PHYSICS 606 : Classical Electrodynamics

Course Description: Electrostatic and magnetostatic fields in vacuum and material medium. Maxwell's equations, radiation, and special relativity. Covariant formulation of the field equations. Fields of a moving charge, motion of particles, radiation reaction, applications to physical phenomena as time permits.

Level: Graduate
Credits: 3
Course Type: Lecture
Prerequisites: PHYSICS 601, 605
Corequisites: None
Grading Basis: LTR, with options

Lectures	:	Monday & Wednesday 2:30-3:45 pm in Hasbrouck 104B
Instructor	:	<PROF_FULL_NAME>, Physical Sciences Building West 105, <PHONE>, <PROF_EMAIL>
Help Hours	:	Fridays 9:00 am in PSB W105 (call/email for other times)
Teaching Assistant	:	<TA_FULL_NAME>, <TA_EMAIL>
TA Help Hours	:	Thursday 5:00-6:00 pm and Friday 4:00-5:00 pm (on weeks homework is due)
TA Zoom	:	<LINK_ZOOM>
Course Webpage	:	Syllabus, lectures, problem sets, and solutions will be posted on Moodle <LINK_MOODLE>

Textbook (Pick one):

- J. D. Jackson, "Classical Electrodynamics", 2nd edition (Gaussian units) or 3rd edition (mostly SI)
- Andrew Zangwill, "Modern Electrodynamics", 1st edition (SI units)

Helpful References:

- A.O. Barut, "Electrodynamics and Classical Theory of Fields and Particles", Dover, for special relativity
- Jerrold Franklin, "Classical Electromagnetism", Dover (Gaussian units)
- David Griffiths, "Introduction to Electrodynamics", 4th edition (SI units)
- Landau and Lifshitz, "The Classical Theory of Fields" (Gaussian units)
- Landau, Lifshitz, and Pitaevskii, "Electrodynamics of Continuous Media" (Gaussian units)
- Melvin Schwartz, "Principles of Electrodynamics", Dover (Gaussian units)

Lectures:

Class will consist of lectures, work on sample problems, discussion of applications, and occasionally homework review. Lecture notes will usually be posted before class. Rather than taking notes furiously during class, you might consider just listening carefully, trying to answer the questions posed in class, and asking questions. **Try doing the reading before class**.

Attendance

Attendance in class in not mandatory, but is highly recommended. **Note that you are responsible for paying attention to all announcements of deadlines, test dates etc given in class**.

Graduate TA Help Sessions:

Our graduate TA <TA_FULL_NAME> will run a discussion/help session every Thursday over Zoom (see link above, time TBD). On weeks in which homework is due, he'll run an additional session on Fridays (time TBD). Bring your questions about lectures, homework etc. This is a great chance to talk about the material and get your questions answered.

Homework:

There will be 7 problem sets of equal weight that count for 40% of your grade. They'll be posted on Moodle, and typically you'll have two weeks to complete the homework, which will be due Fridays 6:00 pm Eastern, uploaded into Moodle as PDF files. Sometimes not all problems will be graded.

Homework Due Dates: Homework will be due at 6 pm on the following dates:
Problem Set 1: Fri Feb 24; Problem Set 2: Fri Mar 10; Problem Set 3: Fri Mar 24; Problem Set 4: Fri Apr 7; Problem Set 5: Fri Apr 21; Problem Set 6: Fri May 5; Problem Set 7: Fri May 19.

Note: you are actively encouraged to form study groups and work with your peers on homework, though solutions must be written up independently. For many of the questions you might be able to find a solution online or in a book, but think very carefully before you do that. Remember, the point of the course is not to get an 'A', but to learn the material. No one will ever look at your grades again, and you just need a 'B' to continue in the program. The best way to learn the material is to challenge yourself and do the problems. If you get in the habit of looking up solutions, you'll be unprepared for the midterm and final. Most importantly, you'll be unprepared for your work as a researcher.

On a related note, **do not post/share the problem sets or their solutions.** You're not helping anyone, and it can lead instructors to come up with less-conventional or less pedagogical problems.

Some advice: Start the problem sets early, work with your peers, get help from the TA.

Late Homework Policy: It's important to post the solutions in a timely manner, so late homework is strongly discouraged. Homework turned in after the due date will lose 10% of the points earned for each day late, up to 5 days, at which point the homework won't be accepted since the solutions will have been posted. Please let me know if you are facing extenuating circumstances (at least 24 hours before the due date) to see if an exception is justified. If you find yourelf overly stressed, consider turning in what you have at the deadline and moving on.

Midterm and Final Exam:

There will be two tests, each worth 30% of your final grade. The first test is scheduled for Wed March 29th, 7:00-9:00 pm in Hasbrouck 138. The second test, which has not yet been scheduled, will be at the end of the semester and also worth 30% of your final grade. It will only cover material since the first test.

Course Grade: will be determined using the following weights, consistent with the recommendations of the Physics Graduate Curriculum Committee:

7 Problem Sets, equal weight	40%
Midterm One (Wed March 29th)	30%
Midterm Two (Date TBD)	30%
Total Score	**100%**

The instructor reserves the right to alter the weighting if circumstances require. Typically this will only be done for the benefit of the students.

Grading Rubric: The Physics Graduate Curriculum Committee recommends the following grading rubric. The instructor reserves the right to alter the rubric if circumstances require. Typically this will only be done for the benefit of the students.

A	A-	B+	B	B-	F
≥ 92	≥ 84 and < 92	≥ 76 and < 84	≥ 68 and < 76	≥ 55 and < 68	< 55

Makeup Exams, Registration with Disability Services:

If you have a conflict (verified by the Registar) or are registered with Disability Services, such that you can't take the midterm or final at the regular time/place, please contact your instructor *at least a week beforehand* so that your needs can be addressed. Other extenuating circumstances will be considered on an individual basis, but must be discussed at least 24 hours before the exam time.

Accommodation Statement:

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements. For further information, please visit Disability Services (https://www.umass.edu/disability/)).

Academic Honesty:

You are actively encouraged to work on homework together, but the midterm and final exam must be done completely independently.

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent (http://www.umass.edu/dean_students/codeofconduct/acadhonesty/).

No Posting, Distributing, or otherwise Transferring of Class Materials:

All class materials, including notes, problem sets, exams, and solutions are not to be posted online or otherwise transferred to others not currently enrolled in the class. Midterm and exam booklets must be returned at the end of the test.

The Physics Graduate Curriculum Committee suggests the following course content. Items below covered at the level of "Classical Electrodynamics", 3rd Edition, by J. D. Jackson, Wiley [ISBN 978-0471309321]. For Relativistic Lagrangians, "The Classical Theory of Fields: Volume 2 (Course of Theoretical Physics Series)" 4th Edition, by L. D. Landau and E. M. Lifshitz, Butterworth-Heinemann [ISBN 978-0750627689]. For Special Relativity, "Electrodynamics and Classical Theory of Fields and Particles", by A. O. Barut, Dover Publications [ISBN 978-0486640389].

Assumed covered in Math Methods:

- Electrostatics, Boundary value problems
- Special Functions, Laplacian and Poisson Equations in cartesian, cylindrical, spherical coordinates
- Expansion
- Magnetostatics
- Basic elements of electrostatics and Magnetostatics in media
- Maxwell's Equations

Special Relativity:

- Minkowski Metric, Vectors, Tensors
- Space/Time-like Paths, Proper Time
- Lorentz Transformations
- Relativistic kinematics
- Relativistic Lagrangians
- Relativistic formulation of Maxwell's equations
- Relativistic transformation of EM fields

Electrodynamics:

- Brief Review of Maxwell's equations, EM wave equation, Plane Waves, Electro- and Magnetostatics, Energy and Angular momentum of EM radiation
- Electromagnetic radiation
- Simple Radiating Systems and Antennae
- Multipole Fields
- Elements of Dynamics of Relativistic Particles and Electromagnetic Fields
- Maxwell Equations in Media
- Radiation by Accelerated Charges
- Near-Field Effects
- Scattering and Diffraction
- Basics of Wave Guides and Resonant Cavities

Suggested Topics: (not in quals, might be covered in each year, in agreement with previous years instructors)

- Basics of Magnetohydrodynamics and Plasma Physics
- Charged Particle Collisions, Energy loss, Bremsstrahlung, Cerenkov Radiation
- EM Radiation in a Dispersive Medium

Preliminary Schedule:

Topic	Weeks	Jackson Sections	Zangwill
introduction, Boundary Conditions	1	I4-I6	3.1-3.6
Electrostatics and BV Problems	1,2	1.1-1.11,2.1-2.11,3.1-3.13	4.1-4.5, 7.1-7.10,8.1-8.7
Electrostatics in Matter	3	4.1-4.7	6.1-6.8
Magnetostatics	4	5.1-5.13	10.1-10..6
Time-varying fields, Macroscopic EM	5	6.1-6.10	13.1-13.9,14.1-14.13
Plane waves, Reflection, Refraction	6	7.1-7.10	16.1-16.5,17.1-17.7
Plane waves in matter, index of refraction			
Wave Guides and Resonant Cavities	7	8.1-8.8	19.1-19.7
Radiating system, multipole fields	8	9.1-9.11	20.1-20.8
Scattering, Diffraction			21.1-21.9
Special Relativity	9,10	11.1-11.11	22.1-22.8
Relativistic Particles in EM Fields	11	12.1-12.8	Jackson
Radiation by moving charges	12	14.1-14.8	23.1-23.6
Multipole fields		16.1-16.8	20.8