PHY604: Computational Physics 4 CH (P190+20T)

Nature of the course: Practical Full Marks: 100 Pass Marks: 50

Course Description:

The aim of the course is to impart some fundamental knowledge of computational physics to solve real physical problems.

Course Objectives:

The objective of this course is to train the students in the methods of computations in physics and aplly them to solve the real problems. At the completion of the course, the student should be able to solve different physical problems using recent computational techniques.

Course Contents

1. **Introduction:** **[12 hours]**
   - **1.1** Motivation
   - **1.2** Important invention by computational physics
   - **1.3** Error, Precision, and Stability in Computational Science
   - **1.4** Limitations of Computational Physics

2. **Basics of Computational Physics:** **[60 hours]**
   - **2.1** Operating Systems – MS Windows and Linux
   - **2.2** Editors in Linux
   - **2.3** Plotting programs – Gnuplot/Xmgrace with examples
   - **2.4** Mathematica,
   - **2.5** Programing language(s)– Fortran/C

3. **Numerical Methods**: **[72 hours]**
   - **3.1** Functions and Roots:
     - 3.1.1 Finding Roots of a function; Newton-Raphson method;
     - 3.1.2 Rates of convergence
     - 3.1.3 Accelerating the rate of convergence
     - 3.1.4 An Example from Quantum Mechanics
   - **3.2** Interpolation and Extrapolation:
     - 3.2.1 Lagrange interpolation
     - 3.2.2 Cubic spline interpolations
     - 3.2.3 Approximation of derivatives
     - 3.2.4 Richardson extrapolation
     - 3.2.5 Curve fitting by least squares
     - 3.2.6 Nonlinear least squares
   - **3.3** Numerical integration:
     - 3.3.1 Trapezoidal Rule
     - 3.3.2 Simpson's Rule,
     - 3.3.3 The simple pendulum,
     - 3.3.4 Multidimensional numerical integration;
     - 3.3.5 Monte Carlo numerical integration
   - **3.4** Ordinary differential equation
     - 3.4.1 Euler methods
     - 3.4.2 Runge-Kutta Methods,

3.4.3 Second order differential equation
3.4.4 Phase space of a simple harmonic oscillator,
3.4.5 One-Dimensional Schroedinger equation (example with anharmonic potential);

3.5 Partial differential equation;
3.5.1 Laplaces equation
3.5.2 Wave equations and heat equation

Note: *Students must be able to write code themselves in each topic with Fortran/C OR develop mathematica module*

4. Applications of computational physics [12 hours]

4.1 Simulation of Ising model,
4.2 ALADIN2.5 in.Astro-particle physics

Text Books:

1. De Vries P. L. **– A first course in computational physics,** John wiley & Sons, New York (1994)
2. Franklin J. **– Computational Methods for Physics,** Cambridge University Press, Cambridge (2013)

References Books:

1. Koonin S. E., Meredith D. C. **– Computational Physics,** Westview press (1990)
2. Anagnostopoulos K .N. **– Computational Physics,** National Technical University, Athens (2014)
3. Scarborough J.B. – **Numerical Analysis,** John Hopkins Press, USA (1962)
4. Press, M. et al. – **Numerical Recipe in C**, Cambridge University Press, or, Foundation Book, India (1998)