Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Science College
Semester-3 (M.Sc.)

Subject: Numerical Techniques in Physics- MSCPH13516

Type of course: Major

Prerequisite: Basics of errors. Knowledge of integral and differential equations for presenting various problems in Physics.

Rationale: The course aims to train learners in the basics of numerical methods and applying these techniques using computers for solving Physics problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
CI	T	P	C	Theory Marks		Practical Marks		CA	
				ESE	MSE	V	P	ALA	
4	0	0	4	60	30	10	00	50	150

Legends: CI-Class Room Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment; ALA- Active Learning Activities.

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Fit It Right** Student have to Analyze a set of experimental data using Gaussian fitting and perform a chi-square test for goodness of fit and upload outcome on GMIU web Portal.	10
2	**Mind the Gaps – Interpolate** Student have to Use Lagrange and cubic spline interpolation to estimate missing data points from a given dataset and upload outcome on GMIU web Portal.	10
3	**Crack the Equation** Student have to Solve a non-linear equation using at least two numerical methods and compare their convergence behavior and upload outcome on GMIU web Portal.	10

4	**Code the Curve** Student have to Numerically solve a first-order differential equation using Euler's and 4th order Runge-Kutta methods and compare results graphically and upload outcome on GMIU web Portal.	10
5	**Simulate a Physical System** Student have to simulate a simple physical system (e.g., free fall, RC circuit, or radioactive decay) using numerical methods for solving differential equations and present the output graphically and upload outcome on GMIU web Portal.	10
	Total	**50**

Course Content:

Unit No	Course content	Hrs	% Weightage
1	**Chapter-1 Error Analysis:** Types of measured physical quantities: Discrete quantities, Continuously distributed quantities, Histogram, Normalized histogram, Best estimate of true value of data, Standard deviation of the means, Gaussian and Lorentzian distributions and their properties, Determination of mean value for a Gaussian distribution, Determination of standard deviation for Gaussian distribution, Chi-square test for of fit, Criteria for goodness of fit, Determination of parameters in linear relationships, Graphical method.	15	25%
2	**Chapter-2 Interpolation, Fitting, Integral equations:** Interpolation: Lagrange interpolation, difference tables, Spline interpolation, Cubic Spline interpolation. Fitting: Linear regression, polynomial regression, fitting exponential and trigonometric functions. Integral equations: Numerical Solution of Fredholm Integral Equation, Numerical Solution of Volterra Integral, Degenerate Kernels, Approximate solutions by series. Approximate Functions: Taylor series representation, Chebyshev series.	15	25%
3	**Chapter-3 Solution of Non-Linear and Simultaneous Algebraic Equations:** Method of successive Bisection, Fixed point iteration method, Method of false position (Regula falsi), Newton Raphson method, Secant method. Convergence criteria of Iterative methods. Solution of simultaneous algebraic equations: The Guass elimination method, Pivoting, Ill conditioned equations, Refinement of solutions, Gauss-Seidel iterative method.	15	25%

4	**Chapter-4 Integration and Solution of Differential Equation:** Numerical differentiation and Integration: Differentiation via interpolation, Differentiation based on polynomial fit, the method of undetermined coefficients, Divided Difference method. Numerical integration using Trapezoidal rule, Simpson-1/3 and Simpson-3/8 rule and Gaussian quadratic formula. Numerical solution of differential equations of the form dy/dx=f(x,y) using Euler's method and 2nd order and 4th order Runge-Kutta methods, Predictor-corrector method, Numerical solution of second order differential equations, Comparision of Runge-Kutta methods, Euler's method and Predictorcorrector method.	15	25%

Suggested Specification table with Marks (Theory):60

Distribution of Theory Marks (**Revised Bloom's Taxonomy**)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage	20%	40%	30%	10%	-	-

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome:

After learning the course the students should be able to:	
CO1	analyze experimental data using statistical tools, distributions, and goodness-of-fit techniques.
CO2	apply interpolation, curve fitting, and numerical methods to solve integral equations and function approximations.
CO3	solve non-linear and simultaneous algebraic equations using iterative and direct numerical methods.
CO4	compute numerical derivatives, integrals, and solve first- and second-order differential equations using standard algorithms.

Instructional Method:

The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory

The internal evaluation will be done on the basis of Active Learning Assignment

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

Reference Books:

[1] Computational Physics – R. C. Verma, P. K. Ahluwalia and K. C. Sharma (New Age Pub)
[2] Computer oriented numerical methods – V. Rajaraman (PHI)
[3] Computer oriented numerical analysis – R. Roychoudhury
[4] A first course in computational physics – Paul L. DeVries and Javier E. Hasbun
[5] Instrumental method of analysis: Willard
[6] Instrumentation, Measurement and Analysis: B. C. Nakra and K. K. Chaudhry (Tata McGrawHill Education).
[7] Data Reduction and Error Analysis for the Physical Sciences: P. R. Bevington and D. K. Robinson (3rd Ed., McGraw Hill Higher Education).