Course Structure along with credit distribution

Curriculum Framework and Credit Allocation for Subjects with Minimal or No Practical Component

The following course structure under FYUP is designed for subjects that do not have practical-based courses or have minimal offerings of practical course-based learning.

(For non-practical/practical-based subjects)

First Year – NHEQF Level- 4.5

Course Category	Semester-I				Semester-II		
	Subject/Title	No. of paper	Credits		Subject /Title	No. of paper	Credits
Discipline Specific core (2 subjects)	DSC-I (Major) Differential Calculus	1	4		DSC-II (Major) Differential Equations	1	4
	DSC-I (Minor) Differential Calculus	1	4		DSC–II(Minor) Differential Equations	1	4
M.D/I.D (Minor)-1 Subject	M.D/I.D (M)-I Basic Equations	1	4		M.D/I.D (M) –II Basic Statistics	1	4
SEC	SEC (MD-SEC-I)	1	3		SEC (MD-SEC-II)	1	3
SEC/AEC	SEC-AMSC Or AEC-Communication Skills	1	3		AEC-Communication Skills or SEC-AMSC	1	3
VAC	Understanding and connecting with environment Or Life Skills & personality development	1	2		Life Skills & personality development Or Understanding and connecting with environment	1	2
Total		6	20			6	20
NHEQF Level 4.5	***Student on exit after successfully completing first year (i.e., securing minimum required 40 credits + 4 Credits in*** one vocational course/skills-enhancement course of 4 credits***) will be awarded "Undergraduate Certificate" of one year, in related field/discipline/subject***						
The student may opt for Communication Skills in one semester, and any one course from Additional Multidisciplinary skill Course (SEC--AMSC) in the other semester.							
AMSC- Additional Multidisciplinary Skill Course (is offered as SEC)							
List of Additional Multidisciplinary Skill course (SEC-AMSC) courses: Following are the courses which will be offered by the University under AMSC under the 4-year U.G. program. University may add new courses under AMSC in future along with the following courses: 1. Plant Nursery Development and Management 2. Basic Yoga practices 3. Physical Education and Sports Management 4. Regional Folklores and their cultural context ***5.*** Indian traditional music ***6.*** Tour and travel Operations							
Communication Skills- AEC ***'Communication Skills' course will be offered in Hindi, English and Sanskrit Languages, student may opt any one language for studying the course***							
Life Skill & Personality Development – VAC ***Understanding and connecting with environment- VAC***							

SYALLABUS

Course Name	Differential Calculus		
Programme	UG	**Credits**	4
Pre-requisitesof the Course	10+2 Level Mathematics		
Course Objectives	The objectives of this course are to introduce: 1. The higher order derivatives and Leibniz's Theorem. 2. Mean Value Theorems and their applications. 3. Indeterminate forms, partial derivatives and tangent and normal. 4. Tracing of Cartesian and polar curves.		
Course Outcomes	After the completion of the course, the learner will be well-versed with 1. To apply the formulae of derivatives. 2. To develop differential equations. 3. To compute the length of the curve, surface area, and volume. 4. To understand numerical methods based on IVP and integration.		
Units	**Topics**		
1	Limit and Continuity (ε-δ definition), Types of Discontinuities, Differentiability of functions, Rolle's theorem, Lagrange's Mean Value theorem, Cauchy Mean Value Theorem and their applications..		
2	Successive differentiation, Leibnitz's theorem, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sinx, cos x, e^x, log(l+x), $(1+x)^m$ Indeterminate forms.		
3	Partial Differentiation, Euler's Theorem for Homogeneous functions, Maxima and minima of functions of two variables, Tangents and normal, Cartesian and polar subtangent and subnormal, Intercepts, Length of the tangent and normal, Length of the perpendicular from the pole on tangent		
4	Curvature: Cartesian, polar and parametric formulae for radius of curvature, Asymptotes, Singular Points, Tracing of curves, Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates		
TextBooks	1. G.B. Thomas, R.L. Finney: Calculus, Pearson Education (2018). 2. H. Anton, I. Bivens, S. Davis: Calculus, John Wiley & Sons (2012) 3. K. Ahmadand, P. Sharma: Text book of Calculus, New Age Publishers (2023). 4. S. Narayan, P.K. Mittal: Differential Calculus, S. Chand (2016).		

Reference Books	1. R. Courant and F. John: Introduction to Calculus and Analysis (Vol. I and II), Springer-Verlag, New York, Inc. (1989). 2. J. Edwards: Differential Calculus for Beginners, Arihant Publications (2016). 3. B. Edwards, R. Larson, R. T. Jones and E. Goldstein: Calculus, Cengage Learning Inc. (10^{th} ed) (2012).

DSC-II (Major/Minor)

Course Name	**Differential Equations**		
Programme	UG	Credits	4
Pre-requisiteof Course	Mathematics at 10+2 Level		
Course Objectives	The main objectives of the course are to introduce the students with: 1. Different types of differential equations. 2. Various methods to solve the differential equations. 3. Applications and mathematical modeling.		
Course Outcomes	Upon completion of this course, the students will be able to: 1. Learn basics of differential equations and mathematical modelling. 2. Formulate differential equations for various mathematical models. 3. Solve first order non-linear differential equations and linear differential equations of higher order using various techniques. 4. Apply these techniques to solve and analyze various mathematical models.		
Units	**Topics**		
1	Classification of differential equations: their origin and applications, initial value problems, boundary value problems, existence of solution. Separable equation and reducible to this form.		
2	Exact differential equations, integrating factors, special integrating factors and transformations. Linear differential equation and Bernoulli equations,first order higher degree equations solvable for x, y, p.		
3	Higher-order differential equations with constant coefficients, basic theory of linear differential equations, The Cauchy-Euler equation, Simultaneous differential equations. Wronskian and its properties Second order linear differential equations with variable coefficients, Inspection Method, Reducible to normal form, Change of Independent Variable, Variation of Parameters. Total differential equations.		
4	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partialdifferential equation of first order, Lagrange's method, Charpit's method.		
TextBooks	1. S.L. Ross: Differential Equations, John Wiley & Sons (2004). 2. D. Somasundaram: Ordinary Differential Equations: A First Course, Narosa Publications (2001). 3. N.M. Kapoor: A text book of Differential Equations, Pitambar Publication Company (2006). 4. D.A. Murray: Introductory Course in Differential Equations, Andesite Press (2017). 5. I. Sneddon: Elements of Partial Differential Equations, Tata McGraw-Hill (1967).		
ReferenceBooks	1. W.E. Boyce, R.C. DiPrima, D.B. Meade: Differential Equationsand Boundary Value Problems, Wiley (11^{th} ed) (2009). 2. K. Ahmed and P. Sharma: Differential Equations, New Age Publishers (2025).		

M.D./I.D.-I

Course Name	Basic Equations		
Programme	UG	**Credits**	4
Pre-requisites of the Course	Linear and quadratic equations.		
Course Objectives	The course objectives are aimed to: 1. Understanding equations and manipulating them by using the properties of operations.		
Course Outcomes	After the completion of the course, the learner will be able to After completing this course, the student will be able to: 1. Solve linear, quadratic and polynomial equations and their applications. 2. Apply equations in real world contexts including physics, chemistry, and economics. 3. Use mathematical software/tools to solve and graph equations. 4. How basic equation course builds on prerequisites.		
Units	**Topics**		
1	**Linear Equations and Systems:** Linear equations in one and two variables, Solution methods: substitution, elimination, graphical, Consistency and inconsistency in systems, Applications in real world problems.		
2	**Quadratic Equations:** General form and nature of roots, Factorisation method, completing the square, and quadratic formula, Discriminant and root types (real, complex, repeated), Graph of quadratic equations, Applications in physics and economics		
3	**Higher Degree Polynomial Equations** Cubic and quartic equations, Rational Root Theorem and Factor Theorem, Descartes' Rule of Signs, Symmetric functions of roots, Graphical behaviour of polynomial functions		
4	**Tools: Use of GeoGebra/Python/ MATLAB** Graphical solution of linear and quadratic equations, Visualisation of roots of polynomial equations, Using software to solve systems of equations, Real-life application modelling using differential equations		

Text Books	1. Irving Ron: Beyond the Quadratic Formula, MAA (2013). 2. Hari Kishan: Theory of Equations, Atlanta Publishers & Distributors (2013). 3. Hall & Knight: Higher Algebra, Arihant Publication (2016).
Reference Books	1. M.R. Spiegel, R.E. Moyer: College Algebra, Schaum's Outlines (2019). 2. College Algebra by OpenStax College Rice University, Houston Texas (2015).

M.D./I.D.-II

Course Name	**Basic Statistics**		
Programme	UG	**Credits**	4
Pre-requisites of Course	The student should have passed the 12th examination and have an understanding of arithmetic and algebraic operations.		
Course Objectives	The course objectives are aimed to: 1. To enable students to organize, present and summarize data. 2. To develop skills in computation of various statistical measures. 3. To interpret statistical results for practical applications.		
Course Outcomes	After completing this course, the student will be able to: 1. Understand fundamental statistical concepts such as types of data, scales of measurement, and methods of data collection. 2. Organize, summarize, and present data using appropriate graphical and numerical techniques, including measures of central tendency and dispersion. 3. Apply basic probability theory and common probability distributions (e.g., binomial, normal) to analyze and model uncertainty in data. 4. Perform basic inferential statistical procedures, including estimation, hypothesis testing, and interpretation of p-values and confidence intervals. 5. Use statistical software or tools (e.g., Python, Excel or R) to perform descriptive and inferential analysis on real-world data sets.		
Units	**Topics**		
1	**Introduction and Data Handling:** Definition and scope of statistics, Types of data: qualitative and quantitative. Scales of measurement: nominal, ordinal, interval, ratio, Collection of data: primary and secondary sources. Frequency distribution, tabulation, graphical representation of data: bar graphs, histograms, pie charts, line graphs		
2	**Descriptive Statistics:** Measures of central tendency: mean, median, mode, Measures of dispersion: range, inter quartile range, variance, standard deviation, Skewness and kurtosis, Percentiles and quartiles, Box plots and interpretation.		
3	**Probability and Distributions:** Basic concepts of probability, Independent and dependent events, Conditional probability, Introduction to random variables, Probability distributions: Binomial, Poisson. Normal distributions and their application.		
4	**Computer-Based Statistical Analysis:** Introduction to statistical software/tools (Excel, R, or Python-depending on what's available), importing and cleaning data from csv, Excel, Using spread sheets or libraries (like pandas in Python) for basic analysis: mean, median, mode, standard deviation, Creating charts: bar chart, histogram, scatter plot, boxplot.		

Text Books	1. W. Navidi: Statistics for Engineers and Scientists, McGraw-Hill (2021). 2. G. C. Beri: Business Statistics, Tata McGraw Hill Education (2013). 3. S. C. Gupta: Fundamentals of Statistics, Himalaya Publishing House (2018).
Reference Books	1. Sheldon M. Ross: Introductory Statistics, Academic Press (2017). 2. Allan Downey: Think Stats: Exploratory Data Analysis in Python, Shroff/O'Reilly (2015).

Second Year – NHEQF Level- 5

Course Category	Semester-III				Semester-IV		
	Subject/Title	No. of paper	Credits		Subject /Title	No. of paper	Credits
Major-I (One Subject) Major	DSC (Major)-III Analytic Geometry	1	5		DSC (Major)-V Real Analysis	1	5
Minor-I (One Subject)	DSC (Minor)-III Basic Analytic Geometry	1	4		DSC (Minor)-IV Elementary Real Analysis	1	4
DSC (Major – Skill-based Course)	DSC-SEC (Major)-IV Numerical Methods	1	3		DSC-SEC (Major)-VI Linear Programming Problems	1	3
M.D/I.D (Minor)- 1 Subject	M.D/I.D-III Basic Calculus	1	4		M.D/I.D-IV Basic Differential Equations	1	4
AEC (Language based courses)	Indian, Modern, Regional Language-I	1	2		Indian, Modern, Regional Language-II	1	2
VAC/AEC	IKS or Culture, traditions and moral values	1	2		Culture, traditions and moral values or IKS	1	2
Total		6	20			6	20
NHEQF Level 5	***Student on exit after successfully completing Second year (i.e., securing minimum required 80 credits + 4 Credits in*** one vocational course/skills-enhancement course of 4 credits***) will be awarded "Undergraduate Diploma" of two year, in related field/discipline/subject.***						

IKS- Indian Knowledge System- AEC

Culture, Traditions and Moral Values- VAC

Students are required to study both courses — *Indian Knowledge System (IKS)* and *Culture, traditions and moral values* — during the 3rd and 4th semesters. However, they will have the flexibility to study one course in each semester.

IMR Language- 'Indian, Modern, Regional Language'- Hindi, Sanskrit and English (Student have to study 2 different languages in the second year with one language in one semester and other language in another semester). One additional course titled **"Heritage of Indian Languages"** shall be offered, which students may opt for **in lieu of any one prescribed language course**, subject to the applicable regulations of the programme.

The department may offer a 3-credit SEC Major course as either a fully theory-based or fully practical-based module.

Note: Student will continue with the same Discipline specific major & Minor in the second year (III& IV Semester) as studied in the first year (I & II semester) of the FYUP.

SYALLABUS

DSC (Major)-III

Course Name	Analytic Geometry		
Programme	UG	**Credits**	5
Pre-requisiteof Course	Coordinate Geometry		
Course Objectives	The objectives of this course are to introduce: 1. Understanding the concepts of direction cosines and direction ratios and working with vectors in three-dimensional space. 2. Understanding a plane using different forms, such as the general form, normal form, and intercept form. 3. Analysing the general and standard forms of a sphere, a cylinder, and a sphere. 4. Exploring Paraboloid, Ellipsoid, Hyperboloid, and their tangent planes and normal.		
Course Outcomes	After the completion of the course, the learner will be able to 1. Apply direction cosines and direction ratios effectively in vector representation, solving problems related to direction and orientation. 2. Derive and manipulate equations of planes, spheres, cylinders, and cones. 3. Mastering dealing with various conicoids such as paraboloids, ellipsoids, and hyperboloids, including tangent planes and normals. 4. Develop strong problem-solving skills, applying mathematical concepts to analyze and solve complex problems related to three-dimensional geometry.		
Units	**Topics**		
1	3-D Cartesian Co-ordinates system, Section formula, Direction Cosines, Direction Ratios, Projection. Equation of plane in different forms, Angles between planes, Position of a point with respect to a plane, Perpendicular distance of a point from a plane, Angle bisector of two planes.		
2	Equation of a straight line in general and symmetrical form, Angles between a line and a plane, Perpendicular distance of a point from a line, shortest distance between two lines, Intersection of three planes.		
3	Sphere: Equation in different forms, Plane section of a sphere, Section of two spheres, Equation of tangent plane, Angle of intersection of two spheres, Radical plane and line, Co-axial systems of spheres.		
4	Equation of a cylinder, Enveloping cylinder of a sphere, Right circular cylinder. Cone with vertex at origin, Condition for general equation of second degree to represent a cone, Right circular cone, Intersection of a cone by a plane.		
5	Conicoid: Paraboloid, Ellipsoid, Hyperboloid, and their tangent planes and normals. Generating Lines: Ruled surfaces, Generating lines of the hyperboloid of one sheet.		
Text Books	1. S. Narayan and P. K. Mittal: Analytic Solid Geometry, S. Chand Publishing Co. (2007). 2. P.K. Jain, K. Ahmad: A Textbook of Analytical Geometry, New Age Publications (2022). 3. R. J.T. Bell: Elementary Treatise on Coordinate Geometry of Three Dimensions. Forgotten Books (2018).		
Reference Books	1. D. Chatterjee: Analytical Geometry of Two and Three Dimensions, Narosa Publishing House (2009). 2. B. Lal: New Analytical Solid Geometry, Atma Ram & Sons (1966).		

DSC (Minor)-III

Course Name	Basic Analytic Geometry		
Programme	UG	**Credits**	4
Pre-requisitesof Course	Coordinate Geometry of Two Dimensions		
Course Objectives	The objectives of this course are to introduce: 1. Understanding the concepts of direction cosines and direction ratios and working with vectors in three-dimensional space. 2. Understanding a plane using different forms, such as the general form, normal form, and intercept form. 3. Analysing the general and standard forms of a sphere, a cylinder, and a sphere. 4. Exploring Paraboloid, Ellipsoid, Hyperboloid, and their tangent planes and normal.		
Course Outcomes	After the completion of the course, the learner will be able to 5. Apply direction cosines and direction ratios effectively in vector representation, solving problems related to direction and orientation. 6. Derive and manipulate equations of planes, straight lines, spheres, cylinders, and cones. 7. Mastering dealing with various conicoids such as paraboloids, ellipsoids, and hyperboloids, including tangent planes and normals. 8. Develop strong problem-solving skills, applying mathematical concepts to analyze and solve complex problems related to three-dimensional geometry.		
Units	**Topics**		
1	3-D Cartesian Co-ordinates system, Section formula, Direction Cosines, Direction Ratios, Projection. Equation of plane in different forms, Angles between planes, Position of a point with respect to a plane, Perpendicular distance of a point from a plane. Angle bisector of two planes.		
2	Equation of a straight line in general and symmetrical form, Angles between a line and a plane, Perpendicular distance of a point from a line, shortest distance between two lines, Intersection of three planes.		
3	Sphere: Equation in different forms, Plane section of a sphere, Section of two spheres, Equation of tangent plane, Angle of intersection of two spheres, Radical plane and line, Equations of central conicoids.		
4	Cylinder: Equation of a cylinder, Enveloping cylinder of a Sphere, Right circular cylinder. Cone: Cone with vertex at origin, Condition for general equation of second degree to represent a cone, Right circular cone, Intersection of cone by a plane.		
Text Books	1. S. Narayan, P. K. Mittal: Analytic Solid Geometry, S. Chand Publishing Co. (2007). 2. P.K. Jain, K. Ahmad: A Text Book of Analytical Geometry, New Age Publications (2022). 3. R. J.T. Bell: Elementary Treatise on Coordinate Geometry of Three Dimensions. Forgotten Books (2018).		
Reference Books	1. D. Chatterjee: Analytical Geometry of Two and Three Dimensions, Narosa Publishing House (2009). 2. B. Lal: New Analytical Solid Geometry, Atma Ram & Sons (1966).		

DSC-SEC (Major)-IV

Course Name	**Numerical Methods**		
Programme	UG	**Credits**	3
Pre-requisite of Course	Elementary Calculus		
Course Objectives	The objectives of this course are to introduce: 1. Understanding the concepts of error. 2. Understanding iteration methods 3. Analysing the interpolated value of the dependent variable using past data.		
Course Outcomes	After the completion of the course, the learner will be able to 1. Knowledge of types of errors. 2. Ability to solve non-linear equations using iterative methods. 3. Ability to interpolate the value of the dependent variable using past data. 4. Ability to differentiate complex functions numerically. Ability to numerically solve complex integrals.		
Units	**Topics**		
1	**Errors in Computation:** Floating point representation of numbers, Significant Digits, Rounding and chopping, Absolute and relative errors, computation of errors using differentials, Truncation error. **Solution of non-linear equations:** Bisection method, Newton-Raphson's method, Successive iteration method.		
2	**Interpolation-**Some operators and their properties, Finite difference table, Error in approximating a function by a polynomial, Newton forward and backward Difference formulae, Gauss forward and backward formulae, Stirling's and Bessel's formulae, Lagrange's method, Divided differences and Newton's divided difference formula.		
3	**Numerical Differentiation** - Differentiation methods based on Newton's forward and backward formulae, Differentiation by central difference formula. **Numerical Integration:** Trapezoidal, Weddle, Simpson's Newton Cotes Formulas, Gaussian Quadrature Formulas.		
Text Books	1. R. K. Gupta, Numerical Methods: Fundamental and Applications, 1st Edition, Cambridge University Press (2019) 2. C. F. Gerald & P. O. Wheatley: Applied Numerical Analysis (7th edition), Pearson Education, India (2008). 3. F. B. Hildebrand: Introduction to Numerical Analysis (2nd edition), Dover Publications (2013). 4. S. S. Sastry: Introductory Methods of Numerical Analysis (3rd edition), PHI (2002). 5. M. K. Jain, S. R. K. Iyengar & R. K. Jain: Numerical Methods for Scientific and Engineering Computation (6th edition), New Age International Publishers (2012).		
Reference Books	1. Robert J. Schilling & Sandra L. Harris: Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole (1999).		

M.D./I.D.-III

Course Name	**Basic Calculus**		
Programme	UG	**Credits**	4
Prerequisites of the Course	Mathematics 10+2 Level		
Course Objectives	The objectives of this course are to introduce: 1. The concept of limit. 2. The intuitive idea of limits and rate of change. 3. The concept of derivatives. 4. Application of derivatives.		
Course Outcomes	After the completion of the course, the learner will be well-versed with 5. To apply the formulae of derivatives. 6. To develop differential equations. 7. To compute the length of the curve, surface area and volume.		
Units	**Topics**		
1	**Introduction to Calculus** What is calculus? History and real-world applications, Functions: definition, types (linear, quadratic, exponential), understanding of functions through graphs, Intuitive idea of limits and rates of change.		
2	**Understanding Limits** Concept of a limit: approaching a value, Evaluating limits using graphs and tables, limits and continuity, hands-on exercises with limit estimation using calculators or software.		
3	**Limits in Practice** Limits at infinity and asymptotic behavior, limit estimation of functions (e.g. 1/x as x approaches infinity), Applications: Modelling of growth and decay, real-world problems (e.g., population growth).		
4	**Introduction to Derivatives** The concept of a derivative: rate of change and slope of a curve, Tangent lines and their significance, derivative as instantaneous rate of change, visualizing tangents using graphing tools, maximum and minimum values (optimization), applications in physics (velocity, acceleration etc.) and economics (cost, revenue etc.), curve sketching for increasing and decreasing functions.		
Text Books	1. Silvanus P. Thompson: Calculus Made Easy, GK Publications (2025). 2. Morris Kline: Calculus: An Intuitive and Physical Approach, Dover Publications Inc. (2003). 3. Sudhir R. Ghorpade, B. V. Limaye: A Course in Calculus and Real Analysis, Springer (SIE), (2006).		

DSC (Major)-V

Course Name	**Real Analysis**		
Programme	UG	**Credits**	5
Pre-requisite of Course	Algebra, Calculus		
Course Objectives	The main objective of this course is: 1. To develop the basic understanding of sets, limits, continuity, differentiability, sequence, series and tests for their convergence.		
Course Outcomes	At the end of this course, the students will be able to 1. Describe the fundamental properties of Real numbers. 2. Demonstrate an understanding of theory of sequences and series, continuity, and differentiability. 3. Understand the theory of limits of functions. 4. Apply the limit, continuity and uniform continuity of functions.		
Units	**Topics**		
1.	Countable and uncountable sets, Axioms and properties of real numbers, Infimum and Supremum of a set, Order completeness property of $\mathbb{R}$, Archimedean property of $\mathbb{R}$, Nested intervals property, Neighborhood, Open set, Limit point, Interior point, Exterior point, Boundary points, Closed set, Derived set, Closure of a set.		
2.	Sequence of real numbers, Monotone sequences, Bounded sequence, limit points of a sequence, limit superior and limit inferior of a sequence, Convergent and non-convergent sequences, Cauchy's sequence, Cauchy's general principle of convergence, Subsequences, Monotone convergence Theorem, Bolzano-Weierstrass Theorem.		
3.	Infinite series, Convergence and divergence of infinite series, Test for convergence of positive term series, Comparison test, Ratio test, Raabe's test, Logarithm ratio test, De Morgan's and Bertrand's test, Root test, Gauss's test, Cauchy's condensation test, Cauchy's Integral test, Alternating series, Leibnitz test, Absolute and conditional convergent**.**		
4.	Limits of functions (ϵ-δ approach), Sequential criterion for limits, Continuous functions, Sequential criterion for continuity & discontinuity, Properties of continuous functions on closed and bounded intervals, Boundedness theorem, Intermediate value theorem, Fixed point theorem, Uniform continuity, Differentiability of a function at a point & in an interval.		
5	Riemann Integral: Partitions, Refinements, Dourbox Theorem, Conditions of integrability, some integrable functions, Fundamental theorem of calculus, definition and existence of Riemann-Stieltjes integral, and important theorems.		
Text Books	1. R.G. Bartleand, D.R. Sherbert: Introduction to Real Analysis, Wiley (2015). 2. T.M. Apostol: Mathematical Analysis, Narosa Publishing House, India (1985). 3. M.K. Singhal, A.R. Singhal: Topics in Analysis, S. Chand & Co. (2015).		
Reference Books	1. R.R. Goldberg: Methods of Real Analysis, Oxford & IBH Publishing Co. (2020). 2. W. Rudin: Principles of Mathematical Analysis, Tata McGraw-Hill (2017).		

DSC (Minor)-IV

Course Name	**Elementary Real Analysis**		
Programme	UG	**Credits**	4
Pre-requisites of Course	Algebra, Calculus		
Course Objectives	The main objective of this course is: 1. To develop the basic understanding of sets, limits, continuity, differentiability, sequence, series and tests for their convergence.		
Course Outcomes	At the end of this course, the students will be able to 1. Describe the fundamental properties of real numbers. 2. Demonstrate an understanding of the theory of sequences and series, continuity, and differentiability. 3. Understand the theory of limits of functions. 4. Apply the limit, continuity, and uniform continuity of functions.		
Units	**Topics**		
1.	Countable and uncountable sets, Axioms and properties of real numbers, Infimum and Supremum of a set, Order completeness property of $\mathbb{R}$, Archimedean property of $\mathbb{R}$, Nested intervals property, Neighbourhood, Open set, Limit point, Interior point, Exterior point, Boundary points, Closed set, Derived set, Closure of a set.		
2.	Sequence of real numbers, Monotone sequences, Bounded sequence, limit points of a sequence, limit superior and limit inferior of a sequence, Convergent and non-convergent sequences, Cauchy's sequence, Cauchy's general principle of convergence, Monotone convergence theorem**.**		
3.	Infinite series, Convergence and divergence of infinite series, Test for convergence of positive term series, Comparison test, Ratio test, Raabe's test, Logarithm ratio test, De Morgan's and Bertrand's test Root test, Gauss's test, Cauchy's Integral test, Alternating series, Leibnitz test, Absolute and conditional convergent**.**		
4.	Limits of functions (ϵ-δ approach), Sequential criterion for limits, Continuous functions, Sequential criterion for continuity and discontinuity, Properties of continuous functions on closed and bounded intervals, Boundedness theorem, Intermediate value theorem, Uniform continuity and some important theorems.		
Text Books	4. R.G. Bartleand, D.R. Sherbert: Introduction to Real Analysis, Wiley (2015). 5. T.M. Apostol: Mathematical Analysis, Narosa Publishing House, India (1985). 6. M.K. Singhal, A.R. Singhal: Topics in Analysis, S. Chand & Co. (2015).		
Reference Books	3. R.R. Goldberg: Methods of Real Analysis, Oxford & IBH Publishing Co. (2020). 4. W. Rudin: Principles of Mathematical Analysis, Tata McGraw-Hill (2017).		

DSC-SEC (Major)-VI

Course Name	Linear Programming Problems (LPP)		
Programme	UG	**Credits**	3
Pre-requisiteof Course	Coordinate Geometry and Inequalities		
Course Objectives	The course objectives are aimed to: 1. Learn the techniques of optimization of a given objective function with constraints.		
Course Outcomes	After completing this course, the student will be able to: 1. Get a basic idea about operations research and solution methodology to get an optimal solution to a real problem. 2. Apply the knowledge of LLP to formulate real-life problems and be able to solve them using the concept of duality. 3. Learn the application of transportation and assignment in real life.		
Units	**Topics**		
1	Errors in Numerical calculations, Bisection Method, False Position Method, Method of Iteration, Newton-Raphson Method, Secant Method, Graeffe's root square method, Ramanujan's method, Muller's method, Rate and Order of convergence of iterative methods.		
2	Finite Difference Operators, Newton's Forward and Backward Interpolation, Central difference interpolation formula (Gauss, Stirling and Bessel), Lagrange's Interpolation, Newton's general interpolation formula, Inverse Interpolation.		
3	**Solution of System of Linear:** Pivoting, Gauss Elimination method, Gauss-Jacobi method, Gauss-Jordan method, Gauss-Siedel method. **Numerical Integration:** Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule, Weddle's Rule.		

TextBooks	1. M. K. Jain: Numerical Solution of Differential Equations, John Wiley (1997). 2. S.S. Sastry: Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd. (2012). 3. E. Balagurusamy: Numerical Methods**,** Tata McGraw Hill Publication (1999).
Reference Books	1. C. F. Gerald, P. O. Wheatly: Applied Numerical Analysis, Addison-Wesley Publishing (2002). 2. B. Bradie: A Friendly Introduction to Numerical Analysis, PHI (2006).

M.D./I.D.-IV

Course Name	**Basic Differential Equations**		
Programme	UG	Credits	4
Pre-requisite of Course	Mathematics at 10+2 Level		
Course Objectives	The main objectives of the course are to introduce the students with: 1. Different types of differential equations. 2. Various methods to solve the differential equations. 3. Their applications and mathematical modeling.		
Course Outcomes	Upon completion of this course, the students will be able to: 1. Classify and identify various types of differential equations. 2. Solve first and second-order differential equations using appropriate methods. 3. Apply differential equations to model physical, biological, and economic systems. 4. Interpret and analyze solutions graphically using mathematical software. 5. Develop algorithmic thinking for numerical and symbolic solutions		
Units	**Topics**		
1	**Introduction and First Order Equations** Definitions: order, degree, general and particular solutions, Formation of differential equations, Solutions of first-order, first-degree equations		
2	**Applications of First-Order Equations** Population growth and decay, Newton's law of cooling, Radioactive decay, Orthogonal trajectories (Cartesian and polar forms), Chemical reaction rates		
3	**Systems and Series Solutions** Simultaneous differential equations (basic examples), Series solution near ordinary point (basic ideas only), Brief idea of singular points, Skills developed		
4	Graphical visualization of slope fields and solutions, Real-world modeling: cooling, decay, motion, Animating simple harmonic motion, Numerical vs analytical comparison for selected problems.		
Text Books	1. George F. Simmons: Differential Equations with Applications and Historical Notes, Tata McGraw Hill (2022). 2. Shepley L. Ross: Differential Equations, Wiley India Pvt. Ltd. (2018). 3. E.D. Rainville, P.E. Bedient, R.E. Bedient: Elementary Differential Equations, Pearson (1997). 4. Schaum's Outline Series: Differential Equations, Tata McGraw Hill (2021). 5. Dennis G. Zill : A First Course in Differential Equations with Modeling Applications, Cengage Learning India Pvt. Ltd. (2016).		

Third Year – NHEQF Level- 5.5

(For non-practical-based subjects)

A student pursuing a Bachelor's degree will be required to continue with the same Major and Minor subjects in the third year as selected in the second year of the four-year undergraduate programme.

Course Type	Semester-V				Semester-VI		
	Subject/Title	**No. of paper**	**Credits**		**Subject /Title**	**No. of paper**	**Credits**
Major-I (One)	**DSC (Major)-VII** **Abstract Algebra**	**1**	**6**		**DSC (Major)-X** **Linear Algebra**	**1**	**6**
	DSC (Major)-VIII **Complex Analysis**	**1**	**6**		**DSC (Major)-XI** **Discrete Mathematics**	**1**	**6**
	DSE (Major) Elective-I **Choose Any One:** 1 Integral Transforms 2 Introduction to Mathematical Modelling 3 Elements of Metric Spaces 4 Elementary Number Theory 5 Mathematical Python	**1**	**4**		**DSE (Major) Elective-II** **Choose Any One:** 1 Integral Transforms 2 Introduction to Mathematical Modelling 3 Elements of Metric Spaces 4 Elementary Number Theory 5 Mathematical Python	**1**	**4**
	DSC-SEC (Major)-IX **Probability and Statistics**	**1**	**4**		**DSC-SEC (Major)-XII** **Optimization Techniques**	**1**	**4**
Minor (One)	**DSC-SEC (Minor)-V** **Elementary Statistics**	**1**	**4**		**DSC-SEC (Minor)-VI** **Vector Analysis**	**1**	**4**
Total		**5**	**24**			**5**	**24**
NHEQF Level 5.5	***Student on exit after successfully completing three years (i.e., securing minimum required 128 credits) will be awarded "Bachelor's Degree" of three year, in related field/discipline/subject.***						
Note: In case of DSC/DSE course, if the department want to introduce practical component, the department may bifurcate the total credits allocated to a course between theory and practical.							
Industrial visit- The Industrial Visit course aims to provide students with practical exposure to real-world industrial environments, bridging the gap between theory and practice. It enhances understanding of industrial processes, workplace technologies, and professional ethics, while also developing observational skills and motivating students towards entrepreneurship.							
Community outreach-The curricular component of 'community outreach' will involve activities that would expose students to the socio-economic issues in society so that the theoretical learnings can be supplemented by actual life experiences to generate solutions to real-life problems.							

SYALLABUS

DSC (Major)-VII

Course Name	**Abstract Algebra**		
Programme	UG	**Credits**	6
Pre-requisiteof Course	Mathematicsat10+2Level		
Course Objectives	The objectives of the course are to: 1. Have an idea of the basic group theory. 2. Develop a deep understanding of subgroups, quotient groups, and homomorphisms. 3. Understand the symmetric groups and symmetries of geometric figures, particularly D_3.		
Course Outcomes	After going through these topics, the students will be 1. Ready to take up advanced course(s) on algebra. 2. Ready to apply the group theoretic concepts in the appropriate problems		
Units	**Topics**		
1	Groups: Binary operation and Algebraic structure, Subgroups, Permutation groups, Cyclic groups, Coset decomposition, Lagrange theorem and its consequences, Normal subgroups, Quotient group.		
2	Homomorphism and Isomorphism, Fundamental theorems of homomorphism, Cayley's theorem, Automorphism and inner automorphism, Automorphism groups and their computation, Normalizer and center of group, Finite groups, Commutator subgroups.		
3	Direct Product, Group actions, Stabilizers and orbits, Conjugacy classes, Cauchy Theorem, Simple groups, Sylow's Theorems and their applications		
4	Rings, Sub-rings, Integral domain, Field, Skew field, Ideals, Characteristic of a ring, Ring Homomorphism, Quotient rings.		
5	Principal ideals, Maximal ideals, Prime ideals, Principal ideal domains, Polynomial rings and irreducibility, Field of quotients of an integral domain, Embedding of an integral domain in a field.		
6	Factorization in an integral domain, Divisibility, Units, Associates, Prime and irreducible elements, Unique Factorization Domain, Euclidean rings.		
TextBooks	1. P.B. Bhattacharya, S.K. Jainand S.R. Nagpal: Basic Abstract Algebra, Cambridge University Press (2010). 2. I.N. Herstein: Topicsin Algebra, JohnWiley, NewYork (2004). 3. J.A.Gallian:ContemporaryAbstractAlgebra,Brooks/ColePub.Co. (2019). 4. V.Sahai, V. Bist: Algebra, Alpha Science International Ltd (2018). 5. S. Singh, Q. Zameeruddin: Modern Algebra, VikasPub. (2006).		
Reference Books	1. J.B. Fraleigh: A First Course in Abstract Algebra, Pearson (2002). 2. M. Artin: Abstract Algebra, Pearson (2011). 3. I.S. Lutharand, I.B.S. Passi:Algebra, Vol.-I,II, Narosa Publications (2013). 4. D.S. Dummit, R.M. Foote: Abstract Algebra, Wiley India (2016).		

DSC (Major)-VIII

Course Name	Complex Analysis		
Programme	UG	**Credits**	6
Pre-requisite of Course	Calculus and Real Analysis		
Course Objectives	To cover the fundamentals of Complex Analysis, Elementary functions with integrals, Bilinear Transformations, Contour Integrals, Introduction to the sum of Series, and Residues.		
Course Outcomes	The outcome of this course will be to prepare the students to take up the course on Advanced Complex Analysis.		
Units	**Topics**		
1	Functions of complex variable, Mappings; Stereographic projection; Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy−Riemann equations, Sufficient conditions for differentiability; Analytic functions and their examples, Harmonic functions.		
2	Elementary functions: Exponential functions, Logarithmic function and its branches, Trigonometric functions, Hyperbolic functions, Complex exponents, Inverse trigonometric hyperbolic functions; Conformal mappings; Bilinear transformations.		
3	Line Integration, Contour integrals and examples, Branch cut, Simply connected and multiply connected domains, Cauchy theorem for a rectangle, Cauchy integral formula, Derivatives of analytic functions.		
4	Anti-derivative theorem, Morera's theorem, Liouville's theorem, the Fundamental theorem of Algebra, Open mapping theorem, Maximum modulus principle, Schwarz lemma		
5	Taylor's series and Laurent's series with examples, Poles and singularities, Residues, The Residue theorem, Evaluation of Improper real integrals.		
6	Power series and radius of convergence, Absolute and uniform convergence of power series, Tests of uniform convergence, Uniqueness theorem.		
TextBooks	1. 1. R. V. Churchill and J. W. Brown. Complex Variables and Applications. McGraw- Hill Education (2014). 2. S. Narayan and P. K. Mittal. Theory of Functions of a Complex Variable. S. Chand & Co. (2021). 3. H. Silverman and S. Ponnusamy. Complex Variableswith Applications, Birkhäuser (2006). 4. L.V. Ahlfors, Complex Analysis, 2nd ed., Tata McGraw Hill (2017).		
Reference Books	1. J. Bakand J.D. Newman. Complex Analysis: Undergraduate Texts in Mathematics. Springer (2010). 2. J.H.Mathews and R.W. Howell. Complex Analysis for Mathematics and Engineering. Narosa, Delhi (2012). 3. D.G.ZillandP.D.Shanahan.AfirstcourseincomplexanalysiswithApplications. Jones & Bartlett Publishers (2003). 4. H.A.Prietley,Introduction to Complex Analysis, Oxford University Press (2003). 5. Murray, R. Spiegel, Complex Variables, Schaum's Outline Series, McGraw-Hill Co., New York (2009).		

DSC-SEC (Major)-IX

Course Name	**Probability and Statistics**		
Programme	UG	**Credits**	4
Pre-requisite of Course	Class XII pass with Mathematics		
Course Objectives	The main objective of this course is to: 1. Make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness. 2. Render the students to several examples and exercises that blend their everyday experiences with their scientific interests to form the basis of data science.		
Course Outcomes	At the end of this course, the students will be able to: 1. Understand some basic concepts and terminology-population, sample, descriptive and inferential statistics including stem-and-leaf plots, dotplots, histograms and boxplots. 2. Learn about probability density functions and various univariate distributions such as binomial, hypergeometric, negative binomial, Poisson, normal, exponential, and lognormal. 3. Understand the remarkable fact that the empirical frequencies of so many natural populations, exhibit bell-shaped (i.e., normal) curves, using the Central Limit Theorem. Measure the scale of association between two variables, and to establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression.		
Units	**Topics**		
1.	Descriptive statistics: Populations, Samples, Stem-and-leaf displays, Dotplots, Histograms, Qualitative data, Boxplots, Frequency distribution, Graphical representation of a frequency distribution, Measures of central tendency, Measures of dispersion, Moments, skewness and kurtosis.		
2.	Notion of Probability, Random experiment, sample space, Mathematical and statistical definitions of Probability of an event, Axiom of probability, elementary properties of probability, equally likely, mutually exclusive, independent and compound events, Conditional probability, Additive law of probability and Multiplicative law of probability, Mathematical expectation, Inverse probability, Baye's Theorem.		
3.	Scatter diagram, Karl Pearson's coefficient of correlation and its calculation, Regression and equations of lines of regression, Rank correlation coefficient, Concept of partial and multiple correlations in case of distribution of three variables. Discrete random variables & probability distributions, Expected values; Probability distributions.		
4.	Continuous random variables, Probability density functions, Uniform distribution, Cumulative distribution functions and expected values, The normal, exponential, and lognormal distributions, sampling distribution and standard error of the sample mean, Central Limit Theorem, Regression line using principle of least squares, Estimation using the regression lines, Sample correlation coefficient and properties.		
Text Books	1. Devore, Jay L. (2016). Probability and Statistics for Engineering and the Sciences (9th ed.). Cengage Learning India Private Limited, New Delhi (2022). 2. S. C. Gupta & V. K. Kapoor: Mathematical Statistics, Sultan Chand & co. Ltd New Delhi (2023) 3. J. N. Kapoor & H. C. Saxena: Mathematical Statistics, S. Chand & co. Ltd, New Delhi (2010).		
Reference Books	1. Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). Introduction to the Theory of Statistics (3rd ed.). Tata McGraw-Hill Pub. Co. Ltd. (2017).		

DSC-SEC (Minor)-V

Course Name	**Elementary Statistics**		
Programme	UG	**Credits**	4
Pre-requisites of the Course	Mathematicsat10+2Level		
Course Objectives	The main objectives of the course are to 1. Understand the basic concepts of statistics, such as measures of centrality and measures of dispersion.		
Course Outcomes	At the end of this course, the students will be able to 1. Apply these concepts in various other subjects, such as Forensic Science, Biotechnology, Economics, etc., and it is a prerequisite to take the advanced courses in statistics.		
Units	**Topics**		
1	Descriptive statistics: Populations, Samples, Stem-and-leaf displays, Dotplots, Histograms, Qualitative data, Measures of location, Measures of variability, Boxplots; Dispersion, range, quartile deviation, mean deviation, standard deviation and mean square deviation, coefficients of dispersion, moments, skewness, kurtosis.		
2	Sample spaces and events, Probability axioms and properties, Conditional probability, Bayes' theorem, and independent events; Discrete random variables & probability distributions, Expected values.		
3	Probability distributions: Binomial, geometric, hypergeometric, negative binomial, Poisson, and Poisson distribution as a limit. Continuous random variables, Probability density functions, Uniform distribution, Cumulative distribution functions and expected values, The normal, exponential, and lognormal distributions.		
4	Sampling distribution and standard error of the sample mean, Central Limit Theorem, and applications; Scatterplot of bivariate data, Regression line using principle of least squares, Estimation using the regression lines; Sample correlation coefficient and properties.		
TextBooks	4. Devore, Jay L. (2016). Probability and Statistics for Engineering and the Sciences (9th ed.). Cengage Learning India Private Limited, New Delhi (2022). 5. S. C. Gupta & V. K. Kapoor: Mathematical Statistics, Sultan Chand & co. Ltd New Delhi (2023) 6. J. N. Kapoor & H. C. Saxena: Mathematical Statistics, S. Chand & co. Ltd, New Delhi (2010).		
Reference Books	2. Mood, A. M., Graybill, F. A., & Boes, D. C. (1974). Introduction to the Theory of Statistics (3rd ed.). Tata McGraw-Hill Pub. Co. Ltd. (2017).		

DSC (Major)-X

Course Name	**Linear Algebra**		
Programme	UG	**Credits**	6
Pre-requisiteof Course	Mathematics courses in previous semesters.		
Course Objectives	The objective of the course is: 1. To introduce the concept of vectors in R^n. 2. Understand the nature of the solution of a system of linear equations. 3. To view the $m \times n$ matrices as a linear function from R^n to R^m and vice versa. 4. To introduce the concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.		
Course Outcomes	After the completion of the course, the learner will be able to 1. Visualize the space R^n in terms of vectors and the interrelation of vectors with matrices. 2. Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces. 3. Learn about linear transformation and its corresponding matrix.		
Units	**Topics**		
1	Fundamental operations with vectors in Euclidean space R^n, Linear combinations of vectors, Dot product and their properties, Cauchy-Schwarz inequality, Triangle inequality. Solving system of linear equations using Gaussian elimination and Application: Curve Fitting, Gauss Jordan row reduction, Reduced row echelon form.		
2	Vector space, subspaces, Linear combinations, linear spans, Sums and direct sums, Linear dependence and independence, Bases and dimensions, Dimensions and subspaces, Coordinates and change of bases.		
3	Linear transformations, rank-nullity theorem, Linear operators, Invertible linear transformations, Matrix representation of a linear transformation, Transpose of a linear transformation, Similarity of Matrices, Linear functional, Dual space and dual basis, Second dual space, hyperspace.		
4	Eigen values and Eigen vectors, Algebraic and Geometrical Multiplicity, Characteristic and Minimal Polynomials, Annihilators, Cayley-Hamilton theorem, Similar Matrices, Diagonalizable operator.		
5	Invariant Subspaces, Direct sum decomposition, Projection on a vector space, Primary decomposition theorem, Canonical Forms, Diagonal forms, Triangular forms, Jordan forms.		
6	Quadratic Forms, Congruence of Matrices, Reduction and Classification of a real quadratic form, Canonical and Normal form of a real quadratic form, Rank, Signature and Index, Various classes of a real quadratic form.		
TextBooks	1. Andrilli, S., and Hecker, D.: Elementary Linear Algebra (5th ed.). Elsevier India (2016). 2. K. Hoffman and R. Kunze: Linear Algebra, Prentice Hall of India, 1972. 3. S. H. Friedberg, A. J. Insel and L. E. Spence: Linear Algebra, Pearson Education, 2015.		
Reference Books	1. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). Linear Algebra and its Applications (5th ed.). Pearson Education. 2. Kolman, Bernard, & Hill, David R. (2001). Introductory Linear Algebra with Applications (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.		

DSC (Major)-XI

Course Name	Discrete Mathematics		
Programme	UG	**Credits**	6
Pre-requisites of Course	Mathematics courses in previous semesters.		
Course Objectives	The objectives of this course are to introduce:		
Course Outcomes	After completing this course, a student will have the knowledge : 1. Of the basic concepts of discrete mathematics used in computer science and other disciplines that involve formal reasoning. The topics include logic, counting, relations, Hasse diagram and Boolean algebra. 2. In mathematical reasoning, combinatorial analysis, discrete structures and applications of lattice theory and Boolean algebra with their properties and applications. 3. Of design of circuits, logic gates, Karnaugh maps and skills to prove by using truth tables. 4. To apply the basics of the automation theory, transition function and table.		
Units	**Topics**		
1	**Propositional Logic-** Proposition logic, Basic logic, Logical connectives, truth tables, Tautologies, contradiction, modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proof by implication, converse, inverse contrapositive, contradiction, direct proof by using truth table.		
2	**Relation**- Definition, types of relation, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation, representation of POSETS using Hasse diagram, chains, maximal and minimal point, greatest lower bound, least upper bound, Lattices and algebraic system, basic properties, sub lattices.		
3	**Boolean Algebra-** Basic definitions and examples, Sub algebra, Boolean functions, Disjunctive normal form, Complete disjunctive normal form, conjunctive normal form, logic circuits, logic networks, design of circuits from given properties, logic gates, and Karnaugh maps.		
4	**Combinatorics-** Inclusion- exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (G.F): properties and solution of recurrence relations of combinatorial problems.		
5	Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Euler's theorem, Isomorphism of graphs, Paths and circuits, Connected graphs, Euler trails and circuits, Hamiltonian paths and cycles, Adjacency matrix, Weighted graphs, Travelling salesman problem.		
6	The Chinese postman problem; Digraphs, Bellman-Ford algorithm, Tournaments, Directed network, Scheduling problem; Trees and their properties, Spanning trees, Kruskal's algorithm, Prim's algorithm, Acyclic digraphs and Bellman's algorithm.		
TextBooks	**1.** C. L. Liu (1986): Discrete Mathematics, Tata McGraw Hill, **2.** Trembley and Manohar (2008): Discrete Mathematics with computer application, Tata McGraw Hill. **3.** Kenneth H. Rosen (2012): Discrete Mathematics and Its Applications, McGraw- Hill.		
Reference Books	1. Bondy, J. A. & Murty, U.S.R. (2008), Graph Theory with Applications. Springer. 2. Chartrand, Gary, & Zhang, P. (2012). A First Course in Graph Theory. Dover Publications.		

DSC-SEC (Major)-IX

Course Name	**Optimization Techniques**		
Programme	UG	**Credits**	4
Pre-requisite of Course	Mathematics at 10+2 Level		
Course Objectives	The course objectives are aimed to: 1. Learn the techniques of optimization of a given objective function with constraints.		
Course Outcomes	After completing this course, the student will be able to: 1. Get a basic idea about operations research and solution methodology to get an optimal solution of real problem. 2. Apply the knowledge of LLP to formulate real-life problems and be able to solve them using the concept of duality. 3. Learn the application of transportation and assignment in real life. 4. Use computer software such as Excel Solver, Lingo, and Octave to solve linear programming problems		
Units	**Topics**		
1	**Basics of OR**: LPP-Introduction, formulation, linear programming in matrix notation, graphical solution of LLP, simplex method, revised simplex method, Introduction to artificial, slack, and surplus variables, two phase and Big-M method.		
2	**Duality and Sensitivity Analysis**: Definition of the dual of an LPP, significance of duality, weak duality, and strong duality, illustration of duality theorems through examples, resolution of degeneracy, duality in LPP, primal-dual relationship, dual simplex method, sensitivity analysis, Modelling of Real-life problems.		
3	**Assignment problem**: Introduction and necessity of assignment problem, balanced and unbalanced assignment problem, Hungarian algorithm for the assignment problem, real-life application of assignment problem. **Transportation Problem**: Introduction and necessity of transportation problem, transportation model problem, Initial basic feasible solution (IBFS) by north west corner rule method, matrix minima method, Vogel's approximation method, optimal solution by modified distribution method, degeneracy in transportation problem, traveling salesmen and its application real-life problem, stepping stone method, transshipment problem.		
4	Introduction to the replacement problem, types, or classification of replacement problem, simple numerical based on types of replacement problem, job sequencing and its applications.		
Text Books	1. G. Hadley: Linear Programming, Narosa Publishing House (1995). 2. F.S. Hillier, G.J. Lieberman: Introduction to Operations Research (SIE) (2021). 3. S.D. Sharma: Operation Research, Kedar Nath Ram Nath Publications (2010).		
Reference Books	2. P.R. Thie, G.E. Keough: An introduction to linear programming and game theory (3rd ed.), New Jersey, John Wiley & Sons (2008). 3. M.J. Osborne: An introduction to game theory, NewYork: Oxford University Press (2009). 4. F. S. Hillier, G.J. Lieberman, B. Nagand P. Basu: Introduction to operations research-concepts and cases (10thed), Tata McGraw Hill (2017). 5. H.A.Taha: Operations research-An introduction (10thed.), Pearson Prentice Hall (2017). 6. S. Mokhtar, Bazaraa, J. John, Jarvis, D. Hanif, Sherali: Linear Programming and Network Flows (2nd ed), John Wiley and Sons (2004).		

DSC-SEC (Minor)-VI

Course Name	Vector Analysis		
Programme	UG	**Credits**	4
Pre-requisites of Course	Mathematics at 10+2 Level		
Course Objectives	The objectives of this course are to: 1. Introduce the fundamental concepts and operations in vector calculus, including differentiation and integration of vector fields. 2. Explore the geometrical and physical significance of vector calculus in real-world applications. 3. Develop proficiency in solving problems using key theorems such as Green's Theorem, Stokes' Theorem, and the Divergence Theorem. 4. Provide tools for understanding advanced topics in mathematics, physics, and engineering.		
Course Outcomes	Upon completion of this course, students will be able to: 1. Perform vector operations and apply them to solve problems in geometry and physics. 2. Evaluate line, surface, and volume integrals with applications to physical fields such as fluid dynamics and electromagnetism. 3. Demonstrate understanding and application of key vector calculus theorems. 4. Relate vector calculus to real-world phenomena in physics, engineering, and beyond.		
Units	**Topics**		
1	Scalar and vector fields, Vector functions: limit, continuity and differentiability, Gradient, Divergence, Curl with physical significance and geometrical interpretation. Directional derivatives and their applications, Identities involving operators.		
2	Concept and evaluation of line integrals in scalar and vector fields with applications, Fundamental theorem of vector calculus, Conservative force field, Parameterization of surfaces and evaluation of surface integrals with applications.		
3	Green's Theorem: statement, derivation, physical interpretation and applications, Stokes' Theorem: statement, derivation, physical interpretation and applications, Divergence Theorem (Gauss's Theorem): statement, derivation, physical interpretation and applications.		
4	Scalar potential, vector potential, irrational and solenoidal fields, Helmholtz decomposition theorem, Laplacian operator and its applications to wave equations, Advanced applications of vector calculus in physics and engineering.		
Text Books	1. J. E. Marsden and A. J. Tromba: Vector Calculus, W. H. Freeman and Company Publishers (2012). 2. S. Narayan: Text book on Vector Calculus, S. Chand (2003). 3. S. Lipschutz, D. Spellman and M. R. Spiegel: Vector Calculus, Schaum's Outline Series, McGraw Hill (2009). 4. G.B. Thomas and R.L. Finney: Calculus, PHI, (2018).		
Reference Books	1. J. Stewart: Calculus-Early Transcendental, Brooks/Cole, Cengage Learning (2012). 2. H. M. Schey: Div, Grad, Curl and All That-An Informal Text on Vector Calculus (2005). 3. E. Kreyszig: Advanced Engineering Mathematics, Wiley (2024).		

DSE (Major) Elective-I/II

Course Name	Integral Transforms		
Programme	UG	**Credits**	4
Pre-requisiteof Course	Differential Equations or its equivalent		
Course Objectives	This course aims to provide 1. Basic ideas of integral transforms and integral equations. 2. Understand the Fourier transform and its properties, and be able to solve the examples based on it. 3. Deep understanding of Laplace Transformation and its real-life application		
Course Outcomes	After the completion of this course, students will be able to 1. Have an understanding of different kinds of integral transforms. 2. Apply the knowledge in areas of Signal Processing and Communications, Data Science, Computational Fluid Dynamics, Software Development etc.		
Units	**Topics**		
1	Basic integral transforms, Laplace transform: definition and properties, Rules of manipulation, Laplace transform of derivatives and integrals, Properties of inverse Laplace transform, Convolution theorem and complex inversion formula.		
2	Fourier Series of piecewise continuous and periodic functions, system of orthogonal functions, convergence of Fourier series, Fourier transform: definition and properties, convolution theorem, Fourier transform of derivatives.		
3	Mellin transform: definition and properties, Mellin transform of derivatives and integrals, Mellin transform inversion theorems, Parseval's theorem. Infinite Hankel transform: definition and properties, Hankel transform of derivatives.		
4	Applications of Laplace transform and Fourier transforms-Solution of ordinary Differential equations, system of differential equations, boundary value problems, partial differential equations, Application to the solution of simple boundary problems by infinite Hankel transforms.		
Text Books	1. L. Debnath and D. Bhatta: Integral Transforms and Their Applications, Book World Enterprises (2006). 2. R. Bhatia: Fourier Series (2^{nd} ed), Hindustan Book Agency, Delhi (2003). 3. A.D. Poularikas: The Transforms and Applications (Handbook), CRC Press (1996).		
Reference Books	1. Tyn Myint-U and L. Debnath: Linear Partial Differential Equations for Scientists and Engineers (4^{th} ed), Birkhauser (2007).		

DSE (Major) Elective-I/II

Course Name	Introduction to Mathematical Modelling		
Programme	UG	Credits	4
Pre-requisite of Course	Differential Equations		
Course Objectives	The main objective of this course is to introduce: 1. Compartmental models and real-life case studies through differential equations, their applications and mathematical modelling. 2. Choosing the most appropriate model from competing types that have been fitted. 3. Fitting a selected model type or types to the data and making predictions from the collected data.		
Course Outcomes	At the end of this course, the students will be able to: 2. Learn the basics of differential equations and compartmental models. 3. Formulate differential equations for various mathematical models. 4. Construct normal equations of best fit and predict the future values.		
Units	**Topics**		
1.	Compartmental diagram and balance law, Exponential decay, Radioactive dating, and lake pollution models, Case study: Lake Burley Griffin, Drug assimilation into the blood, Case study: Dull, dizzy or dead.		
2.	Exponential growth, Density-dependent growth, Equilibrium solutions and stability of logistic equation, Limited growth with harvesting. Interacting Population Models and Phase-plane Analysis: SIR model for influenza, Predator-prey model, Ecosystem model of competing species, and model of a battle		
3.	Analytic methods of model fitting and Simulation: Fitting models to data graphically, Chebyshev approximation criterion, Least-square criterion: Straight line, parabolic, power curve, Transformed least-square fit, Choosing a best model.		
4.	Monte Carlo simulation modelling**:** Simulating deterministic behavior (area under a curve, volume under a surface), Generating random numbers: middle-square method, linear congruence, Simulating probabilistic behavior.		
Text Books	1. B. Barnes, G.R. Fulford: Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed), CRC Press, Taylor & Francis Group (2015). 2. F.R. Giordano, W.P. Fox, S. B. Horton: A First Course in Mathematical Modelling (5^{th} ed), Cengage Learning India (2014).		
Reference Books	1. B. Albright, W.P. Fox: Mathematical Modeling with Excel (2^{nd} ed), CRC Press, Taylor & Francis Group (2020). 2. C.H. Edwards, D. E. Penney, D.T. Calvis: Differential Equations and Boundary Value Problems: Computing and Modeling (5^{th} ed), Pearson (2015).		

DSE (Major) Elective-I/II

Course Name	**Elements of Metric Spaces**		
Programme	UG	**Credits**	4
Pre-requisite of Course	Understanding the Set Theory and Analysis of Real & Complex variables.		
Course Objectives	The main objective of this course is: 1. To give the idea of distance between two elements in a set and to extend the concepts, namely, open sets, closed sets, convergence of sequences, compact sets, continuity of functions, from real line to a metric space. 2. The course focuses on basic notions of metric spaces and their properties.		
Course Outcomes	At the end of this course, a student will know: 1. Basic notions of metric spaces, completeness, and compactness of a metric space 2. Methods and techniques of proving basic theorems on metric spaces, continuous mappings and fixed point theorems. 3. Equivalent methods for introducing a metric in a set. 4. A student can check the features of a function if a given set in metric spaces is open, closed, dense, and compact. 5. The importance of metric spaces in mathematics and its applications in different areas.		
Units	**Topics**		
1.	Definition and examples of metric spaces, Bounded and unbounded metric spaces, Distance between sets, Diameter of a set, Open and closed balls, Interior points and interior of a set, Open set, Neighborhood of a point, Limit point of a set, Closure of a set, Closed set, Boundary points and boundary of a set, Exterior points and exterior of a set, Subspace of a metric space.		
2.	Sequences in a metric space, Convergent and Cauchy sequences, Complete metric spaces, Relation between completeness and closedness, Cantor Intersection Theorem, Completion Theorem, Countability axioms, Densesets, Separable spaces, Nowhere dense sets, Categories and Baire Category Theorem.		
3.	Continuous functions between metric spaces, Sequential criterion for continuous functions, Characterizations of Continuous functions via open and closed sets, Uniform continuous functions, Homeomorphism, Isometry, equivalent metrics.		
4.	Compact metric spaces, Compact sets and their criterion, Relation between compactness, completeness and closedness, Finite intersection property, Bolzano-Weierstrass property, Sequential compactness, Totally bounded spaces, Continuous functions on compact spaces, Separated sets, Connected and disconnected sets, Connected subsets of $\mathbb{R}$, Continuous functions on connected spaces.		
Text Books	1. E.T. Copson: Metric spaces, Cambridge University Press (1968). 2. P.K. Jain and K. Ahmad: Metric Spaces, Narosa Publishing House (4th ed), New Delhi (2024). 3. S. Kumaresan: Topology of Metric Spaces, Narosa Publishing House (2nd ed), New Delhi (2011).		
Reference Books	1. M.O. Searcoid: Metric spaces, Springer (2007). 2. Q.H. Ansari: Metric Spaces Including Fixed Point Theory and Set-valued Maps, Narosa Publishing House, New Delhi (2010).		

DSE (Major) Elective-I/II

Course Name	**Elementary Number Theory**		
Programme	UG	**Credits**	4
Pre-requisite of Course	Understanding of Number System, Algebra and Analysis.		
Course Objectives	The main objective of this course is to introduce: 1. The Euclidean algorithm and linear Diophantine equations, the Fundamental theorem of arithmetic and some of the open problems of number theory viz. the Goldbach conjecture. 2. The modular arithmetic, linear congruence equations, system of linear congruence equations, arithmetic functions and multiplicative functions, e.g., Euler's Phi-function. 3. Introduction of the simple encryption and decryption techniques, and the numbers of specific forms viz. Mersenne numbers, Fermat numbers etc.		
Course Outcomes	At the end of this course, the students will be able: 1. Get familiar with the basic number-theoretic techniques. 2. Comprehend some of the open problems in number theory. 3. Learn the properties and use of number-theoretic functions and special types of numbers. 4. Acquire knowledge about public-key cryptosystems, particularly RSA.		
Units	**Topics**		
1.	Well ordering principle, Archimedean property, First and second principle of finite induction, Division algorithm, Divisibility, Greatest common divisor (gcd), Euclid's lemma, Euclidean algorithm, Least common multiples (lcm), Linear Diophantine equations and applications.		
2.	Fundamental theorem of Arithmetic, The sieve of Eratosthenes, Euclid theorem and the Goldbach conjecture, Theory of congruences: definition, properties and applications, Chinese remainder theorem, System of linear congruences in two variables.		
3.	Fermat's little theorem and its generalization, Wilson's theorem and its converse, Number-theoretic functions for sum and the number of divisors of a positive integer, Multiplicative functions, The greatest integer function, Euler's Phi-function and its properties.		
4.	Basics of cryptography, Hill's cipher, Public-key cryptosystems and RSA encryption and decryption technique, Introduction to perfect numbers, Mersenne and Fermat numbers, Fibonacci sequence and its nature.		
Text Books	1. D.M. Burton: Elementary Number Theory, Tata McGraw-Hill Education (7^{th} ed.), (2017). 2. G.H. Hardy, E. M. Wright: An Introduction to the Theory of Numbers, Oxford University Press (2007).		
Reference Books	1. G.A. Jones, J.M. Jones: Elementary Number Theory, Springer (2005). 2. N. Robbins: Beginning Number Theory, Narosa Publishing House Pvt. Ltd. New Delhi (2007). 3. K.H. Rosen: Elementary Number Theory and its Applications, Pearson Education (2011).		

DSE (Major) Elective-I/II

Course Name	**Mathematical Python**		
Programme	UG	**Credits**	4 (2+2)
Pre-requisite of Course	Basic knowledge of Python		
Course Objectives	The Learning Objectives of this course are as follows: 1. To be able to model and solve mathematical problems using Python Programs. 2. To experience the utility of open-source resources for numerical and symbolic mathematical software systems.		
Course Outcomes	At the end of this course, the students will be using Python: 1. For numerical and symbolic computation in mathematical problems from calculus, algebra, and geometry. 2. To tabulate and plot diverse graphs of functions and understand tracing of shapes, geometries, and fractals. 3. To prepare smart documents with LaTeX interface.		
Units drafted	**Topics**		
1.	**Drawing Shapes, Graphing and Visualization** Drawing diverse shapes using code and Turtle, Using Matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes, Pyplot and subplots, Animations of decay, Bayes update, Random walk.		
2.	**Numerical and Symbolic Solutions of Mathematical Problems** NumPy for scalars and linear algebra on *n*-dimensional arrays, Computing eigen-space, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy, Symbolic computation and SymPy: Differentiation and integration of functions, Limits, Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.		
3.	**Practical (Document generation with Python and LaTeX)** Pretty printing using SymPy, Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MS Excel, Open Document, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations. Software labs using IDE such as Spyder and Python Libraries. • Installation, update, and maintenance of code, troubleshooting. • Implementation of all methods learned in theory. • Explore and explain API level integration and working of two problems with standard Python and LaTex code.		
Text Books	1. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978-1-59327-867-0. 2. Farrell, Peter and et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3. 3. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-9		

Reference Books	1. Sam Morley: Applying Math with Python (2nd ed), Packet Publishing Ltd. (2022) 2. Online resources and documentation on the libraries, such as: https://matplotlib.org, https://sympy.org, https://pandas.pydata.org, https://numpy.org, https://pypi.org, https://patrickwalls.github.io/mathematicalpython/, https://www.overleaf.com/learn/latex/Hyperlinks