هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد NCAAA T4 2020

# Course Specifications

| | |
|---|---|
| **Course Title:** | **Computational Physics** |
| **Course Code:** | **2034216-2** |
| **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:** **11th Level/ 4th Year** | | | | |
| **4. Pre-requisites for this course** (if any)**:NONE** | | | | |
| **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** | **3** | **100%** |
| 2 | **Blended** | | |
| 3 | **E-learning** | | |
| 4 | **Correspondence** | | |
| 5 | **Practical (laboratory)** | | |

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

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

## B. Course Objectives and Learning Outcomes

### 1- Course Description

- Introduce the need for computers in science and the computational physics.
- An over view of the operating systems and programming languages.
- An overview of the interpolation including Lagrange interpolation, Neville's algorithm, linear interpolation, Polynomial interpolation, Cubic spline, Rational function interpolation.
- The numerical differentiation, forward difference, central difference and higher order derivatives will be included.
- Numerical Integration including the rectangular method, Trapezoid method, Simpson method will be studied.
- The solution of nonlinear equations: Bisection method, Newton's method, method of secants, Brute force method.
- Differential equations: Euler method, Numerical errors and instabilities, Runge-Kutta method.
- Monte-Carlo methods: Random number generators, Distribution functions, Acceptance

and rejection method, Inversion method

**2. Course Main Objective**

The understanding of fundamental principles of physics and of how it can be used to explain and predict physical phenomena. Full knowledge of mathematical techniques and the ability to use them in quantitative prediction, modeling physical phenomena and solving complex physical problems.

### 3. Course Learning Outcomes

| | CLOs | Aligned PLOs |
|---|---|---|
| 1 | **Knowledge and Understanding** | |
| 1.1 | Define the basic concepts and theories of computational physics using advanced mathematical theories. | K1 |
| 1.2 | Recognize the mathematical techniques for modeling physical phenomena. | K5 |
| **2** | **Skills :** | |
| 2.1 | Apply the scientific programming for processing and analyzing the physical data. | S3 |
| 2.2 | Develop a computational physics tools that can be used in the different physics fields. | S4 |
| **3** | **Values:** | |
| 3.1 | Work effectively and responsibly even in teamwork in performing activities and experiments in computational physics. | V1 |

## C. Course Content

| No | List of Topics | Contact Hours |
|---|---|---|
| 1 | Unit 1: **Introduction**<br>• The need for computers in science.<br>• What is computational physics?<br>• Operating systems and programming languages. | **4** |
| 2 | Unit 2: **Interpolation**<br>• Lagrange interpolation<br>• Neville's algorithm<br>• Linear interpolation<br>• Polynomial interpolation<br>• Cubic spline<br>• Rational function interpolation | **4** |
| 3 | Unit 3: **Numerical Differentiation**<br>• Forward difference<br>• Central difference and higher order methods<br>• Higher order derivatives | **4** |
| 4 | Unit 4: **Numerical Integration**<br>• Rectangular method<br>• Trapezoid method<br>• Simpson method | **4** |
| 5 | Unit 5: **Solution of nonlinear equations**<br>• Bisection method | **4** |

| | | |
|---|---|---|
| | • Newton's method<br>• Method of secants<br>• Brute force method | |
| 6 | Unit 6: **Differential equations**<br>• Euler method<br>• Numerical errors and instabilities<br>• Runge-Kutta method | **4** |
| 7 | Unit 7: **Monte-Carlo methods**<br>• Random number generators<br>• Distribution functions<br>• Acceptance and rejection method<br>• Inversion method | **4** |
| 8 | **Revision** | **2** |
| **Total** | | **30** |

## 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 | Define the basic concepts and theories of computational physics using advanced mathematical theories. | Lecture<br>Discussion | Written exam |
| 1.2 | Recognize the mathematical techniques for modeling physical phenomena. | Hands on sessions | Homework and Written exam. |
| **2.0** | **Skills:** | | |
| 2.1 | Apply the scientific programming for processing and analyzing the physical data. | Problem solving | Written exam<br>Activities |
| 2.2 | Develop a computational physics tools that can be used in the different physics fields. | Problem solving | Written exam<br>Activities |
| **3.0** | **Values:** | | |
| 3.1 | Work effectively and responsibly even in teamwork in performing activities and experiments in computational physics. | Encourage students to form groups to achieve specific goals. | Homework<br>Projects |

### 2. Assessment Tasks for Students

| # | Assessment task* | Week Due | Percentage of Total Assessment Score |
|---|---|---|---|
| **1** | Activities | Periodically | 10% |
| **2** | Midterm exam | 6th | 30% |
| **3** | Short exam | 9th | 10% |
| **4** | Final exam | 12th | 50% |

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

## E. Student Academic Counseling and Support

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| **Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice:**<br>• Each faculty member is assigned a group of students for continuous academic advice during six office hours weekly (6 hrs./week).<br>• Also teaching staff are available for individual student consultations during office hours |

## F. Learning Resources and Facilities

### 1.Learning Resources

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|---|---|
| **Required Textbooks** | • Nicholas J. Giordano, Hisao Nakanishi, Addison Wesley, “Computational Physics”, 2006. |
| **Essential References Materials** | • Paul L. DeVries, Javier E. Hasbun, A First Course in Computational Physics, $2^{nd}$ Edition, John Wiley & Sons Inc., 1994. |
| **Electronic Materials** | • https://homepage.univie.ac.at/franz.vesely/cp_tut/nol2h/new/<br>• http://www.mrao.cam.ac.uk/~dfb/teaching/computationalphysics/ |
| **Other Learning Materials** | • CD associated with the text books (when available).<br>• Lecture notes and PowerPoints presentations prepared by the lecturer. |

### 2. Facilities Required

| Item | Resources |
|---|---|
| **Accommodation**<br>(Classrooms, laboratories, demonstration rooms/labs, etc.) | • Classrooms<br>• Computational Physics laboratory |
| **Technology Resources**<br>(AV, data show, Smart Board, software, etc.) | • Data show<br>• Laptop<br>• Smart board |
| **Other Resources**<br>(Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list) | None |

## G. Course Quality Evaluation

| Evaluation Areas/Issues | Evaluators | Evaluation Methods |
|---|---|---|
| Student Feedback on Effectiveness of Teaching | Students | Indirect |
| Evaluation of Teaching | Pear reviewer<br>Program coordinator<br>Departmental council<br>Faculty council | Indirect |
| Improvement of Teaching | Program coordinator<br>Relevant committee | Direct |

| Evaluation Areas/Issues | Evaluators | Evaluation Methods |
|---|---|---|
| Quality of learning resources | Students<br>Instructor<br>Faculty | Indirect |
| Extent of achievement of course learning outcomes, | Program coordinator<br>Instructor | Direct |
| Course effectiveness and planning for improvement | Program coordinator<br>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

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