هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد NCAA
T4
2020

Course Specifications

Course Title:	Computational Physics
Course Code:	PHY4205
Program:	Physics
Department:	Physics
College:	Applied Sciences
Institution:	Umm Al-Qura University

Table of Contents

A. Course Identification

1. Credit hours: 4 hrs								
2. Course type								
a.	University	☐	College	☐	Department	√	Others	☐
b.	Required	√	Elective	☐				
3. Level/year at which this course is offered: 12/4th year								
4. Pre-requisites for this course (if any): Theoretical Methods in Physics (4)								
5. Co-requisites for this course (if any):								

6. **Mode of Instruction** (mark all that apply)

Percentage	Contact Hours	Mode of Instruction	No
%100	60	Traditional classroom	1
-	-	Blended	2
-	-	E-learning	3
-	-	Distance learning	4
-	-	Other	5

7. **Contact Hours** (based on academic semester)

No	Activity	Contact Hours
1	Lecture	30
2	Laboratory/Studio	30
3	Tutorial	-
4	Others (specify) Exams/ Quizzes	-
	Total	60

B. Course Objectives and Learning Outcomes

1. Course Description

Computational Physics is designed to cover techniques used in modeling physical systems numerically and analyzing data. It is designed to help students gain experience with programming languages. The course will also demonstrate the processes of these programming languages. Note however that this is not a course in computer programming! Instead, this course is designed to use computer programming to solve scientific problems in physics. One of the most common programming languages used in science (such as FORTRAN, C++, or Python, may be MATLAB or equivalent software) will be chosen by the instructor. Computational techniques will be used to numerically solve systems of linear equations, ordinary differential equations (ODE), and orbit problems with numerical methods. In addition, the students also will be introduced to data fitting techniques.

Computational Physics is a problem-solving course, that is, the measure of a student's progress is demonstrated by the ability to solve numerical problems in physics using computer programming methods. Upon completion of this course, the student will possess the basic knowledge of numerical modeling and data analysis that may be required for graduate study or in a position at a technical corporation.

Besides learning how to solve numerical problems with a computer, the student also will gain experience writing manuscripts in a scientific journal style using the mark-up language LATEX.

2. Course Main Objective

The use of computers for computation and simulation is an integral part of the physics discipline. Moreover, computational physics has become as important as theoretical and experimental physics. Students will learn basic skills in programming in the context of solving physics problems. It is assumed that the student has no computer programming experience, and only modest understanding of physics at an elementary level. Through a variety of projects, the students are to obtain a deeper understanding of physical principles they already learned by solving physics problems and implementing computer simulations. This project-oriented, active learning approach allows students to work more comfortably at their own pace, where the student is engaged in solving problems in exploratory mode to gain better physical insight, similar to what is done in the context of research. In short, the objective of this class is to introduce the student to how computers are used in physics, and for the student to develop the basic skills that will be immediately useful in future classes, and in your career as your skills develop further.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge and Understanding**	
1.1	Demonstrate knowledge in essential methods and techniques for numerical computation in physics	K1 (I,p)
1.2	Apply programming language and relevant packages to solve simple physical problems	K2 (p)
1.3	Employ appropriate numerical methods for solving ordinary differential equations that commonly arise in physics, also for modeling various physical systems	K2 (p)
1...		
2	**Skills :**	
2.1	Model and analyze physical systems .	S1(p)

CLOs		Aligned PLOs
2.2	Integrate programming with experimental data.	S2(p)
2.3		
2...		
3	**Values:**	
3.1	Manage a project (modeling or simulation) with due attention to time and resource management	V1(p)
3.2	Participate effectively in multidisciplinary and/or interdisciplinary teams	V2(p)
3.3		
3...		

C. Course Content

Contact Hours	List of Topics	No
12	**Instructor could choose any one of the following programming Language: Python, CPP, Fortran, or (MATLAB or equivalent software).** **Programming:** How to compile, run, and build the chosen programming software script or code files on different operating systems (Windows and Linux, and may be MacOS). Variables and arrays. Displaying output data, data files, scalar and array operations, built in functions, Conditional Statement: IF, IF Else and Nested IF Else, loops.	
12	**Linear Algebra:** Solving a linear system, Gaussian elimination . Finding eigenvalues and eigenvectors. Matrix (LU and QR) factorizations and examples.	2
9	**Graphics and data analysis:** Plotting + regression and curve fitting.	3
9	**Numerical integration and differentiations:** Integration, differentiations, solving first order and second order Linear equation.	4
3	**Modelling and Simulation:** Harmonic motion example using a variety of numerical approaches.	5
3	**Modelling and Simulation:** Quantum Mechanics: Schrodinger Equation.	6
3	**Modelling and Simulation:** The planetary motion	7
9	**LATEX:** Writing mathematical equations using LaTeX.	8
60	**Total**	

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge and Understanding**		
1.1	Demonstrate knowledge in essential methods and techniques for numerical computation in physics	Lecture	Written exam and Homework reports
1.2	Apply Python, CPP, or Fortran programming language and relevant packages to solve simple physical problems	Lecture Discussion	Written exam
1.3	Employ appropriate numerical methods for solving ordinary differential equations that commonly arise in physics, also for modeling various physical systems		
2.0	**Skills**		
2.1	model and analyze physical systems	Lectures	Written exam and Homework reports
2.2	work with experimental and field data.	Groups discussion	Written exam; and summarizing research papers
2.3			
3.0	**Values**		
3.1	Manage a project (modelling or simulation) with due attention to time and resource management	Groupe assignments Clarify deadlines for delivery of assignments, reports and exams	Evaluate the efforts of each student in preparing the report. Evaluate the work in teams. Evaluation of students presentations.
3.2	Participate effectively in multidisciplinary and/or interdisciplinary teams		
3.3			

2. Assessment Tasks for Students

Percentage of Total Assessment Score	Week Due	Assessment task*	#
10%	continuous	Assignments, Interaction during lectures, and others	**1**
20%	7	Midterm exam	**2**
20%	12	Lab Exam	**3**
50%	13	Final exam	**4**
			5
			6
			7
			8

***Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice :

4 Hours per week during office hours, in the instructor's office or by appointment.

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	-Computational Modeling and Visualization of Physical Systems with Python, Jay Wang (2016) Wiley-VCH. ISBN: 978-1-119-17918-4
Essential References Materials	-Numerical Recipes in Fortran 90, William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Michael Metcalf, Cambridge University Press; 2 edition (September 28, 1996) -Object oriented programming in C++, Robert Lafore, fourth edition, Pearson and Sam Publishing (2001), ISBN 0-672-32308-7. -MATLAB, "An introduction with Applications", fourth edition, Amos Gilat, John Wiley and Sons, INC, 2011, ISBN-13 978-0-470-76785-6.
Electronic Materials	https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf https://www.programiz.com/python-programming https://www.programiz.com/cpp-programming https://web.chem.ox.ac.uk/fortran/fortran1.html
Other Learning Materials	MATLAB

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	Lecture room, Computer room, Library.
Technology Resources (AV, data show, Smart Board, software, etc.)	data show
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	MATLAB, OCTAVE, LaTeX, C++, FORTRAN, AND PYTHON

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Student Feedback on Effectiveness of Teaching	Students	Direct
Evaluation of Teaching	Department	Indirect
Improvement of Teaching	Program leaders	Direct
Quality of learning resources	Faculty	Direct

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Extent of achievement of course learning outcomes	Program leaders	Direct

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	Atif Ismail
Reference No.	
Date	