

COMPUTATIONAL PHYSICS I (Phys.605)

Instructor: Baylie Damtie

Washera Geospace and Radar Science Laboratory
Department of Physics, School of Graduate Studies
Bahir Dar University, Bahir Dar, Gojjam, Ethiopia

Background Information

This course covers fundamentals on computational physics.

Course Objectives

At the end of the course, students will be able to

- identify different components of a computer system and assemble and disassemble these components independently
- use different computer operating systems including Window XP and MAC OS, Linux operating systems
- understand how a digital computer represent number, letters, pictures, musics and so on and carry out different operations
- estimate different errors associated to numerical computing
- know how to use MATLAB for different purposes including numerical differentiation and integration
- solve different types of linear equations numerically
- differentiate and integrate different types of functions numerically
- solve different types of ordinary differential equations numerically
- appreciate the roles of simulation in teaching physics in particular and in understanding the working principles of different physical and engineering systems

1 Introduction

- Introduction to computer
- Identifying different computer accessories
- Types of computer operating systems

- Data Representation
- Precision, errors, stability
- Choice of programming languages

2 Reviewing MATLAB

- Introduction to MATLAB
- Variables and data types in MATLAB
- Arithmetic in MATLAB
- Loops and conditionals in MATLAB
- Input and output in MATLAB
- Standard functions in MATLAB
- How to write User's Own Functions in MATLAB
- Saving and loading of data in MATLAB
- Graphics in MATLAB
- **Project One**

3 Linear Algebra

- Matrices and vectors
- Matrix and Vector Operations in MATLAB
- Linear Equations
- Unsolvable Problems
- Ill-conditioned Problems
- Gauss Elimination
- Gauss-Jordan Elimination and matrix inversion
- LU decomposition
- Iterative solution
- Matrix Eigenvalue
- **Project Two**

4 Interpolation and Curve Fitting

- Linear interpolation and extrapolation
- Lagrange Interpolation Polynomial
- Qubic spline interpolation
- Curve fitting
- Spectra analysis
- **Project Three**

5 Numerical Differentiation and Integration

- Numerical differentiation
 - Numerical differentiation
 - Error analysis
- Numerical integration
 - Equal step methods
 - Gaussian quadrature
 - Orthogonal polynomials, legendre
 - Mesh points and weights with orthogonal polynomials
 - Applications to selected integrals
- **Project Four**

6 Ordinary differential equations

- Initial-value problems of ordinary differential equations
 - Euler methods
 - Runge-Kutta methods
 - Shooting method
 - Method of lines
 - **Project Five**
- Boundary-value problems of ordinary differential equations
 - Introduction
 - Numerical solutions of some selected boundary-value problems
 - Nonlinear Ordinary differential Equations

7 REFERENCE

- Gracia, A. L., Numerical methods for Physics, Prentice-Hall, 1994, (**You can find a photocopy in the Graduate Program Library**)
- Nakamura, S., Numerical analysis and graphic visualization with Matlab, Prentice-Hall, Inc., 1996. (**You can find a photocopy in the Graduate Program Library**)

8 Evaluations

- Weekly programming exercise and report, **20 percent**
- A one major project work on computational physics (here detailed and major scientific report is expected. The students are expected to demonstrate their scientific analysis and interpretation skill by presenting it), **20 percent**
- Mid examination, **20 percent**
- Final examination, **40 percent**

9 Warnings!!

- Copying programs that have been done by previous students or from the internet is totally unacceptable and considered as plagiarism. Your grade points for such kind of work will be absolute zero and if you repeat it you may be dropped from the course following appropriate rules of the University.
- Copying sentences as whole from the internet or from the book is not acceptable.
- All of your files should be in one folder and do not create all sorts of folders and make the computer messy.
- Instruction from the administrator of the virtual laboratory must be followed and executed.