AEP4380/5380, Computational Engineering Physics

INSTRUCTOR: Dr. E. J. Kirkland (ejk14@cornell.edu, 237 Clark Hall)

OFFICE HOURS: Feel free to stop by my office (Clark 237) any time. I will try to be available 2-3:30 PM Mon. and Tue. in my office, or in the computer room (Clark 244).

LECTURE: MWF 11:15 AM - 12:05 PM, location: Clark 247

PREREQUISITES: CS1110 or CS1112, PHYS2214 or PHYS2218,
AEP3330 (Classical Mechanics), AEP3610 (Quantum Mechanics), AEP 4200 (Math)
(or equivalent or permission of the instructor, co-registration in the last 3 is OK)

COMPUTER LAB:

1. AEP computer room, Clark 244, 9AM-2AM, Sun-Fri, 2PM-2AM Sat.
   Fill out form to get you ID card enabled.
2. OPTIONAL: Any other computers available to you

You are responsible for scheduling yourselves to get your work done on time.

BOOKS: W. H. Press, et al., *Numerical Recipes, The Art of Sci. Computing*, 3rd edit., 2007,
(a standard reference book on numerical methods)
(OPTIONAL) M. Newman, *Computational Physics*, 2013, easy to read intro.
to python and computational physics
(OPTIONAL) Landau, Páez, and Bordeianu, *Survey of Computational Physics*, pdf on-line,
(has more physics, python version at
psrc.aapt.org/items/detail.cfm?ID=11578)
(OPTIONAL) Gould, and Tobochnik, *An Intro. to Comp. Sim. Methods, 3rd edit.*,
pdf on-line (has more physics, java version at
www.compadre.org/osp/items/detail.cfm?ID=7375)

Note: *From a Cornell IP address, the text of "Numerical Recipes" is available on-line at numerical.recipes/oldverswitcher.html and the source code for the C++ version is available on-line for Cornell users at numerical.recipes/routines/instbyfile.html (courtesy of Prof. Teukolsky).*

LEARNING OUTCOMES: a) Develop an understanding of numerical methods,
b) Development of programming skills,
c) Develop skills in applying numerical methods to solving physics and engin. problems

WEB URL: mainly canvas.cornell.edu and some on courses.cit.cornell.edu/aep4380/, has copies of the homework etc. and links to useful (free) software such as compilers, data plotting programs and numerical subroutine libraries.

COURSE GRADE: A final grade (S/U or letter) will be based on the following:
80% computer homework assignments (approx. 9 to 11 total),
20% final computer simulation project (with written report)
graduate students registered for AEP5380 are required to do all of the homework,
undergraduates in AEP4380 may drop the lowest homework

Syllabus subject to change. Changes, if any, will be announced on Canvas.

The computer can produce a numerical solution to many practical physics and engineering problems that cannot be solved analytically (for example, the three-body problem, electrostatic fields in complicated boundaries, quantum energy levels, etc.). This course will introduce numerical computation as a means of solving practical physics and engineering problems (an applied numerical analysis course). Sometimes the physics must be reorganized to fit the numerical methods and sometimes the numerical methods must be reorganized to fit the physics. Both of which can produce interesting new ways of understanding the physics. The homework problems will be drawn mainly from classical and quantum mechanics, thermodynamics and electricity and magnetism at the junior/senior level as well as some purely numerical and/or mathematical problems. Numerical differentiation and integration and the numerical solution of ordinary and partial differential equations with initial values and boundary values and other numerical methods such as root-finding, random number generators, and fast Fourier transforms (FFT) will be developed and applied to engineering physics problems. Additional topics such as chaotic nonlinear systems, least squares curve fitting, and Monte-Carlo simulation, will be introduced. If time permits, symbolic math packages such as maxima or sympy, parallel programming, interactive graphics and neural networks may be introduced.

There will be several specific computing homework assignments during the semester and one final project involving a significant amount of engineering physics and programming. The homework will usually be due in Canvas (typically on Wednesday) unless stated otherwise. A solution set will be handed out one week following the due date. Homework will be accepted until the solution set has been handed out (with a penalty for late homework). The final project topic will be separately chosen by each student and may extend the work during the semester or cover additional topics not discussed during the semester. An additional handout on the final project will be given later in the semester. A list of possible projects will be provided. You may chose a project from this list or make up your own project. The reserve reading list also contains several references that might provide some ideas for interesting projects.

The primary programming language will be numba/python (compiled) and possibly C/C++ or julia. Some prior exposure to programming will be assumed, however no previous experience with numba/python will be assumed. The lectures will include a short introduction to programming. Students may use the computers in the AEP computer room or optionally on outside computers. However, only numba/python on the computers in the AEP computer room will be explicitly supported. The further away from this, the less help can be provided to the students.

Cornell University Code of Academic Integrity:

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work. Discussion and collaboration on homework and laboratory assignments is permitted and encouraged, but final work should represent the student's own understanding. Submitting work that has been copied from others, generated by artificial intelligence tools (unless explicitly requested), or downloaded and represented as your own work is a violation of Academic Integrity.

Course materials posted on-line are copyrighted and intellectual property belonging to the author. Students are not permitted to buy or sell any course materials without the express permission of the instructor. Such unauthorized behavior will constitute academic misconduct

RESERVE READING LIST: (many for final projects; most in the Math Lib.)

Computational Physics:

J. D. Anderson, Computational Fluid Dynamics, McGraw-Hill 1995. (QA911.A58 x1995, - in Engin. or Math Library))

A. D. Boardman, edit., Physics Programs, A Manual of Computer Exercises for Students of Physics and Engineering , Wiley 1980. (QC21.2 P57)

Chuen-Yen Chow, An Intro. to Computational Fluid Mechanics, Wiley 1979 (TA357.C53 - in Engin. Library).

C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Vol. 1 and 2, Springer 1991 2nd edit QC 151.F58x 1991.

A. Garcia, Numerical Methods for Physics, Prentice-Hall 1994, (QC 20.G37x) (new edition now available)

H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods, Applications to Physical Systems, Part 1 and Part 2, 2nd edit. Addison-Wesley 1988. (QC21.2 G68)

R. W. Hockney, J. W. Eastwood, Computer Simulation Using Particles, McGraw-Hill 1981,1989. (QA76.9.C65 H68 1989 in Engineering Library)

Y. Jaluria, K. E. Torrance, Computational Heat Transfer, 1986 (TJ260.J26 in Engineering Library)

S. E. Koonin and D. C. Meredith, Computational Physics, Fortran Version, Addison-Wesley 1990. (QC20 K82 C7; may be the old Basic version as the library says they lost the fortran version).

F. C. Moon, Chaotic and Fractal Dynamics, Wiley 1992, Q172.5.C45 M66x, 1992.

D. Potter, Computational Physics, Wiley 1973 (QC20.P86)

Numerical Methods:

S. C. Chapra and R. P. Canale, *Numerical Methods for Engineers, 4th edit.*, (McGraw-Hill, 2002) (TA345.C47x 2002) (new 2005 edition now available)

G. E. Forsythe, M. A. Malcolm, C. B. Moler, Computer Methods for Mathematical Computations, Prentice-Hall 1977. (QA297.F73 C6 in Engineering Library)

C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, 5th edit., Addison-Wesley, 1994 (QA297.G35)

R. W. Hornbeck, Numerical Methods, Quantum Publishers 1975. (QA297.H81 in Engineering Library)

W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, *Numerical Recipes, The Art of Scientific Computing (3rd edit.)*, Cambridge Univ. Press, 2007, (ISBN 978-0-521-88068-8, QA297 .N866 2007)

R. D. Richtmyer and K. W. Morton, *Difference Methods for Initial-Value Problems*, Interscience Publishers, 1967, (QA431.R53 1967)