

Physics 351: Electricity and Magnetism

Fall 2022

“I have also a paper afloat, with a electromagnetic theory of light which, till I am convinced of the contrary, I hold to be great guns.”

– James Clerk Maxwell

Welcome to Physics 351! In this class we will study charges, currents, electric and magnetic fields, and their interactions. Much of the physics is expressed in a single, remarkable set of equations

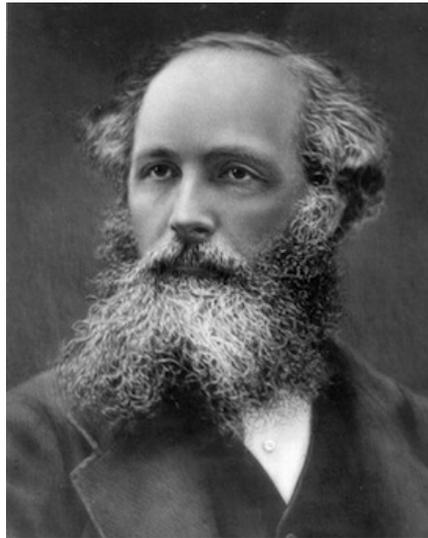
$$\vec{\nabla} \cdot \vec{E} = \frac{1}{\epsilon_0} \rho$$

$$\vec{\nabla} \times \vec{E} + \frac{\partial \vec{B}}{\partial t} = 0$$

$$\vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{B} - \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t} = \mu_0 \vec{J}$$

This formulation of electromagnetism is due primarily to the Scottish physicist James Clerk Maxwell. His equations, in one form or another, describe phenomenon ranging from the propagation of light to the deflection of a compass needle by a magnetic field.



James Clerk Maxwell (1831-1879)

The impact of Maxwell's equations extends well beyond electromagnetism. The Theory of Special Relativity is secreted away inside them, and they are our prototype for a unified description of the basic forces of Nature.

■ Basic Information

PROFESSOR: Dr. Robert McNees (he/him). I will often sign emails as “Bob” but you should address me as “Dr. McNees” or “Professor.” I am asking students to address me this way to help normalize the use of academic titles. If you’re wondering why this is important, have a look at [this article](#) or read Dr. Susan Harlan’s poem “[My First Name.](#)”

EMAIL: rmcnees@luc.edu. You *must* use your “@luc.edu” address when sending me an email. Emails sent from outside accounts sometimes get blocked by Loyola’s mail servers.

OFFICE: Cudahy Science 314. You can stop by any time, or email me if you have questions or want to talk about something.

LECTURES: MWF from 10:25-11:15am in Cudahy Science 406

DISCUSSION: F from 11:30-12:20am in Cudahy Science 406

WEBSITE: The main website for the course is <http://jacobi.luc.edu/p351.html>. This is where you will download homeworks and other documents. Occasionally I will post pdfs on [Sakai](#) when I need to control access.

■ Important: COVID-19 Protocols

While the University has relaxed its universal masking requirement, the fact of the matter is that we are still in a pandemic. I know that I am tired of wearing masks, and I am sure you are too, but indicators like test positivity rates and wastewater surveillance suggest that community transmission is still occurring at very high levels. At the beginning of the fall semester things seem to be trending downward, but levels are still at least as high as they were during the 2020 or 2021 spikes.

With that in mind, and out of respect for the health of housemates and others in regular contact with members of our community, in this class we will wear masks over nose and mouth at all times we are together in the classroom. Intransigent non-compliance will be reported to the Office of Student Conduct Conflict Resolution. If things continue to improve I will revisit this policy.

Everyone is expected to be completely familiar with all of the University’s COVID-19 policies, and to follow them to the letter. Do not come to class if you test positive for, or exhibit any symptoms of, COVID-19. Students who miss class due to COVID-19 symptoms, diagnosis, or quarantine should contact me via email as soon as practicable. Such situations will be handled on a case-by-case basis.

■ Also Important: Video Meetings, Recordings, and Privacy

In this class software may sometimes be used to record lectures and discussions. As a student in this class, your participation in those meetings will be recorded. The recordings will be made available only to students enrolled in the class, to assist those who cannot attend the live session. All recordings will become unavailable to students in the class when the Sakai course is unpublished (i.e. shortly after the course ends, per the Sakai administrative schedule). If for some reason a class must be held over Zoom, students who prefer to participate via audio may disable their video camera so only audio will be captured. Students who wish to disable both audio and video may do so, and take part using Zoom’s chat functionality. The use of all video recordings will be in keeping with the University Privacy Statement.

Privacy Statement

Assuring privacy among faculty and students engaged in online and face-to-face instructional activities helps promote open and robust conversations and mitigates concerns that comments made within the context of the class will be shared beyond the classroom. As such, recordings of instructional activities occurring in online or face-to-face classes may be used solely for internal class purposes by the faculty member and students registered for the course, and only during the period in which the course is offered. Students will be informed of such recordings by a statement in the syllabus for the course in which they will be recorded. Instructors who wish to make subsequent use of recordings that include student activity may do so only with informed written consent of the students involved or if all student activity is removed from the recording. Recordings including student activity that have been initiated by the instructor may be retained by the instructor only for individual use.

■ Course Information and Policies

Objectives

The goal of Physics 351 is to build a sophisticated understanding of electric and magnetic phenomenon. You will develop a facility with these concepts that allows you to model basic physical systems in more detail than the examples you encountered in introductory courses. Mastering the material in this course will prepare you to study electrodynamics at the graduate level, if you decide to go on to grad school.

We will cover the first seven chapters of the textbook along with most of chapters eight and nine. This includes vector analysis, electrostatics, potentials, special techniques for solving the Laplace and Poisson equations, electric fields in matter and the physics of dielectric materials, magnetostatics, magnetic fields in matter and magnetization, electrodynamics, conservation of charge and energy, Poynting's theorem, momentum of electromagnetic fields, and electromagnetic waves.

Prerequisites

The prerequisites for this course are Phys 235 and 301. We will rely heavily on concepts and skills you learned in those courses and their prerequisites, especially material from Math Methods (Phys 301), Multivariable Calculus (Math 263), and Differential Equations (Math 264). You should already feel comfortable with the following:

- Vector calculus
- Line, surface, and volume integrals
- Fundamental theorems associated with the div, grad, and curl differential operators
- Techniques for solving ordinary and partial differential equations

If you feel rusty, please take time to review this material. Students who have not completed the prerequisites may be removed from the course.

Textbook and Materials

The main text for the class is *Introduction to Electrodynamics* (4th edition) by Griffiths. Homework assignments are not taken from the book, so you should be fine using the 3rd edition if you can get a copy. The tone of the book is casual and you will probably find it to be pretty accessible. When I was an undergraduate I used the books by Wangsness and Purcell. Those texts might be useful if something in Griffiths isn't clear. The classic book by Purcell was recently released in a new

edition. I have not used that one, but the original is very good. A more advanced treatment is given in Jackson's *Classical Electrodynamics*, which is the text for practically every graduate E&M course. You can find links to all these books on the [course website](#).

Griffiths' book has a very complete (for our purposes) discussion of vector calculus as it is used to describe electricity and magnetism. If you'd like to see additional discussions of this material, I recommend the book *Mathematical Methods in the Physical Sciences* by Boas, or *Mathematical Methods for Physics and Engineering* by Riley, Hobson, and Bence. For a more advanced treatment refer to *Mathematical Methods for Physicists* by Arfken and Weber. Links to those books can also be found on the course website.

From time to time I will supplement the material from the book with my own notes. Often I will post these as pdf files in the [Notes section](#) of the website. Nice, readable copies of the lecture notes will also be posted online. These will be available on Sakai so that only students enrolled in the course can access them.

Meeting Times and Locations

Lectures take place MWF from 10:25 - 11:15 in room 406 of Cudahy Science. The discussion section is scheduled for 11:30-12:20 on F, in the same room. Exams will be held on Friday during the combined lecture and discussion periods, so you can have more time.

Lecture and Discussion Sections

Class will meet three times each week for lectures, and once each week for a discussion section. **Attendance at weekly lectures and the discussion section is mandatory.** During the lectures we will talk about the material, work through examples, and ask each other lots of questions. Notice that I said "ask each other". You're going to get a lot of questions from me, and I expect to get a lot of questions from you. Most discussion sections will be devoted to the current homework assignment, but sometimes they will include short lectures on interesting material that is outside the scope of the main lectures. Exams will be held on Fridays so we can use the combined discussion section and lecture to give you more time.

Office Hours

Physics 351 has open office hours. That means you can stop by any time if you have a question. If I'm free we can meet right then, and if I'm busy I'll arrange a time for us to meet later on. You can always email me to ask questions or discuss the class, and I will try to get back to you in a reasonable amount of time (see the section on Email). This semester I am very busy on Wednesdays, so that is the worst time to try to find me. Tuesdays and Thursdays are the best times, since I don't teach those days.

Communications Policy

Email is the best way to reach me. I check it frequently, and will try my best to respond promptly. As a rule of thumb I will always respond within 24 hours (usually sooner) during the week. Emails sent over the weekend may not receive a response until Monday. From time to time I will contact you via email and you should feel free to observe the same policy. If I send an email in the evening or late at night, you should not feel obligated to respond until the next day.

Expectations

I expect you to arrive to class ready to discuss the material. That means you should read ahead of the lecture for any material

covered in the text. Homework will be posted weekly, and you should start working on it as soon as it is posted. *Do not* wait for us to go over all the material before you start. Instead, work on the homework and identify any questions you might have, so they are fresh in your mind during lecture. Many of the homework assignments are *long*, in the sense that they will take up a lot of your time. Do not wait until the last minute or you won't finish.

Special Circumstances and Accommodations

Please speak to me if you have any concerns about the course material or your ability to follow course policies. You can reach me by email or you can stop by my office. Rules for schedule conflicts and make up exams are outlined elsewhere in the syllabus, but you should always let me know if something happens that interferes with your ability to participate in the course. If you need special accommodations for exams you should speak with me as soon as possible, and no later than one week in advance. Once I have the appropriate paperwork from SAC (<http://www.luc.edu/sac/>) we can make the necessary arrangements.

Intellectual Property

All lectures, notes, assignments, solutions, and other instructional materials in this course are the intellectual property of the professor. As a result, they may not be distributed or shared in any manner – on paper, electronically, or otherwise – without my explicit written permission. Lectures may not be recorded without my written consent; when consent is given, those recordings may be used for review only and may not be distributed. Sharing copies of homework assignments, solutions, quizzes, or exams with anyone who is not currently enrolled in the course is not allowed. **Providing these materials to students who may enroll in the course at a later date, uploading them to a website, or distributing them in any way, will be reported to department chair and the college. Likewise, obtaining copies of materials, including quizzes and exams, that were used in a previous course is not allowed and will be reported to the department chair and the college.** Recognizing that your work, too, is your intellectual property, I will not share or distribute your work in any form without your written permission.

A lot of students have Chegg accounts and use it or similar services to obtain help solving problems. This is not a good way to learn the material. Following along with someone else's solution doesn't actually help you learn how to solve problems yourself. Also, a lot of the solutions posted to Chegg and similar websites are wrong. In any case, posting copies of homework or exam problems on any website is a violation of my intellectual property rights and, more importantly, constitutes a violation of Loyola's academic integrity policy. Submitting solutions obtained via Chegg or similar websites on a quiz or exam is academic misconduct. A grade of "o" will be assigned and the incident will be reported to the Chair of the Physics Department and the Office of the Dean.

The same goes for solutions manuals: Don't use them. **If I find solutions copied from a solutions manual or similar source it will receive a grade of "o."**

Statement of Intent

By remaining in this course you agree to abide by the rules and policies laid out in this syllabus. Any changes to the syllabus will be announced in class, and the updated syllabus will be posted on Sakai and the course website. Missing class is not a valid reason for being unaware of changes to the syllabus.

■ Homework, Exams, and Grades

Homework Assignments

Homework is assigned most weeks throughout the semester. There will be a total of 12 assignments. Most of them (with a few exceptions at the beginning and end of the semester) are due on Mondays. That gives you plenty of time to work on them after asking questions during our Friday discussions. There will not be assignments due on the Mondays after exams. Homework is handed in at the beginning of class on the day that it is due. Papers must be neat, legible, and presented in order. You should probably work everything out on scrap paper and then write up a “clean” version of your solutions to hand in.

Homework in this class is absolutely essential. You have to do every single problem (along with examples from the lectures and book, extra problems for things you find tricky, etc) to master the skills we’re trying to develop.

You should definitely discuss the homework assignments with your classmates – you might be able to clarify a tough concept for them, or they might point out a good strategy for a confusing problem. But after working together, you must go back and complete the problems on your own. If your solutions look like they were copied from someone else’s work then you need to redo it from scratch. If you can’t explain each step of your solution then you haven’t completed the problem on your own. That is the only way to be sure that you are ready for the exams, and, more importantly, the only way to know if you understand the material.

Do not, under any circumstances, hand in homework copied from another student, a solutions manual, or some source you found on the internet. There are lots of reasons I am telling you this. First, it’s cheating, and I may have to report it to the department chair. (I know, I just told you to work together. That’s why taking what you learned and working out the solution on your own is so important. Don’t worry; I can tell the difference between working together and copying.) Second, and more importantly, you don’t learn anything that way. Obviously you don’t learn anything from copying a classmate’s homework. You have to be able to do this stuff on the exams, and copying won’t prepare you for that. Third, you don’t get much (or any) benefit when you piggyback on a solution that you find online or in a manual. Finding material that you can adapt to another problem is a useful skill, but it’s not the one we’re trying to develop here. Part of understanding the material in this course is figuring out how to deploy it to solve different kinds of problems or model new situations. You only develop that skill by trying different things, playing around with a problem, maybe putting it down for a while and coming back to it later.

Do the homework yourself. In every class I’ve ever taught, students who relied on solutions manuals, online resources, or copying from classmates ended up doing poorly on the exams.

A Warning

Never, ever hand in an assignment that you copied from a solutions manual or found online. You won’t learn anything that way, and it will earn you an automatic grade of “zero” for that assignment. If it happens more than once it will be reported to the Department Chair and the Dean. Consider yourself warned.

Exams

There will be two exams and a final exam. I expect that the exams will be held on October 7 and November 18. The material covered on these exams will be discussed in class. The final exam, which is comprehensive, will be held on Monday, December 12, from 9-11 AM. That's right: it's the first time slot of finals week.

Grades

Grades in the course are primarily determined by homework assignments and exams. The weekly homework grades contribute 35% of your final grade in the class, and two "midterm" exams (October 7 and November 18) count 15% each. A cumulative final on Monday, December 12 (from 9:00-11:00 AM) is worth 30%. The remaining 5% depends on attendance and participation. To receive the full 5% you should do two things that show me you are engaging the material and thinking about what we're doing. First, you must regularly attend lectures and discussion sections. Second, you should ask questions. This can happen in class, in discussion, or office hours. There is no minimum number of questions you need to ask, and if you don't like to speak up in class you can ask them via email. As long as you do these things, you get the 5%.

Once your grades have been added up and converted to a percentage, your final grade will be assigned according to the following table:

Percentage	Letter Grade
100 – 92	A
92 – 90	A–
90 – 88	B+
88 – 82	B
82 – 80	B–
80 – 78	C+
78 – 72	C
72 – 70	C–
70 – 68	D+
68 – 62	D
62 – 0	F

The lower end of each range is inclusive and the upper end is exclusive. So a grade of 90 is an "A–" and not a "B+", while a grade of 73 is a "C" and not an "C–".

For example, suppose you finish the class with a 91% average on the homeworks, grades of 85% and 82% on the two exams, and an 89% on the final. You attended the lectures, actively participated, and asked questions over email a few times, so you get the full 5% for participating. Then your final grade would be

$$91\% \times 0.35 + 85\% \times 0.15 + 82\% \times 0.15 + 89\% \times 0.30 + 5\% = 88.6\%, \quad (1)$$

which earns you a B+.

Makeups and Absences

If you miss one of the exams due to illness, emergency, or a Loyola-approved activity, let me know as soon as possible and

we will schedule a make up. You will need to provide written documentation (from a doctor, for instance, or the university if you are traveling for an event) before the make up exam will be administered. The documentation must be relevant to the date you missed class. For Loyola-approved activities you should let me know as far in advance as possible, and no later than one week before the exam. Absences related to the COVID-19 pandemic are an exception to this policy. Let me know if you have to quarantine and we will work something out.

■ Calendar

We will cover most of the first nine chapters of the textbook, with the exception of parts of chapters 8 and 9. The table below is an estimate of how we'll spend our time.

Week	Date	Chapter	Events
1	August 29, 31; September 2	1	First Class
2	September 5, 7, 9	1, 2	Labor Day
3	September 12, 14, 16	2	
4	September 19, 21, 23	2	
5	September 26, 28, 30	3	
6	October 3, 5, 7	3	Exam 1
7	October 10, 12, 14	3	Fall Break
8	October 17, 19, 21	4	
9	October 24, 26, 28	4, 5	
10	October 31; November 2, 4	5	
11	November 7, 9, 11	5, 6	
12	November 14, 16, 18	6	Exam 2
13	November 21, 23, 25	7	Thanksgiving
14	November 28, 30 ; December 2	7, 8	
15	December 5, 7, 9	9	
16	December 12	-	Final Exam

These dates are subject to change – we may end up ahead of or behind schedule depending on participation and other factors. You will always be notified about any changes made to this schedule.

Other important dates can be [found on the CAS calendar for the Fall 2022 semester](#). Please contact me if you need any accommodations for activities or observances associated with other religious holidays, including *but not limited to* those listed below.

Dates	Religious Holidays
August 7-8	Ashura
September 16-17	Arba'een
September 25-27	Rosh Hashanah
September 26 - October 5	Navratri
October 4-5	Yom Kippur
October 9-16	Sukkot
October 16-18	Shemini Atzeret
October 17-18	Simchat Torah
November 24	Diwali
December 8	Conception

■ Other Things You Should Know

Important Dates

Besides the dates listed on the calendar, there are a few other important dates you should be aware of. September 12 is the last day to can request or cancel the pass/no-pass option. (However, this may not available in your academic program.) The last day to drop this course with a grade of “W” is November 4. After this date, withdrawing from the course will result in a grade of “WF.” You will have received grades on an exam and several homework assignments by this date, which will give you a good idea of how things are going in the course.

I am happy to help you work around important religious holidays that occur during the semester. Please let me know as far in advance as possible and we will work something out.

Academic Integrity

Any incidence of academic dishonesty on a homework assignment or exam will result in a grade of “o” and will be reported to both the Chairperson of the Physics Department and the Dean of the College of Arts and Sciences. The full copy of the CAS Statement of Academic Integrity can be found at the end of this syllabus. Please note that sharing or receiving homework assignments or exam materials from previous semesters falls under the university’s working definition of “plagiarism” and is a violation of the academic integrity policy.

Travel and Exams

Travel plans are not an excuse for missing an exam. This includes travel plans made by parents, without your knowledge. If you are aware of a pre-existing conflict you must let me know during the first week of class, so we can arrange a makeup. *After the first week I will not accept travel conflicts as a valid excuse for missing a quiz or exam.*

Cell Phones and Other Electronics

Please turn off cell phones and other electronic devices during class unless you have an important reason to leave them on. It will be easier to stay engaged and participate without a device competing for your attention. There are lots of important

reasons you might need to leave them on (a sick relative, a kid in daycare, being on-call for work, etc) and that's fine! But if you need to leave your phone on, please set it to vibrate or a low volume.

All devices that can access the internet must be turned off and put away during exams. Using such a device during an exam is a violation of the academic integrity policy and will result in a grade of zero.

How Do I Email A Professor?

It's just like you were writing a letter. Use a salutation, introduce yourself, identify which class you are in, write in complete sentences, don't use slang or abbreviations, be polite, use proper punctuation and grammar, ask questions as clearly as possible, close your message with a sign-off, and write your name at the end of the email.

Why Should I Email A Professor?

Great question. If you need to ask me something outside of class you should email me. I'm pretty good at answering questions over email. But if an email explanation doesn't work then we can meet in person. I'll try to respond promptly, though I may not answer until the next day if you email me late at night. Likewise, if I ever email you with a question in the evening or late at night, you should feel free to wait until the next day to respond. Emails received over the weekend may not be answered until Monday.

Student Support Resources

- ITS HelpDesk: helpdesk@luc.edu (773-508-4487)
- Library Subject Specialists: <http://libraries.luc.edu/specialists>
- Student Accessibility Center: <https://www.luc.edu/sac/>
- Writing Center: <http://www.luc.edu/writing/>
- Ethics Hotline: <http://luc.edu/sglc/aboutus/> (855-603-6988)

College of Arts & Sciences Statement on Academic Integrity

[Read the statement on the CAS website](#)

A basic mission of a university is to search for and to communicate the truth as it is honestly perceived. A genuine learning community cannot exist unless this demanding standard is a fundamental tenet of the intellectual life of the community. Students of Loyola University Chicago are expected to know, to respect, and to practice this standard of personal honesty.

Academic dishonesty can take several forms, including, but not limited to cheating, plagiarism, copying another student's work, and submitting false documents.

Academic cheating is a serious act that violates academic integrity. Cheating includes, but is not limited to, such acts as

- Obtaining, distributing, or communicating examination materials prior to the scheduled examination without the consent of the teacher
- Providing information to another student during an examination
- Obtaining information from another student or any other person during an examination
- Using any material or equipment during an examination without consent of the instructor, or in a manner which is not authorized by the instructor
- Attempting to change answers after the examination has been submitted
- Unauthorized collaboration, or the use in whole or part of another student's work, on homework, lab reports, programming assignments, and any other course work which is completed outside of the classroom
- Falsifying medical or other documents to petition for excused absences or extensions of deadlines
- Any other action that, by omission or commission, compromises the integrity of the academic evaluation process

Plagiarism is a serious form of violation of the standards of academic dishonesty. Plagiarism is the appropriation of ideas, language, work, or intellectual property of another, either by intent or by negligence, without sufficient public acknowledgement and appropriate citation that the material is not one's own. It is true that every thought probably has been influenced to some degree by the thoughts and actions of others. Such influences can be thought of as affecting the ways we see things and express all thoughts. Plagiarism, however, involves the taking and use of specific words and ideas of others without proper acknowledgement of the sources, and includes the following

- Submitting as one's own material copied from a published source, such as print, internet, CD-ROM, audio, video, etc.
- Submitting as one's own another person's unpublished work or examination material
- Allowing another or paying another to write or research a paper for one's own benefit
- Purchasing, acquiring, and using for course credit a pre-written paper

The above list is in no way intended to be exhaustive. Students should be guided by the principle that it is of utmost importance to give proper recognition to all sources. To do so is both an act of personal, professional courtesy and of

intellectual honesty. Any failure to do so, whether by intent or by neglect, whether by omission or commission, is an act of plagiarism.

In addition, a student may not submit the same paper or other work for credit in two or more classes without the expressed prior permission of all instructors. A student who submits the same work for credit in two or more classes without the expressed prior permission of all instructors will be judged guilty of academic dishonesty, and will be subject to sanctions described below. This applies even if the student is enrolled in the classes during different semesters. If a student plans to submit work with similar or overlapping content for credit in two or more classes, the student should consult with all instructors prior to submission of the work to make certain that such submission will not violate this standard.

Plagiarism or any other act of academic dishonesty will result minimally in the instructor's assigning the grade of "F" for the assignment or examination. The instructor may impose a more severe sanction, including a grade of "F" in the course. All instances of academic dishonesty must be reported by the instructor to the chairperson of the department involved, and to the Dean of the College of Arts and Sciences.

The chairperson may constitute a hearing board to consider the imposition of sanctions in addition to those imposed by the instructor, including a recommendation of expulsion, depending on the seriousness of the misconduct. In the case of multiple instances of academic dishonesty, the academic dean of the student's college may convene a hearing board. Students have the right to appeal the decision of the hearing board to the academic dean of the college in which they are registered. The decision of the dean is final in all cases except expulsion. The sanction of expulsion for academic dishonesty may be imposed only by the Provost upon recommendation of a dean.

Students have a right to appeal any finding of academic dishonesty against them. The procedure for such an appeal can be found [here](#).

The College of Arts and Sciences maintains a permanent record of all instances of academic dishonesty. The information in that record is confidential. However, students may be asked to sign a waiver which releases that student's record of dishonesty as a part of the student's application to a graduate or professional school, to a potential employer, to a bar association, or to similar organizations.