

Syllabus

E12 Spring 2026, Swarthmore College

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What is E12 about?

E12 is titled Linear Physical Systems Analysis. This might be a somewhat puzzling or inscrutable title for you. The title of this course has been set by engineering professors who already know what ‘linear physical systems’ are and why their ‘analysis’ is important. You, as a student who has not yet taken this course, may not necessarily be on board with the whole idea. The purpose of this section of the syllabus is to give you some background and motivation for why this course is important. First, let’s look at each word in the course title in turn.

1. Linear

When we use the word ‘linear’, we are referring to a mathematical property of equations. As you know by now, equations are at the heart of engineering, but this course is specifically about *linear* equations. Whether you know it or not, you are already aware of what linearity is, but in this course, you will dive deeper into what makes some phenomena ‘linear’, and — perhaps more importantly — why linear-ness is very useful for engineers.

2. Physical

This course is about physical things, i.e., things that you can see, touch and feel. But what kinds of physics? In this course, you will see that many different kinds of things are governed by suspiciously similar equations, whether you are describing a car's suspension system, a motherboard's power module, a gear train or a steam turbine. The two kinds of physics that we will focus on are: (classical) **mechanics** and (classical) **electromagnetism**. By 'classical', we mean to exclude quantum or relativistic effects, which you should be (at least vaguely) aware of but which you will not encounter in this class. This is not a physics class, however, but an engineering class, which brings us to:

3. Systems

This course is about systems, especially mechanical and electromagnetic systems. For the purpose of this course, you should think of a system as a set of processes that relates inputs to outputs. Given a certain kind of input, what kinds of outputs are predicted by the governing equations? In a physics class, you would dive deep into the why and the how of mechanics and electromagnetism. In this engineering class, we will take the physics equations as given, and we will learn to view physical phenomena — both natural and engineered ones — as (linear) systems in which outputs are related to inputs in predictable ways.

4. Analysis

This class has a laboratory and a lecture component, but both are geared towards *analysis* rather than *design*. This is not to say that design is not important in E12; often, you will be asked to choose parameters that fit certain engineering specifications, i.e., you will be asked to design systems. But this course is primarily about the analysis of relatively simple systems, which is a prerequisite for being able to design more complex ones. The word 'analysis' does *not* have the meaning that it does [in the math department](#). The meaning of the word 'analysis' as used in this course's title is something like "resolution into simpler elements by analysing (opp. synthesis)". If you want to read 10,000 words about what 'analysis' really means, [here you go!](#)

History of the course

E12 is numbered sequentially after E11, and you should see these two classes as a two-semester sophomore-level sequence. These two courses follow each other both logically and chronologically, and used to be named something like 'Linear Physical Systems 1 & 2'. Over time, E11 became specialized toward electrical linear physical systems and E12 toward mechanical linear physical systems, but in E12 you will deal with both electrical and mechanical systems.

To the instructor's knowledge, it appears that E12 has been taught at Swarthmore College since at least 1977. The ideas that you will learn about have an even longer history, and have been 'canon' for engineers, scientists, and applied mathematicians for a long time. These ideas are covered in the engineering curriculum at most institutions, but Swarthmore College is fairly unique in teaching a course with the specific title 'Linear Physical Systems Analysis'.

You may find it interesting that a longtime instructor of E12, Prof. Erik Cheever, who is presently Edward Hicks Magill Professor Emeritus of Mathematics and Natural Sciences at Swarthmore

College, maintains a [website devoted to an earlier version of this course](#). The present instructor will not make use of this website directly, but due to its somewhat legendary reputation, he thinks it's best that you be aware of it.

How will E12 be run?

Summary

- There will be two 1.5 hour **lectures** each week. Attendance at these lectures is required.
- There will be approximately one **homework assignment** each week, due on Thursdays at midnight.
- There will be one 2-hour instructor-led **problem solving sessions** each week on Monday evening. Attendance at these is not required, but will be helpful.
- There will be one Engineering **Wizard Session** on Wednesday evenings.
- The instructor will be available for **office hours** by appointment on Mondays and Wednesdays at most times between 9 AM and 5 PM and on Thursdays before 2 PM. Book an appointment [here](#).
- Open office hours will be from 9 to 10:30 AM on Wednesdays.
- There will be approximately five **laboratory assignments** during the semester.
- The lab instructor's office hours will be 4-5pm on Mondays in Singer 105.
- There will be **one midterm exam** on the evening of March 19 and one **final exam** on **Sunday, May 10 from 7 to 10 PM**

Lectures

This course will be conducted in the form of in-person lectures during the regularly-scheduled meeting time. Lectures will not be recorded and remote participation is not possible. Students are expected to attend every lecture, and to take their own notes. Although the instructor will post lecture slides from class to the website, these do not replace the need for students to actively engage with the material, ideally by taking their own notes.

There are at least three different 'modes' of learning that you will spend your classroom time in. These are:

1. Actively listening to a lecture, ideally while taking your own notes
2. Discussing classroom questions with your peers, TAs, or the instructor
3. Using a personal laptop to execute code provided to you by the instructor, or to access other electronic resources pointed to in class.

Be prepared to switch between these modes of learning as the situation requires it.

Office Hours

It is my practice to maintain an 'open door policy'. You are welcome to come talk to the instructor individually at any time you see the door to Singer 112 open. In addition, you can book an appointment for office hours on Mondays, Wednesdays and Thursdays at various times between 9 AM and 5 PM. Book an appointment [here](#).

Special office hours for E12 will be from 9 to 10:30 AM on Wednesdays. It is not possible to book an appointment during this time.

Homework

Homework assignments are an essential component of this course. Typically, homework will be released on Thursdays and due on the following Thursday, but there may be exceptions to this from time to time.

The assignments for this class are actively developed by the instructor in tandem with the progression of lectures over the course of the semester, and are not ‘canned’ or re-used from previous semesters. Homework problems complement — rather than duplicate — what is covered in class.

Solving engineering problems that you have not seen before is an essential skill that you will develop throughout your studies at Swarthmore, and this class is no exception. You should expect to budget several hours a week to working on homework problems, and I encourage you to make full use of out-of-class resources (Wizard sessions, Problem Solving Sessions, and Office Hours) to help you complete the homework successfully.

It is the instructor’s belief that much learning happens when you wrestle with a problem and solve it on your own. That said, you are encouraged to work together with your peers on homework as long as you turn in work that reflects your own thought process, not someone else’s.

Exams

There will be one **midterm exam** on **Thursday, March 19 at 7:00 PM** covering the first half of the semester and a **final exam** on Sunday, May 10 from 7 to 10 PM that will be cumulative.

Labs

The laboratory component of the course complements what you learn in the lectures, homeworks, and exams by giving you the opportunity to apply your knowledge in a laboratory setting. There are five labs throughout the semester that meet roughly every other week in Singer 245. In lab, you will perform hands-on experiments, collaborate with different lab partners, and practice your technical writing by producing formal lab reports.

Course at a glance

Field	Info
Course Number	ENGR 012
Course title	Linear Physical Systems Analysis
Type	Core ENGR course
Lab	Meets biweekly
Enrollment	60+
Prerequisites	ENGR 6, ENGR 11
Lecture Instructor	Emad Masroor
Lab Instructor	Will Johnson
Lectures	TR 8:30 to 9:45 SCI 199
Problem Session	M 6:00 to 8:00 PM Singer 222
Wizard Session	W 7:00 to 9:00 PM Singer 034/35
Midterm Exam	Thursday March 19 7:00 to 9:00 PM Singer 033, 034/35
Final Exam	TBA
Required Textbook	<i>System Dynamics</i> , Palm. 3rd or 4th ed.
Optional Textbook	<i>Modeling and Analysis of Dynamic Systems</i> , Close, Frederick Newell.

Catalog Description

This course (including the lab) will provide you with an introduction to time-domain and frequency-domain approaches involving the measurement of, modeling, solution to and analysis of linear dynamical systems that occur in many engineering disciplines. The course is designed to enable you to gain experience in closed-form and numerical solutions of ordinary differential equations governing the behavior of single- and multiple-dimensional systems. You will have an opportunity to explore system responses due to impulse, step, sinusoidal, and general inputs. System response characteristics such as superposition, stability, resonance, amplification, and attenuation will be considered.

Schedule of topics

The following table provides a list of topics that will be covered in E12 lectures and labs. This list is somewhat tentative; the selection of topics may change during the semester in response to the learning needs of the class. Always refer to the course website for the most up-to-date information.

Week	Lecture Topic	Due	Lab
1	Math preliminaries	HW 0	
2	First-order systems in time domain	HW 1	1: Impulse Response
3	Frequency domain; Laplace Transform	HW 2	1: Impulse Response
4	Block diagrams & Simulink	HW 3	2: Numerical Soln
5	Second-order systems with no damping	HW 4	2: Numerical Soln
6	State-variable approach	HW 5	3: Biomechanics
7	Second-order systems with damping	HW 6	3: Biomechanics
8	Mechanical modeling of coupled sys	Midterm	4: Coupled pendulum
9	Damping ratio, settling time, etc.	HW 7	No Lab
10	Second-order systems with Laplace	HW 8	4: Coupled pendulum
11	Bode plots	HW 9	No Lab
12	Introduction to Fourier Series	HW 10	5: Fourier Series
13	Vibrations; modes; normal modes	HW 11	5: Fourier Series
14	Further second-order models	HW 12	

Learning Objectives

After completing this course successfully, you should be able to ...

- Mathematically model mechanical and electrical systems using linear differential equations derived from Newton's Laws and Kirchhoff's Laws respectively.
- Distinguish between *linearity* and *nonlinearity* in physical systems, and approximate the latter with the former in appropriate circumstances.
- Solve linear constant-coefficient ordinary differential equations of first and second order, as relevant to mechanical and electrical lumped-parameter models.
- Use the Laplace Transform to transform equations from the time domain to the frequency domain and thereby replace differential equations with algebraic ones.
- Cast linear physical systems into 'input-output' form and quantify the relationship between the input of a system and its output, particularly using the Transfer Function
- Numerically solve the governing equations using software packages in MATLAB, Python, or similar.
- Use block diagrams to model linear physical systems, and become familiar with MATLAB's Simulink package to numerically model these systems with block diagrams.

Teaching Team

Name	Role	Office Hours
Emad Masroor	Lecture Instructor	Wed 9 to 10:30 & by appt.
Will Johnson	Laboratory Instructor	
Kenny Relovsky	Course Wizard	Thu 2:30 to 3:30
Madeline Mountcastle	Course Wizard	Wed 2:00 to 3:00
Bella Thoen	Course Wizard	Tue 3:00 to 4:00
Tanvir Islam	Course Wizard	Thu 12:30 to 1:30
Miles Fleisher	Lab Wizard	
Nick Fettig	Lab Wizard	
Aubree Daugherty	Grader	
Ryder Maston	Grader	
Owen Hoffman	Grader	
Howard Wang	Grader	
Julian Courtney-Bacher	Grader	

Grades

In this course, it is possible for you to calculate your overall numerical score by using the following table of weights. Your final score in the course is a weighted average of the components. Each homework assignment will be weighted equally.

Components of Grade

Component	Grade
Participation	5%
Labs	20%
HW	25%
Midterm	20%
Final	30%

Grade Thresholds

This class uses an absolute threshold for grades. Your grade in E12 is not explicitly compared against your peers' grades, but is instead compared against an absolute standard set by the instructor. Numerical thresholds will be used to convert numeric scores to letter grades according to the Swarthmore College grade definitions.

Definitions of Letter Grades

From the [Swarthmore College catalog](#): A means excellent work; B, good work; C, satisfactory work; D, passing but below the average required for graduation; and NC (no credit),

uncompleted or unsatisfactory work.

The instructor will assign +/- qualifiers to the letter grades, approximately equally spaced across the corresponding letter grades, i.e., 83 is the minimum for a B and 87 the minimum for a B+.

Adjustment of thresholds

The numeric thresholds set out in this document may be adjusted downward in your favor (i.e., by making it easier to get a certain letter grade) and will not be adjusted upward. Should the instructor choose to make such a change, this will translate *all* thresholds downward by the same numeric amount. Such changes are made to bring letter grades in alignment with the College's definitions.

A+ grades are reserved for truly exceptional mastery of linear physical systems analysis.

Letter	Numerical score
A range	90-100
B range	80-90
C range	70-80
D range	60-70
NC	Below 60

Policies

Electronic Communication and Website

This course will make use of four main electronic channels of communication between you and the teaching team (i.e., instructors, wizards, and graders). These are:

1. [Moodle](#)
2. [Gradescope](#)
3. [Course Website](#)
4. [Ed Discussion](#)

Attendance at Lecture

- is required.
- Please be respectful of everyone else's time by being punctual.
- Cell phone use is not permitted in class. If you have an urgent matter to attend to that requires you to use your phone, you may leave the room discreetly and return when you are able to.
- Bring writing implements and a calculator to class.
- In general, electronics are not allowed in class. The only exception to this is tablets or tablet-like devices that you use to take electronic notes with a stylus. Laptops, even for the purpose of taking notes, are a distraction to others and to yourself, and they should not be open unless the instructor has announced otherwise.

Homework Policies

- Late work will automatically incur a penalty of 20% per day, i.e., if the assignment is worth 100 points, 20 points will be deducted from your score if submitted 0-24 hours late, 40 points will be deducted if submitted 24-48 hours late, and so on. You do not need permission to submit late work.
- Exceptions may be granted for extenuating circumstances, such as medical procedures, family emergencies, and other circumstances beyond one's control. These exceptions will be at the discretion of the instructor.
- Each student can request one extension during the semester, of one week's duration, with no penalty. This is a no-questions-asked extension and will be deemed automatically granted when you request before the deadline.
- Homework extensions of all kinds are to be requested using the Google Form located on the [Homework page](#).

Exam Policies

- If you wish to reschedule the midterm exam for a compelling reason, you must make arrangements by Friday March 6, the day before spring break.
- If you wish to reschedule the final exam for a compelling reason, you must make arrangements by the last day of class.

- If you need to miss an exam for an acute medical reason, you should contact the instructor by email as soon as you are able to.
- A no-show at an exam will ordinarily result in a score of zero on that exam.

Lab Policies

- Attendance at lab is required for the full duration (1:15-4pm).
- Please be respectful of everyone else's time by being punctual.
- Do not plan to leave lab early. Schedule any other commitments after 4pm since your experiment will often take the full time.
- Students must attend their assigned lab section. Labs are at capacity, so the lab instructor cannot accommodate changing lab sections.
- There will be one week of make-up labs for students in extenuating circumstances that prevented them from attending lab.
- Students must complete and submit all five labs in order to pass the course.

Use of 'Artificial Intelligence'

Technologies known as 'Artificial Intelligence', such as Large Language Models, come with serious risks when used in an educational setting, and do more harm than good when used liberally.

Note that OpenAI's website [states](#):

ChatGPT is designed to provide useful responses based on patterns in data it was trained on. But like any language model, it can produce incorrect or misleading outputs. Sometimes, it might sound confident—even when it's wrong.

With this in mind:

- You are not prohibited from using Large Language Model (LLM) based tools such as ChatGPT, Gemini, etc. to help you study for this course.
 - At an early stage in your education about any topic, this is not advisable, since you won't be able to verify that the output of the LLM is not "incorrect or misleading" in any particular case.
 - Once you are confident about your knowledge, gained from more reliable sources, you may benefit from language models' ability to summarize and synthesize ~~information~~ text.
- You are prohibited from using Large Language Models to produce anything that you turn in for this class.

Violations of this policy will be treated as cases of academic misconduct.

Relying on AI tools to produce work that you should know how to do yourself puts you at a serious disadvantage compared to your peers who can produce such work without the help of these tools. If you only know how to solve a problem by 'asking an AI to do it', you have not learned what you were supposed to learn.