**Syllabus template**

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| **Semester: 5** | |
| **Programme: Mathematics** | |
| **Course: Numerical Analysis** | |
| **Paper code: C3MT230532T / C3MT230532P** | **Credits: ?** |
| **Hours/week : 3+2** | |
| **Category: Core/MDC/SEC/VAC : Core** | |
| **Theory / Practical / Composite : Composite** | |
| **No of Modules : Nil** | |

**Course Overview: Numerical Analysis**

This course provides a comprehensive introduction to the theory, numerical method and its analysis. In particular it will give idea of managing error and its stability. It aims to develop students' ability to solve real-world mathematical problems which cannot be solve analytically. and hence solve them numerically. arising in science, Emphasis is on both theoretical methods and implementation through programming in C language. The course is structured into major modules: Idea of significant figure, Interpolation, Derivative, Integration, System of linear equation, First Order ODEs each progressing in conceptual depth in method and Problem- solving sophistication through Computer program.

**Course Outcome: Numerical Analysis**

1. Understand the genesis of Error; explain the origin and bounds.
2. Understand the requirement of Interpolation Apply results of Algebra and Analysis in Interpolation and analyze the error. Apply it through computer programming.
3. Analyze lacuna of derivative and Integration in real world. Create methods and apply it through computer programming.
4. Determine numerical solution of non-linearequation in one variable. Analyze the idea of convergence and stability. Create new method evaluating results of Mathematical analysis and Algebra which can be applied to computer programming.
5. Determine numerical solution of system of linear equation as an extension of school level solution technique. Analyze the error and stability. Apply it through computer programming
6. Create new method evaluating results of Mathematical analysis and Algebra which can be applied to computer programming for solving Ordinary differential equation.
7. Create Computer Program for all these techniques.

**Prerequisites:** ***Basic knowledge about any prior course***

**SYLLABUS**

| UNIT/Module | CONTENT | HOURS or NUMBER OF CLASSES | CO Mapping | COGNITIVE LEVEL |
|---|---|---|---|---|
| **I.** | Errors in Numerical Computations: Relative error, Absolute error, Percentage error, round-off rules and Round-off error, inherent errors, | **3** | **CO1** | **K1,K2** |

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|---|---|---|---|---|
| | Significant digits and Numerical instability. Error of a sum, difference, product & quotient of two approximate numbers Operators $\Delta$ ,$\nabla$,$\mu$ , $\delta$ , E (Definitions and simple relations among them) | | | |
| **II.** | Interpolation: Polynomial Interpolation, Weierstrass Approximation Theorem (statement only). Vandermonde's determinant. Equi-spaced arguments. Difference Table.]. Uniqueness of Interpolation formula and their Error. Deduction of Newton's Forward and Backward interpolation . Lagrange's interpolation formula .Newton divided difference formula. Newton's divided difference formula identified as a discrete version of Taylor's finite series. Deduction of Interpolation from Newton Divided Difference Formula Inverse Interpolation. Hermite interpolation formula: a combination of Function value and Derivative. Different interpolation formulae viewed as various basis choices of the vector spacePn[a,b]. Comparative study of various Interpolation formula. | **13** | **CO2,** | **K2, K3, K4** |
| **III.** | Numerical Differentiation: Basic idea and deduction from Interpolation Formula**.** | **1** | **CO3** | **K2,K3** |
| **IV.** | Numerical Integration: Deduction of Newton-Cotes formula. Basic Trapezoidal, Simpson's 1/3 rd, Simpson's rule 3/8 rule and their composite forms. Error estimates of these formulae. Deduction of Mechanical quadrature formula by Integrating Interpolation formula. Degree of precision. | **5** | **CO3** | **K3,K4,K5** |
| **V.** | Numerical Solution of non-linear equations: Location of a real root by Tabular method. Bisection method. Regula Falsi and Newton-Raphson methods. Generalized Newton | **8** | **CO4** | **K4,K5,K6** |

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|---|---|---|---|---|
| | Raphson method for multiple roots. Fixed point iteration method. Discussion of convergence of these methods. order of convergence | | | |
| **VI.** | Numerical solution of a system of linear equations: Direct method— [Gauss elimination method, Gauss-Jordan elimination method]. Idea of Partial Pivoting and Check formula. Iterative method— [Jacobi iteration method, Gauss- Seidel method] and their convergence. | **5** | **CO5** | **K3,K4,K5,K6** |
| **VII.** | Solution of Ordinary First order initial value differential equation by Euler , Heun, Runge Kutta method. Idea of Multistep method like Adams-Bashforth. | **4** | **CO6** | **K4,K6** |
| **VIII.** | **List of Practicals**: The following set of problems from Numerical Analysis are to be done on computer using C language:<br>1. Newton's Forward and Backward interpolation polynomial.<br>2. Lagrange's interpolation.<br>3. Trapezoidal, Simpson's 1/3- rule, Simpson's 3/8th rule, Weddle's rule for fixed number of Node.<br>4. Convergence of Trapezoidal, Simpson's 1/3- rule, Simpson's 3/8th rule, Weddle's rule.<br>5. Method of Tabulation, Bisection, Regula Falsi, Fixed point iteration, Newton-Raphson method.<br>6. Numerical solution of a system of linear equations: (Direct method) Gauss elimination and Gauss –Jordan.<br>7. (Iterative method) Gauss-Jacobi and Gauss- Seidel iteration method. Matrix inversion.<br>8. Power method for finding the extreme eigenvalues of real square matrix<br>. 9. Numerical solution of ordinary differential equation (Single step methods) —Euler's method, Modified Euler along with iterative method, Runge-Kutta method (fourth order). 10. Multistep methods: Adams Bashforth method. | **26** | **CO7** | **K6** |
| **Text Books** | | | | |
| **1. 1. Numerical Analysis: Sinha Pradhan** | | | | |
| **2. Numerical Analysis for Scientist And Engineers: Madhumangal Pal** | | | | |

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| **3. Numerical Analysis and algorithm: P.K.Niyogi** |
| **Suggested readings** |
| **1. An Introduction to Numerical Analysis: Kendall E Atkinson** |
| **2. Elementary Numerical Analysis: An algorithmic Approach: Conte & Boor** |
| **3. An Introduction to numerical Analysis: Gupta &Bose** |
| **Web Resources** |
| **1.** |
| **2.** |
| **3.** |
| **4.** |
| **Evaluation:**<br>**Theory: 45 (End Semester) CIA:15 (10(MidSem)+2(Assignment)+3(Atte ndance))**<br>**Practical: 40 (38 (CIA)+ 2 Attendance** |
| **Paper Structure for Theory Semester Exam : 4 questions each carrying 10 marks out of 7 questions + one 5 mark question out of 2 questions** |

**Course outcomes (COs) and Cognitive Level Mapping**

| COs | CO Description | Cognitive levels |
|---|---|---|
| **CO1** | Errors in Numerical Computations: Relative error, Absolute error, Percentage error, round-off rules and Round-off error, inherent errors, Significant digits and Numerical instability. Error of a sum, difference, product & quotient of two approximate numbers Operators $\Delta$ ,$\nabla$,$\mu$ , $\delta$ , E (Definitions and simple relations among them) | K1, K2 |
| **CO2** | Interpolation: Polynomial Interpolation, Weierstrass Approximation Theorem (statement only). Vandermonde's determinant. Equi-spaced arguments. Difference Table.]. Uniqueness of Interpolation formula and their Error. Deduction of Newton's Forward and Backward interpolation. Lagrange's interpolation formula .Newton divided difference formula. Newton's divided difference formula identified as a discrete version of Taylor's finite series. Deduction of Interpolation from Newton Divided Difference Formula Inverse Interpolation. Hermite interpolation formula: a combination of Function value and Derivative. Different interpolation formulae viewed as various basis choices of the vector spacePn[a,b]. Comparative study of various Interpolation formula. | K2, K3, K4 |
| **CO3** | Numerical Integration: Deduction of Newton-Cotes formula. Basic Trapezoidal, Simpson's 1/3 rd, Simpson's rule 3/8 rule and their composite forms. Error estimates of these formulae. Deduction of Mechanical quadrature formula by Integrating Interpolation formula. Degree of precision. | K2,K3,K4,K5 |
| **CO4** | Numerical Solution of non-linear equations: Location of a real root by Tabular method. Bisection method. Regula | K4,K5,K6 |

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| | Falsi and Newton-Raphson methods. Generalized Newton Raphson method for multiple roots. Fixed point iteration method. Discussion of convergence of these methods. order of convergence | |
| **CO5** | Numerical solution of a system of linear equations: Direct method— [Gauss elimination method, Gauss- Jordan elimination method]. Idea of Partial Pivoting and Check formula. Iterative method— [Jacobi iteration method, Gauss- Seidel method] and their convergence. | K3,K4,K5,K6 |
| **CO6** | Solution of Ordinary First order initial value differential equation by Euler , Heun, Runge Kutta method. Idea of Multistep method like Adams-Bashforth | K4,K6 |
| **CO7** | **List of Practical**:<br>1. Newton's Forward and Backward interpolation polynomial.<br>2. Lagrange's interpolation.<br>3. Trapezoidal, Simpson's 1/3- rule, Simpson's 3/8th rule, Weddle's rule for fixed number of Node.<br>4. Convergence of Trapezoidal, Simpson's 1/3- rule, Simpson's 3/8th rule, Weddle's rule.<br>5. Method of Tabulation, Bisection, Regula Falsi, Fixed point iteration, Newton-Raphson method.<br>6. Numerical solution of a system of linear equations: (Direct method) Gauss elimination and Gauss –Jordan.<br>7. (Iterative method) Gauss-Jacobi and Gauss- Seidel iteration method. Matrix inversion.<br>8. Power method for finding the extreme eigenvalues of real square matrix<br>. 9. Numerical solution of ordinary differential equation (Single step methods) —Euler's method, Modified Euler along with iterative method, Runge-Kutta method (fourth order). 10. Multistep methods: Adams Bashforth method. | K6 |