هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

2023
TP-153

Course Specification

(Bachelor)

Course Title:	Computer Applications in physics (2)
Course Code:	2033101-2
Program:	Bachelor in Physics
Department:	Physics Department
College:	Science
Institution:	Taif University
Version:	*Course Specification Version Number*
Last Revision Date:	*Pick Revision Date.*

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (2)					
2. Course type					
A.	☐University	☐College	☒ Department	☐Track	☐Others
B.	☒ Required		☐Elective		
3. Level/year at which this course is offered: (5th Level / 3rd Year)					
4. Course general 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.					
5. Pre-requirements for this course (if any): Computer Applications in physics (1)					
6. Co-requisites for this course (if any):None					
7. Course Main Objective(s): 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.					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	4	100%
2	E-learning	0	0%
3	Hybrid • Traditional classroom • E-learning	0	0%
4	Distance learning	0	0%

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	15
2.	**Laboratory/Studio**	45
3.	**Field**	
4.	**Tutorial**	
5.	**Others (specify)**	
Total		60

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

Code	Course Learning Outcomes	Code of CLOs aligned with program	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.	K5	Lectures	Written exam and Homework reports

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
1.2	Identify the key physical principles and its constraints underlying.	K1	Lectures and Group discussions	Written exam
...				
2.0	**Skills**			
2.1	Solve mathematics and physics problems using programming language.	S3	Lectures	Written exam and Homework reports
2.2	Formulate data with Python/C++ languages	S3	Lecture and Group discussion	Labs reports
...				
3.0	**Values, autonomy, and responsibility**			
3.1	Show responsibility for work independently and as a part of team.	V1	Group discussion	Project
...				

C. Course Content

No	List of Topics	Contact Hours
	Part-1	
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.	1
5.	Derivatives: Lagrange polynomials, Newton difference polynomials, finite difference approximations.	1
6.	Numerical integration: simple quadrature (trapezoid, Simpson), Newton-Cotes formulas using divided difference polynomials, Gauss quadrature, integration with adaptive step size, special cases (oscillating functions, improper integrals, singularities, multiple integrals).	1
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,	1

	the Kepler and 3-body problems, chaotic dynamics in nonlinear systems, quantum Eigen-functions and eigenvalues.	
9.	Linear Algebra (solving linear algebraic equations, the eigenvalue problem) Matrices, BLAS algorithms, programming with objects.	1
10.	Partial Differential Equations: Elliptic, parabolic and hyperbolic equations, Poisson's equation in electrostatics, wave motion, spectral methods, quantum wave packet motion.	1
11.	Fourier transform: 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. Introduction to the Monte Carlo simulations for the many-body problem.	1
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
	Part-2 Experiments	
1	Numerical integration: simple quadrature (trapezoid, Simpson), Newton-Cotes formulas using divided difference polynomials, Gauss quadrature, integration with adaptive step size, special cases (oscillating functions, improper integrals, singularities, multiple integrals).	3
2	Solution of non-linear equations: Minimization and maximization of functions, multidimensional root finding, nonlinear models of data.	6
3	Ordinary differential equations: Initial value and boundary value problems, the Kepler and 3-body problems, chaotic dynamics in nonlinear systems, quantum eigenfunctions and eigenvalues.	3
4	Linear Algebra (solving linear algebraic equations, the eigenvalue problem) Matrices, BLAS algorithms, programming with objects.	6
5	Partial Differential Equations: Elliptic, parabolic and hyperbolic equations, Poisson's equation in electrostatics, wave motion, spectral methods, quantum wavepacket motion.	3
6	Fourier transforms: discrete Fourier transforms, fast Fourier transforms.	3
7	**Classical mechanics:** Projectile and particle motion (physics of sport) Few body problems in application to satellite and planetary motion. Classical scattering	6
8	**Monte Carlo simulation:**	6

	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.	
9	Chaos: Poincare maps, the butterfly effect, Fourier analysis of nonlinear systems.	6
10	Data fitting and analysis: least squares method, linear and non-linear functions.	3
Total		**60**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Assignments and Interaction during lectures	continuous	10%
2.	Midterm exam	7th	20%
3.	Periodical exam	12th	10%
4.	Weekly practical reports	continuous	15%
5.	Final practical exam	15th	5%
6.	Final exam	16th	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	Numerical Methods for Physics, 2nd Edition, Alejandro L. Garcia (Prentice Hall, Upper Saddle River, NJ, 2000).
Supportive References	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). A First Course in Computational Physics and Object-Oriented Programming with C++ by David Yevick, Cambridge University Press (2005).
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. Mathematica software

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	- Lecture room with max 50 seats. Laboratories with max 15 places.
Technology equipment (projector, smart board, software)	- Computer room containing at least 10 stations - Software (C++, Python, MATLAB, Mathematica, Origin ......) data show, Smart Board, software
Other equipment (depending on the nature of the specialty)	Not applicable for this course

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Department	Indirect
Effectiveness of Students assessment	Students	Indirect
Quality of learning resources	Faculty	Direct
The extent to which CLOs have been achieved	Program leaders	Direct
Other		

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

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	PHYSICS DEPARTMENT COUNCIL
REFERENCE NO.	NO. 4-45
DATE	27/09/2023 (12/03/1445)

قسم الفيزياء
Physics Department
جامعة الطائف TAIF UNIVERSITY