Syllabus for PHY 432 Electromagnetism

Dr. Christensen

2013 Fall Semester: MWF 11:00–12:05, S226

Textbook: "Introduction to Electrodynamics" (4e) Griffiths

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PHY 432 (4-0)
Prerequisites:  PHY 142, MAT 202, MAT 310
Electric and magnetic fields in free space and in materials, electromagnetic fields and
waves and radiation are discussed.
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1 Goals and Outcomes

1.1 Departmental Goals: To Provide Training to Think about Electrical Phenomenon as a Physicist Would

Through the class discussion and lecture, you will be exposed to *the principles and foundations of classical and modern physics* as they apply to electromagnetic fields at an *advanced* level. **Recall that hearing information – even if it *sounds reasonable* – does not equate to understanding relationships or techniques.** Solving the homework problems, on the other hand, *will* help you to incorporate these principles into your general understanding of the world. In the homework problems, you will be asked *to generalize and extend foundational theories in complex applications* of electromagnetic fields at an *advanced* level.

1.2 Goals of the Instructor: To Build Insight for the Application of Maxwell's Equations

Using the four pillars of this course (**Gauss' Law**, **Faraday's Law**, **No Magnetic Monopoles**, and **Ampere's Law**) will enable you to think about new electromagnetic phenomenon in the manner of a professional physicist. These four principles are both *fundamental* and *powerful*, because they capture the essence of the field and they enable one to understand previously unrecognized relationships.

Because the goal is to train you how to think, with electromagnetism as the context, the primary goal is to recognize the advantages of having a set of fundamental equations. The secondary goal is to understand the application of the thought process in electromagnetism.

1.3 Impact of Goals on Expectations

Your grades on the homework and exams will reflect your knowledge of the principles and foundations and your ability to generalize and extend these. The point of turning in work is to show me how well you understand the material. The point of grading work is to show you how well you understand as well as how well you communicate your understanding. Please review returned homework to learn what you didn't understand.

You will be asked to use (mathematically solve) and to explain Maxwell's equations on every exam. If you understand these equations in the way of a physicist, then it should be obvious if you need the differential form, the integral form, or the related boundary condition. If you understand these equations in the way of a physicist, then algebraic or calculus errors should produce a result that is recognizably inappropriate. If you understand these equations in the way of a physicist, then you should have some intuition about what the answer will look like before you start solving the problem. You will have an opportunity on your exams to answer these types of questions.

The homework is the heaviest portion of your grade because practicing these problems is where you develop your understanding. Work these out well before they are due. Some of the problems are very difficult and will require discussion. The ideal classroom experience will be when you bring enough homework questions to keep me from lecturing (although I will have a lecture prepared in the event that you do not ask questions).

2 Grading

5% **JITT questions:** The syllabus provides a schedule of topics covered on each day. You should come to class prepared to answer questions about such topics. To help you prepare, there will be a JITT-question (or two) posted to the MyTMC. There may also be quick quiz questions on paper set at the beginning of class.

25% **Homework:** You will be given three categories of homework: There are "Due" problems, which will be turned in and for which the solutions will be posted after the due date. There are "Do" problems, which will not be turned in and for which the solutions will be posted to the MyTMC class website before the "Due" problems are due to help you figure out the solutions to the "Due" problems. I expect you to look over and to attempt these problems. There are "Extra" problems, which are problems that I like and have selected for useful practice. The solutions to these will not be posted, but you are welcome to ask, in class or during office hours, about how one might solve them.

3x15% **Exams:** There will be three one-hour tests and a two-hour comprehensive final exam. Each exam will have
+25% an in-class, closed-book portion. They may also have an open-book and/or take-home portion.

100% **Grades:** Final grades will be reported as a percentage of the sum of the adjusted earned points.

3 Course Policies

Attendance: Physical attendance is mandatory. Mental attendance is appreciated (not to mention helpful). If "something comes up," contact me (note, email, voice mail, courier, same-day word-of-mouth) **beforehand**.

Athletics: It is your personal responsibility to inform me if you will miss class **before** you miss class. Even if an email is being sent on your behalf, see me before or after class so that I can inform you of variations from the syllabus. It is your responsibility to inform me of incoming report cards before you bring them so that I can have a grade available.

Late Policy: No credit will be given for problems worked in class regardless of attendance in the class. Late homework loses 5 points per day (not per class period). Sat & Sun together count as 1 day.

Missed Exams: Make up exams **must** be scheduled before regular exam time. Documented, unforeseen events will be dealt with on a case-by-case basis.

Office Hour Policy My schedule (with office hours) is posted on my office door. I expect to be in my office most days from about 8:00am to about 4:30pm. You are welcome to stop by whenever you have a question. Be aware that my posted schedule also lists times which I will *probably* be in my office. I am also available by appointment.

Expectations: Grades are tied to numerical scores according to the following criterion. I consider a mid-C to be average for physics majors who are going on to graduate school.

"A"	Outstanding	> 90
"B"	Above Average	80-90
"C"	Average	70-80
"D"	Below Average	60-70
"F"	Did not successfully complete requirements	< 60

"+" is the upper half of the range.

3.1 Campus Policies and Services

In compliance with Thomas More College policy and legislation requiring equal access, appropriate accommodations for students with disabilities are available. If you have a documented physical or learning disability for which you require special accommodations, please see Veronica Lubbe, Coordinator Academic Support Services Administration Building room 3336, (859) 344-3521, as soon as possible. This includes students who have previously received accommodations at TMC.

4 Schedule

Week	Day	Topic	Eqns	Pre-class Readings
8/19	M	(no class)		
	W	1. Review Math Meth. 301/302	$\vec{\nabla}\Phi$, $\vec{\nabla}\cdot\vec{E}$, $\vec{\nabla}\times\vec{A}$	Chap 1
	F	2. Review Math Meth. 301/302	$\vec{\nabla}\Phi$, $\vec{\nabla}\cdot\vec{E}$, $\vec{\nabla}\times\vec{A}$	Chap 1
8/26	$\boxed{M_1}$	3. $\vec{E}$-field, Coulombic Force, Superposition	$\vec{F} = q\vec{E}$	2.1-2
	W	4. Electric Flux, Gauss' Law	$\begin{cases} \oint_S \vec{E}\cdot d\vec{a} = \int_V (\rho/\varepsilon_o)\, dv \\ \vec{\nabla}\cdot\vec{E} = \rho/\varepsilon_o \end{cases}$	2.2
	F	5. Electrostatic Potential and Potential Energy	$\begin{cases} \vec{E} = -\vec{\nabla}V, \vec{F} = -\vec{\nabla}U \\ U = \frac{1}{2}\int_V (\varepsilon_0\vec{E})\cdot\vec{E}\, dv \end{cases}$	2.3-4
9/2	M	======== **Labor Day - No Class** ========		
	W	6. Capacitors	$U = \frac{1}{2}\sum_i\sum_j c_{ij}\Phi_i\Phi_j = C\Delta\Phi$	2.4-5
	$\boxed{F_2}$	7. Rectangular Poisson & Laplace	$\nabla^2\Phi = -\rho/\varepsilon_o$	2.3.3,3.1,3.3
9/9	M	8. Spherical & Cylindrical Poisson & Laplace		3.1,3.3
	W	9. Multipoles	$\lVert\vec{r}-\vec{r}'\rVert^{-2}$	3.4
	F	10. Multipoles & Dirac Delta Function	$\delta(\vec{x}-\vec{a})$	1.5,3.4
9/16	M	11. Method of Images		3.2
	$\boxed{W_3}$	12. Dipoles, Dielectric Polarization	$\vec{p}$, $\sigma = \vec{P}\cdot\vec{n}$, $\rho = -\vec{\nabla}\cdot\vec{P}$	4.1,4.2
	F	13. Review		
9/23	M	14. $\boxed{\Rightarrow \textbf{Test 1} \Leftarrow}$		$\boxed{\text{Chap:1-3}}$
	W	15. $\vec{E}$ & $\vec{D}$ fields, ε, & χ	$\begin{cases} \vec{D} = \varepsilon\vec{E}, \vec{P} = \chi\vec{E} \\ \vec{D} = \varepsilon_o\vec{E} + \vec{P} \end{cases}$	4.3-4
	F	16. $\vec{E}$ & $\vec{D}$ fields, ε, & χ	$\begin{cases} \vec{D} = \varepsilon\vec{E}, \vec{P} = \chi\vec{E} \\ \vec{D} = \varepsilon_o\vec{E} + \vec{P} \end{cases}$	4.3-4
9/30	M	17. Boundary Conditions	$(\vec{D}_{2n} - \vec{D}_{1n}) = \sigma, E_{1t} = E_{2t}$	4.4
	$\boxed{W_4}$	18. Magnetic Force and Source (Current Density)	$\vec{F}_C = q(\vec{E} + \vec{v}\times\vec{B})$	5.1
	F	19. Biot-Savart Law, Magnetic Flux	$\vec{B}(\vec{r}_2) = \frac{\mu_o}{4\pi}I_1\oint_1 \frac{d\vec{l}_1\times(\vec{r}_2-\vec{r}_1)}{\lvert\vec{r}_2-\vec{r}_1\rvert^3}$	5.2
10/7	M	20. Ampere's Law	$\oint_C \vec{B}\cdot d\vec{l} = \mu_o\int_S \vec{J}\cdot d\vec{a}$	5.3

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Week	Day	Topic	Eqns	Pre-class Readings
	W	21. Magnetic Vector Potentials	$\begin{cases} \vec{B} = \vec{\nabla} \times \vec{A} \\ \vec{\nabla} \times \vec{B} = \mu_0 \vec{J}, \vec{\nabla} \cdot \vec{B} = 0 \end{cases}$	5.4
	F	======== **Fall Break - No Class** ========		
10/14	$\boxed{M_5}$	22. Magnetization, Susceptibility, Permeability	$\vec{M} = \chi_m \vec{H}$, $\vec{H} = \frac{1}{\mu_0}\vec{B} - \vec{M}$	6.1,6.3-4
	W	23. Bound Currents	$\vec{J} = \vec{\nabla} \times \vec{M}$, $\vec{K} = \vec{M} \times \hat{n}$	6.2
	F	24. Boundary Conditions	$(\vec{B}_{2n} - \vec{B}_{1n}) = 0$, $H_{1t} = H_{2t}$	6.3-4
10/21	$\boxed{M_6}$	25. Continuity & Ohm's Law	$\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$, $\vec{E} = \sigma_c \vec{J}$	8.1.1,7.1.1
	W	26. Review		
10/25	F	27. $\boxed{\Rightarrow \textbf{Test 2} \Leftarrow}$		$\boxed{\text{Chap 4-6}}$
10/28	M	28. Induction & Electromotive "Force"	$\mathcal{V} = -\frac{d\Phi}{dt}$	7.1
	W	29. Faraday's Law	$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	7.2
	F	30. Faraday's Law	$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	7.2
11/4	M	31. Displacement Current Density	$J_D = \frac{\partial \vec{D}}{\partial t} = \frac{\partial}{\partial t}(\varepsilon_0 \vec{E} + \vec{P})$	7.3
	W	32. Maxwell's Equations		7.3
	$\boxed{F_7}$	33. Energy (Poynting) in Electromagnetic Fields	$\vec{S} = \vec{E} \times \vec{H}$	8.1
11/11	M	34. (Angular) Momentum in Electromagnetic Fields	$\vec{p} = \mu_o \varepsilon_o \int \vec{S}\, dv$	8.2.3-4
	$\boxed{W_8}$	35. General Properties of Waves	$v^2 \vec{\nabla}^2 f = \ddot{f}$, T, λ, ω, k	9.1
	F	36. Review		
11/18	M	37. $\boxed{\Rightarrow \textbf{Test 3} \Leftarrow}$		$\boxed{\text{Chap 7-8}}$
	W	38. Boundary Conditions		9.1.3-4
	F	39. Electromagnetic Waves in Vacuum		9.2
11/25	M	40. Electromagnetic Waves in Matter		9.3
	W	**Thanksgiving Break**		
	F			
12/2	$\boxed{M_9}$	41. Review: **BRING QUESTIONS**		Comprehensive
	W	42. Review: **BRING QUESTIONS**		Comprehensive
	F			
12/12	Th	43. **Final Exam**: 8:30am –10:30am		Comprehensive