Course title: Applied numerical methods			
Course code: ENR 159	**No. of credits:** 3	**L-T-P:** 24-10-22	**Learning hours:** 56
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Dr. Som Mondal	**Course instructor(s):** Dr. Som Mondal/ Dr. Aviruch Bhatia		
Contact details: som.mondal@terisas.ac.in			
Course type: Elective	**Course offered in:** Semester 2		

Course description

This course is designed for application of numerical methods in solving problems related to renewable energy technologies. The course starts with introduction of numerical methods and its applicability in renewable technologies with an introduction to basic computation using MATLAB/Python. It covers the concepts of solution techniques of linear and non-linear equations and systems of equations. In module 3, differentiation and integration using numerical methods are covered. Application of different initial value and boundary value problems in renewable energy using finite difference method is taught in module 4. An introduction to solution of partial differential equation and finite element method is also covered. Computational practical problem solving is an integral part of the course.

Course objective

The objective of the course is to prepare students with knowledge of numerical methods which may be applied to solve complex problems in renewable energy field.

Course contents

Module	Topic	L	T	P
1	**Introduction** Application of numerical methods in renewable energy Introduction to various softwares, their capabilities, limitation and tools, basic computation process.	2	0	0
2	**Linear equation and non-linear equations** Linear algebraic equations and matrices Gauss elimination, LU-factorization, matrix inverse and condition, Eigen value problems, Iterative methods, Convergence and accuracy of Iterative methods Solution of non-linear equations: Regula-Falsi method, Fixed-point Iteration, Newton-Raphson Method, Order of Convergence Solution of system of non-linear equations Case study	8	2	6
3	**Numerical differentiation and integration** Numerical differentiation: high-accuracy differentiation formulas, first order and second order differentiation, derivatives of unequally spaced data, derivatives for data with errors, partial derivatives Numerical integration: numerical integration formulas, numerical integration of functions, integrals for data with errors, Trapezoid and Simpson's rules for even and uneven spaced data.	6	2	6
4	**Solution of ordinary differential equation (ODE)** Implicit & explicit Finite-Difference Method (FDM), FDM for Initial Value ODE, Modified Euler Method; Runge-Kutta Method, Multi-point Methods Boundary Value-ODE, Dirichlet and Neuman boundary conditions Solution of second order partial differential equations: elliptic and parabolic equations Case studies	8	6	10
		24	**10**	**22**

Evaluation criteria

- Assignments: (after completion of module 6) - 20%
- Written and Practical Test 1: (after completion of modules 1, and 2) - 15%
- Written and Practical Test 2: (after completion of module 3) - 15%
- Written and Practical Test 3: (at the end of the semester after completion of modules 4) - 50%

Learning outcomes

- To formulate engineering problems and develop algorithm for numerical solution. (Test 1)
- Understand and identify the right numerical methods for solution. (Test 2 and 3)
- Solve the problems using software like MATLAB, PYTHON etc. (Test 2 and 3)

Pedagogical approach

A combination of class-room interactions, practical, tutorials and assignments.

Materials

Recommended readings

Chapra, S.C., "Applied Numerical Methods with MATLAB", Tata McGraw Hill, New Delhi, 2007
Chapra, S.C. and Canale, R.P., "Numerical methods for Engineers", Tata McGraw Hill, New Delhi, 2007
Jain, M.K., Iyenger, S.R.K. and Jian, R.K., "Numerical Methods for Scientific and Engineering Computation, New Age International ltd", New Delhi, 2008
Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons Inc, India, 1999
Saumyen Guha and Rajesh Srivastava, "Numerical Methods for Engineering and Science", Oxford Higher Education, 2010
Joe D. Hoffman, "Numerical Methods for Engineers and Scientists", Second Edition, Taylor and Francis, USA, 2001

Additional information (if any):NA

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Dr. Sumit Basu, Professor, Mechanical Engineering, Indian Institute of Technology Kanpur
2. Dr. Suresh A. Kartha, Associate Professor, Civil Engineering, Indian Institute of Technology Guwahati