Elective course IDC 600

Course Title: Math & Computation using Python

Course No: IDC 600 level

Course proposers: Mahendra K. Verma (KSS, Physics) + Sachchida Nand Tripathi (KSS, Civil), Rajesh Ranjan (AE)

About the course: Mathematics and computation are essential in various fields, from data science to engineering and social sciences. This course will introduce programming concepts using Python as a language, as well as computational tools essential for engineering and science. In addition, essential mathematics for Artificial Intelligence (AI) will be reviewed. This course will empower a student to use Python to implement and visualize solutions. By the end of the course, a student will be able to develop a toolkit of computational techniques that will enhance his/her problem-solving capabilities.

Participating Departments for floating the course: Aerospace engineering, Kotak School of Sustainability. It is anticipated that more departments will be interested in this course.

Departments from which students can take the course for credit: Aerospace Engineering, Kotak School of Sustainability. It is anticipated that more departments will be interested in this course.

Units: 3-0-0-0-9 [3 lectures, 9 credits]

Prerequisite: Basic knowledge in computer programming and mathematics

Who can take the course: Ph. D., M. Sc., and Advanced UG students.

Course Contents:

Python Programming [10 lectures]

1. Introduction to Computers
2. Control Structures (conditional and iterative)
3. Functions in Python
4. lotting and data analysis
5. Input/Output in Python

Review of Mathematics [10 lectures]

1. Probability and Statistics, error analysis
2. Linear algebra: Solve Ax = b, Eigenvalues and eigenvectors

Numerical Methods [20 lectures]

1. Solving equations — Iterative procedure, Newton's method, Secant method
2. Interpolation, Numerical Integration (Newton-Cotes, Gaussian quadrature)
3. Numerical Differentiation
4. ODE (ordinary differential equation) solvers: Stability and accuracy issues, Explicit vs. Implicit schemes, Predictor-corrector methods (Euler, Runge-Kutta), Multistep methods (Adam-Bashforth). Stiff equations, Leap-frog and Verlet methods
5. Fourier transform & PDE (partial differential equation) solvers using spectral method

6. Finite-difference method to solve complex PDEs: Examples—Diffusion equation, Navier-Stokes equation

Textbooks and References:

1. M. K. Verma, Practical Numerical Computing Using Python, Independent Publication (2021).
2. J. H. Ferziger, Numerical Methods for Engineering Applications, 2nd Ed., John Wiley & Sons (1998).
3. Mark Newmann: Computational Physics with Python, 2nd Ed., Computational Physics with Python
4. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer (2016)
5. Rubin H. Landau and M. J. Paez, Computational Physics: Problem Solving With Computers, John Wiley (1997).
6. R.Srivastava and S. Guha, Numerical Methods for Engineering and Science, Oxford Univ. Press (2010)
7. E. Kreyszig, Advanced Engineering Mathematics, Wiley (2023)
8. NPTEL course: https://onlinecourses.nptel.ac.in/noc23_ph46/preview

Signatures of the proposers:

Mahendra Verma

Sachchida Nand Tripathi

Rajesh Ranjan

17/4/2025

This Course is APPROVED/ ~~NOT APPROVED.~~ Convener, DPGC, Kotak School of Sustainability

This Course is APPROVED/ NOT APPROVED: Convener, DPGC, Department of Aerospace Engineering