Centre for High Energy Physics
Faculty of Science
University of the Punjab, Lahore

Course Outline

Program	BSCP	Course Code	CPHY 482	Credit Hours	3 (2+1Lab)
Course Title	**Computational Physics Simulations I**				

Course Introduction

This course is about studying physical systems through simulations. Simulations are aimed at providing information about the physical systems very near to the reality. In this course the details of different deterministic as well as indeterministic problems will be explored with or without using random numbers. This course has vast level of applications such as in exploring the dynamics of complex situations such as; military applications, weaponry processes, missile designing and testing, manufacturing processes, etc. The simulations can be performed by using computer programming environments of C++/C#/Python, etc.

Learning Outcomes

Following objectives are expected at the end of this course:

1. Students will be able to convert differential forms of any physical problems into iterative forms.
2. The students will acquire applied expertise of programming languages such as Python while performing simulations.
3. The students will be able to better understand the underlying physics details in the topics involved in this course.

Course Content

Week 1	Course Introduction involving its scope and applications, etc.
	Introductory Lab work in the programming environment of C++/C#/Python, etc.
Week 2	Realistic Projective Motion: The Effects of Air Resistance, The effects of Air density and Altitude on Projectile motion
	Lab work for simulation of Realistic Projective Motion
Week 3	Non-linear damped driven oscillatory systems, Oscillatory motion and Chaos
	Lab work for simulation of Realistic Projective Motion
Week 4	Weather Prediction, Navier Stokes equations and the Lorenz Model
	Lab work for simulation of Non-linear damped driven oscillatory systems
Week 5	Solar system and the Kepler's laws
	Lab work for simulation of Non-linear damped driven oscillatory systems
Week 6	Electromagnetic Potentials and Fields
	Lab work for simulation of Solar system and the Kepler's laws
Week 7	Electromagnetic mirror and its applications
	Lab work for simulation of Solar system and the Kepler's laws

Week 8	Waves and optics: Interference, diffraction and polarization
	Lab work for simulation of Electromagnetic mirror and its applications
Week 9	Frequency spectrum of waves on a string; Motion of a realistic string
	Lab work for simulation of Waves and optics: Interference, diffraction and polarization
Week 10	Random Systems: Generation of random numbers
	Lab work for simulation of motion of a realistic string
Week 11	Monte Carlo method
	Lab work for generation of random numbers of different types
Week 12	Random walks
	Lab work for simulation of random walks
Week 13	Self-avoiding walks
	Lab work for simulation of self-avoiding walks
Week 14	Diffusion process and random walks
	Lab work for simulation of diffusion process
Week 15	Entropy and the arrow of time
	Lab work for simulation of entropy of diffusion system
Week 16	Cluster growth models
	Lab work for simulation of cluster growth models/processes

Textbooks and Reading Material

1. Computational Physics: Problem Solving with Computers (2nd edition), Rubin H. Landau, *John Wiley & Sons* (2000).
2. Computational Physics (2st edition), Nicholas J. Giordano, *Prentice Hall* (2005).
3. Computational Physics, Mark Newman, *CreateSpace Independent Publishing Platform* (2012).
4. Computational Physics, Jos Thijssen, *Cambridge University Press* (2007).
5. Applied Computational Physics, J. F. Boudreau and E. S. Swanson, *Oxford University Press* (2017).

Teaching Learning Strategies

1. The instructor will detail out the process/concept of converting the mathematical forms (such as differential equations) of physical problems into iterative forms which can be used for computer simulations.
2. The instructor will provide the details about the programming environment of C++/C#/Python etc.
3. Students will learn the concept of converting the differential equations, etc. into iterative form and will practice by solving the exercise problems.
4. Students will practice the process of making algorithms and implementing them in the available arbitrary programming language.
5. Students will learn how to analyze the simulation results in order to have better physics understanding.

Assignments: Types and Number with Calendar			
At least two assignments and two quizzes. A course project may also be assigned.			
Assessment			
Sr. No.	**Elements**	**Weightage**	**Details**
1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes: Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.