Course Outline: Physics 322: Electromagnetic Theory I
Carl Adams, Fall 2009

- **Summary:** This course deals primarily with a vector-calculus based description of static electric fields in cases of fixed charges, conductors, and dielectrics. Descriptions of moving charges (for the case of steady electric currents) and resulting static magnetic fields are also presented. This also serves as an introduction to the Maxwell equations and the classical description of electromagnetic fields. Problem solving makes frequent use of symmetry and invariance. At times it also involves computer analysis.

- **Text:** *Introduction to Electrodynamics* David J. Griffiths, 3rd edition. At least 90% of the course material is in the text but there are times I will present additional concepts for which you are responsible. Please see the list of other EM texts.

- **Grading scheme:**

  - Assignments (5) 30%
  - Midterms (Oct. 15 and Nov. 16) 30%
  - Comprehensive Final Exam 40%

  I draw your attention to Section 3.9 of the Academic Calendar **Regulations on Plagiarism, Cheating, and Academic Dishonesty**. This would include copying answers from a solution set and passing it off as your own work.

  I support a safe classroom environment where all students are treated equally regardless of gender, race, religion, sexuality, and gender identification.

  Assignments are due in my office by 4 p.m. on the due date (Sept. 21, Oct. 5, Oct. 26, Nov. 9, Dec. 2). The assignment mark will be penalized by 10% for each teaching day the assignment is late after the due date up to a maximum of one week. After one week or if in special circumstances where I circulate solutions prior to that time (a warning will be given) the assignment will be worth zero. (I may still mark the assignment if you would like to see how well you did.) I will return the assignments within 7 days or sooner. A considerable portion of the midterm and exam questions will be based on assignments and examples covered in class and in the book so it is very important that you understand these solutions. All midterms and exams will be closed book with copies of the front and back covers of the text. Midterms will take place in class on the dates listed above. There are no scheduled tutorials for this class but if the class wishes I will try to arrange for question and answer doughnut periods prior to the midterms.

- **Office Hours:** Rm 1006 Physical Sciences Complex, x5337 or in research lab PS 1063. Email: cadams@stfx.ca. I am usually in my office or lab from 10 to 5 each day with the exception Tuesdays, classes and labs. Formal office hours will be Monday 10:30 to 11:30, Wednesday 9:15 to 10:05, and Thursday 11:15 to 12:05. This overlaps with blocks C, D, and P. Let me know if you would like a special appointment.

- **Website:** http://www.stfx.ca/people/cadams/physics322

- **Course Outline:** Follows chapters 1 to 5 of the text.

  0. Introduction and Motivation (1 lecture)

1. Essential 3-Dimensional Vector Calculus (7 lectures)
   (a) Vectors
      i. Rotations
      ii. Definition of a Vector
      iii. Motivation for using Vectors
      iv. Einstein Summation
   (b) Cartesian, Spherical Polar, and Cylindrical Coordinates
   (c) Vector and Scalar Fields
   (d) Relationship of Vectors to Tensors
   (e) Integral vector calculus with parametrizaton
   (f) Div, grad, and curl operations with geometric interpretations
   (g) Stokes and Gauss Theorems
   (h) Dirac Delta Function and Helmholtz Theorem
2. Electrostatics (7 lectures)
   (a) Coulomb's Law and Electric Field
   (b) Gauss' Law in integral and differential form
   (c) Electric Fields of points, planes, wires, shells, and spheres
   (d) Poisson's Equation and Green's Function
   (e) Boundary Conditions for the Electric Field
   (f) Energy of an Electric Field
   (g) Conductors and Capacitors
3. Special Techniques for Solving Electrostatic Problems (7 lectures)
   (a) Laplace's Equation and Uniqueness Theorem
   (b) Solutions for grounded planes and spheres in external fields
   (c) Image Charge Methods for planes and spheres
   (d) Separation of variables in Cartesian and Spherical coordinates
   (e) Multipole Expansion
4. Dielectrics (5 lectures)
   (a) Definition of Polarization and its Realization in Matter
   (b) The displacement field $\mathbf{D}$, free charge, and modified Gauss Law
   (c) Boundary conditions and symmetric problems with displacement field
5. Magnetostatics (6 lectures)
   (a) Currents and the Continuity Equation
   (b) Lorentz Force
   (c) Biot-Savart Law
   (d) Divergence and Curl of $\mathbf{B}$
   (e) Magnetic Vector Potential $\mathbf{A}$

- **Stuff You Should Know:** You would have seen these following topics in MATH 111, MATH 112, PHYS 120, PHYS 241 (or MATH 361), and MATH 267. Techniques (diagrams, integration, different coordinate systems) from PHYS 242 will also be quite useful. Review if you need to! I will not be able to re-explain these topics in class but I may be able to assist during office hours. It is not expected that you will have taken a course in vector calculus so I will develop that topic as needed.

1. Multivariable integration and differentiation.
2. High degree of competency in single variable differentiation and integration.
3. Constructing diagrams and employing useful and consistent notation.
4. Basics of curvilinear coordinates (cylindrical, spherical polar) and vector multiplication (cross product, dot product).
5. Taylor's series and power series expansion and approximation.
6. How to use some type of graphing package to produce hard copies. (Most students have used Maple in the past.)
7. Electromagnetic theory at the level of PHYS 120 (i.e. can you use Gauss' Law in integral form to give the electric field of a sphere?)
8. Ability to handle and interpret notation for vectors and scalars.