

PHYS 632 -- Electromagnetic Theory -- Spring 2021

Instructor:	Chung-Sang Ng
Office:	Reichardt 108 (for office hours) and Elvey 706E but work from home for the time being
Phone:	474-7367 (forward to my cell phone)
E-mail:	cng2@alaska.edu
Class meets:	MWF 9:15 AM - 10:15 AM, online
Office hours:	TBD 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:	Blackboard

I. Course Description

The UAF Catalog listing for PHYS 632: "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 selected topics mainly from Chapter 6 to 11 during the spring 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 on Blackboard.

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 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/2009/maxwells-equations/>

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 explain 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 on Blackboard. 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, 5% of the final grade is for participation. During some 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 not 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 a midterm exam around Friday, March 5, and a final exam due around the final week. They are open book work at home exams. Midterm exam counts towards 15% of the total grade. The final exam counts towards 35 % of the total grade. ***You must not miss the midterm exam and the Final Exam (except for documented illness or family emergency)***.

Tips for getting more points in an exam: 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 for this semester will be a 10 minute talk and a presentation file for the talk. The presentation file should be short enough so that it can be presented in about 10 minutes. Then there will be a few more minutes for questions. There should also be a list of references in the file, although you don't need to read through it. Your talk should cover at least the following aspects: 1. What are the main conclusions of this paper and do you find them interesting or important (and why)? 2. 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 details and you don't have to understand everything in the paper but you need to show your effort trying to understand it)? 3. 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, waves, radiation, relativity,... etc). You should be able to find many papers using the search function.

Deadlines: You will need to work with me to finalize your choice of a paper by Monday, February 15, by submitting a copy (or a link) of the paper on Blackboard. A first draft of the presentation file (with enough details) is due on Monday, April 12 so that I can give you some feedback. The final presentation file is due on Wednesday, April 28 before the presentations starting 8 AM. Every student is expected to attend and participate in all presentations.

X. Grading

The final grade will be composed of:

Participation	5 %	Lowest grades of 3 days are dropped
Project	10%	
Midterm exam	15 %	Mandatory
Final exam:	35 %	Mandatory
Homework	35 %	Homework set with lowest grade is dropped
Total:	100 %	

Midterm and Final exams are mandatory, while Participation, Project, and Homework are optional in the sense that grades for each of them will be counted only if it can increase your total grade. If either one or any

of them would decrease your total grade, it will be replaced by the average grade of both exams. 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 online office hours will be announced later. 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. 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 on Blackboard. 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)	Main Topics	Homework due (coverage)
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		Assignment)		
1/11	M	6.4	Coulomb gauge; Green functions for the wave equation	
1/13	W	6.5	Retarded solutions	
1/15	F	6.6	Derivation of the macroscopic Maxwell equations	
1/20	W	6.7	Poynting's theorem; Conservation of energy and momentum	HW 1
1/22	F	6.8 - 6.9	Poynting's theorem for dispersive/dissipative media/harmonic fields	
1/25	M	6.10	Transformations: rotation/reflection/time reversal	HW 2
1/27	W	7.1 - 7.2	Plane Waves in a Nonconducting Medium; Polarization	
1/29	F	7.3 - 7.4	Reflection and Refraction; Total Internal Reflection	
2/1	M	7.5 - 7.6	Frequency Dispersion; Propagation in Ionosphere/Magnetosphere	HW 3
2/3	W	7.8 - 7.9	Superposition of Waves; Group Velocity; Spreading of a Pulse	
2/5	F	7.10	Causality; Kramers-Kronig Relations	
2/8	M	8.1	Fields at the Surface of and Within a Conductor	HW 4
2/10	W	8.2 - 8.3	Cylindrical Cavities and Waveguides	
2/12	F	8.4 - 8.5	Rectangular Waveguide; Energy Flow and Attenuation	
2/15	M	8.6 - 8.7	Perturbation of Boundary Conditions; Resonant Cavities	HW 5 ; Choice of paper for the project
2/17	W	8.8 - 8.9	Power Losses; Q of a Cavity; Ionosphere as a Resonant Cavity	
2/19	F	8.10	Multimode Propagation in Optical Fibers	
2/22	M	8.11	Dielectric Waveguides	HW 6
2/24	W	9.1-9.2	Fields and Radiation of a Localized Oscillating Source; Electric Dipole Fields and Radiation	
2/26	F	9.3 - 9.4	Magnetic Dipole/Electric Quadrupole Fields and Radiation; Center-Fed Linear Antenna	
3/1	M	9.6	Spherical Wave Solutions of the Scalar Wave Equation	HW 7
3/3	W	9.7	Multipole Expansion of the Electromagnetic Fields	
3/5	F		Mid-term exam	
3/15	M	9.8	Multipole Fields, Energy and Angular Momentum of	HW 8

			Multipole Radiation	
3/17	W	9.9 - 9.10	Angular Distribution; Sources of Multipole Radiation	
3/19	F	9.11 - 9.12	Multipole Radiation in Atoms and Nuclei; Center-Fed Antenna	
3/22	M	10.1	Scattering at Long Wavelengths	HW 9
3/24	W	10.2	Perturbation Theory of Scattering; Rayleigh's Scattering	
3/26	F	10.3 - 10.4	Spherical Wave Expansion of a Vector Plane Wave; Scattering by a Sphere	
3/29	M	10.5 - 10.6	Scalar Diffraction Theory; Vector Equivalents of the Kirchhoff Integral	HW 10
3/31	W	10.7 - 10.8	Vectorial Diffraction Theory; Complementary Screens	
4/2	F	10.9	Diffraction by a Circular Aperture; Remarks on Small Apertures	
4/5	M	10.10	Scattering in the Short-Wavelength Limit	HW 11
4/7	W	11.1 - 11.2	Before 1900; Einstein's Two Postulates; Some Recent Experiments	
4/9	F	11.3	Lorentz Transformations; Basic Kinematic Results of Special Relativity	
4/12	M	11.4 - 11.5	Addition of Velocities; 4-Velocity; Relativistic Momentum and Energy	HW12; First draft of project presentation
4/14	W	11.6	Mathematical Properties of the Space-Time of Special Relativity	
4/16	F	11.7	Matrix Representation of Lorentz Transformations/Infinitesimal Generators	
4/19	M	11.9	Invariance of Electric Charge; Covariance of Electrodynamics	HW13
4/21	W	11.10	Transformation of Electromagnetic Fields	
4/23	F	14.1	Lienard-Wiechert Potentials and Fields for a Point Charge	
4/26	M	14.2	Total Power Radiated by an Accelerated Charge: Larmor's Formula	HW14
--	--	14.3 - 14.4	Radiation Emitted by an Arbitrary, Extremely Relativistic Charge	
--	--	16.1 - 16.2	Radiative Reaction Force; Conservation of Energy	
4/28	W		8:00 AM to 10:00 AM Project presentation	Project presentation

				file due
5/3	M		This is absolutely the last day for submitting any of your work (by 5 PM) to me, as well as discussing with me about your grades.	
5/5	W		Final grades will be submitted by noon. They will also be posted on Blackboard.	

STUDENT PROTECTIONS AND SERVICES STATEMENT:

Every qualified student is welcome in my classroom. As needed, I am happy to work with you, disability services, veterans' services, rural student services, etc. to find reasonable accommodations. Students at this university are protected against sexual harassment and discrimination (Title IX), and minors have additional protections. For more information on your rights as a student and the resources available to you to resolve problems, please go the following site: www.uaf.edu/handbook/.

UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: <https://alaska.edu/nondiscrimination/>.

Your instructor follows the University of Alaska Fairbanks Incomplete Grade Policy: “The letter “I” (Incomplete) is a temporary grade used to indicate that the student has satisfactorily completed (C or better) the majority of work in a course but for personal reasons beyond the student’s control, such as sickness, has not been able to complete the course during the regular semester. Negligence or indifference are not acceptable reasons for an “I” grade.”

Effective communication: Students who have difficulties with oral presentations and/or writing are strongly encouraged to get help from the UAF Department of Communication’s Speaking Center (907-474-5470, speak@uaf.edu) and the UAF English’s Department’s Writing Center (907-474-5314, Gruening 8th floor), and/or CTC’s Learning Center (604 Barnette Street, 907-455- 2860).