NATIONAL INSTITUTE OF TECHNOLOGY: TIRUCHIRAPPALLI- 620 015

DEPARTMENT OF MATHEMATICS

COURSE OUTLINE TEMPLATE			
Course Title	**Numerical Methods**		
Course Code	**MAIR 43**	**No. of Credits**	**3**
Department	**Mathematics**	**Course: B. Tech** **Branch: ICE (Section A)**	
Pre-requisites Course Code	**Knowledge of Basic Calculus and algebra**		
Course Coordinator(s) (if, applicable)	**Dr. T.N.Janakiraman**		
Other CourseTeacher(s)/Tutor(s)		**Email Id**	**Telephone No.**
Dr. T.N.JANAKIRAMAN		**janaki@nitt.edu**	**9894794198, 9489066245**
Course Type	√ **Core course** ☐ **Elective course**		

COURSE OVERVIEW

- **To have general awareness and understanding of**
  - **(1) Variousnumerical methods some which give exact solutions and many give approximate solution, which is a pure and applied branch of mathematics**
  - **(2) Sequential algorithms(schemes) for the concepts introduced in the course with time complexity(not included in the syllabus) and convergence analysis of solution of the problems and implementation of the schemes.**
- **To understand various applicationsof the introduced concepts in various engineering problems.**

COURSE GENERAL OBJECTIVES

- **To make the students to understand very well about the theory related to the numerical mathematical schemes and develop the logic and reasoning in framing in the implementation of the scheme to get desired (exact or approxiate) solution in the polynominal time for the engineering and scientific problems.**
- **To train students with mathematical and algorithmic aspects so that students will be motivated to design new schemes for the solutions with better approximation to the given problems.**
- **To train the students to fix best approxiamated continuous mathematical function for the**

given disctere data and also generate new data which are consistent to the given data.

Learning Specific Objectives:

To introduce

1. **numerical methods for Solving Linear Systems**
2. **numerical methods to solve equations of one variable as well as system of equations with two variables.**
3. **interpolating Polynomials and best curve fitting methods for the given data.**
4. **numerical differentiation and integration**
5. **numerical solutions of Ordinary Differential Equations.**

Digital representation of numbers, Finite precision arithmetic, Machine Precision, Measuring errors, convergence of iterative sequences, Taylor series, Order Notation. Numerical Solution of $f(x) = 0$: Bisection method, Secant method, Newton's method , Newton's method for $f(x, y) = 0,\ g(x, y) = 0$. Order of convergence.

Solution of linear system of equations –Direct method: Gaussian elimination, Gauss-Jordan methods, LU Decomposition method-Crout's method. Algorithm for tri-diagonal system, Iterative method: Jacobi and Gauss-Seidal's method -sufficient conditions for convergence -Eigen Value problems-power method.

Interpolation: Lagrange's method, Newton's divided difference, forward and backward difference interpolation method. Least squares fitting of a curve to data-Polynomial curve fitting, exponential curve $(y = ae^{bx} + c)$ fitting to data.

Numerical Differentiation based on interpolation and finite difference. Numerical Integration-Closed and open type integration rules -Trapezoidal rule, Simpson's $1/3$ rule and $3/8$ rule, mid-point and two-point rule. Adaptive integration based on Simpson's

rule. Gauss quadrature methods, Integrals with infinite limits $(\int_0^\infty e^{-x} f(x)dx)$.

Numerical solution of ordinary differential equations: Taylor's series method, Single step method-Euler's method, Euler's modified method, Fourth orderRunge-Kutta method. Fourth order R-K method for simultaneous equations and 2nd order ODE. Multi step methods: Milne's and Adams method.

Learning Specific outcomes: On completion of the course, students should be able to

1. **compute numerical solution of given system AX=B by direct and iterative methods.**
2. **compute largest eigenvalue and its corresponding eigenvector of matrix A.**
3. **compute numerical solution of f(x)=0 and nonlinear equations with two variables,**
4. **interpolate function and approximate the function by polynomial.**
5. **Compute numerical differentiation and integration of** $f(x)$.
6. **Compute best curve fit for the given data by curve fitting method.**
7. **Compute numerical solution of ordinary differential equations by finite difference method.**

Reference Books:

1. **Jain, M.K., Iyengar, S.R. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age International, 2012.**
2. **S.S. Sastry, Introductory methods of numerical Analysis, 4/e, Prentice Hall of India, New Delhi, 2005.**
3. **David Kincaid and Ward Cheney, Numerical Analysis\, 3rd edition, American Mathematics Society, (Indian edition) – 2010.**
4. **Gerald, C.F., and Wheatley, P.O., 'Applied Numerical Analysis', Addison-Wesley Publishing Company, 1994.**

COURSE OUTCOMES (CO)

Course General Outcomes	Aligned Programme Outcomes(PO)

(1) To decide the nature of the general problem related to numerical methods, whether to try for exact or approximate solution for it. **(2) To decide which scheme may be applied to get solution with desired approximation.** **(3) With the help of theoretical knowledge, logic of programming and computational skill, developing the sense of analysis of nature of convergence of the solution due to the implemented scheme and nature of the problem.** **(4) To propose hybrid schemes for the given problem to get better approximate solutions.** **(5) Become motivated to apply these schemes in various engineering fields.** **(6) To implement the algorithms/schemes in the computing system and to analyze the output for various data/functions**	**Theengineeringundergraduates will apply their knowledge of logic, reasoning and computational and related mathematical techniquesto engineering advanced problems.**

COURSE TEACHING AND LEARNING ACTIVITIES

S. No.	Week	Topic	Mode of Delivery
	Week- 1 **Week - 2**	**1. Introduction to Numerical Methods and its applications, a overview of the syllabus.(Two Sessions)** **2. Various typeserrors in numerical methods, some definitions and mathematical examples.** **3. Analysis of order of convergence and time complexity of algorithm(scheme). Theoretical explanation and examples.** **1. Bisection method-Theoretical explanation of scheme-implementation-error analysis.** **2. Regula-falsi Method-Theoretical explanation of scheme-implementation-error analysis.** **3. Newton-Raphson Method-Theoretical explanation of scheme-implementation-error analysis.** **4. Some applications of Newton-Raphson method.**	**Chalk and Talk**

	Week-3	1. Secant method. A derived method from Newton Raphson procedure and implementation. 2. Newton's method of solving F(x,y)=0 and G(x,y)=0-Scheme and various possible modifications on the improved solution. Limitation of procedure. 3. Problem on solving equations of type F(x,y)=0 and G(x,y)=0. 4. Solution to linear non homogeneous simultaneous equations using Direct method Gauss elimination and Gauss-Jordan schemes-implementation - exact solution.	Chalk and Talk
	Week-4	1. Critical cases in the schemes and problem related above procedure and application to find inverse of a matrix.. 2. Triangularization method- Crout's scheme-derivations. 3. Problem –implentation of Crout's scheme. Application to find inverse of a matrix 4. Iterative procedures-Gauss-Jacobi's scheme and Gauss- Siedel Scheme- Condition for convergence-Diagonal domination. Time complexity(not included in the syllabus, only for motivation to design efficient algorithm).	
	Week -5	1. Problems implementing the above schemes. 2. Algorithm for tri-diagonal system. 3. Finding dominant eigen value and its eigen vector. Apllication to find smallesteigen value and the eigen vector of a matrix-Power method-implementation of scheme. 4. Introduction to finite difference operators and their mutual relations.	Chalk and Talk
	Week-7	1. Newton-Gregory forward and backward difference formulae-derivation and their applications.(Equal interval in at least one of the variables data) 2. Problems using forward and backward interpolation schemes. 3. Applications- finding missing value(s) in a sequence- error propagation in the difference table. 4. Newton's divided difference formula- Properties-Application in unequal interval data.	Chalk and Talk

	Week -8 Week -9	1. Problem- implementation of Newton's divided difference scheme. 2. Lagrange's formula-derivation –Application. 3. Problem-implementation. 4. Method of least squares- Scheme derivation –Apllications. 5. Problems related to case fitting to $y = ax+b$, $y= ax^2+bx+c$, 6. Problems related to fitting the data to $y= ax^b+c$, ab^x+c. 7. Problems related to fitting the data which are reducible to above forms. 8. Newton-forward and backward formula for first , second and higher order derivatives-derivation and application.	Chalk and Talk
	Week-10 Week-11	1. Problem related to numerical differentiation. 2. Newton-Cote's formula- Derivation of Numerical integration formula using Trapezoidal rule, Simpson's 1/3rd and 3/8 th rule. Error estimation in those schemes(Two sessions). 3. Problems- applications of those schemes. 1. Problems-application of above continued. 2. Gaussian quadrature formula –Two point and three point schemes-derivation and Problems (three sessions)	Chalk and Talk
	Week-13 Week-14	Numerical solutions for ordinary differential equations- 1. Taylors' Series Method.-Problem on single first order differential equation and Application to Simultaneous two first order diferential equations.(Two sessions) 2. Euler's Methods-Formula derivation and Problems –Applications(Two sessions) 1. R.K. Method of Order II and IV-Formula and problem applications to Single first order, Simultaneous two first order and second order differential equations order.(Two sessions) 2. Milne's and Adam's Predictor and corrector Methods-rough sketch of derivation of formula-Problem applications.(Two sessions)	Chalk and Talk
	Week-15	1. Doubt Clarifications regarding all concepts, Students' view on the relevancy of the course for applications, other topics to be studied by students for further knowledge and applications, discussion on the examination question pattern, scheme of marks and grading policy.(One/two Session). End of lecture series.	Chalk and Talk
COURSE ASSESSMENT METHODS			

S.No.		Week/Date	Duration	% Weightage
1.	Cycle Test –I	6th week	1 Hour and 30 minutes	20%
2.	Cycle Test-II	12th week	1 Hour and 30 minutes	20%
3.	Retest	15th week	1 Hour and 30 minutes	
4.	Assignments/Seminar			10%
5.	End Semester Exam		3 Hour	50% Total : 100 Marks

ESSENTIAL READINGS : Textbooks, reference books Website addresses, journals, etc

Reference Books

1. M.K.Jain, S.R.K. Iyengar, R.K. Jain Numerical Methods for Scientific and Engineering computation, Second Edition, 2009, New Age International Publishers.
2. S.S.Sastry, Introductory Methods of numerical Analysis, Fourth Edition, Pretice Hall of India, New Delhi, 2005.
3. Ward Cheney and David Kincaid, Numerical Mathematics and Computing, Sixth edition, Cengage Learning, 2007.

COURSE EXIT SURVEY

Periodic: May be after completion of every Unit of the syllabus, after each of the Cycle tests and last one at end after covering full syllabus.

COURSE POLICY:

Sincerity in doing assignments, teacher-students interaction during lecture programmein class environment, Group interaction(to develop and clarify doubts while doing computation in the class room environment), at least 75% of the attendance and importance on the attendance for the weak students(to have more participation in learning program), Giving additional topics for the capable students to work on the related topics in the syllabus.

Students, who missed all cycle tests and retest must redo the course. Students who get very low marks in the cycle tests and weak students with lack of attendance must attend extra sessions at the department of Mathematics to get the eligibility to write the final exam. Students, who are found not satisfied even after enough additional coaching for their improvement, either they , may be allowed to redo the course or will be permitted to go for formative evaluation depending on the approval of both Mathematics and ICE departments HODs.

Availability of the C, oursecoordinator. outside the class room:

The Course Coordinator can be contacted through the mobile numbers (9894794198, 9489066245) for appointments to have discussion outside the class room environment.

FOR SENATE'S CONSIDERATION
Dr. T.N JANAKIRAMAN Course Faculty _____ CC-Chairperson _____ HOD _____ 11/1/17