# COP: Computational Physics

Programme: B.Tech. (CSE/ECE/CCE) Year: 2014-15 Semester : 2nd semester
Course : Science Credits : 4 Hours : 40

**Course Context and Overview (100 words):**

Programming skills along with the adequate knowledge of laws of physics which govern the real world has become necessary in various fields of study. Examples are - simulations of rocket launches, analysis of chaotic systems like the weather, animation in movies and games to name a few. This course teaches the programming techniques with emphasis on solving physics and engineering problems.

**Prerequisites Courses:**

None

**Course outcomes(COs):**

| **On completion of this course, the students will have the ability to:** |
|---|
| **CO1:** Write Matlab programs. |
| **CO2:** Apply fundamental knowledge of Physics in engineering problems. |
| **CO3:** Identify, formulate and solve some standard Physics problems. |
| **CO4:** Chalk out the path of approach to solve some non-standard Physics problems. |
| **CO5:** Analyse data derived from any Physics experiment. |
| **CO6:** Communicate an idea by oral, written and graphical method (if required) |

**Course Topics:**

| **Topics** | **Lecture Hours** |
|---|---|
| **UNIT I: Introduction to Matlab & Error Analysis** | 3 |
| 1. Introduction to Matlab – Basic interface | |
| 2. M files: Script and function files | |
| 3. Difference between matlab and other programming languages | |
| 4. Various command commands in matlab | |
| (More on matlab is taught as and when required in class) | |

| | |
|---|---|
| 5. Error Analysis | |
| **UNIT II: Root finding methods** | 5 |
| 1. Graphical Method | |
| 2. Bracket Methods | |
| 3. Open End Methods | |
| 4. Matlab commands | |
| 5. Case Study | |
| **UNIT III: System of Linear Equations** | 5 |
| 1. Gauss elimination Method | |
| 2. LU Decomposition | |
| 3. Special Matrices | |
| 4. Matlab left division | |
| 5. Gauss Seidel | |
| 6. Eigenvalues | |
| 7. Case Study | |
| **UNIT IV: Interpolation** | 4 |
| 1. Linear Interpolation | |
| 2. Newton's interpolation technique | |
| 3. Lagrange interpolation | |
| 4. Pitfalls in interpolation | |
| 5. Spline interpolation technique | |
| 6. Matlab commands for interpolation | |
| 7. Case Study | |
| **UNIT V**: **Differentiation & Integration** | 4 |
| 1. Difference formulas for 1st order and 2nd order differentiation | |
| 2. Trapezoidal rule | |
| 3. Simpson's rule | |
| 4. Romberg integration | |
| 5. Gauss-quadrature and Gauss-Legendre formula | |
| 6. Case Study | |
| **UNIT VI: Ordinary Differential Equations** | 5 |
| 1. Intial value problems | |
| a) Euler method | |
| b) Heun's method | |
| c) Runge-Kutta method of order four | |

| | |
|---|---|
| d) 2nd order differential equation | |
| e) Multi-step method and stiffness | |
| 2. Boundary Value problem | |
| a) Shooting method | |
| b) Finite difference method | |
| 3. Case Study | |
| **UNIT VII: Partial Differential Equations (PDE)** | 4 |
| 1. PDE in first order | |
| 2. PDE in 2nd order in 1+1 dimensions | |
| 3. PDE in 2nd order in 2+1 dimensions | |
| 4. Case Study | |
| **UNIT VIII: Advanced data fitting** | 4 |
| 1. Linear regression | |
| 2. General linear least-squares and non-linear regression. | |
| 3. Case Study | |
| **UNIT IX: Fourier Analysis** | 3 |
| 1. Curve fitting with sinusoidal functions | |
| 2. Fourier series and its applications | |
| 3. Fourier transform and its applications | |
| **UNIT X: Random Processes and Monte Carlo Simulation** | 3 |
| 1. Multi dimensional numerical integration | |
| 2. Monte Carlo integration | |
| 3. Monte Carlo simulations | |
| 4. Case Study | |

**Textbook references (IEEE format):**
**Text Book:**

1. S. Chapra, Applied Numerical Methods: With MATLAB for Engineers and Scientists. Applied Numerical Methods with MATLAB for Engineers and Scientists, New Delhi: McGraw-Hill, 2005.

2. S. Chapra and R. Canale, Numerical methods for engineers. McGraw-Hill international editions, New Delhi: McGraw-Hill, 1988.

3. V. Rajaraman, Computer Oriented Numerical Methods 3Rd Ed. Delhi: PHI Learning Pvt. Ltd., 2004.

4. R. Pratap, Getting Started With Matlab 7: A Quick Introduction For Scientists And Engineers. The Oxford Series in Electrical And Computer Engineering, New Delhi, India: Oxford University Press, Incorporated, 2006.

5. S. Chapman, Matlab Programming with Applications for Engineers. New Delhi: Cengage Learning, 2012.

**Reference books:**

1. P. DeVries and J. Hasbun, A First Course in Computational Physics. New Delhi: Jones & Bartlett Learning, 2011.

2. N. Giordano and H. Nakanishi, Computational Physics. Pearson/Prentice Hall, 2006.

**Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):**

**Evaluation Methods:**

| Item | Weightage |
|---|---|
| Quiz1 | 20 |
| Quiz2 | |
| Quiz3 | |
| Quiz4 | |
| Midterm | 30 |
| Final Examination | 50 |

**Prepared By:** Dr. Anjishnu Sarkar
**Last Update:** _____