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 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, straight lines, 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, 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 1. To apply the formulae of derivatives. 2. To develop differential equations. 3. 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, sequences, 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, 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-requisite of 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 the completion of the course, the learner will be able to 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 able to solve them using the concept of duality. 3. Learn the application of transportation and assignment in real life.		
Units	**Topics**		
1	Linear programming problem: Standard, Canonical and matrix forms, Graphical method; Convex set and their properties, Hyperplanes, Extreme points; Basic solutions, Basic feasible solutions, Simplex method, special cases in simplex method: Degeneracy, Alternative Optima, Unbounded Solutions, and Infeasible Solution.		
2	Artificial Variables, Two-Phase Method, Big-M method. Motivation and formulation of dual problem, Primal-Dual relationships, Fundamental theorem of duality, Dual Simplex Method.		
3	Necessity of the transportation problem, Definition and formulation, Methods of finding initial basic feasible solutions, Northwest-corner rule. Least-cost method, Vogel's approximation method, Algorithm for solving transportation problem**,** Necessity of assignment problem, Introduction to Assignment Problem, Mathematical formulation of Assignment problems. Hungarian method of solving Assignment Problems.		

Text Books	1. Bazaraa, Mokhtar S., Jarvis, John J., and Sherali, Hanif D.: Linear Programming and Network Flows (4th ed.). John Wiley and Sons, 2010. 2. Hadley, G.: Linear Programming, Narosa Publishing House, New Delhi, 1997. 3. Taha, Hamdy A.: Operations Research: An Introduction (9th ed.), ,Pearson, 2010. 4. Hillier, Frederick S. and Lieberman, Gerald J.: Introduction to Operations Research (11th ed.)., McGraw-Hill, Education (India) Pvt. Ltd, 2021.
Reference Books	1. Thie, Paul R., & Keough, G. E.: An Introduction to Linear Programming and Game Theory, (3rd ed.), Wiley India Pvt. Ltd, 2014.

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).		