Physics 610, Scientific Computation

**Course Outline**

(3 S.H.) This course will teach students to build computational tools for a classroom/laboratory environment. Students will learn standard computational physics algorithms and use these algorithms to build classroom activities to bring back to their classroom and/or data analysis tools to bring back to their physics laboratory. Topics include programming basics, data analysis, computational physics algorithms and analysis of classroom data. Prerequisites: : Introductory Electromagnetism (WSU Physics 222 or 202 or equivalent course) and Calculus (WSU Math 213 or equivalent course). Instructor permission is also acceptable. Offered every other year. Online only.

**Physics subfield: Computational Physics**

**Learning Outcomes**

Students will:

1. Students will code standard computational physics algorithms.
2. Students will assess the limitations of computational physics algorithms.
3. Students will create and use appropriate debugging tools to test and code.
4. Students will create and use computational tools to analyze physics data.
5. Students will create and use computational tools to analyze classroom data.

These goals will be assessed via weekly homework and occasional exams.

Additionally, students will:

1. Build an original computational tool for classroom or laboratory work.

This goal will be assessed via a final project.

Physics 510 Course Topic Overview

1. Introduction to Programming
   1. Introduction to language of choice
   2. Using resources such as PICUP, software/data carpentry and others
2. Computer representation of numbers
   1. Floating point numbers
   2. Errors and uncertainties in computations
3. Analysis of classroom data
   1. Writing programs to simplify analysis of classroom data
      1. Plotting data
      2. Statistical analysis of classroom data
      3. Other graphical displays of data
4. Numerical derivatives
   1. Forward difference, central difference and extrapolated difference methods
   2. Second derivatives
   3. Error analysis
5. Numerical Integration
   1. Gaussian Quadrature, Trapezoid and Simpson’s Rule
   2. Monte Carlo Integration
   3. Integration Error
6. Random Numbers
   1. Features of random number generators
   2. Central Limit Theorem
   3. Modeling experimental physics data using random numbers
   4. Random walks and thermodynamic examples
7. Solving Differential Equations
   1. Euler, Euler-Cromer and Range-Kutta algorithms
   2. Kinematics, simple harmonic motion, wave equations and other examples
   3. Non-linear dynamics
8. Data Fitting
   1. Fitting Methods
   2. Fitting libraries
   3. Fitting experimental data
9. Fourier Transforms
   1. Discrete Fourier Transforms and Fast Fourier Transforms
   2. Spectral analysis of nonstationary signals
   3. Fourier analysis of oscillators
10. Student Projects
    1. Bringing code into the freshman physics classroom
    2. Write code for he physics laboratory setting
    3. Building a classroom activity or an original data analysis