Physics 441 – Fall 2017
Dr. John S. Colton

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TA: TA Information is posted to the course website.
Course Website: http://www.physics.byu.edu/faculty/colton/courses/phy441-Fall17/. You can navigate there via www.physics.byu.edu → Courses → Class Web Pages → Physics 441 (Colton).
Learning Suite: We will not use Learning Suite at all.
Max: I will use the Physics Department online system for keeping track of grades: http://max.byu.edu.

Prerequisites: Everyone should have had Physics 220 and Physics 318. Please talk to me ASAP if for some reason you have not.

Textbook: The textbook for this class is *Introduction to Electrodynamics*, by David Griffiths (3rd or 4th edition). This is the standard textbook used in electrodynamics classes across the country, and will be the dominant source for my lectures and homework problems. We'll cover chapters 1 – 6 and part of chapter 7 in Phys 441 and the rest of chapter 7 along with chapters 8 – 12 in Phys 442.

Course Objectives: In this class you will learn the physics of electricity and magnetism. This is one of the three major topics in the traditional study of physics, the other two being classical mechanics and quantum mechanics—you have already dealt with all three in your freshmen/sophomore classes, you are likely in the process of dealing with all three as junior/senior level classes, and if you proceed on to graduate school in physics, you will almost certainly take additional classes on all three topics. They are fundamental!! In this class and in Physics 442 we will cover topics somewhat similar to Physics 220, but in more detail, and with much more mathematics. Physics 441 will culminate with Maxwell's Equations, the fundamental set of four equations in classical physics which govern the behavior of electric and magnetic fields and their interactions with matter.

The official BYU Learning Outcomes for this class are that a student successfully completing this course should be able to do the following:

- **Vector Calculus** - Demonstrate the ability to apply the concepts of vector calculus as used in Maxwell's equations.
- **Integrating Static Sources** - Demonstrate the ability to integrate over a source distribution to calculate time-independent fields and potentials for both electricity and magnetism. Also demonstrate the ability to use Gauss's law and Amperes law to find electric and magnetic fields in symmetric situations.
- **Image Charges and Currents** - Demonstrate the ability to use vacuum harmonics, image charges, and image currents to solve for time-independent electric and magnetic potentials and fields.
- **Material Influences** - Demonstrate the ability to calculate electric and magnetic fields in the presence of matter which can be electrically and magnetically polarized, including the ability to solve problems involving torques and potential energies of electric and magnetic dipoles.

Due to covering part of chapter 7 in Phys 441 (which didn't used to be done), we should probably add this additional learning outcome, stolen from 442:

- **Time Dependence** - Calculate time-dependent electric fields using Faraday's law and calculate time-dependent magnetic fields using Maxwell's displacement current.

Student Email Addresses: I may periodically send class information via email to your email address that is listed under myBYU. If that is not a current address for you, please update it.

Grading: If you hit these grade boundaries, you are guaranteed to get the grade shown. I may make the grading scale easier than this in the end if it seems appropriate, but I will not make it harder. Because students are not graded relative to each other, it is to your advantage to learn collaboratively.

A	93%	B+	85%	C+	71%	D+	59%
A-	89%	B	79%	C	65%	D	53%
		B-	74%	C-	62%	D-	50%

Grades will be determined by the following weights:

- Homework: 30%
- 3 Midterm Exams: 45%
- Final Exam: 25%

Homework: This will be a very homework-intensive class, and homework scores will count as a substantial fraction of your overall course grade. In the semester-long version of this class, students spent 6 hours per week on homework. Some weeks may be more, others less, and some students may require more, others less.

Homework is due at class time on the due-date; turn it in to Dr. Colton at the start of class. I will generally hand out homework solutions at the same time; therefore **no late homework will be accepted**. However, to allow you a mulligan, your lowest homework score will be dropped. If you have exceptional circumstances where you feel need additional aid beyond that please talk to me individually.

Collaboration: You are encouraged to collaborate with other students while working on the homework problems, but remember that "collaborate with" means "work together with" and not "copy from". Just as it is your responsibility to not copy from others, it is also your responsibility to make sure that others do not copy from you. If you do work together with one or more other students in order to solve a problem, please acknowledge them in your homework assignment. That is a standard practice for professional scientists and I think students should adhere to this practice as well. On each applicable problem, please write "Worked with [*list of names*]" at the top.

Cheating: You can likely find solutions to many of Griffiths' problems via internet searching. If you google a problem and then copy down the solution, this is considered cheating just as if you had copied from another student. However, if you google a problem and use the resources you find in order to **learn** about the problem and how to get started with your own solution, that's probably OK. It's a fine line; please take care to stay on the "safe" side. If you do use internet resources, be sure to acknowledge them as you do other students.

Grading: HW problems will be graded out of 4 points: 4 points are earned for a well-presented correct solution. 3 points are earned for a solution with only minor errors, or for a correct but unclear solution. 2 points are earned for a very wrong solution which had a substantial amount of effort. 1 point is earned for a wrong solution with little effort put into it. 0 points are earned if the homework problem is not done at all. Half points may be awarded if deemed appropriate.

Extra Mile Points: For each assignment I will assign bonus points to one or more students for clarity/neatness/going the extra mile.

The Homework System: Follow these rules when writing up an assignment. Points may be lost for not following these guidelines.

1. **Take at least 1 page per problem (start each problem on a new page)**, and write at most one equation per line. I realize that this may not be environmentally friendly—but it is better for both you and the TA this way.

2. Answers should be **boxed** at the bottom of the solution where applicable, and if numerical should include **units** and be given to **three significant digits**. That means you must use more than three significant digits as you are working the problem, so that you don't have rounding errors in your final answer.

3. **Staple** your problem set. And staple your problems **in order**.

4. **Be neat**. My homework solutions will be an example of how I expect your homework assignments to look. When I prepare a homework solution, I typically work the problem out first on scratch paper before making a neat final copy. I strongly encourage you to do the same with the homework you hand in to me. Part of being neat includes:
    a. **Draw a picture or sketch** for every problem (with only rare exceptions).
    b. On or near your picture, **label the information that was given in the problem** (e.g. "E = 1 V/m", "v = 3000 m/s", etc.).
    c. On or near your picture, **label the information that you are trying to figure out** (e.g. "r = ?").
    d. **Be clear about your reasons for tackling the problem the way you did** (i.e. write things down like "…using Gauss's Law to calculate the electric field …", or "…because of the given boundary conditions …"). Consider your homework solution to be a communication between you and the grader.
    e. **Write down the equation(s)** you are using with variables, before you plug in any numbers or do any substitutions. If solving a numerical problem, solve symbolically first as far as you can. **Do not use equations without knowing exactly what each variable in the equation represents in your problem!** One of my pet peeves is when students use the wrong quantity in an inappropriate equation, simply because the equation happens to use a letter that is similar to the one you're interested in—for example, plugging a voltage instead of speed into the $KE = ½ m v^2$ equation. Do not expect to get any partial credit if you make an error like that!

    Neatness is important because it shows you **take pride in your work**. As mentioned above, I feel so strongly about this aspect that I will give bonus points to people whose homework demonstrates they have gone the extra mile.

5. Think about whether **your answer is reasonable**. For numerical problems, do the numbers make sense? E.g. can an electron move at 10^9 m/s? If you get an unrealistic numerical answer, then figure out what you did wrong, or at the very least say something like "This doesn't make sense; I likely made a mistake." For symbolic problems, do the units of the quantities in your final equation yield the proper units of the answer? If not, it cannot be correct.

6. **Consult your colleagues.** Exchange phone numbers and emails with other students in the class. I strongly recommend you talk with one or more of your fellow students the evening before the homework is due, to make sure you got the same answers. If you turn in an incorrect answer without first consulting with others, you really have only yourself to blame when you lose points.

7. As mentioned previously, remember to **acknowledge your collaborators and resources** by writing e.g. "Worked with John Smith and Jane Roberts; learned from similar problem at thiswebsite.com" at the top of the relevant problem. If you worked with someone, or if another student or website taught you how to do a problem—give them credit! As mentioned above, that is the standard practice for professional scientists and I see no reason why students should not adhere to this practice.

8. Again, **do not let others copy your work**, **do not copy others' work, and do not merely copy solutions from internet resources**!

Solutions: I will hand out homework solutions. **You are responsible for knowing and understanding the material in those solutions.**

Exams: Three midterm exams will be given, currently planned to be in the Testing Center. A comprehensive final exam will be given.

BYU Policies:

Honor Code. In keeping with the principles of the BYU Honor Code, students are expected to be honest in all of their academic work. Academic honesty means, most fundamentally, that any work you present as your own must in fact be your own work and not that of another. Violations of this principle may result in a failing grade in the course and additional disciplinary action by the university. Students are also expected to adhere to the Dress and Grooming Standards. Adherence demonstrates respect for yourself and others and ensures an effective learning and working environment. It is the university's expectation, and my own expectation in class, that each student will abide by all Honor Code standards. Please call the Honor Code Office at 422-2847 if you have questions about those standards.

Academic Honesty. The first injunction of the Honor Code is the call to "be honest". Students come to the university not only to improve their minds, gain knowledge, and develop skills that will assist them in their life's work, but also to build character. "President David O. McKay taught that character is the highest aim of education" (The Aims of a BYU Education, p.6). It is the purpose of the BYU Academic Honesty Policy to assist in fulfilling that aim. BYU students should seek to be totally honest in their dealings with others. They should complete their own work and be evaluated based upon that work. They should avoid academic dishonesty and misconduct in all its forms, including but not limited to plagiarism, fabrication or falsification, cheating, and other academic misconduct.

Sexual Harassment. Title IX of the Education Amendments of 1972 prohibits sex discrimination against any participant in an educational program or activity that receives federal funds. The act is intended to eliminate sex discrimination in education and pertains to admissions, academic and athletic programs, and university-sponsored activities. Title IX also prohibits sexual harassment of students by university employees, other students, and visitors to campus. If you encounter sexual harassment or gender-based discrimination, please talk to your professor or contact one of the following: the Title IX Coordinator at 801-422-2130; the Honor Code Office at 801-422-2847; the Equal Employment Office at 801-422-5895; or Ethics Point at http://www.ethicspoint.com, or 1-888-238-1062 (24-hours).

Student Disability. Brigham Young University is committed to providing a working and learning atmosphere that reasonably accommodates qualified persons with disabilities. If you have any disability which may impair your ability to complete this course successfully, please contact the University Accessibility Center (UAC), 2170 WSC or 422-2767. Reasonable academic accommodations are reviewed for all students who have qualified, documented disabilities. The UAC can also assess students for learning, attention, and emotional concerns. Services are coordinated with the student and instructor by the UAC. If you need assistance or if you feel you have been unlawfully discriminated against on the basis of disability, you may seek resolution through established grievance policy and procedures by contacting the Equal Employment Office at 422-5895, D-285 ASB.

Physics 441 – Electrostatics & Magnetism – Fall 2017: Tentative schedule
HW is due at the start of class on the days indicated.

Lecture	Date	Day	Topic	Reading (Griffiths)	Assignments
1	Sep 6	W	Review of some 220 topics; Coordinate systems	"What you should already know about fields and potentials" handout; 1.4	
2	Sep 8	F	Review of differential vector calculus	1.2	
3	Sep 11	M	Review of integral vector calculus; Dirac delta function	1.3, 1.5, (skipping 1.6)	
4	Sep 13	W	Coulomb's law	2.1.1-2.1.4	HW 1 due (sections 1.4, 1.2, 1.3)
5	Sep 15	F	Coulomb's law worked problems	2.1.4 cont.	
6	Sep 18	M	Coulomb's law worked problems, cont.; Field lines; Flux; Gauss's law	2.1.4 cont., 2.2.1	
7	Sep 20	W	Gauss's law worked problems	2.2.3	HW 2 due (1.5, 2.1, 2.2.1)
8	Sep 22	F	Divergence of **E**; Curl of **E**; Electric potential	2.2.2, 2.2.4, 2.3.1-2.3.2	
9	Sep 25	M	Electric potential worked problems	2.3.4	
10	Sep 27	W	ρ, V, **E** summary; Potential energy; Conductors	2.3.3, 2.3.5 (first part), 2.4, 2.5.1	HW 3 due (sections 2.2.2-2.2.4, 2.3.1-2.3.4)
11	Sep 29	F	Conductors, cont.; Discontinuities in **E** & V; Induced charges	2.5.1 cont., 2.3.5 (remainder), 2.5.2	
12	Oct 2	M	Capacitance; Force on a conductor	2.5.4, 2.5.3	
13	Oct 4	W	Review of Chapters 1, 2 **Exam 1 begins (Ch 1-2, HW 1-4)**	n/a	HW 4 due (sections 2.3.5, 2.4, 2.5)
14	Oct 6	F	Laplace's equation; Relaxation	3.1	
15	Oct 9	M	Images; Separation of variables **Exam 1 ends (late fee after 8 am, last test 6 pm)**	3.2, 3.3.1	
16	Oct 11	W	SoV worked problems	3.3.1, cont.	
17	Oct 13	F	SoV in spherical coordinates (Legendre polynomials)	Legendre polynomials handout; 3.3.2	HW 5 due (sections 3.1, 3.2, 3.3.1)
18	Oct 16	M	SoV in spherical coordinates, cont.	3.3.2 cont.	
19	Oct 18	W	Multipole expansion.; MP worked problems	3.4.1-3.4.4	
20	Oct 20	F	MP worked problems, cont.	3.4.4 cont.	HW 6 due (sections 3.3.1 cont, 3.3.2, 3.4.1-3.4.2)
21	Oct 23	M	Polarization; Bound charges	4.1, 4.2	
22	Oct 25	W	Bound charges, cont.; Polarization worked problems; Electric displacement; Gauss's law for **D**; Susceptibility	4.2 cont., 4.3.1-4.3.2, 4.4.1	
23	Oct 27	F	Permittivity; Dielectrics; Gauss's law for **D** worked problems	4.4.1 cont.	HW 7 due (sections 3.4.3-3.4.4, 4.1, 4.2)
24	Oct 30	M	Energy stored in electric field; Forces on dielectrics; Discontinuity in ***D***	4.4.3-4.4.4, 4.3.3	
25	Nov 1	W	Boundary value problems with linear dielectrics	4.4.2	
26	Nov 3	F	Review of Chapters 3, 4 **Exam 2 begins (Ch 3-4. HW 5-8)**	n/a	HW 8 due (sections 4.3, 4.4)
27	Nov 6	M	Lorentz force law; Currents and magnetism; Biot-Savart law	5.1, 5.2	

28	Nov 8	W	BSL worked problems; Ampere's law **Exam 2 ends (late fee after 8 am, last test 9 pm)**	5.2 cont., 5.3.1-5.3.2	
29	Nov 10	F	Amp. Law worked problems; Comparison of magnetostatics and electrostatics; Vector potential	5.3.3-5.3.4, 5.4.1	
30	Nov 13	M	Multipole expansion of **A**; **J**, **A**, **B** summary	5.4.3, 5.4.2 (first part)	HW 9 due (sections 5.1, 5.2)
31	Nov 15	W	Magnetization; Fields of magnetized objects (bound currents)	6.1.1-6.1.2, 6.1.4 (skipping 6.1.3); 6.2	
32	Nov 17	F	Bound current worked problems	6.2 cont.	
33	Nov 20	M	The **H**-field; Ampere's law for **H**; χ and μ	6.3.1-6.3.2, 6.4.1	HW 10 due (sections 5.3, 5.4, 6.1)
34	Nov 21 (Fri classes)	T	**H**-field worked problems	6.4.1, cont.	
35	Nov 27	M	Hysteresis; Discontinuities in ***B*** and ***H***; Energy considerations	6.4.2, 5.4.2 (remainder), 6.3.3	
36	Nov 29	W	Electromotive force; Motional EMF; Faraday's law; The induced electric field	7.1.2-7.1.3, 7.2.1-7.2.2 (skipping 7.1.1, 7.2.3-7.2.4 until Phys 442)	HW 11 due (sections 6.2, 6.3, 6.4)
37	Dec 1	F	Maxwell's last equation; Displacement current	7.3.1-7.3.2 (skipping 7.3.3, 7.3.5-7.3.6 until Phys 442; skipping 7.3.4 completely)	
38	Dec 4	M	Review of Chapters 5, 6, 7a **Exam 3 begins (Ch 5-7, HW 9-12)**	n/a	HW 12 due (sections 7.1.2-7.1.3, 7.2.1-7.2.2, 7.3.1-7.3.2)
39	Dec 6	W	Analysis of circuits	"What you should already know about circuits" handout; Complex numbers handout; Advanced circuits handout #1	
40	Dec 8	F	Circuits, cont. **Exam 3 ends (late fee after 8 am, last test 9 pm)**	Advanced circuits handout #2	
41	Dec 11	M	Circuits, cont.	Advanced circuits handout #3	
42	Dec 13	W	E&M equations as convolutions; A discussion of units	Convolutions handout; Appendix C	HW 13 due (Circuits)
n/a	Dec 15	F	**Probable SPS-sponsored final exam review**	n/a	