IIT Mandi

Course Name	: **Basic Programming Lab**
Course Number	: QT 303P
Credits	: 2-0-1-3
Prerequisites	: Engineering Mathematics (Linear Algebra, Complex algebra, basics of 2nd of ODEs and initial value problems, 2nd order PDEs and boundary value problems, Probability and Statistics, Random variables). Maxwell's equations and EM theory at the level of the core physics syllabus from AICTE model
Curriculum Intended for	: UG/PG/PhD
Distribution	: Elective PG/Elective UG
Semester	: Odd/Even

Preamble: This course is meant to provide students a quick hands-on experience in scientific computing and its applications to areas within Quantum Technologies. Students of this course learn (i) Basics of programming, (ii) To write programs to solve scientific problems, (iii) Techniques for scientific computing, (iv) Applications to quantum mechanics and electromagnetism

1. **Course Content and syllabus:**

- Basics of programming
    - Data structures, classes, Object-oriented programming
    - Data storage and retrieval, Memory allocation
    - Scientific plotting, documentation of codes
- Simple algorithms and benchmarking run time
    - Sorting
    - Searching
    - Arithmetic algorithms like GCD, Prime factorisation
- Numerical Integration and differential equations
    - Linear 2nd Order ODEs with constant coefficients
    - Linear 2nd order ODEs with variable coefficients
    - Boundary value problems
        - Poisson equation
        - Laplace equation
        - Wave equation
        - Diffusion Equation
- Numerical techniques in linear algebra
    - Matrix inverse
    - Eigenvalue problem
    - Diagonalisation of matrices
    - Singular value decomposition
- Numerical techniques in Probability and Statistics
    - (Pseudo) Random number generation
    - Computing statistical moments for data samples
    - Least Squares fitting
    - Error Analysis

    - Hypothesis Testing
    - Monte Carlo sampling
- Applications to Quantum Mechanics (can be done using openly available modules in languages like Python, Julia etc.)
    - Eigen energies of coupled two level systems
    - Eigen energies of two-level system coupled to oscillator (Jaynes-Cummings Model)
    - Driven two-level system – Rabi Problem
    - Driven damped oscillator — coherent states
- Applications to EM theory (e.g. magnetic field simulation)
    - Electrostatic charge distributions
    - Magnetostatic current distributions
    - Finite Element techniques for electromagnetic simulations

Course References:

Computational Physics, Nicholas Giordano, Hisao Nakanishi, 2nd edition, Pearson-Addison Wesley (2005)