هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA
T4
2020

Course Specifications

Course Title:	**Computer Applications in physics (2)**
Course Code:	**2033101-2**
Program:	**Bachelor in Physics**
Department:	**Physics Department**
College:	**College of Science**
Institution:	**Taif University**

Table of Contents

A. Course Identification

1. Credit hours: 2							
2. Course type							
a.	University	☐	College	☐	Department	√	Others ☐
b.	Required	√	Elective	☐			
3. Level/year at which this course is offered: 8th Level / 3rd Year							
4. Pre-requisites for this course (if any)**: Computer Applications in physics (1) 2032204-3**							
5. Co-requisites for this course (if any)**: None**							

6. Mode of Instruction (mark all that apply)

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

7. Contact Hours (based on academic semester)

No	Activity	Contact Hours
1	**Lecture**	20
2	**Laboratory/Studio**	20
3	**Tutorial**	0
4	**Others** (specify)	0
	Total	**40**

B. Course Objectives and Learning Outcomes

1. Course Description

This course integrates numerical analysis and computer programming languages to study a variety of problems in classical, quantum and statistical physics. The course will cover numerical algorithms for root finding, interpolation, matrix inversion, numerical differentiation, and quadrature, data analysis, Fourier transformation, and computer graphics. Numerical analysis topics will include solution of linear and nonlinear differential equations, boundary value and eigenvalue problems, and Monte Carlo simulation.

2. Course Main Objective

This course will give participants an introduction to the solution of physics problems using computers. The strategy involves the theoretical exposition of a broad set of methods, the computational work in the class and a system of evaluation based only in small project works and respective reports (a final project has a free theme). These works should allow students to develop skills of research and individual work on solving advanced problems in Physics.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	**Knowledge and Understanding**	
1.1	Recall the correct names and functions of the used programming language package which facilitate the physical problems processing.	K5
1.2	Identify the key physical principles and its constraints underlying.	K1
2	**Skills :**	
2.1	Solve mathematics and physics problems using programming language.	S3
2.2	Formulate data with Python/C++ languages	S3
3	**Values:**	
3.1	Show responsibility for work independently and as a part of team in performing simple and complicated programming in Matlab.	V1

C. Course Content

No	List of Topics	Contact Hours
1	Introduction (Computation and Science).	1
2	Tools of computational physics.	1
3	Short introduction to Python/C++.	1
4	Interpolation: linear and polynomial interpolation, divided difference polynomials, equidistant points -Newton's forward/backward difference, spline interpolation.	2
5	Derivatives: Lagrange polynomials, Newton difference polynomials, finite difference approximations.	1
6	Numerical integration: simple quadratures (trapezoid, Simpson), Newton-Cotes formulas using divided difference polynomials, Gauss quadratures, integration with adaptive step size, special cases (oscillating functions, improper integrals, singularities, multiple integrals).	2
7	Solution of non-linear equations: Minimization and maximization of functions, multidimensional root finding, nonlinear models of data.	1
8	Ordinary differential equations: Initial value and boundary value problems, the Kepler and 3-body problems, chaotic dynamics in nonlinear systems, quantum eigenfunctions and eigenvalues.	1
9	Linear Algebra (solving linear algebraic equations, the eigenvalue problem) Matrices, BLAS algorithms, programming with objects.	2
10	Partial Differential Equations: Elliptic, parabolic and hyperbolic equations, Poisson's equation in electrostatics, wave motion, spectral methods, quantum wavepacket motion.	2
11	Fourier transforms: discrete Fourier transforms, fast Fourier transforms.	1
12	**Classical mechanics:** Projectile and particle motion (physics of sport) Few body problems in application to satellite and planetary motion. Classical scattering	1
13	**Monte Carlo simulation:** Random numbers (generators, uniform and non-uniform distributions). Monte Carlo integration. Metropolis sampling. Random walk (unrestricted, restricted, persistent, self-avoiding), diffusion.	2

	Introduction to the Monte Carlo simulations for the many-body problem.	
14	Chaos: Poincare maps, the butterfly effect, Fourier analysis of nonlinear systems.	1
15	Data fitting and analysis: least squares method, linear and non-linear functions.	1
Total		20
No	**Part-2 Experiments**	**Contact Hours**
1	Numerical integration: simple quadrature's (trapezoid, Simpson), Newton-Cotes formulas using divided difference polynomials, Gauss quadrature's, integration with adaptive step size, special cases (oscillating functions, improper integrals, singularities, multiple integrals).	2
2	Solution of non-linear equations: Minimization and maximization of functions, multidimensional root finding, nonlinear models of data.	2
3	Ordinary differential equations: Initial value and boundary value problems, the Kepler and 3-body problems, and chaotic dynamics in nonlinear systems, quantum Eigen functions and eigenvalues.	2
4	Linear Algebra (solving linear algebraic equations, the eigenvalue problem) Matrices, BLAS algorithms, programming with objects.	2
5	Partial Differential Equations: Elliptic, parabolic and hyperbolic equations, Poisson's equation in electrostatics, wave motion, spectral methods, and quantum wave packet motion.	2
6	Fourier transforms: discrete Fourier transforms, fast Fourier transforms.	2
7	**Classical mechanics:** Projectile and particle motion (physics of sport) Few body problems in application to satellite and planetary motion. Classical scattering	2
8	**Monte Carlo simulation:** Random numbers (generators, uniform and non-uniform distributions). Monte Carlo integration. Metropolis sampling. Random walk (unrestricted, restricted, persistent, self-avoiding), diffusion. Introduction to the Monte Carlo simulations for the many-body problem.	2
9	Chaos: Poincare maps, the butterfly effect, Fourier analysis of nonlinear systems.	2
10	Data fitting and analysis: least squares method, linear and non-linear functions.	2
Total		40

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	Recall the correct names and functions of the used programming language package which facilitate the physical problems processing.	Lecture	Written exam and Homework reports
1.2	Identify the key physical principles	Lecture and	Written exam

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
	and its constraints underlying.	Group discussion	
2.0	**Skills**		
2.1	Solve mathematics and physics problems using programming language.	Lectures	Written exam and Homework reports
2.2	Formulate data with Python/C++ languages	Lecture and Group discussion	Labs reports
3.0	**Values**		
3.1	Show responsibility for work independently and as a part of team in performing simple and complicated programming in Matlab.	Group discussion	Project

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Midterm exam	6th	20%
2	Activities	Periodically	10%
3	Lab reports	Weekly/ 9th	20%
4	Final Lab Exam	10th	10%
5	Final exam	12th	40%

***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 :

-Each faculty member is assigned a group of students for continuous academic advice during six weekly office hours (6 hrs./week).
-Also teaching staff are available for individual student consultations during this period.

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	1- A Survey of Computational Physics by R.H. Landau, M. J. Paez and C. C. Bordeianu, Princeton University Press (2008) 2- Computational Physics, by J. M. Thijssen, Cambridge University Press (2007) (2nd edition). 3- A First Course in Computational Physics and Object-Oriented Programming with C++ by David Yevick, Cambridge University Press (2005).
Essential References Materials	1- Numerical Methods for Physics, 2nd Edition, Alejandro L. Garcia (Prentice Hall, Upper Saddle River, NJ, 2000).
Electronic Materials	1. Wolfram Research: http://functions.wolfram.com/ 2. Digital Library of Mathematical Functions at NIST: http://dlmf.nist.gov/http://www.razi-center.net/ 3. https://lms.tu.edu.sa/

Other Learning Materials	1- MATLAB software for solving differential equations. 2- Mathematica software

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Lecture room with max 50 seats. - Laboratories with max 15 places
Technology Resources (AV, data show, Smart Board, software, etc.)	- Computer room containing at least 10 stations - Software (C++, Python, MATLAB, Mathematica, Origin ……) - Data show, Smart Board, software
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	Not applicable for this course

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Student Feedback on Effectiveness of Teaching	Students	Indirect
Evaluation of Teaching	Pear reviewer Program coordinator Departmental council Faculty council	Indirect
Improvement of Teaching	Program coordinator Relevant committee	Direct
Quality of learning resources	Students Instructor Faculty	Indirect
Extent of achievement of course learning outcomes,	Program coordinator Instructor	Direct
Course effectiveness and planning for improvement	Program coordinator Instructor	Indirect

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	**Department Council / Committee of academic development**
Reference No.	
Date	October 2, 2022