SKILL ENHANCEMENT COURSE (PHYSICS)

Semester I

Physics - SEC - 1 : Computational Physics - 1
(Credits: 03)
Lab: 60 Lectures

Report Writing and Presentation Tools

Getting Started with Python Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, set, tuples, classes, dictionaries and strings, basic ideas of object oriented programming.

NumPy Arrays; Indexing; Iterating. Creating Arrays : array(), arange(), linspace(), zeros(). Basic Operations : Add, Subtract, Multiply, Divide, and Exponentiation. Vector/Linear Algebra.

MatPlotLib and PyPlot 2D Plot; Interactive Plotting; Plot method; Labels; Log and Polar Plots; Multiple Figures and Curves; Subplots;

Interpolation and Curve Fitting Interpolation Schemes : Nearest Neighbor; Linear; Quadratic; Spline. Least-Squares Fit: Linear and Polynomial.

Roots of equations Real roots of single variable function; iterative approach; qualitative behavior of the function; Closed domain methods (bracketing): Bisection; False position method; Open domain methods: Newton-Raphson, Secant method; Roots of polynomials; Roots of non-linear equations.

Reference Books

[1] Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers (8ed), McGraw-Hill.
[2] Rubin H. Landau, Manuel J. Páez and Cristian C. Bordeianu, Computational Physics: Problem Solving with Python (3ed), Wiley.
[3] Alex Gezerlis, Numerical Methods in Physics with Python, Cambridge.
[4] Jaan Kiusalaas, Numerical methods in engineering with Python 3, Cambridge.

Semester II

Physics - SEC - 2 : Computational Physics - 2
(Credits: 03)
Lab: 60 Lectures

Linear algebra Matrix Factorizations: QR Factorization; Gram-Schmidt Orthogonalization; Householder Triangularization; LU and Cholesky factorization; Schur factorization; Direct elimination methods: Gauss elimination (pivoting, scaling); Tridiagonal systems; Iterative methods: Jacobi iteration; Conjugate Gradients; Eigenvalue problems: Rayleigh Quotient; Arnoldi and Lanczos methods.

Monte Carlo Simulation Random Sequences; Random-Number Generation; Examples : Value of π, Random Walk, Spontaneous Decay.

Differentiation Forward Difference; Central Difference; Backward Difference; Extrapolated Difference; Second Derivatives.

Integration Quadrature as Box Counting; Trapezoid Rule; Simpson's Rule; Gaussian Quadrature; One and Multidimensional Monte Carlo Integration.

Ordinary Differential Equations Initial-Value Problems : Euler's Method; 2^{nd} and 4^{th} Order Runge-Kutta Methods; Simultaneous Differential Equations. Boundary-Value Problems : Shooting Method; Matrix Approach.

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[1] Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers (8ed), McGraw-Hill.

[2] Rubin H. Landau, Manuel J. Páez and Cristian C. Bordeianu, Computational Physics: Problem Solving with Python (3ed), Wiley.

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