning of Linear Regression**: Assessing the Accuracy of the Model; Multiple Linear Regression; Qualitative Predictors; Extensions of the Linear Model; Potential Problems; The Marketing Plan; Comparison of Linear Regression with K-Nearest Neighbors.

3. **Statistical Learning of Classification:** An Overview of Classification; The Logistic Model; Making Predictions; Multiple Logistic Regression; Linear Discriminant Analysis; Quadratic Discriminant Analysis; A Comparison of Classification Methods.
4. **Statistical Learning from Re-sampling:** Cross Validation; The Validation Set Approach; Leave One-Out Cross-Validation; k-Fold Cross-Validation; Bias-Variance Trade-Off for k-Fold; Cross Validation; Cross-Validation on Classification Problems; The Bootstrap.
5. **Model Selection and Regularization:** Hyperparameter tuning, Subset Selection; Shrinkage Methods; Ridge Regression; The Lasso; Dimension Reduction Methods; Considerations in High Dimensions; High-Dimensional Data; Regression in High Dimensions; Interpreting Results in High Dimensions.
6. **Statistical Learning of Tree-based Models:** The Basics of Decision Trees; Regression Trees; Classification Trees; Trees Versus Linear Models; Advantages and Disadvantages of Trees; Bagging, Random Forests, boosting; Bagging; Random Forests; Boosting.
7. **Boosting Algorithm:** AdaBoost, Gradient, and XG Boosting algorithm.
8. **Statistical Unsupervised Learning:** The Challenge of Unsupervised Learning; Principal Components Analysis; Clustering Methods; K-Means Clustering; Hierarchical Clustering; Practical Issues in Clustering.

Course Learning Outcomes		**Teaching Strategies**	**Assessment Methods**
CO1	**Develop** skills to select and formulate appropriate model for machine training	L, D, QA	T, ASG, F
CO2	**Analyze** general frameworks for data mining and apply them to practical problems	L, D, QA, CS	T, ASG, F
CO3	**Build** and evaluate machine learning models	L, D, QA, CS	T, ASG, F
CO4	**Apply** cross-validation and hyperparameter tuning	L, D, QA, CS	T, ASG, F
CO5	**Implemen**t clustering and dimensionality reduction methods	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping										
Course Outcomes (CO)	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3					3
CO2	3	3	3	3	3		3		3	3
CO3	3	2	3	3		3	3			3
CO4	3	2	3							3
CO5	3	3	3	3	3					3
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials

1. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2021). An Introduction to Statistical Learning with Applications in R. 2nd Edition, New York: Springer.
2. Murphy, K. P. (2023). Probabilistic machine learning: Advanced topics. MIT press.
3. Alpaydin, E. (2020). Introduction to machine learning. MIT press.
4. Hastie, T., Tibshirani, R. and Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. 2nd Edition, New York: Springer.
5. Boehmke, B., and Greenwell, B. M. (2019). Hands-on machine learning with R. Chapman and Hall/CRC.

Course Code	**DS 302**		**Course Type**	**Core (Theory)**		**Level 3 Term I**	
Course Title	**Time Series Analysis and Forecasting**					**Credit Hr**	**2**
Prerequisite	**Mathematical Statistics (STAT 201), Stochastic Calculus (MATH 304)**					**Contact Hr**	**2**
Rationale	This course will provide the fundamental techniques for analyzing data collected sequentially over time. It equips students to model temporal dependencies, identify underlying patterns like trends and seasonality, and build predictive models. The knowledge is essential for making informed decisions and accurate forecasts in fields such as economics, finance, supply chain management, and climate science.						

Course Objective

- To introduce the principles and methods of forecasting.
- To introduce various components of time series and time series models which cater to the real-world
- To help students explore and use the various criteria used for performance evaluation.
- To address both the aspects of descriptive and predictive analytics.

Contents
Introduction Meaning of Time Series, Objectives of Time Series Analysis, Simple Time Series Models, Stationary Models, Autocorrelation Function, Time Series Components **Time Series Decomposition** Estimation and Elimination of Trend and Seasonal Components, Moving Averages, Classical Decomposition, X11 Decomposition, SEATS Decomposition, STL Decomposition, Testing Estimated Noise Sequence. **Stationary Processes** Basic Properties, Linear Processes, ARMA Processes, Properties of Sample Mean and Autocorrelation Function, Forecasting Stationary Time Series, World Decomposition. **ARMA Models** ARMA (P, Q) Process, ACF and PACF of ARMA (P, Q) Process, Forecasting ARMA Process. **Spectral Analysis** Spectral Densities, Periodogram, Time-Invariant Linear Filters, Spectral Density of ARMA Process **Modeling and Forecasting with ARMA Process** Preliminary Estimation, Maximum Likelihood Estimation, Diagnostic Checking, Forecasting, Order Selection. **Non-stationary and Seasonal Time Series Models** ARIMA Models for Nonstationary Time Series, Identification Techniques, Unit Roots in Time Series Models, Forecasting ARIMA Models, Seasonal ARIMA Models, Regression with ARMA Errors. **Forecasting Technique** Naïve procedures, Simple Exponential Smoothing, Holt-Winters method, Holt-Winters Seasonal method, Box-Jenkins Forecasting, Choosing Forecasting method, Forecast accuracy. **State-Space Models** State-Space Representation, Basic Structural Model, State-Space Representation of ARIMA Models, Kalman Recursions.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental principles and processes of forecasting, including various model evaluation criteria.	L, D, QA	T, ASG, F
CO2	**Explain** the application of univariate ARIMA methods and smoothing techniques for time series analysis..	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** real-world forecasting problems using both univariate and multivariate time series methods.	L, D, QA	T, ASG, F

CO4	**Evaluate** model quality by applying appropriate criteria and critically assessing forecasting performance across different methodologies.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	1	2						
CO2	2	2	2	2	1	1				
CO3	2	3	3	2	2					
CO4	2	2	2	2	3	2				

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** Brockwell, P. J. and Davis, R. A. (2016). Introduction to Time Series and Forecasting, 6th Edition, Springer, New York. **2.** Box, G. E. P. B., Jenkins, G.M., Reinsel, G,C. and Ljung, G, M. (2015). Time Series Analysis: Forecasting and Control. 5th Edition, Wiley. **3.** Montgomery, D. C., Jennings, C. L., and Kulahci, M. (2015). Introduction to time series analysis and forecasting. John Wiley & Sons.
Supplementary Readings	**1.** Chatfield, C., & Xing, H. (2019). The analysis of time series: an introduction with R. Chapman and Hall/CRC. **2.** Woodward, W. A., Gray, H. L., & Elliott, A. C. (2021). Applied time series analysis with R. 2nd Edition. CRC Press.
Others	-

Course Code	MATH 350		Course Type	Core (Theory)		Level 3 Term I	
Course Title	Math Lab XI: Introduction to Machine Learning					Credit Hr	0.75
Prerequisite	None					Contact Hr	1.5
Rationale	This lab equips students with practical skills to analyze knowledge about machine learning algorithms to predict the pattern of a dataset etc.						

Course Objective

The learning objectives of this course are to

- Practice different algorithms that aligned with DS 301.

Contents

As per the theoretical course 'DS 301: Introduction to Machine Learning'.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Implement** various algorithms to visualization projects	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1		3	2	3	3	3			3	3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

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Course Code	MATH 351		Course Type	Lab (theory)		Level 3 Term I	
Course Name	Math Lab XII: Data Visualization					Credit Hr	1.5
Prerequisite	Introduction to data science					Contact Hr	3.0
Rationale	The Data Visualization course is designed to provide students with a deep understanding of today's data-driven world. The course is vital for students aiming to pursue careers in data analysis, business intelligence, and machine learning, as it combines theoretical knowledge with practical applications. This course is valuable for students seeking a robust understanding of core computer science concepts, problem-solving skills, and the ability to convey data-driven insights effectively in various professional contexts.						

Learning Objective
The learning objectives of this course are to • To design and implement common data structures, including arrays, linked lists, stacks, and queues. • To master the use of data visualization libraries and tools to generate effective and engaging visualizations.

Contents
1. **Data Visualization Principles**: Introduction to data visualization, Perception and cognition in data visualization, Choosing right visualization for data. 2. **Data Visualization Tools**: Introduction to data visualization libraries (e.g., Matplotlib, Seaborn), Creating basic data visualizations: bar charts, line charts, scatter plots, etc., Customizing visualizations for clarity. **3.** **Interactive Data Visualization:** Interactive data visualization libraries (e.g., Plotly, Bokeh), Building interactive dashboards.

Course Learning Outcomes (CO)		Teaching Strategies	Assessment Strategies
CO1	**Design** and implement common data structures such as arrays, linked lists, stacks, and queues	L, D, QA, CS	T, ASG, F
CO2	**Utilize** data visualization libraries and tools to create effective and meaningful data visualizations.	L, D, QA, CS	T, ASG, F
CO3	**Evaluate** and select appropriate visualization techniques to communicate data-driven insights clearly.	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes	**Program Learning Outcomes (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3			3	3					3
CO2	3			2		2				3
CO3	3		3	3	3	3		2	3	3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

1.	Michael, T., Goodrich, Roberto, T., and Michael H. G. (2013). Data Structures and Algorithms in Python, Wiley.
2.	Nathan, Y. (2013). Data Points: Visualization That Means Something, Wiley.
3.	Rahman, A., Abdulla, F., & Hossain, M. M. (2024). Scientific Data Analysis with R: Biostatistical Applications. Chapman & Hall/CRC Press
4.	Edward, R. T. (2001). The Visual Display of Quantitative Information, 2nd edition, Graphics Press.

Course Code	**MATH 352**		**Course Type**	**Core (Theory)**		**Level 3 Term I**	
Course Title	**Math Lab XIII: Time Series Analysis and Forecasting**					**Credit Hr**	**0.75**
Prerequisite	**None**					**Contact Hr**	**1.5**
Rationale	This lab equips students with practical skills to analyze knowledge time series and forecasting.						
Course Objective							
The learning objectives of this course are to aligned with DS 302.							
Contents							
As per the theoretical course 'DS 302: Time Series and Forecasting'.							

Course Code	**MATH 305**		**Course Type**	**Core (Theory)**		**Level 3 Term II**	
Course Title	**Abstract Algebra**					**Credit Hr**	**3**
Prerequisite	**Real Analysis**					**Contact Hr**	**3**
Rationale	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 set of 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, homological algebra, Algebraic Geometry etc.						
Course Objective							

- Introduce students to the basic concepts of algebraic structures embedded in Group and Ring Theories.
- Explain to students the role commutativity plays in Abstract Algebra.
- Demonstrate to students that there is a partial converse of Lagrange theorem.
- Capture the canonical homomorphism via normality leading to isomorphism of two groups.
- Demonstrate to students that this is a branch of pure mathematics of which applications to real life situations is still employable.
- Emphasize the fact that abstract concepts arise from the analysis of concrete situations.
- Develop student's power to think for himself in terms of concepts, include a variety of examples on each topic.
- Capture the canonical homomorphism via normality leading to isomorphism of two groups.

Contents

Part A: Groups

Group

Groupoids. Semigroups. Monoids. Order of an element of a group. Cyclic group. Dihedral Groups, Matrix Groups.

Subgroup and Coset

Subgroups. Algebra of complexes. Subgroup generated by a complex. Cosets. Coset decompositions. Lagrange's theorem. Normal subgroups. Quotient (factor) groups. Product of cosets.

Permutation Group

Permutation groups. Symmetric groups of permutations. Cyclic permutations. Transpositions. Even and odd permutations. Altering groups.

Group Morphisms

Homomorphisms and isomorphisms of groups. Cayley's theorem. Automorphism. Inner automorphism. Outer automorphism. The isomorphism theorems.

Part B: Rings

Ring

Rings. Various types of rings. Properties of rings. Characteristic of a ring.

Subring and Ideal

Subring. Ideal. Principle ideal. Maximal ideal. Prime ideal. Quotient ring.

Ring Morphisms

Homomorphism of rings. Isomorphism theorems. Embedding of an integral domain in a field

Domains

Divisibility. Units. Associates. Highest common factor (HCF). Least common multiple (LCM). Coprimes. Prime elements. Irreducible elements. Principal ideal domains. Euclidean domains. Unique factorization domains.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Describe the group, sub-group, order, symmetric groups, permutation groups, alternating groups cyclic group, etc and their related examples, rings, subrings, ideals and their classification.	L, D, QA	T, Q, ASG, F
CO2	Explain abstract algebraic construction of number sets and operations and see from where the constructs derive	L, D, QA	T, Q, ASG, F
CO3	Illustrate the topics related to theorems such as Lagrange's, Frobenius counting formula and differentiate between different structures and understand how changing properties give rise to new structures.	L, D, QA	T, Q, ASG, F
CO4	Gather deep knowledge about normal groups, quotient groups, a center of groups, theorems of Homomorphisms and isomorphisms and justify the concepts between them for rings.	L, D, QA	T, Q, ASG, F
CO5	Apply group theory in a real-life phenomenon and define Characteristic of an integral domain. Prime Fields; structure of prime fields, extension field apply the abstract algebra in real-world life	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		3		3					2
CO2	3		3		3					2
CO3	3		3		3					2
CO4	2		2	3	2					2
CO5	2		2	3	3				2	2

Learning Materials

Recommended Readings	1. Israel Nathan Herstein, Topics in Algebra, John Wiley & Sons. 2. W. K. Nicholson, Introduction to Abstract Algebra, John Wiley & Sons. 3. J. B. Fraleigh, Introduction to Abstract Algebra, Pearson Education India. 4. M. Artin, Algebra, Pearson. 5. David S. Dummit, Richard M. Foote, Abstract Algebra, John Wiley and Sons Inc.
Supplementary Readings	1. Judson, T. W., and Stephen F. (2015). Abstract Algebra, Theory and Applications. Orthogonal Publishing L3C, USA
Others	-

Course Code	MATH 306		Course Type	Core (Theory)		Level 3 Term II	
Course Title	**Numerical Analysis-II**					**Credit Hr**	**2**
Prerequisite	**Numerical Analysis I**					**Contact Hr**	**2**
Rationale	This course focus on the approximation methods for solving matrix algebra, system of linear equations and system of nonlinear equations. This course also introduces different approximation methods for ordinary differential equations (ODEs), initial value problems (IVPs), boundary value problems (BVPs). It also focus on finite difference method for partial differential equations (PDEs).						

Course Objective

- To gain knowledge on several effective numerical methods for solving nonlinear equations of two or more variables.
- This course also introduces different approximation methods for solving systems of the ordinary differential equation (ODE) and initial value problems (IVPs).
- Students will learn different methods for solving linear and nonlinear BVPs.
- Helps to understand the solution techniques of Parabolic, Elliptic, and Hyperbolic PDEs

Contents

Nonlinear System of Equations
Fixed point iteration method and Newton's method for functions of several variables.

IVP for ODE
Explicit Adams-Bashforth (AB) methods, and implicit Adams-Moulton (AM) methods, predictor-corrector methods. Solution of higher-order differential equations, and systems of differential equations.

Matrix Algebra
Eigenvalues and eigenvectors, Power method

BVP for ODE
Shooting method for linear problems, Finite difference methods (FDM) for linear and nonlinear problems

Parabolic PDEs (1D problems)
Solution of 1D heat equation using FDM, Explicit, Fully implicit and Crank-Nicolson Methods, Matrix formulation of the model

Elliptic PDEs
Solution of 2D Poisson's and Laplace's equations using FDM

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Enable to solve 1st order 1st degree differential equations using some important methods like Euler's method, Higher-order Taylor's method, implicit and explicit Runge-Kutta methods, Newton's method of several variables.	L, D, QA	T, Q, ASG, F
CO2	Analyze the numerical solution and its stability	L, D, QA	T, Q, ASG, F
CO3	Learn about convergence analysis of different numerical methods. of equations.	L, D, QA	T, Q, ASG, F

CO4	analyze the stability of various single-step and multi-step methods.	L, D, QA	T, Q, ASG, F
CO5	describe the boundary value problem and solve them using a method like the Linear shooting method, shooting method for nonlinear BVP.		
CO6	Find out the real-life applications of this course and the construction of MATLAB programs for numerical solutions		

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3		3		3	2				2
CO2	3		3		3					2
CO3	3		3		3					2
CO4	3		2	3	2					2
CO5	3		2	3	3					2
CO6	3	3	2							2

Learning Materials

Recommended Readings	1. R.L. Burden & J.D. Faires, Numerical Analysis. 2. Eddre Suli and Devid F Mayers, Introduction to Numerical Analysis., second edition 3. K. Atkinson & W. Han Kendall Atkinson, Weimin Han, Theoretical Numerical Analysis: A Functional Analysis Framework 4. M.A. Celia & W.G. Gray, Numerical Methods for Differential Equations. L.W. Johson & R.D. Riess, Numerical Analysis. 5. M.A. Celia & W.G. Gray, Numerical Methods for Differential Equations. 6. L.W. Johson & R.D. Riess, Numerical Analysis.
Supplementary Readings	
Others	-

Course Code	MATH 307		Course Type	Core (Theory)		Level 3 Term II	
Course Title	Introduction to Mathematical Finance					Credit Hr	2
Prerequisite						Contact Hr	2
Rationale	Continuation of the course 'Stochastic Calculus' to the modern Mathematical Finance area. The domain of stochastic processes, mainly Brownian motion, in the application area of mathematical finance has been introduced with rigorous structural studies. Celebrated Black and Scholes model has been introduced, derived and intuitively explained which paves the path to study more advanced jump processes and ARCH/GARCH processes in mathematical finance area in MS.						

Course Objective

- To get the stochastic mathematics concepts providing grounds to study the stock markets, bond markets and financial risk management used in banks and insurance companies
- To engage in research and further studies in the horizon of Mathematical Finance, Actuarial Science and Financial Risk Management. Numerical simulation of studies of SDE's used in these areas are also in the objectives of this module.

Contents

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.

Overview of basic concepts in securities markets

Exchange-traded markets; Over-the-counter markets; Forward contracts; Future contracts; Options; Types of traders, etc.

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.

Hedging strategies and managing market risk using derivatives

Financial derivatives; 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.

Asset Price Model

Efficient market hypothesis, The asset price model, Binomial distribution, Normal distribution, The Brownian motion, Ito's Lemma

Black-Sholes Analysis

Hypothesis of no-arbitrage-opportunities, Basic properties of option prices, The Black-Scholes Equation, Risk Neutrality, Trading strategy involving options, Variations on Black-Scholes models

Numerical Methods

Monte Carlo method, Binomial methods, Finite difference methods.

American Option

American option as a free boundary problem, American option as a linear complementary problem

Exotic Options

Binaries, Compounds, Chooser options, barrier option, Asian options and lookback options.

Bonds and Interest rate derivatives

Bond Models, Interest models, Convertible bonds.

Path-Dependent Options

General Method, Average strike options, European calls, American call options, Put-call parity for average strike option, Lookback Option, A lookback put with European exercise feature, Lookback put option with American exercise feature.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Understanding of Random Walk to BM; construction of BM; BM in stock price dynamics; covariance and correlation of BMN.	L, D, QA	T, Q, ASG, F
CO2	Learn properties of conditional expectation and martingale.	L, D, QA	T, Q, ASG, F
CO3	Use of Stochastic differential equations and Ito integrals for BM, SDE for arithmetic BM; geometric BM, martingale method in continuous time framework	L, D, QA	T, Q, ASG, F
CO4	Valuation of European options like digital call, Asset-or-noting call, standard European call	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	2		2				2	2
CO2	3	2	3		3					2
CO3	3	3	3	2	3				2	2
CO4	3	3	3	2	3	2		2	3	2

Learning Materials

Recommended Readings	1. Sheldon M. Ross, An Introduction to Mathematical Finance: Options and Other Topics 2. David G. Luenberger, Investment Science. 3. Paul Wilmott, Sam Howison, and Jeff Dewynne, The Mathematics of Financial

	Derivatives: A Student Introduction. 4. J. Robert Buchanan, An Undergraduate Introduction to Financial Mathematics, World Scientific Publishing Company. M.A. Celia & W.G. Gray, Numerical Methods for Differential Equations. 5. L.W. Johson & R.D. Riess, Numerical Analysis.
Supplementary Readings	1. Mathematics of Finance – L. L. Smail 2. An introduction to Financial Engineering – Marek Capinski and Tomasz Zastawni.
Others	-

Course Code	**DS 303**		**Course Type**	**Core (theory)**		**Level 3 Term II**	
Course Name	**Data Mining**					**Credit Hr**	**2.0**
Prerequisite	**Introduction to data science**					**Contact Hr**	**2.0**
Rationale	The Data Mining course is designed to provide students with a deep understanding of data mining concepts and techniques, essential in today's data-driven world. This course covers a wide range of topics, from the fundamentals of data mining and knowledge discovery to advanced techniques. The course is vital for students aiming to pursue careers in data analysis, business intelligence, and machine learning, as it combines theoretical knowledge with practical applications. This course is valuable for students seeking a robust understanding of core computer science concepts, problem-solving skills, and the ability to convey data-driven insights effectively in various professional contexts. It prepares students for a wide range of career opportunities and provides essential skills for both technical and non-technical roles.						

Learning Objective

The learning objectives of this course are to

- To understand the basics of data mining, including data mining tasks, and the difference between supervised and unsupervised learning.
- To master the concepts of fuzzy sets and fuzzy relations, including their properties, operations, and applications.
- To gain proficiency in machine learning algorithms such as Naïve Bayes, genetic algorithms, neural networks, and Support Vector Machines.
- To understand the fundamental concepts of data structures and their importance in data analysis.

Contents

1. **Related Concepts of Data Mining**: Meaning of Data Mining and Knowledge Discovery, Basics, Data Mining Tasks, Supervised & Unsupervised Learning, Classification & Regression.
2. **Fuzzy Set:** Concept, Classical Set, Set Operation, Boolean Logic, Basic Concepts and Representations of Fuzzy Sets. Determination of Membership Functions, Properties and Operations of Fuzzy Sets.
3. **Fuzzy Relation:** Classical Relations and Reasoning, Fuzzy Relations and its Types, Operations

on Binary Fuzzy Relations, Fuzzy Reasoning. Database/OLTP Systems, Logic, Information Retrieval, Decision Support Systems, Dimensional Modeling, Multidimensional Schemas, Indexing, Data Warehousing, OLAP, Web Search Engines, Machine Learning, Pattern Matching.

4. **Naïve Bayes Classification & Genetic Algorithms:** Supervised Learning, Naive Bayes Algorithm, Bayes Theorem, Naive Bayes Classification, Multinomial Naïve Bayes Classification. Genetic Algorithms, Fitness function, selection, crossover, mutation.
5. **Neural Network:** Basic Neuron Model, Perception, Multiplayer Perception, Recurrent Network, Hopfield Network, Boltzmann Machine Network, Kohonen Self-Organizing Network, Determining the Winning Neuron, Learning Algorithm, Neural Network-based Algorithms, Propagation, NN, Supervised Learning, Radial Basis Function Network, Perceptrons.
6. **Decision tree & Classification**: Concept, Statistical based Algorithms, Regression, Bayesian Classification, Distance-based Algorithms, K-Nearest Neighbors, Decision Tree-based Algorithms, Rule based Algorithms, Generating Rules from DT, Generating Rules from Neural Net.
7. **Support Vector Machine:** Maxima/Margin Classifier; Support Vector Classifiers; Support Vector Machines; SVMs with More than Two Classes; Relationship to Logistic Regression
8. **Clustering:** Hierarchical and Non-Hierarchical Clustering, Clustering PAM Algorithm, Clustering with Genetic Algorithms, Clustering with Neural Networks, Clustering Large Databases, Clustering with Categorical Attributes.
9. **Association Rules**: Meaning of Association, Large Item Sets, Basic Algorithms, Apriori Algorithm, Sampling Algorithm, Partitioning, Parallel and Distributed Algorithms, Data Parallelism, Task Parallelism, Advanced Association Rules, Quantitative Association Rules, Measuring Quality of Rules.
10. **Text Mining:** Introduction and overview of quantitative text analysis and its applications. Information extraction, Basics of Text Mining, Common Text Mining Visualizations, Sentiment Scoring, Hidden Structures, Topic Modeling.
11. **Web Mining:** Web Content Mining, Crawlers, Harvest System, Virtual Web View, Personalization, Web Structure Mining, Page Rank, Clever, Web Usage Mining, Preprocessing, Data Structures, Pattern Discovery & Analysis.

Course Learning Outcomes (CO)		Teaching Strategies	Assessment Strategies
CO1	**Define** data mining and identify its key tasks.	L, D, QA	T, ASG, F
CO2	**Explain** and contrast the principles of supervised and unsupervised learning.	L, D, QA	T, ASG, F
CO3	**Describe** the properties, operations, and applications of fuzzy sets and fuzzy relations	L, D, QA	T, ASG, F
CO4	**Apply** the core concepts of machine learning algorithms, including Naïve Bayes, genetic algorithms, neural networks, and Support Vector Machines	L, D, QA, CS	T, ASG, F
CO5	**Analyze** the importance of fundamental data structures in the context of data analysis.	L, D, QA, CS	T, ASG, F
CO6	**Design** and implement common data structures such as arrays, linked lists, stacks, and queues	L, D, QA, CS	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcomes	Program Learning Outcomes (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3									3
CO2	3									3
CO3	3		3						2	3
CO4	3	2	3	3	3				3	3
CO5	3		3	3	2					3
CO6	3			3	3					3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

1. Dunham, M. H. (2020). Data Mining: Introductory and Advanced Topics, 1st Edition, Pearson.
2. Larose, D. T. (2006). Data Mining: Methods and Models, Wiley-Interscience, India.
3. Aggarwal, C. C. (2015). Data mining: the textbook. New York: springer.
4. Schalkoff, R. (2005). Pattern Recognition Statistical, Structural and Neural Approaches, John Wiley and Sons, New York.
5. Han, J., Kamber, M. and Pei, J. (2022). Data mining concepts and techniques, 4th edition, Morgan Kaufmann.

Course Code	DS 304		Course Type	Core (Theory)		Level 3 Term II	
Course Title	Big Data Analytics					Credit Hr	2
Prerequisite	Database Management System (DS 202), Introduction to Machine Learning (DS 301), Data Mining (DS 303)					Contact Hr	2
Rationale	This course will provide a comprehensive foundation in the principles and tools required to manage, process, and extract value from massive datasets. Students will develop in-demand technical skills in distributed computing frameworks like Hadoop and Spark, and programming languages such as Python and SQL for large-scale data manipulation. The curriculum is designed to build robust analytical and problem-solving abilities, enabling students to derive actionable insights and make data-driven decisions that are critical in today's business, research, and technology landscapes						

Course Objective

This module aims to equip the learner with a range of most relevant topics that pertain to contemporary analysis practices, and are foundational to the emerging field of big data analytics. Learners are guided through the theoretical and practical differences between traditional datasets and Big Data datasets. An overview of the initial collection of data will be explored for multiple data sources. A formal grounding in analytical statistics is a major part of the module curriculum. Learners are expected to apply principles of statistical analytics to solve problems and inform decision making. Learners achieve this through developing knowledge and understanding of statistical analytics techniques and principles while applying these techniques and principles in typical real world scenarios.

Contents

Introduction to Big Data

Definition, characteristics and applications of Big Data in various fields.

Data pre-processing

Data collection and extraction – scraping data, data cleaning- handling missing values, noisy data and outliers; redundancy and correlation analysis, tuple duplication, conflict detection and resolution. Structured and unstructured data and databases – relationa and NoSQL databases. Data reduction– overview, Wavelet transformation, Attribute Subset Selection, Data Cube Aggregation; Data Transformation and Discretization.

Introduction to Big Data Analytics

Techniques to address data analysis issues related to data volume (Scalable and Distributed analysis), data velocity (High-Speed Data Streams), Data Variety (Complex, Heterogeneous, or Unstructured data), and Data Veracity (Data Uncertainty).

Database management essentials for Big Data organization and manipulation

Introduction to data organization (lists, queues, priority queues, trees, graphs, hash). Basic graph models and algorithms for searching, shortest path algorithms, flow networks, matching. Processing and streaming Big Data, introduction to data architecture software including Map Reduce, Hadoop distributed file system, Spark, Terradata, and how these tools work.

Data Analysis and Visualization Techniques

Descriptive statistics, probabilistic modeling of Big Data (e.g., graphical models, latent variable models, hidden Markov models.) Bayesian Inference (e.g., variational inference, expectation propagation, sampling.) Bayesian Machine Learning (e.g., Bayesian linear regression). Fundamentals of data visualization, Infographics, layered grammar of graphics. Introduction to Modern, mosaic plots, parallel coordinate plots, introduction to GGobi data visualization system, linked plots, brushing, dynamic graphics, model visualization.

Big Data Ethics and Privacy

Ethical considerations in data collection and analysis, privacy and security concerns in Big Data, legal and regulatory frameworks for Big Data.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the process of gathering large datasets from diverse sources and explain the role of statistics in big data analysis.	L, D, QA	T, ASG, F
CO2	**Explain** suitable statistical measures and analytical techniques for different data structures, and present summary statistics effectively.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** big data implementations using practicality and usefulness metrics, and apply statistical methods to generate new insights.	L, D, QA	T, ASG, F
CO4	**Evaluate** assumptions in large datasets using advanced statistical analytics, and critically assess data quality and analytical approaches.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	1	3						
CO2	2	3	2	3	1	1				
CO3	2	3	3	3	2	2	1	2	2	1
CO4	3	2	2	2	3	3	3	2	2	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** Li K-C, Jiang H, Yang LT, and Cuzzocrea A (2015). Big Data: Algorithms, . Analytics, and Applications. Chapman & Hall/CRC. **2.** Erl T, Khattak W, and Buhler P (2016). Big Data Fundamentals: Concepts, Drivers & Techniques. The Prentice Hall

Supplementary Readings	**1.** Big Data: Principles and Best Practices of Scalable Real-Time Data Systems by Nathan Marz and James Warren **2.** Mining of Massive Datasets by Jure Leskovec, Anand Rajaraman, and Jeffrey David Ullman
Others	-

Course Code	**GELM 301**		**Course Type**	**Core (Theory)**		**Level 3 Term II**
Course Title	**Leadership Management**				**Credit Hr**	**2**
Prerequisite					**Contact Hr**	**2**
Rationale	The course is designed to make students understand the overlapping connection between engineering and management in an organization through the study of varied management practices and leadership traits as an engineer.					

Course Objective

- To introduce different management functions and approaches.
- To expose students to different views and styles of leadership
- To understand how an organization functions collaboratively with managers and engineers.
- To understand various personality traits and its impact on leadership and management.
- To solve real-world management problems as an engineer.

Contents

Introduction to Leadership and Management

Definition of leadership and management, basic difference between a leader and a manager, relation of leaders and managers with respect to efficiency and effectiveness, qualities of leader and managers with examples from history.

Management Fundamentals

Definition of management & manager, levels of management, management functions and skills, Mintzberg's managerial roles, Henri Fayol's management principles, strategic management.

Leadership & Motivation

Motivation, Maslow's hierarchy needs, theory of X & Y, motivators and hygiene factors, goal setting theory, reinforcement theory, equity theory, expectancy theory, Leadership styles, leadership trait theory, managerial grid, contemporary leadership, conflicts negotiation, leadership issues in 21st century, cross cultural leadership, engineer as a leader and some simple case discussions on leadership (positive and toxic leadership) in the class (Interactive Learning).

Organizational Management

Organization, departmentalization, chain of command, unity of command, cross functional area, authority, centralization and decentralization, traditional & contemporary organization, matrix project structure, learning structure, organizing collaboration.

Planning and goal setting
Foundation of planning; goals of plan, types of goal, types of goal & plan, goal setting, MBO, well written goal; Control: Controlling process, controlling for organizational performance, types of control: (feed-forward, feedback & concurrent), balanced scorecard, contemporary issues in control, workplace concern & workplace violence.

Change and Innovation
Change and innovation, internal and external for change, changing process, creativity vs innovation.

Attitude
Components of Attitude, behaviour model and characteristics model; behaviour vs. attitude, job attitude, job involvement, job satisfaction and customer satisfaction

Personality
Personality determinants: heredity and environment, Myers-Briggs Type Indicator, Big five personality model, personality traits (core self-evaluation, Machiavellianism, narcissism, selfmonitoring, risk taking, proactive personality).

Perception and Individual Decision Making
Factors influencing perception, attribution theory, errors/biases in attribution, Factors of individual decision making, rational decision making, bounded rationality, satisfice, common errors in decision making, creativity in decision making

Understanding Work Team
Work group, work team, problem solving team, self-managed work team, cross functional team, virtual team, team effectiveness, team challenges

HR Management
Process of Human Resource Planning, forecasting demand for labour, staffing, internal supply of labour, performance appraisal

Operations Management
Project managing basics, goals and boundary of project, WBS, scheduling a project, Demand and supply forecasting, inventory control.

Information Technology and Management
Management Information System (MIS), Enterprise Resource Planning (ERP) - For introductory knowledge.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Familiarize with the fundamental concepts of leadership and management skills	L, D, QA	T, Q, ASG, F

CO2	Understand the role and contribution of a leader in achieving organizational goals	L, D, QA	T, Q, ASG, F
CO3	Understand the contribution of leadership traits and management skills in decision making and solving real life problems	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2							3		2	3
CO3							3			3

Learning Materials

Recommended Readings	1. Gupta, A. K. Engineering Management. India, S. Chand Publishing, 2014. 2. Telsang, Martand. Industrial Engineering and Production Management: For Undergraduate, Postgraduate Courses and Diploma Programmes in Mechanical, Production and Industrial Engineering Students. A Useful Guide for HE, Management Courses, Professional Engineers and Competitive Examinations for GATE and UPSC and Engineering Services Examinations. S. Chand, 2006. 3. Yukl, Gary. Leadership in Organizations, 9/e. Pearson Education India, 1981. 4. Whetten, David Allred, Kim S. Cameron, and Mike Woods. Developing management skills. Upper Saddle River, NJ: Prentice Hall, 2007.
Supplementary Readings	
Others	-

Course Code	**MATH 353**		**Course Type**	**Lab (Theory)**		**Level 3 Term II**	
Course Title	**Math Lab XIV (MATLAB/PYTHON: Numerical Analysis)**					**Credit Hr**	**1.5**
Prerequisite						**Contact Hr**	**3**
Rationale	This course is designed to equip students with the essential skills to efficiently calculate and visualize the problems in MATLAB/Python , enabling them to analyze and present data effectively for various research and analytical purposes.						

Course Objective

- To introduce the students to MATLAB/PYTHON as programming and scientific computing tool.
- To enable the students to solve basic problems and matrix operations using MATLAB/PYTHON.
- To introduce the students to basic numerical techniques to solve first order ordinary differential equations, numerical integration
- To familiarize the students with basic plotting tools available in MATLAB/PYTHON

Contents

Problem Solving: Problems in the concurrent course MATH 306: Numerical Analysis-II will be solved using the Computer Algebra System (CAS) MATLAB / PYTHON.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Students will develop a comprehensive understanding of various numerical techniques to solve differential equations	L, D, QA	T, Q, ASG, F
CO2	Familiarize the basic plots using MATLAB/PYTHON	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									2
CO2		3								

Learning Materials

Recommended Readings	1. A Guide to MATLAB - for Beginners and Experienced Users", 2nd Ed., Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, Cambridge University Press, 2006. 2. Pratap Rudra, Getting started with MATLAB: A quick Introduction for Scientist and Engineers, Oxford University Press, 2010. 3. Wolfram S., The Mathematica, Cambridge University Press, 2003. 4. Learning Python by Mark Lutz 5. Python Cookbook by David Beazley and Brian K. Jones
Supplementary Readings	
Others	-

Course Code	MATH 354		Course Type	Lab		Level 3 Term II
Course Name	**Math Lab XV: Data Mining**				**Credit Hr**	**0.75**
Prerequisite					**Contact Hr**	**1.5**
Rationale	The Data Mining lab equips students with practical skills to analyze large datasets and present insights effectively. Through hands-on exercises, learners apply key data mining techniques to discover patterns and trends, and use visualization tools to communicate results clearly. This course helps students develop essential competencies for data-driven decision-making and prepares them for careers in data analytics, AI, and related fields.					

Learning Objective

The learning objectives of this course are to

- Practice data mining techniques aligned with DS 303.

Contents

As per the theoretical course 'DS 303: Data Mining'.

Course Learning Outcomes (CO)		Teaching Strategies	Assessment Strategies
CO1	**Understand** the software (MATLAB/ Python/R)	L, D, QA	T, ASG, F
CO2	**Implement** data mining and visualization projects	L, D, QA	T, ASG, F

(L- Lecture, D- Discussion, QA- Question & Answer Session, CS- Case Study, T- Test, Q- Quiz, ASG- Assignment, F- Final Exam)

CO-PO mapping

Course Outcome	Program Learning Outcomes (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3								2
CO2		3	2	3	3	3			3	3

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Course Code	MATH 355		Course Type	Lab		Level 3 Term II	
Course Name	**Math Lab XVI: Big Data Analysis**					**Credit Hr**	**0.75**
Prerequisite						**Contact Hr**	**1.5**
Rationale							

Learning Objective

The learning objectives of this course are to

- Practice data analysis techniques aligned with DS 304.

Contents

As per the theoretical course ‘DS 304: Big Data Analysis’.

Course Code	MATH 399		Course Type	Oral		Level 3 Term II	
Course Name	**Presentation on Modern Trends in Mathematics and Data Science**					**Credit Hr**	**1.0**

Learning Objective

The learning objectives of this course are to

- Oral assessment of second-year course knowledge and applications.

Contents

Presentation on any topic (or selected by academic committee) taught in the Third Year.

Course Learning Outcome (CO)

Demonstrate comprehensive understanding of third-year subjects.

Course Code	MATH 401		Course Type	Core (Theory)		Level 4 Term I
Course Title	Introduction to Functional Analysis				Credit Hr	3
Prerequisite	Real Analysis (MATH 203)				Contact Hr	3
Rationale	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.					

Course Objective

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.

Contents

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental concepts of topological linear spaces and the main theorems of functional analysis, including their theoretical foundations.	L, D, QA	T, ASG, F
CO2	**Explain** the properties of bounded linear maps between topological linear spaces and illustrate key steps in important proofs with variations	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** the application of duality principles and other theoretical results in concrete mathematical situations and calculations.	L, D, QA	T, ASG, F
CO4	**Applying** mathematical concepts by constructing examples and counterexamples, and critically applying functional analysis theorems to various contexts	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2							
CO2	3		2		1	1				
CO3	2	2	3	1	2	1				
CO4	2	1	2	1	3	1				
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	13. E. Taylor, Introduction to Functional Analysis, Wiley 14. E. Kreyszig, Introduction to Functional Analysis with Applications, Wiley 15. J. Maddox, Elements of Functional Analysis, Cambridge University Press 16. B, Rynne, M. A. Youngson, Linear Functional Analysis, Springer 17. M. Schechter, Principles of Functional Analysis, American Mathematical Society
Supplementary Readings	4. Geraldo Botelho, Daniel Pellegrino, Eduardo Teixeira – Introduction to Functional Analysis, Springer 5. C.N. Banach & E.M. McCash – Fundamentals of Functional Analysis 6. Walter Rudin – Functional Analysis 7. Angus E. Taylor & David C. Lay – Introduction to Functional Analysis
Others	-

Course Code	**MATH 402**		**Course Type**	**Core (Theory)**		**Level 4 Term I**
Course Title	**Industrial Mathematics**					**Credit Hr** 3
Prerequisite	**Differential Equations (MATH 201)**					**Contact Hr** 3
Rationale	This course introduces mathematical methods tailored for industrial and real-world applications. It equips learners with tools for modeling, optimization, and data-driven problem solving across engineering, manufacturing, and business contexts. By bridging theory with practice, the course strengthens analytical skills and prepares students to tackle complex industrial challenges.					
Course Objective						

- To provide excellent technical knowledge and skills in the mathematical tools and techniques needed for mathematical modelling, both analytical and numerical, of industrial problems
- To impart the skills needed to develop and evaluate logical arguments, including but not limited to those invoking mathematical concepts and principles.
- To develop expertise in all stages of mathematical modelling: abstracting the essentials of problems into a form amenable to mathematical analysis, carrying out that analysis and interpreting the results in terms of the original problem, e.g., as actionable recommendations.
- To provide training in the excellent communication and teamwork skills needed to work in a cross functional or multidisciplinary team.
- To develop the skills needed to work independently, including the self-awareness needed to recognise strengths and when to ask for help. This should be demonstrated in particular by the planning and execution of an advanced project in the area of industrial mathematics

Contents

Statistical reasoning
Random variables, Uniform distributions, Gaussian distributions, The binomial distribution, The Poisson distribution, Taguchi quality control.

Data acquisition and manipulation
The z-transform, Linear recursions, Filters, Stability, Polar and Bode plots, Aliasing, Closing the loop, Why decibels?

Cost benefit analysis
Present value, Life cycle costing.

Microeconomics
Supply and demand, Revenue, cost, and profit; Elasticity of demand, Duopolistic competition, Theory of production, Leontiev input/output.

Frequency domain methods
The frequency domain, Generalized signals, Plants in cascade, Surge impedance, Stability, Filters, Feedback and root-locus, Nyquist analysis, Control.

Divided differences
Euler's method, Systems, PDEs, Runge-Kutta

Splines
Why cubics? m-Splines, Cubic spline.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** mathematical and computational approaches for solving industrial problems using appropriate terminology	L, D, QA	T, ASG, F
CO2	**Explain** the development and application of suitable numerical and analytical methods for industrial problem-solving.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** the results of mathematical approaches while critically evaluating their underlying assumptions.	L, D, QA	T, ASG, F
CO4	**Evaluate** mathematical findings and effectively communicate them to both technical and non-technical audiences.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping										
Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	2	1	1					
CO2	2	3	2	2	2	3	1			
CO3	2	2	3	3	3	2	2	1		
CO4	1	2	2	2	3	3	2	2	2	2
(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)										

Learning Materials	
Recommended Readings	1. C. R. MacCluer , Industrial Mathematics: modeling in industry, science, and government, Prentice Hall, 2000. 2. Industrial Mathematics: Case Studies in the Diffusion of Heat and Matter by Glenn R. Fulford & Philip jeBroadbridge. 3. Industrial Mathematics Practically *Applied* by Paul V. Farnsworth
Supplementary Readings	**1.** Joshi, Amiya K. Pani, Sanjeev V. Sabnis – *Industrial Mathematics* **2.** Avner Friedman & Walter Littman – *Industrial Mathematics: A Course in Solving Real-World Problems* **3.** Philip Broadbridge – *Industrial Mathematics: Case Studies in the Diffusion of Heat and Matter*
Others	-

Course Code	**MATH 403**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Mechanics**					**Credit Hr**	**3**
Prerequisite	**Physics I & II (PHY 101, PHY 201), Differential Equations (MATH 201)**					**Contact Hr**	**3**
Rationale	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.						
Course Objective							

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
Contents

Part A: Statics

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.

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

Stable and Unstable Equilibriums: Definitions of stable and unstable equilibriums with examples, some important theorems involving stable and unstable equilibriums.

Part B: Dynamics

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.

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.

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.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental concepts of coplanar force systems, center of gravity, stable/unstable equilibrium, and the key parameters of Simple Harmonic Motion (S.H.M.).	L, D, QA	T, ASG, F
CO2	**Explain** the theorems related to S.H.M., the process of compounding two collinear S.H.M.s, and the principles of motion under central forces, including apses**.**	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** problems involving resultant forces and couples, determine centroids using integration, and resolve accelerations in polar and cylindrical coordinate systems.	L, D, QA	T, ASG, F

CO4	**Evaluate** the equilibrium conditions of rigid bodies, assess the stability of systems, and apply advanced theorems to solve complex problems in particle dynamics.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	1	2	1						
CO2	3	2	2	1	1	1				
CO3	2	2	3	2	2	1		1	1	
CO4	2	2	2	2	3	2				1

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	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. 3. Introduction to Mechanics by Kleppner & Kolenkow.
Supplementary Readings	1. Engineering Mechanics: Dynamics by J.L. Meriam and L.G. Kraige 2. Classical Mechanics by Herbert Goldstein 3. A Student's Guide to Lagrangians and Hamiltonians" by Patrick Hamill
Others	-

Course Code	MATH 404		Course Type	Core (Theory)		Level 4 Term I	
Course Title	Optimization Techniques					Credit Hr	3
Prerequisite	Linear Algebra (MATH 104), Multivariate Calculus (MATH 205)					Contact Hr	3
Rationale	This course will provide a foundational understanding of core optimization algorithms and strengthen problem-solving abilities for obtaining the best possible outcomes in engineering, data science, and operational research. Students will master both the theory behind convergence and efficiency and the practical skills to model complex real-world problems, select appropriate algorithms, and implement computational solutions. This rigorous training is designed to build a systematic and analytical approach to decision-making, a critical skill for tackling challenges in areas like machine learning, supply chain management, and financial engineering.						

Course Objective

This course is an introductory and practical course to the study of operations research application in mining projects. It is designed primarily for mining engineering students to replicate what is happening in the mining industry in classroom so as to be able to apply the knowledge and skills gained during and after course of study to real life situations they might face in the industry. It involves demonstration of principles and techniques of operations research using real life projects. Topics to be covered include operation research and model formulation, solution of the operation research model, phases of an operation research study, techniques of operation research or operations research solution tools such as Linear Programming (LP) (Two phase (two variables) LP, Three phase (three variables) LP),Transportation models, Nonlinear Programming etc.

the objectives of this course are to introduce students to the techniques of operations research in mining operations, provide students with basic skills and knowledge of operations research and its application in mineral industry and introduce students to practical application of operations research in big mining projects.

Contents

Part A: Operation Research

Basics of Operations Research (OR)

Definitions, characteristics, necessity, classification and scope of OR, modeling and methods of OR, applications and limitations of OR.

Integer programming

Introduction, Types of integer programming problem, Gomory's all integer cutting plane method, Gomory's mixed integer cutting plane method, branch and bound method.

Assignment and Travelling Salesman Problem

Mathematical formulation, relationship with linear programming problem, solution procedure and applications.

Game Theory

Two person zero sum game, maximin-minimax pure strategies, mixed strategies and expected payoff, games without saddle point, graphical method, dominance principle, symmetric game, solution of $m \times n$ game by linear programming and Brown's algorithm.

Decision Analysis

Decision alternatives, states of nature or events, pay-off, different decision making environments, use of subjective probabilities in decision making, use of posterior probabilities in decision making (Bayesian Analysis), decision tree analysis.

Forecasting and Time-series Analysis

Types of forecasts, forecast errors, Time series models, moving averages, exponential smoothing, trend adjusted exponential smoothing, seasonal variations with trend, least squares method, monitoring and controlling forecasts.

Markov Chains

Characteristics of Markov chain, state and transition probabilities, transition probability matrix, steady state conditions, absorbing state, transient state, recurrent state, application of Markov chain in business problems.

Queuing theory

Characteristics of queuing system, probability distributions in queuing system, single server queuing models, multi-server queuing models, birth and death process.

Part B: Stochastic Optimization

Introduction

Introduction to Stochastic Programming, basics of SP, formal approaches to stochastic programming, discussion of different problem classes and their characteristics, probability and random variables etc.

Deterministic VS Stochastic Linear Program

Linear Programming (LP) problems, LPs involving many variables when the outcome of the decisions can be predicted with uncertainty, uncertainty about the demand, uncertainty about the input prices, uncertainty about the technical coefficient matrix. LP equivalent of a SP.

Two-Stage Recourse Problem

Scenarios generation, formulation of scenario-based SP, Formulation of 2-stage recourse problem, the solution in the 1st-stage, the solution in the second stage and application in real life. Fixed distribution pattern with fixed demand, fixed distribution pattern with uncertain demand, Variable distribution pattern with uncertain demand.

Multi-Stage Recourse Problem

Formulation of scenario-based SP, Formulation of multi-stage recourse problem, solution in different methods and application in real life. Fixed distribution pattern with fixed demand, fixed distribution pattern with uncertain demand, Variable distribution pattern with uncertain demand.

Chance Constrained SP

Formulation of chance constrained SP, solution in different methods and application in real life.

Stochastic Integer Program

Formulation of stochastic integer program (IP), recourse problems, simple integer recourse, probabilistic constraints, and solution in different methods and application in real life.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental concepts of Linear Programming Problems (LPP), the Simplex Method, and the structures of Transportation and Assignment problems.	L, D, QA	T, ASG, F
CO2	**Explain** the principles of the Dual Simplex Method, the relationship between primal and dual problems, and various methods for solving Nonlinear Programming Problems.	L, D, QA	T, ASG, F

CO3	**Analyze and interpret** linear programming models by formulating LPPs, determining feasible regions, solving them using graphical and simplex methods, and finding optimal solutions for transportation and assignment problems.	L, D, QA	T, ASG, F
CO4	**Evaluate** the sensitivity of solutions to changes in parameters and select appropriate algorithms to solve complex optimization problems.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	2	1						
CO2	2	3	2	2	1	1				
CO3	2	3	3	3	2	1				2
CO4	2	2	2	2	3	2				

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** J.K. Sharma, Operations Research: Theory and Applications, Macmillan India Limited, 2006. **2.** C.R. Kothari, An introduction to Operational Research, Vikas Publishing, 1992. **3.** John R. Birge and Francois Louveaux, Introduction to Stochastic Programming, Springer **4.** Operations Research and Financial Engineering, **5.** Peter Kall and Stein Wallace, Stochastic Programming, JOHN WILEY & SONS, New York, USA.
Supplementary Readings	**1.** S.R. Yadav and A.K. Malik, Operations Research, Oxford University Press, 2015. **2.** R. Panneerselvam, Operations Research, PHI Learning Pvt. Ltd., 2006 **3.** Urmila Diwekar, Introduction to Applied Optimization, Springer, Vishwamitra Research Institute, Clarendon Hills, IL, USA. **4.** Lecture on Stochastic Programming: Modelling and Theory, SIAM, Alexander Shapiro, Darinka Dentcheva and Andrzej Ruszczynski. Philadelphia
Others	-

Course Code	MATH 405		Course Type	Core (Theory)		Level 3 Term I	
Course Title	Introduction to Actuarial Mathematics					Credit Hr	3
Prerequisite	Mathematical Statistics (STAT 201), Probability (STAT 101), Stochastic Calculus (MATH 304)					Contact Hr	3
Rationale	This course will introduce the mathematical foundations of risk analysis and financial decision-making. Students will learn to apply probability, statistics, and calculus to insurance, pensions, and investment problems. It will bridge theoretical mathematics with practical applications in finance and prepares learners for actuarial careers.						

Course Objective

Actuarial Mathematics course is designed to equip the students with training in theoretical and practical aspects of Actuarial Science in order for them to work in life and non-life insurance companies (designing insurance products and valuing financial contracts and investing funds); consultancy (offering advice to occupational pension funds and employee benefit plans); government service (supervising insurance companies and advising on the national insurance); and also in the stock exchange, industry, commerce and academia. These problems involve analyzing future financial events, especially where future payments involved have certain or uncertain timing. The traditional areas in which actuaries operate are: life and general insurance, pensions, and investment. Actuaries are also increasing moving into other fields like health insurance, solvency measurements and asset liability management, financial risk management, mortality and morbidity investigation and so on, where their analytical skills can be employed. Currently, there is high demand for Actuarial Science expertise locally, regionally and internationally.

Contents

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.

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.

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

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.

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.

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

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.

Net Premium
Fully continuous premiums, Fully discrete premiums, True mthly Payment Premiums, commutation

functions, and Apportionable premiums.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental mathematical principles and advanced techniques used to solve a wide variety of actuarial science problems..	L, D, QA	T, ASG, F
CO2	**Explain** the application of actuarial mathematics to real-world problems in insurance, finance, and investment, communicating the processes and solutions clearly in both written and oral forms.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** complex actuarial problems by selecting and applying appropriate technological tools and mathematical methods to develop effective solutions.	L, D, QA	T, ASG, F
CO4	**Evaluate** practical actuarial challenges and propose justified solutions, demonstrating readiness for professional application through project-based or research-oriented work.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	2	2						
CO2	2	2	2	3	1	2				
CO3	2	2	2	3	1					
CO4	3	3	3	2	2	2		1	1	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** Bowers, Gerber, Hickman, Jones Nesbitt: Actuarial Mathematics **2.** Petr Zima Robert L. Brown, Mathematics of Finance, Schaum's outlines **3.** Chris Ruckman, Joe Francis, Financial Mathematics: A Practical Guide for Actuaries and other Business Professionals.
Supplementary Readings	**1.** Actuarial Mathematics for Life Contingent Risks by David C. M. Dickson, Mary R. Hardy & Howard R. Waters **2.** Actuarial Mathematics by Bowers, Gerber, Hickman, Jones & Nesbitt (SOA)
Others	-

Course Code	MATH 406		Course Type	Core (Theory)		Level 4 Term I	
Course Title	Combinatorics					Credit Hr	3
Prerequisite	Discrete Mathematics (MATH 204), Number Theory (MATH 106)					Contact Hr	3
Rationale	This course will provide the fundamental principles of counting, arrangement, and selection, forming the backbone of discrete mathematics. It develops rigorous logical reasoning and sophisticated problem-solving skills applicable to algorithm design and analysis. This makes it an essential discipline for computer science, cryptography, and probability theory.						

Course Objective

- Become familiar with fundamental combinatorial structures that naturally appear in various other fields of mathematics and computer science
- Learn counting techniques
- Emphasis to apply counting methods to solve problems
- Write coherent and logically sound arguments
- Assimilate and use of novel and abstract ideas.

Contents

Strings, Sets and Binomial Coefficients

Introduction to enumeration of strings of letters or numbers with restrictions, as well as permutations and combinations, Combinatorial proofs and the binomial theorem.

Inclusion-Exclusion

Basics of Inclusion-exclusion, Derangements, Mobius inversion, Stirling and Bell numbers, partitions, recursive formulae, Rook number, Rook polynomials, Erdos-KoRado theorem.

Well-ordering, Recurrence, Induction and Generating Functions

A variant of induction suitable for recurrences; existence theorem; Strong Induction, Pigeonhole Principle and Complexity. Nonhomogeneous and nonlinear recurrence equations.

Graph and Counting Graphs

Finite geometries of graphs and their automorphism groups, Colorings, Chromatic polynomials, Turan’s theorem, Matching, Hall’s Theorem, Exact and asymptotic enumerations for certain graphs of given size. Graph algorithms (Networks and the Max-flow min-cut theorem).

Probability

Basic concepts and their relation to enumeration. Discrete random variables, Ramsey number, Ramsey’s theorem and some of its variants. Concentration inequalities. An introduction to information theory.

Polya's Enumeration Theorem

Coloring the vertices of a square, Burnside Lemma, Polya's theorem and its application.

Combinatorics in Different Faces

Markov chain, The Stable Matching theorem, Arithmetic Combinatorics, Lovasz Local Lemma. Combinatorial games.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** solutions to iterated processes by relating recurrences to induction, generating functions, or combinatorial identities, and explain the fundamental concepts of Markov chains.	L, D, QA	T, ASG, F
CO2	**Explain** the fundamental results and methods from probability, analysis, and linear algebra used to solve problems in discrete mathematics and Ramsey theory.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** counting problems by selecting appropriate combinatorial tools (induction, graphs, recurrences, etc.), proving exact or approximate enumerations, and constructing examples that demonstrate tool utility or limitations.	L, D, QA	T, ASG, F
CO4	**Evaluate** complex discrete mathematical problems by applying methods from probability, analysis, and algebra to prove results and solve unseen problems of similar nature.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	1	2	1						
CO2	3	2	2	1	1	1				
CO3	2	2	3	1	1					
CO4	2	2	2	2	3	2			1	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. M.T. Keller and W.T. Trotter, Applied Combinatorics, 2. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics, Addison Wesley 3. Alan Tucker, Applied Combinatorics, Wiley & Sons 4. Richard A. Brualdi, Introductory Combinatorics, Pearson 5. B. Douglas, Introduction to Graph Theory, Prentice Hall
Supplementary Readings	1. A Walk Through Combinatorics by Miklós Bóna 2. The Art of Combinatorics by Richard A. Brualdi
Others	-

Course Code	**MATH 407**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Meteorology**					**Credit Hr**	**3**
Prerequisite	**Hydrodynamics/Fluid Dynamics (MATH 409), Physics II (PHY 201)**					**Contact Hr**	**3**
Rationale	This course will provide a scientific foundation for understanding atmospheric processes, weather systems, and climate dynamics. Students will develop the ability to analyze meteorological data and models, strengthening their skills in weather forecasting and interpretation. This knowledge is essential for careers in forecasting, environmental science, aviation, and addressing the challenges of climate change.						

Course Objective

- To produce graduates who possess knowledge of physical structure, properties, behavior and physical processes of the atmosphere.
- To produce graduates who have a general knowledge of precipitation pattern, formation of cloud and cloud classification, high and low pressure, temperature and their impacts on environment.
- To produce graduates who will be able to understand the behavior of the atmospheric high and low pressure regions from which various atmospheric phenomena (e.g. tornadoes, cyclone, thunderstorm, cold wave etc.) produced and spread.
- To produce graduates who have a general knowledge of a range of atmospheric phenomena and applications, and have expertise in one or more program sub-disciplines or related interdisciplinary areas.
- To produce graduates who are equipped to contribute to solving problems in the atmospheric sciences and related disciplines.

Contents

Meteorological Concepts

Meteorology, synoptic meteorology, Climatology, Physical meteorology, Dynamic meteorology, Agricultural meteorology, applied meteorology.

Atmosphere

Origin of the atmosphere, layering of the atmosphere; troposphere, stratosphere, mesosphere, thermosphere, exosphere and other layers of atmosphere, Composition of the atmosphere, homogeneous atmosphere, height of homogeneous atmosphere.

Thermodynamics of dry air

Pressure, temperature and ideal gas law; The Maxwell-Boltzmann distribution, hydrostatic equilibrium, surface pressure and mass of the atmosphere, surface pressure and sea level pressure, Heating, working and the First law; Enthalpy and the second law.

Thermodynamics of moist air

Six ways of quantify moister content, potential pressure, potential temperature, static stability of moister non-condensing air. The Clausius-Clapeyron equation, level of cloud formation.

Atmospheric Radiation

Solar radiation, Characteristic of Sun, nature of solar radiation, Geographical and seasonal distribution of solar radiation, Deposition of solar radiation with and without cloudy skies. Solar radiation and Earth-troposphere system, terrestrial radiation, characteristics and transmission through the atmosphere, Greenhouse effects, Causes of greenhouse effects, future trends of G H effects, Sea level changes, Impact of 1-meter sea level rise in Bangladesh.

Cloud and cloud formation

Cloud formation, cloud classification, various types of clouds, cloud droplet growth, droplet growth by diffusion and condensation, terminal velocity of falling drops. Lightning and thunder, formation and various stages of thunderstorm and thunderstorm safety.

Vorticity

The circulation theorem, vorticity, the vorticity equation in Cartesian and isobaric coordinates, scale analysis, potential vorticity, Ertel potential vorticity, shallow water potential vorticity conservation.

Tropical Cyclone

Formation stage, Immature stage, mature stage, terminal stage; Climatological conditions for tropical cyclone formation, North Indian Ocean, Large scale conditions associated with tropical cyclone formation.

Inclusion-Exclusion

Basics of Inclusion-exclusion, Derangements, Mobius inversion, Stirling and Bell numbers, partitions, recursive formulae, Rook number, Rook polynomials, Erdos-KoRado theorem

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the vertical structure of the atmosphere, including the properties of different layers and the typical variations of temperature, pressure, humidity, and wind.	L, D, QA	T, ASG, F
CO2	**Explain** the physical processes behind cloud formation, precipitation, thunderstorm development, and various mesoscale phenomena like tropical storms and tornadoes.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** the forces driving atmospheric motions and the relationships between basic atmospheric variables to understand diverse weather phenomena.	L, D, QA	T, ASG, F

CO4	**Evaluate** the concepts of climate change and the potential influences of human activities on climate patterns and atmospheric conditions.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	1	1	2						
CO2	2	2	2	2	1	1				
CO3	2	2	3	3	2	1				
CO4	2	1	2	3	3			3	2	1

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** J. Houghton, The Physics of Atmospheres. **2.** James R .Holton: An Introduction to Dynamic Meteorology **3.** Rodrigo Caballero, Lecture notes in Physical Meteorology. **4.** R. R. Rogers and M. K. Yau, A short course in cloud physics.
Supplementary Readings	**1.** Meteorology Today" by C. Donald Ahrens **2.** Grant W. Petty, A first course in Atmospheric Radiation. **3.** Mid-Latitude Weather Systems" by the COMET Program
Others	-

Courses MATH 401–MTH 407 to be offered by the Academic Committee (Four courses has to be taken: 12 Credits)

Course Code	**DS 401**	**Course Type**	**Core (Theory)**	**Level 4 Term I**
Course Title	**Deep Learning and Neural Networks**		**Credit Hr**	**2**
Prerequisite	**Introduction to Machine Learning (DS 301)**		**Contact Hr**	**2**
Rationale				

Course Objective

- This course introduces the fundamental principles and practical applications of Neural Networks and Deep Learning.
- Students will explore a range of neural architectures and learning algorithms, gaining both theoretical understanding and practical experience in developing AI solutions.
- Emphasis is placed on both foundational knowledge and applied problem-solving through real

world data and use cases.

- Through a combination of lectures, interactive tutorials, hands-on assignments, and a final project, students will design, implement, evaluate, and optimize neural network models.
- The course uses state-of-the-art tools and frameworks (e.g., TensorFlow, PyTorch) to build models in areas such as natural language processing and pattern recognition.
- Students will acquire the ability to develop innovative solutions, manage complexity, and integrate neural approaches to address unpredictable challenges in specialized domains.

Contents

Foundations of Neural Networks
Introduction to artificial intelligence and machine learning hierarchy, Biological inspiration of neural networks, The perceptron and multi-layer perceptron (MLP), Activation functions: Sigmoid, Tanh, ReLU, Leaky ReLU, Softmax, Forward and backward propagation mechanisms.

Optimization and Regularization
Cost/loss functions (MSE, Cross-Entropy), Gradient descent and stochastic gradient descent (SGD), Learning rate schedules and momentum, Regularization techniques: L1/L2, dropout, early stopping, Batch normalization and data augmentation.

Deep Architectures
Introduction to deep neural networks, Vanishing and exploding gradients, Initialization strategies (Xavier, He, etc.), Role of depth, width, and nonlinearity in expressiveness, Hyperparameter tuning and performance evaluation

Convolutional Neural Networks (CNNs)
Concepts of convolution and pooling, CNN architectures: LeNet, AlexNet, VGG, ResNet, Transfer learning and fine-tuning, Applications in computer vision: image classification, object detection, segmentation, Implementation of CNN models using TensorFlow/PyTorch

Recurrent Neural Networks (NNs) and LSTMs
Sequential and time-series data processing, Basic RNN architecture and limitations, Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRU), Applications: speech recognition, sentiment analysis, sequence prediction, Implementation of RNN and LSTM in Python frameworks

Transformer Models and Advanced Topic
Introduction to attention mechanisms, Transformer architecture and its components (Encoder–Decoder, Self-Attention), Applications in NLP (BERT, GPT, translation models), Transfer learning in NLP and fine-tuning pre-trained models, Cloud-based training and deployment of deep learning models

Visualization, Ethics, and Applications
Data preprocessing and visualization for deep learning, Model interpretability and explainable AI (XAI), Cloud and GPU computing environments for deep learning, Ethical implications of AI: bias, fairness, transparency, sustainability, Real-world case studies: image recognition, speech synthesis, recommendation systems.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Explain foundational concepts of neural networks including perceptrons, MLPs, activation functions, forward/backward propagation, and biological inspirations.	L, D, QA	T, Q, ASG, F
CO2	Apply optimization algorithms, regularization methods, and normalization techniques to train deep neural networks effectively.	L, D, QA	T, Q, ASG, F
CO3	Design and implement deep architectures, analyze vanishing/exploding gradients, perform initialization, tune hyperparameters, and evaluate model performance.	L, D, QA	T, Q, ASG, F
CO4	Build and evaluate Convolutional Neural Networks (CNNs) using modern frameworks (TensorFlow/PyTorch) for computer vision applications.	L, D, CS, QA	T, Q, ASG, F
CO5	Apply recurrent models (RNN, LSTM, GRU) to sequential/time-series tasks and implement them using deep learning libraries.	L, D, CS, QA	T, Q, ASG, F
CO6	Understand and apply Transformer models, attention mechanisms, and pre-trained NLP models (BERT, GPT) including fine-tuning and deployment.	L, D, CS, QA	T, Q, ASG, F
CO7	Use visualization tools, explainable AI (XAI) methods, and understand ethical considerations including bias, fairness, and responsible AI deployment.	L, D, CS, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	2	2	3					2
CO2	3	3	3	2	3					2
CO3	3	3	3	3	3					2
CO4	3	3	3	2	2					2
CO5	3	3	3	2	3				2	2
CO6	3	3	3	3		2			2	2
CO7	2	2	2	2		3	2	3	3	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	1. Goodfellow, I., Bengio, Y., & Courville, A. Deep Learning, MIT Press 2. Chollet, F. Deep Learning with Python, 2nd Ed., Manning Publications 3. Data Communications and Networking - Behrouz Forouzan 4. Computer Networks - Andrew S. Tanenbaum 5. Complete Networking: A Top Down Approach Featuring the Internet - James F. Kurose, Keith W. Ross 6. Floridi, L. Ethics of Artificial Intelligence, Oxford University Press 7. Neural Networks and Deep Learning" by Michael Nielsen:
Supplementary Readings	
Others	-

Course Code	**GESE 401**		**Course Type**	**Core (Theory)**		**Level 4 Term I**	
Course Title	**Data Privacy and Ethics**					**Credit Hr**	**2**
Prerequisite						**Contact Hr**	**2**
Rationale	This course provides a foundational understanding of the ethical frameworks, legal regulations, and technical practices necessary to protect individual privacy and ensure the ethical use of data. It empowers students to navigate the complex trade-offs between innovation, utility, and individual rights, preparing them to be conscientious professionals in data-driven roles.						

Course Objective

- Identify and analyze ethical dilemmas in data collection, analysis, and deployment.
- Explain the key principles of major data privacy regulations like GDPR and CCPA.
- Apply technical concepts of data anonymization and de-identification.
- Assess the societal impact of algorithmic systems, including bias and fairness.
- Develop a framework for making ethically sound decisions in data-related projects.

Contents

Foundations of Data Ethics

Introduction: Why Data Ethics Matter, Core Ethical Frameworks (Utilitarianism, Deontology, Virtue Ethics), Case Studies in Unethical Data Use (e.g., Cambridge Analytica)

The Legal Landscape of Data Privacy

GDPR (General Data Protection Regulation)
Principles, Individual Rights, and Compliance, CCPA/CPRA (California Consumer Privacy Act)
and other regional laws, The Concept of Informed Consent and Legitimate Interest

Technical Foundations of Privacy

Data Anonymization vs. Pseudonymization, Techniques: k-anonymity, l-diversity, t-closeness, Differential Privacy,The limitations of de-identification and re-identification risks

logorithmic Fairness and Bias

Types of Algorithmic Bias (historical, representation, measurement), Defining and Measuring Fairness (group vs. individual fairness), Techniques for Mitigating Bias in Machine Learning Models

Ethics in Practice

Ethical AI Governance and Model Auditing, Designing for Privacy: Privacy by Design and Default, The role of the Data/Ethics Officer and building an ethical organizational culture.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** fundamental concepts of data ethics and privacy, including key legal and regulatory frameworks such as GDPR, CCPA, and HIPAA.	L, D, QA	T, ASG, F
CO2	**Explain** he sources and effects of bias, discrimination, and ethical dilemmas in data-intensive systems and algorithmic decision-making.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** the multifaceted challenges surrounding privacy, technology, law, and policy, and critically assess research literature and real-world software or business artifacts from these perspectives.	L, D, QA	T, ASG, F
CO4	**Evaluate** and conduct ethical, social, or privacy assessments of data-driven projects, and design appropriate mitigation strategies or privacy-sensitive approaches for modern technology	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	2		1	1						
CO2	2	1	2	2	1	1				
CO3	2	2	3	3	2	1				
CO4	2	2	3	3	3	2	1			

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** The Ethical Algorithm by Michael Kearns and Aaron Roth **2.** Privacy in Context by Helen Nissenbaum **3.** An Introduction to Privacy for Data Professionals by the IAPP (International Association of Privacy Professionals)

	4. The Ethical Algorithm: The Science of Socially Aware Algorithm Design by Michael Kearns and Aaron Roth
Supplementary Readings	**1.** Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy by Cathy O'Neil **2.** EU General Data Protection Regulation (GDPR): A Practical Guideby Peter Carey **3.** The New Rules of Data Privacy: Building a Strategy for Your Organization by H. V. Jagadish, Christopher M. Lecraw, and Stuart Madnick
Others	-

Course Code : MATH 450 **Course Name : Math Lab XVII: Deep Learning and Neural Networks**	**Credit Hour: 0.75** **Contact Hour: 1.5**
Course Contents	
As per the theoretical course ‘DS 401.	

Course Code	**MATH 408**		**Course Type**	**Core (Theory)**		**Level 4 Term II**	
Course Title	**Differential Geometry and Tensor analysis**					**Credit Hr**	**3**
Prerequisite	**Multivariate Calculus (MATH 205), Linear Algebra (MATH 104)**					**Contact Hr**	**3**
Rationale	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.						

Course Objective

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

Contents

Part A: Differential Geometry

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).

Serret-Frenet's Formulae

Curvature, Torsion, Helices, Spherical Indicatrix of tangent, etc. Involutes, Evolutes, Bertrand curves.

Vector Functions of Two Variables

Tangent and normal plane to the surface. Principal normal, binormal and Fundamental planes, theorems on curvature and torsion.

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. \

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, Dupin Indicatrix, Third Fundamental form, Theorem of Beltrami-Ennerper. The equation of Gauss-Weingarten.

Part B: Tensor Calculus

The Tensor Concept

Covariant and Contravariant tensors, Cartesian tensors, symmetric and skew-symmetric tensors. Christoffel's symbols, Transformation laws of Christoffel's symbols and their applications.

Covariant Differentiation

Covariant derivatives, The Riemann-Christoffel tenser and the Ricci tensor, the zero tensor, Intrinsic derivative, Bianchi identity, Covariant curvature tensor, Flat Space.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental concepts of space curves including tangent, normal, binormal, curvature, torsion, and the spherical indicatrices of these elements.	L, D, QA	T, ASG, F
CO2	**Explain** the properties of curves including involutes, evolutes, and Bertrand curves, and illustrate different types of fundamental forms of surfaces.	L, D, QA	T, ASG, F

CO3	**Analyze and interpret** geometric problems by applying Serret-Frenet formulae to compute curvature, torsion, and other geometric properties of space curves.	L, D, QA	T, ASG, F
CO4	**Evaluate** surface properties by applying fundamental forms and magnitudes to calculate mean curvature, Gaussian curvature, and angles between surface directions.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	1	2							
CO2	3	2	2	1	1	1				
CO3	2	2	3	1	2	1				
CO4	2	2	2	1	3	2			1	1

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

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

Course Code	MATH 409		Course Type	Core (Theory)		Level 4 Term II	
Course Title	Hydrodynamics and Fluid Dynamics					Credit Hr	3
Prerequisite	Differential Equations (MATH 201), Physics II (PHY 201)					Contact Hr	3
Rationale	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.						

Course Objective

- To understand the concept of fluid and to be able to explain the properties of fluid.
- To understand the hydrostatic forces acting on a solid surface immersed in liquid and to be able to calculate them in a specific situation.
- 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.
- To understand the concept of dimensional analysis and to be able to apply it in a specific situation.
- To understand about the Navier-Stokes equation, steady and unsteady laminar flow.

Contents

Part A: Hydrodynamics

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.

Continuous Motion

Equations of continuity; equations of continuity in spherical and cylindrical polar co-ordinates; 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.

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.

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.

Part B: Fluid Dynamics

Fundamentals of Fluid Dynamics

Definition of fluid dynamics, viscosity; Newtonian and non-Newtonian fluids; body and surface forces; stress and rate of strain and their relation; Newton's law of viscosity.

Navier-Stokes Equation of Motion

Navier-Stokes equations of motion of a viscous fluid; equation of state for perfect fluid; conservation of energy; conservation of mass.

Dimensional Analysis

Dimensional homogeneity; dynamical similarity; Reynolds principle of similarity and significance; Reynolds/ Prandtl/ Grashof/ Rayleigh/ Richardson's/ Eckert/ Peclet/ Nusselt numbers; Some dimensionless coefficients employed in the study of viscous fluid flow-skin-friction coefficient, lift and drag coefficient; dimensional analysis; technique of dimensional analysis: Rayleigh's technique, Buckingham π– theorem.

Steady and Unsteady Laminar Flow

Exact solutions of steady and unsteady plane flows: Parallel flow through a straight channel and generalized Couette flows; plane Poiseuille flow; flow through a circular pipe-the Hagen-Poiseuille flow; flow between two parallel plates; flow over a suddenly accelerate flat plate; flow over an oscillating wall. General concepts and properties of boundary layer theory; Prandtl's boundary layerequations; similarity concepts and similarity solutions of the boundary layer equation.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental properties of fluids and the basic equations governing fluid motion, including continuity, Euler's equation, and Bernoulli's equation.	L, D, QA	T, ASG, F
CO2	**Explain** the concepts of circulation, vorticity, sources, sinks, and doublets, and demonstrate understanding of dimensional analysis in fluid mechanics.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** viscous flow problems using Navier-Stokes equations and derive exact solutions for steady and unsteady plane flows.	L, D, QA	T, ASG, F
CO4	**Evaluate** complex fluid flow situations by applying Prandtl's boundary layer equations and assessing the applicability of various fluid mechanics principles.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	1	1	2					
CO2	3	1	2	1		3				

CO3	2	2	2	2	1	1				
CO4	2	3	3	2	2					

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	**1.** L.M. Mine Thomosn, Theoretical Hydrodynamics, Dover Publication. **2.** F.M. White, Fluid Mechanics, McGraw-Hill
Supplementary Readings	**1.** H. Schlichting, Boundary Layer Theory, McGraw-Hill, New York. **2.** F. Chorlton, A Text Book of Fluid dynamics, CBS Publication
Others	-

Course Code	**MATH 410**		**Course Type**	**Core (Theory)**		**Level 4 Term II**
Course Title	**Scientific Computing and Simulations**				**Credit Hr**	**3**
Prerequisite	**Numerical Analysis I & II (MATH 202, MATH 306)**				**Contact Hr**	**3**
Rationale	Scientific computing and simulations play a vital role in various areas of science ranging from biology to modeling of complex physical systems. Various algorithms and mathematical methods are used in computing and simulations. Scientific computing is now considered as another distinct mode of science and it complements and builds relation between theory and experimentations. This course will help to formulate a model of a practical phenomenon, then to develop an algorithm after discretizing the model and finally, the execution of the algorithm as a computer programming.					

Course Objective

- A rigorous description of the concepts of symbolic algorithms.
- Contemporary knowledge on some methods and techniques.
- The knowledge of implementation of methods by using some software packages and toolkits.
- Introductory ideas about deterministic and stochastic simulations.

Contents

Introduction to scientific computing

Introduction to symbolic mathematics systems. Effective use of symbolic mathematics systems and their limitations. Program design; writing well-structured programs; debugging techniques. Data analysis, plotting and smoothing; Key mathematical algorithms such as the Euclidean algorithm and the fast Fourier transform.

Modular algorithms and interpolation: Introduction to modular algorithms, their efficient implementation for fast symbolic/numeric computations. Curve Fitting and Interpolation. Modelling of Biological Systems, Artificial Intelligence, Statistical Computing. Number theoretic algorithms in coding and cryptography. Fast algorithms for multiplication of numbers and polynomials, for manipulation of series, fast matrix manipulation, fast factorization of polynomials, Integer and polynomial arithmetic, Solution of systems of polynomial. Applications of Groebner.

Modern algorithms for sorting, searching and retrieving information with applications to genomic research and text processing.

Introduction to parallel computing: Threaded programming versus message passing, Parallel Processing and Grid Computing

Stochastic simulations: Monte Carlo method, Continuum simulations: Schrodinger

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the main methods of non-numerical analysis of functions and processes, and explain the fundamental principles of modern information search algorithms..	L, D, QA	T, ASG, F
CO2	**Explain** the bases of algorithm construction and analysis, and illustrate how these methods can be applied to academic and simple practical instances..	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** the results of advanced numeric and symbolic experiments designed for applied mathematical models	L, D, QA	T, ASG, F
CO4	**Evaluate** and apply various simulation methods to solve practical problems in diverse fields, demonstrating critical assessment of the approaches used.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	2	1						
CO2	2	3	2	2	1	1				
CO3	2	3	3	2	2	1	1			
CO4	2	2	2	2	3	2	1	2	2	

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	1. J. von zurGathen and J. Gerhard. Modern Computer Algebra. Cambridge University Press, 3rd ed., 2013 2. J.A. Storer. An Introduction to Data Structures and Algorithms. Springer, 2002 3. D.Sankoff, J.Kruskal. Time Warps, String Edits, and Macromolecules. The Theory and Practice of Sequence Comparison (CSLI Pub., 1999).
Supplementary Readings	1. Juan Manual Duran,Computer Simulations in Science and Engineering: Concepts – Practices – Perspectives, Springer 2. Scientific Computing, Simulations, and Modeling, Mathematics LibreTexts
Others	-

Course Code	**MATH 411**		**Course Type**	**Core (Theory)**		**Level 4 Term II**	
Course Title	**Mathematical Biology**					**Credit Hr**	**3**
Prerequisite	**Differential Equations (MATH 201), Statistics (STAT 201)**					**Contact Hr**	**3**
Rationale	Mathematical Biology provides the essential framework for translating biological processes into precise mathematical models. This course equips students to analyze the dynamics of biological systems, from cellular interactions to population ecology, using differential equations and computational tools. The knowledge is crucial for simulating complex biological phenomena, predicting outcomes, and driving innovation in fields like medicine, epidemiology, and genetics.						

Course Objective

- **Develop mathematical models:** Learn to create mathematical models for biological systems, such as population growth, predator-prey dynamics, cell division, and nerve impulse transmission.
- **Analyze and interpret models:** Analyze models to find steady states, stability, and understand system dynamics through techniques like phase-plane analysis.
- **Apply differential equations:** Use ordinary and partial differential equations to describe biological phenomena, including tissue growth, pattern formation, and disease spread.
- **Study specific biological phenomena:** Apply mathematical techniques to understand complex biological processes, such as the spread of infectious diseases, heartbeat dynamics, and molecular evolution.

- **Integrate computation:** Use computational tools like MATLAB or Python to simulate models and analyze data.

Contents

Introduction to modeling in Biology

Mathematical modeling and Mathematical modeling in Biology. Basic idea to create a model in Biology.

Analysis of Dynamic Mathematical Models (Discrete and Continuous)

Graphical Analysis, Linearization and Bifurcation for First Order Differential Equations and Phase Plane Analysis for Second Order Differential Equations.

Population Models for single species

Discrete Population Models: Introduction: Simple Models, Logistic-Type Model, Fishery Management Model and Delay Models. Continuous population model: Simple Model, Logistic Model, Insect Outbreak Model, Harvesting a Single Natural Population and Delay Models.

Population Dynamics of Interacting Species

Host-parasitoid Interactions, Predator–Prey Models: Lotka–Volterra Systems, Competition, Mutualism or Symbiosis.

Infectious Diseases

The Simple Epidemic and SIS Diseases, SIR Epidemics, SIR Endemics- No Disease-related Death and Including Disease-related Death.

Modelling on Chemical Reaction Network

Closed and Open networks, Dynamic behavior of reaction networks, and Numerical simulation of differential equations.

Excitability

The Hodgkin–Huxley Model- History of the Hodgkin–Huxley Equations, Voltage and Time Dependence of Conductance’s, Qualitative Analysis, The FitzHugh Nagumo Equations- The Generalized FitzHugh-Nagumo Equations, Phase-Plane Behavior.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** key mathematical models that unify related concepts in geometry and their applications in biological contexts.	L, D, QA	T, ASG, F

CO2	**Explain** how geometric thinking and mathematical modeling provide a framework for solving qualitative problems in mathematics and biology.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** mathematical models to solve geometric and biological problems, enhancing qualitative reasoning skills	L, D, QA	T, ASG, F
CO4	**Evaluate** the applicability of different modeling approaches to biological systems and assess their effectiveness in solving real-world problems	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	**Program Learning Outcome (PO)**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	1	2	2						
CO2	2	2	2	2	1					
CO3	2	2	3	3	2	1	1			
CO4	2	1	2	2	3	2	1		3	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	**1.** J.D. Murray, Mathematical Biology: I. An Introduction **2.** Nicholas F. Britton, Essential Mathematical Biology **3.** James Keener and James Sneyd, Mathematical Physiology I. **4.** S. J. Chapman, A. C. Fowler & R. Hinch, An Introduction to Mathematical Physiology **5.** G. Bard Ermentrout, David H. Terman, Mathematical Foundations of Neuroscience
Supplementary Readings	**1.** Alla Borisyuk, Avner Friedman, Bard Ermentrout, David Terman - Tutorials in Mathematical Biosciences **2.** Peter Dayan, L. F. Abbott -Theoretical Neuroscience Computational and Mathematical Modeling of Neural Systems-The MIT Press (2005). **3.** H. Wilson - Spikes, Decisions and Actions, Visual Sciences Center, University of Chicago.
Others	-

<table>
<tr><td>Course Code</td><td>MATH 412</td><td></td><td>Course Type</td><td>Core (Theory)</td><td></td><td colspan="2">Level 4 Term II</td></tr>
<tr><td>Course Title</td><td colspan="5">Fuzzy Mathematics</td><td>Credit Hr</td><td>3</td></tr>
<tr><td>Prerequisite</td><td colspan="5">Discrete Mathematics (MATH 204), Abstract Algebra (MATH 305)</td><td>Contact Hr</td><td>3</td></tr>
<tr><td>Rationale</td><td colspan="7">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.</td></tr>
<tr><td colspan="8">Course Objective</td></tr>
<tr><td colspan="8">Contents</td></tr>
<tr><td colspan="8">Crisp Sets and Fuzzy Sets
An overview of crisps sets; the notion of fuzzy sets; basic
Concepts of Fuzzy Sets
An overview of classical logic; fuzzy logic.
Operations of Fuzzy Sets
General discussion; fuzzy complement; fuzzy union; fuzzy intersection combinations of operations; general aggregation operations.
Fuzzy Arithmetic
fuzzy numbers, linguistic variables, arithmetic operations on intervals and fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.
Fuzzy Relations
Crisp and fuzzy relations; binary relations on a set; equivalence and similarity relations; compatibility or tolerance relations; orderings; morphisms; fuzzy relational equations</td></tr>
</table>

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the fundamental concepts of fuzzy set theory, including the differences between classical and fuzzy sets, and explain key properties like alpha-cuts and fuzzy numbers.	L, D, QA	T, ASG, F
CO2	**Explain** the principles of binary fuzzy relations, including domain, range, inverse, and composition, along with relevant definitions and theorems.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** fuzzy arithmetic operations, solve fuzzy equations, and apply alpha-cut representations to convert between classical and fuzzy sets	L, D, QA	T, ASG, F

CO4	**Evaluate** real-world problems by applying fuzzy set theory methodologies and designing appropriate fuzzy models for practical applications.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2	1						
CO2	3		2		1	1				
CO3	2	2	3	2	2					
CO4	2	2	2	2	3	2	1	1	2	1

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials

Recommended Readings	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
Supplementary Readings	1. John N. Mordeson, Premchand S. Nair, Fuzzy Mathematics: An Introduction for Engineers and Scientists 2. Apostolos Syropoulos, Theophanes Grammenos, A Modern Introduction to Fuzzy Mathematics
Others	-

Courses MATH 408–MTH 412 to be offered by the Academic Committee (Two courses has to be taken: 06 Credits)

Course Code	DS 402		Course Type	Core (Theory)		Level 4 Term II	
Course Title	**Data Security**					**Credit Hr**	**2**
Prerequisite						**Contact Hr**	**2**
Rationale	To teach students the basics of security issues relating to various cyber-physical systems including industrial control systems and those considered critical infrastructure systems.						

Course Objective

- To examine the architecture of a complex system.
- To identify significant vulnerabilities and threats, and apply appropriate security technologies and methods to ensure the overall security of the system.
- To study advanced cybersecurity principles and best practices are applied to develop a comprehensive cyber defense program for an enterprise against cyber threats.

Contents

Fundamental concepts
Confidentiality, integrity and availability, assurance, authenticity and anonymity; threats and attacks, security principles, Ethical issues in security.

Cryptographic concepts
Encryption, digital signatures, simple attacks on cryptosystems, cryptographic hash functions, digital certificates, Diffie-Hellman Key Exchange Algorithm.

Cryptography
Symmetric cryptography, public-key cryptography, cryptographic hash functions, digital signatures, details of AES and RSA cryptography.

Security
Operating systems concepts, process security, memory and file system security, physical security, application program security, network security concepts, browser security.

Security Attacks
Buffer overflow and other vulnerabilities due to insecure programming, foot printing, social engineering, Trojans and backdoors, sniffing, denial of service, session hijacking, dictionary attack on password protected systems, threats on components like web servers, web applications, mobile platforms, wireless networks.

Security Measures
Firewall, Intrusion detection and prevention

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	Apply cybersecurity principles and methods to defend an information system against cyber threats.	L, D, QA	T, Q, ASG, F
CO2	Analyze the requirements of a comprehensive security plan for an organization.	L, D, QA	T, Q, ASG, F
CO3	Design and customize a comprehensive security plan by integrating network defense tools and measures.	L, D, QA	T, Q, ASG, F

CO4	Develop communication skill by presenting topics on cyber and physical security.	L, D, QA	T, Q, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3									
CO2	3									
CO3		2								
CO4										1

Learning Materials

Recommended Readings	1. Cyber-Physical Security: Protecting Critical Infrastructure at the State and Local Level by Robert M. Clark 2. Cyber Security for Cyber Physical Systems - 1st ed. 2018 by Saqib Ali. 3. Industrial Network Security, Second Edition: Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems (2nd Edition), by Eric D. Knapp and Joel Thomas Langill
Supplementary Readings	
Others	-

Course Code	**DS 403**	**Course Type**	**Core (Theory)**	**Level 4 Term II**
Course Title	**AI Model Deployment and MLOps**		**Credit Hr**	**2**
Prerequisite	**Differential Equations (MATH 201)**		**Contact Hr**	**2**
Rationale	The course **AI Model Deployment and MLOps** aims to equip students with the skills to deploy, monitor, and maintain AI models in real-world environments. It covers essential MLOps practices, tools, and techniques to ensure models are reliable, scalable, and production-ready. This course bridges the gap between AI development and practical implementation, preparing students for industry-ready AI projects.			

Course Objective

- Provide students with an understanding of AI model deployment processes and best practices.
- Teach students essential MLOps tools and techniques for monitoring, versioning, and scaling models.
- Develop skills to bridge the gap between AI development and production environments.

- Prepare students to design, deploy, and maintain reliable and production-ready AI systems

Contents

Model Deployment
Techniques for deploying AI/ML models; cloud vs on-premises deployment; containerization using Docker.

Model Monitoring and Maintenance
Monitoring model performance, logging, handling data drift, and retraining strategies.

Versioning and CI/CD for AI Models
Version control for datasets and models, CI/CD pipelines, and automation in ML workflows.

Scalability and Cloud Services
Scaling AI applications using cloud platforms, orchestration tools (e.g., Kubernetes), and serverless deployment.

Security and Governance
Ensuring model security, compliance, and ethical considerations in production environments.

Course Learning Outcomes (CO)		Teaching Strategy	Assessment Methods
CO1	**Describe** the process and best practices of AI model deployment and MLOps.	L, D, QA	T, ASG, F
CO2	**Explain** techniques for monitoring, maintaining, and scaling AI models in production.	L, D, QA	T, ASG, F
CO3	**Analyze and interpret** challenges in AI deployment such as data drift, performance degradation, and scalability issues.	L, D, QA	T, ASG, F
CO4	**Apply** MLOps tools and frameworks to build, deploy, and manage production-ready AI systems.	L, D, CS, QA	T, ASG, F

(L– Lecture, D– Discussion, CS– Case Study, QA– Question & Answer Session, EXP-Experiment, T – Test ; PR – Project ; Q – Quiz; ASG – Assignment; Pr – Presentation; R - Report; F – Final Exam)

CO-PO Mapping

Course Learning Outcomes (CO)	Program Learning Outcome (PO)									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	1			1	1					
CO2	2	3	2	2	2	3	1			

CO3	2		3		3	2	2	1		
CO4	1	2	2	2	3	3	2	2	2	2

(Numerical method used for mapping which indicates 3 as high, 2 as medium and 1 as low level of matching)

Learning Materials	
Recommended Readings	1. Emmanuel Ameisen – Building Machine Learning Powered Applications 2. Mark Treveil & Alok Shukla – Machine Learning Engineering 3. Alok Shukla – MLOps: Continuous Delivery and Automation Pipelines in Machine Learning 4. Andriy Burkov – The Hundred-Page Machine Learning Book
Supplementary Readings	5. Chip Huyen – Designing Machine Learning Systems 6. Ian Pointer – Practical MLOps 7. Robust MLOps Frameworks for Automating the AI/ML Lifecycle in Cloud Environments – discusses automation of model training, deployment, and monitoring using MLOps in cloud system

Course Code : MATH 451 **Course Name : Math Lab XVIII** (AI Model Deployment and MLOps)	**Credit Hour: 1.50** **Contact Hour: 3.00**
Course Contents	
As per the theoretical course DS 403	

Course Code : MATH 490 **Course Name : Project Work/ Thesis**	**Credit Hour: 3.00** **Contact Hour: 6.00**
Course Contents	
As per the Departmental instructions.	

Course Code	MATH 499		Course Type	Oral		Level 4 Term II	
Course Name	**Presentation on Modern Trends in Mathematics and Data Science**					**Credit Hr**	**1.0**

Learning Objective

The learning objectives of this course are to

- Oral assessment of second-year course knowledge and applications.

Contents

Presentation on any topic (or selected by academic committee) taught in the Fourth Year.

Course Learning Outcome (CO)

Demonstrate comprehensive understanding of fourth-year subjects.