Course Syllabus
Southeast Missouri State University

Department of Physics | **Course No. EP461/EP502**
Title of Course: Computer Applications | **Revision: Spring, 1999**

I. Catalog Description

Use of computers for the solution of physics and engineering problems in mechanics, thermodynamics, electromagnetics, modern physics and applied optics. Spring of even years only. Prerequisites: PH-231, MA-245, MA-334. (3)

II. Prerequisites

PH231 General Physics II
MA245 Vector Calculus
MA334 Computer Programming

III. Course Objectives

A. Introduce the student to the algorithms commonly used by physicists and engineers in solving complex problems in research and industry using high-speed computers.

B. Introduce the student to the general methods of analysis of problems in applied physics and engineering and the formulation of efficient algorithms for computer program implementation involving (1) matrix algebra (2) matrix inversion and diagonalization (3) multiple integrals and integral equations (4) special functions and coefficients.

C. Gain proficiency in implementing and debugging selected algorithms for the solution of physics and engineering problems using TURBO BASIC, FORTRAN 77, MATHCAD and MATLAB.

D. Gain proficiency in the use of scientific subroutines for the analysis of complex problems including computer testing of the range of applicability of selected subroutines supplied by computer resource centers.

IV. Expectations of Student

A. All students
   1. The student is expected to become proficient at solving selected problems in physics and engineering using the computers available on campus.
   2. The student is expected to analyze selected problems in physics and engineering and construct the required algorithms using the techniques discussed in class and to implement the algorithms on the computer and test its range of applicability and degree of accuracy.
   3. The student is expected to be able to implement selected algorithms available from published literature and use them to solve selected problems in physics

and engineering.

4. The student is expected to construct a reasonably efficient computer program for the solution of assigned problems using available scientific subroutines, and render it operational within an assigned time period.
5. The student is expected to be able to convert complex equations in physics or engineering into interpretable graphical or tabular output using the computer within the assigned time period using the semester. The equations may involve matrix expressions, diagonalization of matrices, multiple integrals, special functions, or coefficients.
6. The student is expected to be able to analyze the results obtained from the computer to ascertain their degree of accuracy and reliability.

B. Graduate students - Demonstrate research ability by submitting an original term project related to Computational Physics. The project will involve (1) computer programming (2) use of selected periodicals in the field of Computational Physics (3) technical writing. The completed project report will be due one week before the final exam.

V. **Course Outline** (Hours)

A. Introduction to computational physics (6)

1. Review of program languages and use of scientific subroutines and functions
2. Method of linking various programs into one program and testing for its operational efficiency
3. Improvement of time of computation and related aspects of programming
4. Program documentation and retrieval methods

B. Applications to problems in optics (5)

1. Ray tracing using Snell's law for selected geometries
2. Matrix optics and its implementation on the computer
3. Use of subroutines for graphical analysis of algorithms
4. Diffraction and interference problems using the computer
5. Discussion of current topics in optics and lens design (selected from physics journals)
6. Research in the field of computational optics (review of articles selected from physics journals)

C. Hour examination (1)

D. Computer applications to problems in engineering mechanics (6)

1. Analysis of various structures using matrix methods
2. Analysis of stability of structures using well-known algorithms and supplied subroutines from matrix inversion
3. Analysis of stress diagrams for selected structures using computer graphs and three dimensional plots
4. Construction of algorithms for the solution of mechanics problems on the computer
5. Methods of testing reliability of computer solutions

6. Discussion of current optics in applied mechanics (articles selected from available physics journals in computational physics)

E. Computer applications to problems in advanced dynamics (5)
   1. Formulation of the problem and method of solution
   2. Improvement of the efficiency of computation for problems with large number of parameters
   3. Use of differential equation algorithms for certain well-defined problems in dynamics
   4. Use of complex variables for stability analysis on the computer
   5. Methods of testing reliability of computer solutions in various classical dynamics problems
   6. Current topics in computational physics selected from published conference proceedings and physics journals

F. Hour examination (1)

G. Computer applications in thermal analysis (7)
   1. Representation of empirical thermophysical data using matrix methods
   2. Use of thermophysical data in computer programs through subroutines and special functions
   3. Interactive methods used in the analysis of selected problems in engineering thermodynamics
   4. Solution of selected heat transfer problems using well-known algorithms and subroutines
   5. Computer solution & simulation of selected problems in kinetic theory and statistical mechanics
   6. Discussion of current topics in computational physics selected from published literature and private communication

H. Computer applications in Electrodynamics and Modern Physics (7)
   1. Efficient computation of electrical fields and equi-potential surfaces of various charge distributions
   2. Matrix methods for the reduction of algorithms for computation of charge distributions in specified geometries
   3. Use of special function subroutines for field calculations on the computer
   4. Computation of interaction energy of specified charge distributions in atoms and molecules using supplied algorithms and subroutines
   5. Computation of magnetic field for various geometries using matrix methods and special functions
   6. Implementation of matrix inversion subroutines for solution of Kirchoff type problems with large number of unknowns
   7. Discussion of selected topics from physics journals

I. Recent developments in computational physics (6)
   1. Atomic and molecular problems with large number of parameters requiring very high speed computers
   2. Discussion of certain algorithms used in well known computing labs (such as

IBM Watson Research Center, and UCLA)

3. Topics selected from International and other conferences in computational physics and engineering

J. Hour examination (1)

Total Hours: 45

VI. Textbook and other references

A. No textbook is used for the course.

B. The following reference books are available to students

1. Methods of Computational Physics (Vol. 1-10)
2. Atomic Structure Calculations, F. Herman (Univ. Microfilms)
3. Fortran Codes for Classical Methods in Linear Dynamics by F. O. Smetana, (McGraw Hill, 1982)
4. Algorithms and Computer Codes, NRCC Proceedings, University of California, (1984-1998)
5. Calculation of Atomic Structure, D. R. G. Hartree (Wiley, N.Y.)
6. Computational Physics, David Potter (John Wiley, 1980)
7. IBM System FORTRAN IV Programmer's Guide (1980)
8. IBM Scientific Subroutines (IBM Corporation, 1980)
9. Computational Physics, S. E. Koonin, Cal. Inst. Tech. (Benjamin, 1988)
10. Matlab and Mathcad user's Guide (1998)

C. The following journals and other literature are referenced.

1. Computer Physics Communication (1982-)
2. Journal of Computational Physics (1975-)
3. Journal of Algorithms
4. Journal of Applied Physics
5. Journal of Mathematical Physics
6. Mathematics of Computation
7. Journal of Chemical Physics
8. Handbook of Mathematical Functions (M. Abramowitz, NBS Publications)
9. Reviews of Modern Physics

VII. Basis for Student Evaluation

A. Undergraduate Students

1. Three 1-hour exams - 100 points
2. Special problems (homework) - 100 points
3. Final exam - 100 points

Total: 300 points

B. Graduate Students

1. Three 1-hour exams - 90 points
2. Final exam - 80 points

3. Homework - 80 points
4. Term project - 50 points

Total: 300 points