**School of Engineering and Physical Sciences**
**Department of Mathematics and Physics**

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| **Course Name** | Computational Physics |
| **Course Code** | PHY 360 |
| **Course Credit Hours** | 3 |
| **Prerequisite** | MAT 125, MAT 130 |
| **Course Objective** | The aim of this course is to make student acquainted with major computational methods and simulations to understand different real-world problems. |
| **Course Description** | In this course, applications of physics will be integrated with several computational tools to simulate, analyze and visualize a wide range of physical systems. The overall goal is to learn the modelling/programming techniques and dig into large-scale simulation to extract physical knowledge from a dataset. |
| **Method(s) of Instruction(s)** | • Every topic will be discussed through a theory lecture<br>• A practice lecture through computer programs<br>• Write up her/his own programs for further practice |

## COURSE CONTENT BY TOPIC

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| **Module #1** | **Introduction to Computational Physics:** Physics and Computational Physics, Distinguish the scientific programming from other programming concept, Introduction to Computer Algorithms and Languages, Types of Error in Computation, Minimizing the Error. |
| **Module #2** | **Basic Numerical Methods**: Interpolation, Lest Square Approximation, Spline Approximation, Random Number Generation. |
| **Module #3** | **Numerical methods for matrices:** Basic Matrix operations, Linear Equation Systems, Eigenvalue Problem, Gaussian Elimination, The Faddeev-Leverrier Method, Random Matrix. |
| **Module #4** | **Differential equation:** Initial-value problems, The Euler and Picard methods, The Runge-Kutta Method, Boundary Value and Eigenvalue Problem, Linear Equations and Sturm-Liouville Problem, The One-Dimensional Schrödinger Equation |
| **Module #5** | **Spectral analysis:** Fourier Analysis and Orthogonal Functions, Discrete Fourier Transform, Fast Fourier Transform, Power Spectrum of a Driven Pendulum |
| **Module #6** | **Molecular Dynamics simulation**: General behavior of a classical system, Basic methods for many-body systems, Verlet algorithm. |
| **Module #7** | **Monte-Carlo simulation:** Introduction, Monte Carlo integration, Monte Carlo for Ising model, Variational quantum Monte Carlo simulations, Ground State of Helium Atom, Green's function Monte Carlo simulations, Path-integral Monte Carlo simulations, Quantum lattice model. |
| **Actual contact hours**: Lecture: 3 hours per week; 36 hours per semester | |

## TEXTBOOK REQUIREMENT

1. An Introduction to Computational Physics, Tao Pang
2. Computational Physics, J. M. Thijssen
3. Computational Physics, Rubin H. Landau, Manuel J. Páez, Cristian C. Bordeianu

## ASSESSMENT STRATEGY AND GRADING SCHEME

NSU's grading and performance evaluation policies will be followed in assigning your grade. Please note that all final grades are subject to departmental review and approval. A guideline of course assessment is as follows-

| Class Attendance | Quiz | Assignments/Projects | Midterm | Final |
|---|---|---|---|---|
| 5% | 15% | 15% | 30% | 35% |

## MAPPING OF COURSE OUTCOMES

| CLO-# | Outcome Types | Bloom's Taxonomy level (C- Cognitive, A- Affective, P- Psychomotor) | Delivery Method | Assessment Tools | |
|---|---|---|---|---|---|
| **CLO-1** | Understand the scientific programming and identify the probable computational errors in a defined system and minimize the errors. | C2, P2 | Lecture, Demonstration and Discussion | Quiz, Assignment | Mid Term Exam |
| **CLO-2** | Utilize the code of interpolation for real data to understand different approximation methods and show the outcomes from the dataset. | C3, P3 | Lecture, Demonstration and Discussion | Quiz, Assignment | |
| **CLO-3** | Perform matrix operations numerically and minimize the errors. | C3, P3 | Lecture, Demonstration and Discussion | Quiz, Assignment | |
| **CLO-4** | Interpret initial value problems, simulate and analyze an ideal physical system numerically. | C4, P3 | Lecture, Demonstration and Discussion | Quiz, Assignment | Final Exam |
| **CLO-5** | Illustrate the use of Fourier functions and apply Fourier transform numerically. | C3, P3 | Lecture, Demonstration and Discussion | Quiz, Assignment | |
| **CLO-6** | Identify and distinguish the methods for many-body systems. Perform Monte Carlo (MC) simulation and write scientific report. | C6, P4 | Lecture, Demonstration and Discussion | Quiz, Assignment | |