Course Specification

(Postgraduate Programs)

Course Title:	Modeling and Simulation in Physics
Course Code:	PHY 6233
Program:	Master of Science in Physics
Department:	Physics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University
Version:	3
Last Revision Date:	*26/09/2024*

Table of Contents

A. General information about the course:

1. Course Identification:

1. Credit hours: 3				
2. Course type				
A.	☐ University	☐ College	☒ Department	☐ Track
B.	☐ Required		☒ Elective	
3. Level/year at which this course is offered: Level 3 or 4/Year 2				
4. Course General Description:				
This course will introduce the solution of physics problems using computers. Assuming no previous computer programming experience, the course will introduce the basic ideas and programming skills of computational physics and students will develop their own computer software to solve problems in quantum mechanics, electromagnetism, biophysics, mechanics, chaos, nonlinear dynamics, and other areas.				
5. Pre-requirements for this course (if any): None				
6. Pre-requirements for this course (if any): None				
7. Course Main Objective(s):				

At the end of this course, students will be able to:

- **Select the proper formulation for describing specific physical phenomenon,**
- **Build high quality computer program.**
- **Choose the most accurate numerical techniques adaptable for modeling the physical phenomenon.**

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	60	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		

No	Mode of Instruction	Contact Hours	Percentage
4	Distance learning		

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	**30**
2.	**Laboratory/Studio**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**30**
5.	**Others (specify)……**	**0**
	Total	**60**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**Outline the key modelling strategies and mathematical/computational techniques.**	**K1**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Participation. ▪ Discussions.
1.2	**Describe models in a variety of scientific disciplines.**	**K1, K2**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.
1.3	**Outline a computational investigation of a particular model system and present results from a computer simulation study in line with scientific standards.**	**K2, K3**	• Lectures. • Class discussions. • Tutorials.	▪ Participation. ▪ Exams. ▪ Discussions. ▪ Homework.
2.0	**Skills**			
2.1	**Explain and summarize the basic knowledge gained from studying modeling and simulation in physics.**	**S1, S2**	• Lectures. • Class discussions. • Tutorials.	▪ Exams. ▪ Discussions. ▪ Participation.
2.2	**Develop the students ability to solve and analyze problems in physics related the topics covered by the course.**	**S2, S3**	• Problem classes and group tutorial. • Homework assignments as well as problems solutions.	▪ Exams. ▪ Discussions. ▪ Homework.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
2.3	**Communicate in a clear and concise manner orally, and using IT for acquiring and analyzing information.**	**S4**	• Lectures. • Class discussions. • Tutorials. • Encourage students to use electronic mail and internal network for submitting homework and assignments. • Use digital library.	▪ Exams. ▪ Participation and activities of students in the course community and blackboard. ▪ Homework.
3.0	**Values, autonomy, and responsibility**			
3.1	**Show the collaboration and inter-professionalism in class discussions or team works, as well as solve problems independently.**	**V1, V2, V3**	• Small team tasks • Open discussion at classroom. • Office hours.	▪ Participation ▪ Homework. ▪ Mini-project(s).

C. Course Content:

No	List of Topics	Contact Hours
1.	**An Introduction to MATLAB:** Programing: Initiation to MATLAB, MATLAB commands and language, arithmetic, variables, expressions and functions, elementary calculus, collections of expressions, equations, complex numbers, plotting, vectors and matrices, assuming properties, conditions and if-then construction, looping with for and while, Functions and procedures.	**8**
2.	**Non-linear Equations:** particle in a box potential, iterative method, bisection, newton-Raphson's method, the secant method, physical examples, exercises and projects.	**8**
3.	**Numerical differentiation and interpolation:** numerical differentiation, first and second derivative, examples, polynomial interpolation and extrapolation, numerical interpolation, extrapolation and fitting of data, error analysis, exercises and projects.	**8**
4.	**Numerical Integration:** Introduction, Newton-Cotes quadrature, equal step methods, trapezoidal, rectangle and Simpson methods, Adaptive integration, Gaussian quadrature, Applications to selected integrals, Treatment of singular Integrals, Scattering equation and principal value integrals, exercises and projects.	**10**
5.	**Linear Algebra and Eigenvalues:** Mathematical intermezzo, Linear, Gaussian elimination, LU decomposition of a matrix, Solution of linear systems of equations, Inverse of a matrix and the determinant, Tridiagonal	**8**

	systems of linear, Eigenvalue, Similarity transformations, Schrödinger's equation through diagonalization, Numerical solution of the Schrödinger equation by diagonalization, Program example and results for the one-dimensional harmonic oscillator, exercises and projects.	
6.	Differential Equations: Ordinary differential equations, Finite difference methods, Euler method, Runge-Kutta methods, Physics examples, Ideal harmonic oscillations, Damping of harmonic oscillations and external forces, The pendulum, a nonlinear differential equation, Spinning magnet, Partial differential equations, Analytic and numerical solutions for the one-dimensional diffusion equation, Analytic and numerical solutions of wave equation in two dimensions, Two point boundary value problems, exercises and projects.	**10**
7.	**Monte Carlo Methods:** Definitions, First illustration of the use of Monte-Carlo methods, crude integration, Second illustration, particles in a box, Radioactive decay, Program example for radioactive decay of one type of nucleus, exercises and projects.	**8**
Total		**60**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**Class Activities (class quizzes, homework, solving problems, etc.....)**	**weekly**	**20 %**
2.	**Midterm Exam 1**	**6th week**	**20 %**
3.	**Midterm Exam 2**	**12th week**	**20 %**
4.	**Final Exam**	**16th week**	**40 %**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	
Supportive References	**-K. Erleben, J. Sporring, K. Henriksen, H. Dohlmann, Physics-Based Animation, Charles River Media, 2005.** **-H. Gould, J. Tobochnik, W. Christian, A. Wesley, An Introduction to Computer Simulation Methods: Applications to Physical Systems, 3rd Edition, 2006.**
Electronic Materials	**https://units.imamu.edu.sa/colleges/en/science/Pages/default.aspx**
Other Learning Materials	**Multimedia associated with the textbook and the relevant websites.**

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	- Classrooms - Simulation rooms
Technology equipment (Projector, smart board, software)	- Classroom equipped with a whiteboard and a projector.
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	- Students. - Second examiner	Indirect (The student will complete evaluation forms at the end of semester. Final exam is evaluated by the second examiner)
Effectiveness of students' assessment	- Instructors	Direct (exams, HW, project, ...)
Quality of learning resources	- Faculty - Students	Indirect (surveys)
The extent to which CLOs have been achieved	- Instructors - Program Leaders	Direct (excel sheet)
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	Quality Unit-Physics Department
REFERENCE NO.	Department council No. 6
DATE	26/09/2024