Physics 301: Mathematical Methods in Physics

Mathematical Methods in Physics introduces you to the mathematical techniques used to model physical systems and solve problems that arise in the physical sciences. We will cover orthogonal coordinates systems, Fourier series, vector calculus in curvilinear coordinates, series solutions of differential equations and special functions, techniques for solving partial differential equations, and additional material as time allows.

Who Am I?

Professor: Dr. Robert McNees.

Email: rmcnees@luc.edu. Please use your "@luc.edu" address when sending me an email. Emails sent from an external account (like gmail) are occasionally blocked by Loyola's servers.

Office: Cudahy Science Building 308.

Office Hours: TBA

Course web page: We will not be using Sakai for this course. Instead, all class materials can be found at this website.

Course Information and Policies

Objectives

The goal of Physics 301 is to introduce you to the mathematics you will need for describing physical systems and solving more realistic problems than the basic examples in your introductory courses.

This is one of the most important courses in the Physics major, because it equips you with skills and techniques needed in courses like mechanics, electromagnetism, optics, and quantum mechanics. The material is also highly relevant for engineering, computer science, and related fields. Everything you do from here on out in the physics major will rely on the things we learn in this course. So you should think of this material as foundational, and try to really master everything we cover. Devoting time to this course will have a significant payoff in your junior and senior years.

The prerequisites for Phys 301 are Phys 235 (Modern Physics) and Math 263 (Multivariable Calculus). We will rely heavily on concepts and skills you learned in these courses and their prerequisites, including

- Single variable calculus: Derivatives and integrals of functions of a single variable, Taylor series
- Multivariable calculus: Functions of multiple variables; partial derivatives; divergence, gradient, and curl; line, surface, and volume integrals; Green's theorem; Stokes's Theorem

- Vectors: Components, dot products, cross products, magnitude, basis vectors, unit vectors

If you feel a little rusty on any of these topics, please take the time to thoroughly review them in your multivariable book or the text for this course. Also, Differential Equations (Math 264) is a co-requisite for this course. It covers material that you will need to know later in the semester. If you have a conflict with the pre- or co-requisites for the course please contact me right away.

Since most of you are taking this course along side Phys $\pi \times 10^2$ (Theoretical Mechanics), we will spend the first few weeks developing a command of orthogonal coordinate systems. Our presentation of the material will tend to use notation similar to what you encountered in your multivariable calc class, which may be a little different than the way things are written in your mechanics book.

After orthogonal coordinates we will quickly review infinite polynomial series, including Taylor and MacLaurin series, and then begin our exploration of Fourier series. Fourier's technique allows us to represent functions on a finite interval as an infinite sum of sin and cos terms. This allows us to decompose the vibrations of a string into a fundamental frequency and its harmonics, or use a sum of trig functions to approximate a square or sawtooth wave in electronics. If time allows we will also discuss the Fourier transform.

After Fourier Series we will cover vector calculus, extending the basics of div, grad, and curl that you learned in Math 263. We will begin with a review in Cartesian coordinates, and then develop vector calculus in general orthogonal coordinate systems. Most of our examples will focus on the Cartesian, Cylindrical Polar, and Spherical Polar coordinate systems most frequently encountered in the physics major. Depending on the pace of the course we may also introduce a useful notation for vectors and vector operations introduced by Einstein.

Around mid-March we will begin our study of series solutions of differential equations. By that point you will have covered the necessary prerequisites in Math 264. We will develop techniques for finding finite and infinite series solutions of wide classes of differential equations, with particular emphasis on a few equations (Legendre, Bessel) that frequently show up in models of physical systems. The solutions of these equations have several useful properties – they can be used like a set of 'basis vectors' for certain kinds of functions – which we will explore.

Finally, the last part of the course will be devoted to partial differential equations. This is a complex subject, so we will focus on techniques for solving separable PDEs (Laplace, heat, wave, Poisson) encountered in your physics courses.

Throughout the semester we will sometimes use MATHEMATICA to automate or check certain kinds of calculations. We will often devote some of our time in discussion section to the basics of MATHEMATICA, and reviewing how it can be used to extend the calculations we perform in class.

Textbook and Materials

The textbook is *Mathematical Methods in Engineering and Physics* by Felder & Felder. The book's website is `http://felderbooks.com`. Additional references, which you may find helpful, are listed on

the course website. From time to time I will also post supplementary notes there.

The university has a site license which allows you to install MATHEMATICA on your laptop. You can find information on obtaining the software here.

Meeting Times and Location
Lectures take place TTh 11:30 - 12:45, in Cuneo 109. The discussion section meets Th 10:00-10:50, in Cudahy Science Building 207.

Lectures and Discussion Sections
Class will meet three times each week for lectures, and once each week for a discussion section. 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. The weekly discussion section will be devoted to the current homework assignment, learning the basics of MATHEMATICA, or additional material that is somewhat outside the scope of the lectures. **Attendance at weekly lectures and the discussion section is mandatory.**

Office Hours
I will hold office hours each week. The times will be announced in class and posted in an updated version of this syllabus. My office is in room 308 of Cudahy Science Building, one floor above our classroom. Stop by during office hours and I'll be happy to answer questions. If you can't make office hours we can set up an alternate time to meet – just send me an email or speak to me in class. Don't assume that I am too busy!

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 (everything after orthogonal coordinate systems). Homework will be posted frequently. You should start working on the homework as soon as it is posted. *Do not* wait for us to go over all the material before you start working on the homework. Instead, work on the homework and identify any questions you might have, so they are fresh in your mind during lecture.

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 quizzes and 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 (https://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, or exams with anyone who is not enrolled in the course is not allowed. Providing these materials to students who may enroll in the course at a later date, or obtaining them from students who have already taken the course, will be considered a violation of Loyola's academic integrity policy and will be reported to the department 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.

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. Missing class is not a valid reason for being unaware of changes to the syllabus.

Homework, Quizzes, Exams, and Grades

Homework Assignments
Homework will be assigned throughout the semester – approximately once a week, with occasional gaps due to holidays, exams, etc. I expect that there will be a total of ten (10) homework assignments. Each assignment must be handed in at the beginning of class on the day that it is due. Solutions will be available in my office after the homework is handed in, so late homework is not allowed.

Homework in this class is absolutely essential. You have to do every single problem (as well as 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 need to 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 that and copying.) Second, and again, 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 in different kinds of problems. 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 and online resources ended up doing poorly on the exams, where they didn't have access to that material.

Exams

There will be two exams and a final exam. I expect that the exams will be held during the week of 2/25-3/1, and 4/8-4/12. Exact dates will be set once we've had a chance to talk about everyone's exam schedule, so we can try to minimize conflicts with other courses. The material covered on these exams will be discussed in class. The final exam, which is comprehensive, will be held on Tuesday, April 30, from 9-11 AM.

Grades

Each of the two in-class exams will count for 15% of your grade, and the final exam counts 30%. Homework counts for 35%, and the last 5% of your grade comes from participation. The participation grade is secured by attending class, asking questions, and coming to see me at least twice during the semester with questions about homework or course material. Multiple unexcused absences will lower your participation grade.

I reserve the right to make adjustments to the grading algorithm, but I will never make a change that causes you to receive a grade that is lower than the one you would receive using the formula outlined above.

Once your final average for the class is calculated, a letter grade will be assigned according to the following scale:

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 – 60	D−
Below 60	F

Makeups and Absences

If you miss a homework assignment or one of the in-class 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 in advance.

Calendar

The following is a tentative schedule for the semester. This is the first time I have taught this course at Loyola, so these dates are subject to change. I will always notify you about any changes I make to this schedule.

Week	Dates	Topics
1	1/14-1/18	Intro, Orthogonal coordinate systems
2	1/21-1/25	OCS
3	1/28-2/1	OCS
4	2/4-2/8	Fourier series
5	2/11-2/15	FS
6	2/18-2/22	FS
7	2/25-3/1	Exam 1, Vector calc
8	3/4-3/8	*Spring Break*
9	3/11-3/15	VC
10	3/18-3/22	Series solutions, special functions
11	3/25-3/29	SS, SF
12	4/1-4/5	SS, SF
13	4/8-4/12	Exam 2, Partial differential equations
14	4/15-4/19	PDEs
15	4/22-4/26	PDEs

Other Things You Should Know

Academic Integrity

Any incidence of academic dishonesty on a quiz or exam will result in a grade of "0" 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.

Cell Phones and Other Electronics

No phones in class, period. Do not send or check text messages. If this becomes a distraction (to me or the other students) you will be asked to leave. Just turn your phone off before class starts.

Please tell me if you have an important reason to leave your phone on, like a sick family member or a kid in daycare. I completely understand, and I'm fine with that. Just let me know before class.

If you feel like you need to use a laptop or tablet in class, be sure you use it for taking notes and nothing else. I will occasionally spot-check laptops. If I see anything not related to what we're talking about in class, you will be asked to leave. There's a growing body of literature that suggests that taking notes by hand is much better for retention than typing on a laptop. I won't tell you how to take notes, and of course there are lots of good reasons why typing may be your best or only option. But consider trying to write things down instead of typing them if you are able, and see how it works for you.

All electronic devices must be turned off and put away, completely out of sight, during exams. If any such device is visible it will constitute a violation of the academic integrity policy and result in a grade of zero on the exam.

Travel and Exams

Travel plans are not an excuse for missing a quiz or 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. Pay very close attention to that last sentence.

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 studentÕs 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 studentÕs 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. A more detailed description of this issue can be found here.

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 instructorÕs 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 studentÕs record of dishonesty as a part of the studentÕs application to a graduate or professional school, to a potential employer, to a bar association, or to similar organizations.