Physics 650/750-1E | Classical Electrodynamics I | Fall, 2005

MWF 12:20 - 1:10 pm
Rm. 445 Campbell Hall
Textbook: Classical Electrodynamics (3rd edition) by J. D. Jackson
Course Website: http://homework.phy.uab.edu/~harrison/phys750

Instructor: Harrison
Office: 308 CH
Hours: 2:30 - 3:30 pm MWF
e-mail: jgharrison@uab.edu

Grading: Exam I (20%) | Exam II (25%) | Homework (15%)
Project (10%) | Final Exam (30%) | Mon., Dec. 12, 10:45 am - 1:15 pm

Grading Scale: 100 - 90 A, 89 - 80 B, 79 - 70 C, < 70 F

You may bring one (1) 5” x 8” notecard with formulas, equations, examples, etc for reference during each exam. Notecard must be turned in with the exam.

Course Objectives: Electro- and magneto- statics, boundary value problems, electromagnetic induction
The objectives of the course are to develop conceptual understanding and problem-solving skills in the area of electrodynamics at an advanced level. While it is true that a course at this level generally employs more advanced mathematical techniques for solving problems, you should not make the mistake of replacing conceptual understanding with mathematical dexterity. To assist you in that effort, you may find it helpful to employ some of the free software packages listed in the Project Assignment section below to numerically solve and visualize some of the systems discussed in the text.

Syllabus: The syllabus is tentative. You are responsible for any changes announced during the lecture period.

Week	Mon	Wed	Fri	Assignment	CH	Due
Aug.14	NO CLASS	NO CLASS	Ch. “I”; 1.1 - 1.3			
21	1.3 - 1.6	1.6 - 1.9	1.9 - 1.11			
28	1.11 – 1.12	1.12 – 1.13; 2.1	2.1 – 2.2	1, 3*, 5*, 6*, 7, 10	1	Sep. 2
Sep. 4	NO CLASS	2.2 - 2.4	2.5 – 2.7	17, 19*, 21*, 23	1	Sep. 9
11	2.8 – 2.9	2.9 – 2.10	2.10 – 2.11	1*, 2*, 10*, 11	2	Sep. 16
18	2.11 – 2.12	3.1 – 3.2	3.3 – 3.4	13*, 15, 21, 23*	2	Sep. 23
25	3.4 - 3.5	Exam I (Ch. 1- 2)	3.5 – 3.6			
Oct. 2	3.6 - 3.7	3.7 - 3.8	3.8 – 3.9	1*, 6*	3	Oct. 7
9	3.9 - 3.10	3.10 – 3.11	3.12 (skip 3.13)			
16	3.12; 4.1 – 4.2	4.2	4.3	9*, 12, 13*, 14*, 20	3	Oct. 21
23	4.3 – 4.4	4.4 – 4.5	4.5	1*, 4, 6*, 7*	4	Oct. 28
30	4.6 – 4.7	4.7	5.1 – 5.2			
Nov. 6	5.2 – 5.3	5.3 – 5.4	5.5 – 5.6	9*, 13*	4	Nov. 7
13	Exam II (Ch. 3 - 4)	5.6 – 5.7	5.8 – 5.9			
20	5.10 – 5.12	NO CLASS	NO CLASS			
27	5.12 (skip 5.13 - 5.14)	5.15 – 5.16	5.16 – 5.17	3*, 6*, 10, 13	5	Nov. 28
Dec. 4	Project Rep. 5.17	NO CLASS	NO CLASS	19*, 21*, 22, 27*	5	Dec. 5
11	Final Exam (Ch 1- 5)					

***Graded:** 50% credit if turned in before noon on “due date +1”; no credit after that.

Project Assignment

Goal: To familiarize yourself with computational techniques for solving problems in electricity and magnetism. The packages employed are fairly representative of commercial packages now available. These suites range in price and capability from shareware, 250 -node-limit codes like Quickfield which can be run on fairly modest PC's to $15,000/yr 500,000-node-limit packages (ANSYS, FEMLAB) requiring mainframe- or cluster computer power. Other shareware packages are available on the internet. (Check out www.emclab.ee.umr.edu/numer.html.) Check out student packages from ANSOFT (www.ansoft.com) that are quite capable for free programs. There are also Excel and Matlab libraries of various EM programs.

Structure: The computational basis for packages which are designed for use in geometries with very little or no symmetry is usually the finite-element method. The method can be loosely described as follows: 1) One builds a model of the systems of interest using a module designed for that purpose (the "modeler") which is part of the software package. 2) Then the various regions in the model are divided into closed planar figures (rectangles, triangles) for 2-d problems or polyhedra (tetrahedra, hexahedra) for 3-d problems. This "meshing" procedure is carried out in another module (the "mesher"). Good packages offer automatic meshers which allow the user to make finer meshes in the model in regions where rapid changes in the computed quantities are anticipated. 3) Physical properties (dielectric constants, conductivity, etc.) are assigned to the various parts of the model in another module. 4) Boundary conditions are then applied (Dirichlet or Neumann). 5) Finally the problem is solved by the "solver" module. The quantity to be solved is expressed as a continuous function written as a low-order polynomial with coefficients determined by the value of the quantity at the corners (nodes) of the triangles or tetrahedra. Thus the problem of solving for the unknown function (E, Φ, B, etc.) reduces to finding a self-consistent set of values on the nodes. It is really not that much different from the idea of fitting some data to some functional forms by the process of linear regression, except that here we don't have data, but rather a differential equation and boundary conditions that the function must satisfy. There are many good introductory books on the finite-element method that can be consulted for a thorough discussion of the method -- we will not need to go further into it here.

Assignment: Attached is a list of ideas for possible electrostatic and magnetostatic problems that you can solve numerically. Each of you will be assigned to a group and the group must choose two problems to work on, at least one must be from the list . You will then define and set up the problem and generate the solution. The solved problems must be put on a diskette or CD or (if small enough) emailed to me as a zip or tar file by Dec.5 at 5 pm. In addition, *one* member of each group will give an oral report on the final day of class; *the other* member(s) of the group must turn in a written report on each of the two problems; each write-up should be no longer than 3 pages and should contain the following items: 1) A description of the problem; 2) A summary of the steps taken to set up the problem on the chosen software; 3) A discussion of your results. This section is where you let me know just how well you understood what you found. While it would be ideal to have figures from the output as part of the report, the hardcopy capabilities of some packages may be somewhat limited. If you think figures clarify your report, feel free to take advantage of that in preparing figures for your report.

Problem Ideas:

1) **Electrostatic field due to a uniformly charged ring** of radius *a* around the equator of a conducting or dielectric sphere or cylinder of radius *b* < *a*.

2) **"Computational Jackson" :** Pick a suitable problem from Jackson that can be solved analytically and solve it numerically.

3) **Helmholtz coil:** Set up two coils with specified currents and show how the uniformity of the B-field near the axis midway between the coils is affected by the coil radii and their separation. Add a permeable region between the coils and see its effect.

4) **Electric field due to a uniformly charged cylindrical shell** with inner radius *a* and outer radius *b* and length L. Examine hollow and dielectric-filled cases.