

PHYS 631 -- Electromagnetic Theory -- Fall 2024

Instructor:	Chung-Sang Ng
Office:	Reichardt 108 and Elvey 706E
Phone:	474-7367
E-mail:	cng2@alaska.edu
Class meets:	MWF 9:15 AM - 10:15 AM, Reichardt 207
Office hours:	MWF 10:15 AM - 11:15 AM at Reichardt 108, T 2-3 PM at Elvey 706E, 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:	Canvas

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 on Canvas.

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 explain everything in details by lecturing. Students must help themselves by reading and studying the textbook and watching videos I post 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 Canvas. 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. 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. 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. Questions will be posted on Canvas. If you answer by hand writing, please scan your answers and submit on Canvas.

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 Canvas. Solutions to some questions from the textbook will be posted on Canvas 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, October 18, and a final exam around Wednesday December 11 from 8:00 AM to 10:00 AM. 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 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 (<http://iopscience.iop.org/journal/0143-0807>, which can be accessed through the UAF network linked from <http://library.uaf.edu/>). For access from home, you should install a UAF VPN program. 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 7, by submitting a copy (or a link) of the paper on Canvas. A first draft of the report (with enough details) is due on Monday, November 11 so that I can give you feedback for your final report, which is due absolutely no later than December 16.

X. Grading

The final grade will be composed of:

Participation	5 %	Lowest grades of 5 days are dropped
Midterm exam	15 %	Mandatory
Final exam:	35 %	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 MWF 10:15-11:15 AM, just after classes. 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 Canvas. 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 Canvas 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
8/26	M	I.1	Maxwell equations in vacuum	
8/28	W	I.2 - I.6	Maxwell equations in media; Boundary conditions	
8/30	F	1.1 - 1.4	Electric field of a static point charge; Gauss's Law	
9/4	W	1.5 - 1.6	Electric scalar potential; Surface charges	
9/6	F	1.7 - 1.9	Poisson and Laplace equations; Green's theorem	HW #1
9/9	M	1.10 - 1.11	Formal solution of electrostatic problem; Electrostatic energy	
9/11	W	2.1 - 2.3	Method of images; Grounded or insulated conducting sphere	
9/13	F	2.4 - 2.6	Conducting sphere at fixed potential or with a uniform \mathbf{E}; Green Function	HW #2
9/16	M	2.7 - 2.8	Conducting sphere with hemispheres at different V; Orthogonal functions	
9/18	W	2.9 - 2.10	Laplace equation in rectangular coordinates; Sum of a Fourier Series	
9/20	F	3.1 - 3.2	Laplace equation in spherical coordinates; Legendre Polynomials	HW #3
9/23	M	3.3	Boundary value problems with cylindrical symmetry	
9/25	W	3.5 - 3.6	Associated Legendre functions; Spherical harmonics	
9/27	F	3.7 - 3.8	Laplace equation in cylindrical coordinates; Bessel functions	HW #4
9/30	M	3.9	Green function in spherical coordinates	
10/2	W	3.10	Potential Problems using Spherical Green Function Expansion	
10/4	F	3.11	Green function in cylindrical coordinates	HW #5
10/7	M	3.12	Eigenfunction expansions	Choice of paper for the project

10/9	W	4.1	Multipole expansion	
10/11	F	4.2 - 4.3	Multipole expansion in an external field; Electrostatics with media	HW #6
10/14	M	4.4	Boundary value problems with dielectrics	
10/16	W	4.5 - 4.6	Polarization; Susceptibility	
10/18	F		Mid-term exam	HW #7
10/21	M	4.7	Electrostatic energy in dielectric media	
10/23	W	5.1 - 5.3	Biot-Savart Law; Ampere's Law	
10/25	F	5.4 - 5.5	Vector potential; Magnetic induction	HW #8
10/28	M	5.6	Magnetic fields of a localized current distribution; Magnetic moment	
10/30	W	5.7	Force, torque, and energy in an external magnetic field	
11/1	F	5.8	Macroscopic equations; magnetic permeability; Boundary conditions	HW #9
11/4	M	5.9	Boundary value problems in magnetostatics	
11/6	W	5.10 - 5.11	Magnetized sphere; Magnetization in an external field	
11/8	F	5.12	Magnetic shielding; Spherical shell of permeable material in \mathbf{B}	HW #10
11/11	M	5.15	Faraday's Law of induction	First draft of the project report
11/13	W	5.16	Energy in magnetic field	
11/15	F	5.17	Self and mutual inductance	HW #11
11/18	M	5.18	Quasi-static magnetic fields; Eddy currents; Magnetic diffusion	
11/20	W	6.1 - 6.3	Displacement current; Vector and scalar potentials; Gauge transformation	
11/22	F	6.4	Green functions for the wave equation	HW #12
12/25	M	6.5	Retarded solutions	
12/2	M	6.6	Derivation of the macroscopic Maxwell equations	
12/4	W	6.7	Poynting's theorem; Conservation of energy and momentum	
12/6	F	6.8 - 6.9	Poynting's theorem for dispersive/dissipative media/harmonic fields	
12/11	W		Final (8-10 AM)	
12/16	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
12/18	W		Final grades will be submitted by noon. They will also be posted on Canvas.	

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).

Syllabus Addendum (Revised 8/22/2022)

COVID-19 statement: Students should keep up-to-date on the university's policies, practices, and mandates related to COVID-19 by regularly checking this website:

<https://sites.google.com/alaska.edu/coronavirus/uaf?authuser=0>

Further, students are expected to adhere to the university's policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

Student protections statement: UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: <https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/>.

Disability services statement: I will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

ASUAF advocacy statement: The Associated Students of the University of Alaska Fairbanks, the student government of UAF, offers advocacy services to students who feel they are facing issues with staff, faculty, and/or other students specifically if these issues are hindering the ability of the student to succeed in their academics or go about their lives at the university. Students who wish to utilize these services can contact the Student Advocacy Director by visiting the ASUAF office or emailing asuaf.office@alaska.edu.

Student Academic Support:

- Speaking Center (907-474-5470, uaf-speakingcenter@alaska.edu, Gruening 507)
- Writing Center (907-474-5314, uaf-writing-center@alaska.edu, Gruening 8th floor)
- UAF Math Services, uaf-traccloud@alaska.edu, Chapman Building (for math fee paying students only)
- Developmental Math Lab, Gruening 406
- The Debbie Moses Learning Center at CTC (907-455-2860, 604 Barnette St, Room 120, <https://www.ctc.uaf.edu/student-services/student-success-center/>)
- For more information and resources, please see the Academic Advising Resource List (https://www.uaf.edu/advising/lr/SKM_364e19011717281.pdf)

Student Resources:

- Disability Services (907-474-5655, uaf-disability-services@alaska.edu, Whitaker 208)
- Student Health & Counseling [6 free counseling sessions] (907-474-7043, <https://www.uaf.edu/chc/appointments.php>, Gruening 215)
- Center for Student Rights and Responsibilities (907-474-7317, uaf-studentrights@alaska.edu, Eielson 110)
- Associated Students of the University of Alaska Fairbanks (ASUAF) or ASUAF Student Government (907-474-7355, asuaf.office@alaska.edu, Wood Center 119)

Nondiscrimination statement: The University of Alaska is an affirmative action/equal opportunity employer and educational institution. The University of Alaska does not discriminate on the basis of race, religion, color, national origin, citizenship, age, sex, physical or mental disability, status as a protected veteran, marital status, changes in marital status, pregnancy, childbirth or related medical conditions, parenthood, sexual orientation, gender identity, political affiliation or belief, genetic information, or other legally protected status. The University's commitment to nondiscrimination, including against sex discrimination, applies to students, employees, and applicants for admission and employment. Contact information, applicable laws, and complaint procedures are included on UA's statement of nondiscrimination available at www.alaska.edu/nondiscrimination. For more information, contact:
UAF Department of Equity and Compliance
1692 Tok Lane, 3rd floor, Constitution Hall, Fairbanks, AK 99775
907-474-7300
uaf-deo@alaska.edu

Additional syllabi statement for courses including off-campus programs and research activities:

University Sponsored Off-Campus Programs and Research Activities

We want you to know that:

1. UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: www.alaska.edu/nondiscrimination.
2. Incidents can be reported to your university's Equity and Compliance office (listed below) or online reporting portal. University of Alaska takes immediate, effective, and appropriate action to respond to reported acts of discrimination and harassment.
3. There are supportive measures available to individuals that may have experienced discrimination.
4. University of Alaska's Board of Regents' Policy & University Regulations (UA BoR P&R) 01.02.020 Nondiscrimination and 01.04 Sex and Gender-Based Discrimination Under Title IX, go to: <http://alaska.edu/bor/policy-regulations/>.
5. UA BoR P&R apply at all university owned or operated sites, university sanctioned events, clinical sites and during all academic or research related travel that are university sponsored.

For further information on your rights and resources [click here](#).