UG Semester IV
Paper 7: Mathematical Methods

Credit: 4 **T:04**

Course Outcomes:

1. To develop mathematical skills in calculus and analysis.
2. To get knowledge of Laplace Transforms and Fourier series.
3. To get acquainted with the essentials of calculus of variations.

UNIT I

Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchy sequence, limit superior and limit inferior of a sequence, subsequence, Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic test, de Morgan and Bertrand's tests, alternating series, Leibnitz's theorem, absolute and conditional convergence. Sequences and series of functions: point wise and uniform convergence of sequences of functions, consequences of uniform convergence, integration and differentiation of series of functions.

UNIT II

Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Convolution theorem, inverse Laplace transforms, Solution of the differential equations using Laplace transforms.

UNIT III

Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite), Fourier integral.

UNIT IV

Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives, Functionals dependent on more than one independent variable, Variational problems in parametric form.

References:

Text Books:

1. T.M. Apostol. Mathematical Analysis, Pearson
2. RG Bartle, Introduction to Real Analysis, Wiley India

Suggested Readings:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata- McGraw Hill
2. A.S. Gupta, Calculus of Variations with Applications Prentice Hall India.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 8: Ordinary Differential Equations

Credit: 4 **T:04**

Course Outcomes:

1. Formulate Differential Equations for various Mathematical models.
2. Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.
3. Apply these techniques to solve and analyze various mathematical models.
4. Conceptualize nature of critical points.

UNIT I

Differential Equations of first order and first degree, variable separable equations and equations reducible to this form, linear equations and Bernoulli equations, Exact differential equations and integrating factors, special integrating factors and transformations. Differential Equations of first order and higher degree, Clairaut equation, singular solutions. Orthogonal trajectories.

UNIT II

Linear Differential Equations with constant coefficients, homogeneous linear equation with constant coefficients, Wronskian, its properties and applications. Second order linear differential

equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters.

UNIT III

Systems of first order equations, linear systems, homogeneous linear systems with constant coefficients, Volterra's prey predator equations, The phase plane & its phenomena, types of critical points & Stability, Critical points & stability for linear system, stability by Liapunov's direct method.

UNIT IV

Series solutions of differential equations, Power series method. Bessel, Legendre and Hypergeometric functions and their properties, recurrence and generating relations.

References

Text Books:

3. B. Rai, D.P. Choudhary & H.J. Freedman, A Course in Differential Equations.
4. S. L Ross, Differential Equations, 3rd Edition, Wiley

Suggested Readings:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill

(For students with Mathematics as a minor subject)

Paper Q4: Applicable Mathematics– IV

Credit: 2 **T:02**

Course Outcomes:

1. To understand application and techniques of solving various types of ordinary differential equations.
2. To understand the Laplace transforms and its applications in solving differential equations.
3. To understand Fourier series and Fourier transforms.
4. To understand standard techniques for finding numerical solution of ordinary differential equations.
5. To know the basic concepts of complex analysis including Cauchy's integral formula, derivative of analytic functions, Taylor's and Laurent's series.

UNIT I

Functions of complex variables - analytic functions, Cauchy - Riemann equations, harmonic functions, Cauchy's integral theorem.

UNIT II

Cauchy's integral formula, derivatives of analytic functions, formulae for first, second and nth derivatives, Taylor's and Laurent's series, singularities, zeroes and poles of order n.

UNIT III

Laplace transforms - existence theorem, Laplace transforms of derivatives and integrals, inverse Laplace transform, convolution theorem, applications to simple linear differential equations.

UNIT IV

Periodic functions, Fourier series, Fourier expansion of piecewise monotonic functions, half and full range expansions, Fourier transforms (finite and infinite), Fourier integral.

References:

Textbooks:

1. J.W. Brown and R.V. Churchill : Complex Variables and Applications, Mc Graw Hill.
2. Complex Variables, Schaum's Outline Series
3. G. F. Simmons : Differential Equations with Applications and Historical Notes, Tata McGraw Hill.
4. T. M. Apostol : Mathematical Analysis.

Vocational Course in Mathematics

Paper VC-2: Introduction to LaTeX using Overleaf

Credit: 2 **T:02**

Course Objectives:

1. To provide an introduction to technical writing, complex graphics, and computer presentations with LaTeX
2. To create basic types of LaTeX documents (article, report, letter, book)
3. To format words, lines, and paragraphs, design pages, create lists, tables, references, and figures in LaTeX.
4. To typeset the complicated mathematics: basic formulas (inline), centered and numbered equations, aligning multi-line equations.
5. To list the content and references: creating a table of contents, lists of figures and tables, create bibliographies, and generate the index.
6. To create professional presentation slides using LaTeX.

Course Outcomes:

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

1. Having the skill of using high-quality typesetting system.
2. LaTeX for publication of research papers, theses and book chapters.
3. Typesetting of complex mathematical formulae using LaTeX.
4. Create Tables, Graphics and Pictures Lists, Arrays and Bibliography by using LaTeX.
5. Create Slides with Beamer.

UNIT I

Introduction to LaTeX. Online Overleaf access. Structure of LaTeX document. Defining class of the document. Packages and different environments. Writing the first LaTeX content. Creating a Title, chapters and sections and their labeling, basics of LaTeX syntax, page style, fonts, font sizes, font styles.

UNIT II

Labelling Table of Contents, coloured text, boxes, theorems, comments & spacing, special characters, line breaking. Columns, multi-columns and minipages. Page numbering, foot notes, headers and footers. Fancy page styles. Short cuts and definitions.

UNIT III

Introduction to mathematics environment, writing Greek symbols, some basic mathematics type structure: fractions, superscript, subscript, overline, underline etc.Matrix, determinant and other similar structure. Writing Equations and Arrays. Equation references. Introduction to *amsmath* package. Various mathematical operation symbols.Inserting pictures and tables, creating reference database.

UNIT IV

Presentations in LaTeX. Introduction to beamer class. Themes of beamer presentations.

Recommended Books:

1. LaTeX 2e: An Unofficial Reference Manual by Karl Berry, Stephen Gilmore, et al.
2. Latex: A Document Preparation System, 2/E, A Document Preparation System User's Guide and Reference Manual Leslie Lamport
3. https://www.cs.ntua.gr/~sivann/books/LaTeX%20-%20User's%20Guide%20and%20Reference%20Manual-lamport94.pdf
4. https://www.overleaf.com/learn
5. https://www.colorado.edu/aps/sites/default/files/attached-files/latex_primer.pdf