PHYS 631 -- Electromagnetic Theory -- Fall 2016

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Class meets:	MWF 9:15 AM - 10:15 AM, Reichardt 138
Office hours:	MWF 8:10 AM - 9:10 AM or by appointment
Credits:	3 credits: 3 hours/week of lecture.
Textbook:	Classical Electrodynamics, Jackson, 3rd edition, John Wiley & Sons, ISBN#: 9780471309321
Prerequisites:	Graduate standing
Course Home Page:	http://www.gi.alaska.edu/~chungsangng/phys631/phys631.html

I. Course Description

The UAF Catalog listing for PHYS 631: "Electrostatics, magnetostatics, Maxwell's equations, and potentials. Lorentz equations, field energy, gauge conditions, retarded potentials, waves, radiation and tensor formulations."

In terms of the content of the textbook (which you must have and bring to classes), we will try to cover most topics from Chapter 1 to 6 during the fall semester. We will not cover everything in these chapters, due to the fact that we only have limited amount of time, not because other topics are not important. At the end of this syllabus is a tentative schedule which lists topics we plan to cover in more details. This is subject to change. So you should check frequently the online version of this page: http://www.gi.alaska.edu/~chungsangng/phys631/phys631.html

II. Course Goals

The main goal of this course is to introduce you to the fundamental concepts, phenomena, and theories of electromagnetism, at the beginning graduate level. Emphasis will be on the theoretical aspects of the subject because the mathematical treatments covered in this course are very fundamental and should help students doing research in other branches of physics.

III. Student Learning Outcomes

- Know how to solve assigned problems in weekly homework assignments.
- Be able to solve most E&M PhD comprehensive exam questions in recent years.
- Obtain good understandings on useful concepts, as well as theoretical and mathematical tools related to electromagnetic theory that can help students to conduct their own graduate research

IV. Textbook

You must have a copy of the textbook: Classical Electrodynamics, by J. D. Jackson (3rd edition, John Wiley & Sons, ISBN#: 9780471309321). It is very important that you read the Section(s) covered within each lecture and try to follow derivations before you come to that lecture. Please refer to the schedule below (subject to change) for such reading assignments. You should bring your textbook to the lectures.

Errata of the textbook can be found in: http://bcs.wiley.com/he-bcs/Books?action=index&itemId=047130932X&bcsId=3728
More recent errata can be found in: http://www-theory.lbl.gov/jdj/Errata%282010%29.pdf
If you are curious about what does Jackson look like recently, check this out:
http://videoglossary.lbl.gov/#n45 (http://www.youtube.com/watch?v=f_6K7qsJs6s)

You will find it extremely useful to have some mathematical references, handbooks, or tables, e.g., table of integrals. There are many options available from the Internet, but you should be cautious about the accuracy of information obtained there. One recommendation is Abramowitz and Stegun: Handbook of Mathematical Functions, which can be downloaded freely. Another one is the *NRL Plasma Formulary*, which you can order a free copy or download it online.

References: No reference book is reserved in the library. I am also not writing down a list of reference books. Since reading Jackson alone will take up a lot of time and effort, I don't want to give an impression that you need to read any other books. However, if you are having difficulties on some elementary E&M concepts, please review your favorite undergraduate textbooks on E&M. And if you are having difficulties on mathematical methods, you will need to read other textbooks on mathematical physics. Nowadays you may of course search for suggestions on these books easily online.

V. Instructional method and reading assignments

The course is for 3 credits, and so 3 hours per week are devoted to "lectures" in the classroom. However, since this is a graduate level course and that the topics and mathematics are quite advanced, there is not enough time to explains everything in details by lecturing. Students must help themselves by reading and studying before each class. You are expected to ask questions and contribute to discussion in class about physical concepts and mathematical derivations for that class. I will not have time to go through all the text and derivations, but will try to answer questions that you found difficult. Any materials that we don't have time to go through in that class have to be left for self-study by students themselves. If you still have difficulties, you need to come to my office hours (or set up another time) and ask for additional help.

Lecture notes with some derivations filling in gaps between equations can be downloaded via the course home page (http://www.gi.alaska.edu/~chungsangng/phys631/phys631.html) by clicking at the topics of the lectures in the schedule. These notes are not to replace the lectures themselves or the textbook.

VI. Participation grade

To encourage you to finish reading assignments before classes and to practice what we are learning, 10% of the final grade is for participation. During each lectures, I would ask some questions so that you can write down your answers and derivation on your notebook or a piece of paper. Only participation is graded regardless of the correctness of your answer. An absence will result in no participation grade unless it is excused based on documented reasons (e.g. research trip, sickness, or emergency). However, since I will not count the five lowest grades, those can be used for unexcused absences.

VII. Homework

Doing homework is the most important factor in doing well in this class. There will be approximately one homework set assigned per week, usually on Fridays, and is usually due in the following Friday before class. However, you should work on your homework as early as possible before a deadline so that you can have time to ask for help during classes or in my office hours if you encounter difficulties in solving these problems. Late homework will not be accepted.

To emphasize the importance of doing homework, homework grade will count towards 35% of the total grade of the course, excluding the assignment with the lowest grade.

Homework questions will <u>not</u> be assigned from questions in the textbook, due to the fact that many solutions can be found easily online. Instead, questions from will be selected from other sources, including past PhD comprehensive exams. You need to show steps of how you used the method leading to that answer. I will grade the homework based on the method used, as well as the answer. Therefore, you should submit your partially finished work. This will help you getting partial credit, and let me identify your difficulties. Also, your work should be clean and clear enough for me to understand.

While it is good for you to have discussion with classmates or search the Internet for additional information, your submitted homework should be of your own, but not a direct copy from another source. If you finish a question with the help of another person, a solution book, or a solution you found in the Internet or passed on to you from another student, you need to cite that at the end of your answer for that question. There is no deduction of points for using help that you cited if it is not a direct copy. However there can be deduction up to the maximum points of that homework set if you used help but failed to cite. Also, you should use help only to enable you to do a problem yourselves. Keep in mind that you will be required to do similar questions on your own during exams (closed books in the exams, and also in the PhD comprehensive exam). In addition, it is against the UAF Honor Code to misrepresent work which is not your own. Plagiarism on homework or on an exam will result in a failing grade.

Solutions to the homework problems will be available to you after the due date. Therefore, late homework will not be accepted. The homework assignments will be posted on Blackboard. Solutions to some questions from the textbook will be posted on Blackboard as exercises. Although they will not be graded and you don't need to submit answers for them, it is very helpful for your understanding of the course materials if you put some effort in trying to solve them, as well as study the solutions provided to you.

VIII. Examinations

There will be an one-hour in-class midterm exam on Friday, October 21, and a two-hour final exam on Wednesday December 14 from 8:00 AM to 10:00 AM. They are closed book exams with questions at a level similar to those in past PhD comprehensive exams. Calculators, computers, and communication devices are also not allowed. However, special or unusual formula or integrals essential to a particular question will be written down for that question. Midterm exam counts towards 15% of the total grade. The final exam counts towards 30 % of the total grade. ***You must not miss the midterm exam and the Final Exam (except for documented illness or family emergency).***

<u>*Tips for getting more points in an exam*</u>: Exam questions will be graded based on the method used, as well as the answer. Therefore, you should write down explicitly and clearly step by step how you come up with your answers. Even if you don't know how to answer a question (or parts of a question), write down everything you can think of that might help formulate an approach to answer it. If you don't know how to answer the first part of a question, you should move on to answer other parts by assuming an answer to the first part. This will help you getting partial credit.

IX. Project

Since this course is mainly for graduate students, who are supposed to do physics research, part (10 %) of the total grade will be given for doing a project. The final product of the project will be a written report reviewing a journal paper. The report should be short (less than 10 clearly readable pages, excluding the required list of references), but long enough to cover at least the answers to the following questions: 1. (2.5%) What are the main conclusions of this paper and do you find them interesting or important (and why)? 2. (2.5%) What are the main mathematical/numerical/experimental methods used in this paper and do you believe the validity of the results (and why -- you don't need to repeat the presentation of the paper in the report and you don't have to understand everything in the paper but you need to show your effort trying to understand it)? 3. (5%) What research can you suggest that is directly related to the main points of this paper that hasn't been done yet (you will need to perform a search to see if your suggested research, or similar ideas, has been done by other people)?

Although you may choose from any physics journal, I would strongly recommend searching a paper in journals aiming at the level of graduate students, e.g. the American Journal of Physics (http://scitation.aip.org/ajp/ which can be accessed through the GI network at the Elvey building) or the European journal of physics (which can be accessed through the UAF network linked from http://library.uaf.edu/). Topic of the paper you choose has to be related to one or more of the topics covered in this semester (e.g., Maxwell equations; electrostatics, magnetostatics,... etc). You should be able to find many papers using the search function.

Again, the report has to be done by yourself and so you need to cite any help in writing the report. If two of you would like to work together as a group on the same paper so that you can have discussion, you need to let me know first and each one needs to write his or her own report independently.

Deadlines: You will need to work with me to finalize your choice of a paper by Monday, October 10, by sending a copy (or a link) of the paper to me by email. A first draft of the report (with enough details) is due on Monday, November 14 so that I can give you feedback for your final report, which is due absolutely no later than December 19.

X. Grading

The final grade will be composed of:

Participation	10 %	Lowest grades of 5 days are dropped
Midterm exam	15 %	Mandatory
Final exam:	30 %	Mandatory
Project	10 %	Mandatory
Homework	35 %	Homework set with lowest grade is dropped
Total:	100 %	

The course will be graded approximately according to the following scale:

> 90 %	A
83 % -- 90 %	A-

76 % -- 83 %	B+
70 % -- 76 %	B
63 % -- 70 %	B-
56 % -- 63 %	C+
50 % -- 56 %	C
43 % -- 50 %	C-
36 % -- 43 %	D+
30 % -- 36 %	D
23 % -- 30 %	D-
< 23 %	F

Note that the passing grade for graduate students is B. Therefore, in order to pass this course, you should get most of the points in homework/project/participation, and to get enough points in exams.

XI. Getting Help

My office hours are 8:10 AM - 9:10 AM on Mondays, Wednesdays, and Fridays. I will be at Reichardt 108 during these office hours. Canceled office hours will be announced in class or by email. If you need to see me beside these office hours, please set up a time by appointment to come to my office at Elvey 706E. These are hours set aside especially to help you - do not feel like you are imposing or cheating by coming in. If you have problems that need immediate attention, please send me an e-mail or give me a call at my office phone number.

I have set up a home page for the course: http://www.gi.alaska.edu/~chungsangng/phys631/phys631.html. I may put additional materials that may be helpful to you later. So, please come back often, especially to check any changes in the schedule. The UAF Blackboard site for this course will be made available to students, but will not be used to provide communication about this course. I might post grades there but those might not be updated very frequently.

XII. Disabilities Services

The Physics Department will work with the Office of Disabilities Services (http://www.uaf.edu/disability/) to provide reasonable accommodation to students with disabilities.

XIII. Tentative Schedule

Below is a tentative schedule (subject to change):

Date	Day	Text (Reading Assignment)	Main Topics	Homework due
8/29	M	I.1	Maxwell equations in vacuum	
8/31	W	I.2 - I.6	Maxwell equations in media; Boundary conditions	
9/2	F	1.1 - 1.4	Electric field of a static point charge; Gauss's Law	
9/7	W	1.5 - 1.6	Electric scalar potential; Surface charges	

9/9	F	1.7 - 1.9	Poisson and Laplace equations; Green's theorem	HW #1
9/12	M	1.10 - 1.11	Formal solution of electrostatic problem; Electrostatic energy	
9/14	W	2.1 - 2.3	Method of images; Grounded or insulated conducting sphere	
9/16	F	2.4 - 2.6	Conducting sphere at fixed potential or with a uniform **E**; Green Function	HW #2
9/19	M	2.7 - 2.8	Conducting sphere with hemispheres at different *V*; Orthogonal functions	
9/21	W	2.9 - 2.10	Laplace equation in rectangular coordinates; Sum of a Fourier Series	
9/23	F	3.1 - 3.2	Laplace equation in spherical coordinates; Legendre Polynomials	HW #3
9/26	M	3.3	Boundary value problems with cylindrical symmetry	
9/28	W	3.5 - 3.6	Associated Legendre functions; Spherical harmonics	
9/30	F	3.7 - 3.8	Laplace equation in cylindrical coordinates; Bessel functions	HW #4
10/3	M	3.9	Green function in spherical coordinates	
10/5	W	3.10	Potential Problems using Spherical Green Function Expansion	
10/7	F	3.11	Green function in cylindrical coordinates	HW #5
10/10	M	3.12	Eigenfunction expansions	Choice of paper for the project
10/12	W	4.1	Multipole expansion	
10/14	F	4.2 - 4.3	Multipole expansion in an external field; Electrostatics with media	HW #6
10/17	M	4.4	Boundary value problems with dielectrics	
10/19	W	4.5 - 4.6	Polarization; Susceptibility	
10/21	F		Mid-term exam	HW #7
10/24	M	4.7	Electrostatic energy in dielectric media	
10/26	W	5.1 - 5.3	Biot-Savart Law; Ampere's Law	
10/28	F	5.4 - 5.5	Vector potential; Magnetic induction	HW #8
10/31	M	5.6	Magnetic fields of a localized current distribution; Magnetic moment	
11/2	W	5.7	Force, torque, and energy in an external magnetic field	
11/4	F	5.8	Macroscopic equations; magnetic permeability; Boundary conditions	HW #9
11/7	M	5.9	Boundary value problems in magnetostatics	
11/9	W	5.10 - 5.11	Magnetized sphere; Magnetization in an external field	

11/11	F	5.12	Magnetic shielding; Spherical shell of permeable material in **B**	HW #10
11/14	M	5.15	Faraday's Law of induction	First draft of the project report
11/16	W	5.16	Energy in magnetic field	
11/18	F	5.17	Self and mutual inductance	HW #11
11/21	M	5.18	Quasi-static magnetic fields; Eddy currents; Magnetic diffusion	
11/23	W	6.1 - 6.3	Displacement current; Vector and scalar potentials; Gauge transformation	
11/28	M	6.4	Green functions for the wave equation	
11/30	W	6.5	Retarded solutions	
12/2	F	6.6	Derivation of the macroscopic Maxwell equations	HW #12
12/5	M	6.7	Poynting's theorem; Conservation of energy and momentum	
12/7	W	6.8 - 6.9	Poynting's theorem for dispersive/dissipative media/harmonic fields	
12/9	F		Review	
12/14	W		Final (8:00 AM to 10:00 AM)	
12/19	M		This is absolutely the last day for submitting your report to me, as well as discussing with me about your grades.	Final project report
12/21	W		Final grades will be submitted by noon. They will also be posted on Blackboard.	