ME 3012 Systems Analysis & Control and Vibrational Responses

Learning Outcomes

Dr. Bob Williams

The objectives of this course are to introduce the student to the modeling, simulation, and classical control of single-input-single-output linear time-invariant systems. Ordinary differential equation derivation and solution will be accomplished using both time domain and frequency domain techniques. Theoretical controller design will be presented for first-, second-, and higher-order systems. In-class discussions and demonstrations will connect the course lecture to real-world applications. A side-objective is to use MATLAB as a powerful software tool in controller design and linear system analysis. The course project is intended to have each student team apply the class principles to real-world control systems via simulation. This course provides practice in technical writing (weekly homework memos and final project report) and practice in technical presentation (final project presented orally to the class). Specific topics include:

1. Students will be able to explain the history and some examples of control systems.

2. Students will be able to accomplish linear system modeling.

3. Students will be able to solve linear initial value problem ordinary differential equations.

4. Students will be able to use Laplace transforms for linear initial value problem ordinary differential equations solutions and control systems derivations.

5. Students will be able to derive transfer functions and draw block diagrams.

6. Students will be able to analyze the stability, disturbances, transient and steady-state responses, dynamic shaping of responses for feedback control systems.

7. Students will be able to design and simulate linear single-input, single output controllers for dynamic systems via parameter matching.

8. Students will be able to design output attenuation correction factors, plus internal and external pre-filters for control systems.

9. Students will be able to apply the root-locus method for the design and analysis of feedback control systems.

10. Students will be able to solve first- and second-order, free and forced, undamped and damped mechanical vibrational systems initial value problem ordinary differential equations.

11. Term project: complete linear system modeling, simulation, and controller design for a real-world control system. Done by teams of two students, all teams choose a unique control system. Must be presented orally to the class and in a written report.

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ABET Outcomes

Mastery Level Outcome

e.3a) An ability to solve common engineering problems, including problems involving linear system modeling and analysis of 1 DOF system responses due to free and forced input.

e.3b) The ability to model and simulate single-input single-output linear systems.

Competence Level Outcome

c.12) The ability to design, implement and evaluate controllers for linear systems.

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Syllabus and Policy

Dr. Bob Williams 262 Stocker, 740-593-1096 williar4@ohio.edu	Fall 2024 Class # 7153 people.ohio.edu/williams

Time & Venue

8:35 – 9:30 a.m. M W F 3 credit hours ARC 212

Prerequisites

ME 3011, MATH 3400

Description

Modeling and formulations of physical systems. Transient and steady-state dynamic responses, and other fundamental theory of automatic controls and applications.

Office Hours

12 – 1:30 p.m. M W and by appointment

Required NotesBooks

Linear Systems Control for Mechanical Engineers, Dr. Bob Productions, 2024.
Linear Systems Control for Mechanical Engineers (lulu.com)

Mechanical Vibrations, Dr. Bob Productions, ©2024 (also used in ME 3011)
Mechanical Vibrations (lulu.com)

I would NOT use all your Stocker prints for hardcopies of these two required NotesBooks.

Required Textbook

none

ME 3012 Course Website

https://people.ohio.edu/williams/html/Courses.html

Dr. Bob's MATLAB Primer and Matrices Review

https://people.ohio.edu/williams/html/PDF/MATLABPrimer.pdf
https://people.ohio.edu/williams/html/PDF/MatricesLinearAlgebra.pdf

Dr. Bob's Atlas of Models and Transfer Functions

https://people.ohio.edu/williams/html/PDF/ModelTFAtlas.pdf

External Control Systems Tutorials

ctms.engin.umich.edu

Homework

Six homework assignments will be collected via hardcopy at the start of class as shown in the schedule on the following two pages. Each homework will be assigned via email two weeks before it is due. A **Memo** (see sample memo) summarizing the work must be the first page of each homework submission.

Quizzes

Six quizzes will be given in class as shown in the schedule on the following two pages. All quizzes are closed notes and closed NotesBook. Quiz 3 is the Midterm (20 pts), and Quiz 6 is the Final (30 pts).

Homework/Quiz Makeup Policy

You can make up any quiz, with a valid written OU excuse, before the next class. For planned absences with a valid OU excuse, please turn in the homework early. For unplanned absences with a valid OU excuse, you can turn in the homework ASAP afterwards. You must turn in the homework early if you have an unexcused absence on one of those HW due dates.

Capstone Term Project

The term project is assigned here:

https://people.ohio.edu/williams/html/PDF/Proj3012.pdf.

The standard project team size is two, though it may be done singly. One final report will be submitted per pair and all partners earn the same grade, in general. The project will be evaluated via an interim report, a final oral presentation, and a final report.

Academic Dishonesty

Cheating in any form will not be tolerated. A grade of zero will be registered for any infraction, and the matter will be referred to University Judiciaries. There will be a zero-tolerance punishment of plagiarism in any form – the assignment in question will receive a zero and you will be referred to University Judiciaries. Cite all references properly and do not copy ANY text (with the possible exception of an important short quote, in quotation marks, attributed and referenced properly).

Attendance

Full attendance is required. Class participation is expected. No homework, quiz, or exam can be made up without a valid written OU excuse.

Grading

Homework 30%	Quizzes 35%	Project 35%

93.3-100	90-93.3	86.7-90	83.3-86.7	80-83.3	76.7-80	73.3-76.7	70-73.3	66.7-70	63.3-66.7	60-63.3	< 60
A	A–	B+	B	B–	C+	C	C–	D+	D	D–	F

ME 3012 Fall Semester 2024 Schedule

Week	Date	Day	Topic	Notes	HW	Quiz	Proj
1	26-Aug	Mon	Syllabus, videos				
		Wed	Intro to Controls	1.1			
		Fri	First-order ODE	2.1			
2	2-Sep	Mon	Labour Day Holiday				
		Wed	2nd-order ODE, over, critical, under, undamped	2.1.2			
		Fri	Laplace Transform Intro	2.2.1			
3	9-Sep	Mon	1st- and 2nd-order ODE solns	2.2.2			
		Wed	Quiz 1			Q1	
		Fri	Transfer Functions	3.1			
4	16-Sep	Mon	Block diagrams, four rules, example, Project signup	3.2			Sign
		Wed	Damping examples	4.2	HW1		
		Fri	Quiet private study and contemplation; reflection				
5	23-Sep	Mon	Generic 2nd-order sys, Re-Im zeta-wn	4.2			
		Wed	Quiz 2			Q2	
		Fri	Second-order performance characteristics	4.2			
6	30-Sep	Mon	1st- and 2nd-order transient response	4.4			
		Wed	System Type, Stability	4.5-6	HW2		
		Fri	Controller design intro	5.1			
7	7-Oct	Mon	Root-Locus	5.2			
		Wed	Quiz 3 Midterm			Q3	
		Fri	Wellness Day Holiday				
8	14-Oct	Mon	Quiet private study and contemplation; reflection				Int
		Wed	Controller Ex 1, P, output attenuation	5.3-4	HW3		
		Fri	Controller Ex 1, lead, output attenuation, pre-filter	5.5-6			

ME 3012 Fall Semester 2024 Schedule (continued)

Week	Date	Day	Topic	Notes	HW		Proj
9	21-Oct	Mon	Cont Ex 1, PID, Gp	5.7			
		Wed	Quiz 4			Q4	
		Fri	Cont Ex 2, Cont Ex 3 (OL zeros)	5.8-9			
10	28-Oct	Mon	Input effort and Disturbances	5.11,5.12			
		Wed	2nd-order free vibes - undamped SHM, alt, spec, shak	V3.2	HW4		
		Fri	SHM energy, Pend energy, MATLAB SHM Ex, Phasors	V3.2			
11	4-Nov	Mon	State-space, MATLAB, Simulink	V3.2.4			
		Wed	Quiz 5			Q5	
		Fri	Underdamped 2nd-order, Examples	V3.3			
12	11-Nov	Mon	Veteran's Day Holiday				
		Wed	Capstone project work day		HW5		
		Fri	Capstone project work day				
13	18-Nov	Mon	Capstone project presentations				Pres
		Wed	Capstone project presentations				Pres
		Fri	Logarithmic Decrement, Final project report due	V3.3			Final
14	25-Nov	Mon	Thanksgiving Holiday				
		Wed					
		Fri					
15	2-Dec	Mon	Forced undamped 2nd-order, ex, beat, resonance	V4.2			
		Wed	Forced underdamped second-order, ex, resonance	V4.3	HW6		
		Fri	Quiz 6 Final			Q6	

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Homework Policy

Homework assignments will be collected via hardcopy at the start of class as shown previously in the schedule, every other Monday. Each will be assigned via email two weeks before it is due. A **Memo** (see sample memo next page) summarizing the work must be the first page of each HW submission.

Please see the Homework/Quiz drop and makeup policies already presented in this syllabus.

1) No late homework assignments will be accepted. Each homework assignment is due at the beginning of class as scheduled.

2) No computer excuses will alter deadlines. In the event of problems, do your best.

3) Don't e-mail your homework to me or ask me to print it out.

4) Each assignment must be neat, with answers clearly noted and supporting information provided.

5) One complete hand calculation must be provided (if the computer is used to solve multiple problems) to verify your results.

6) MATLAB software is required. I am available to help during office hours or by appointment. For an extensive introduction to the MATLAB software, please see Dr. Bob's MATLAB Primer (whose link was given earlier).

MEMO-WRITING. A MEMO MUST BE INCLUDED WITH YOUR HOMEWORK RESULTS EACH WEEK. An example is given on the next page. This should be a *brief* technical communication addressed to me, summarizing the week's homework assignments and bottom-line results. Your single memo must summarize all assignments each week. LENGTH LIMIT: *one single-sided page, 12 pt font*. Without a MEMO your HW score for the week will be entered as zero. If the MEMO is not clear, credit can also diminish. A memo is required from the first HW assignment through the last.

OHIO UNIVERSITY

Russ College of Engineering & Technology
Department of Mechanical Engineering

DATE: August 31, 2024

TO: Dr. Bob

FROM: Ima Student

SUBJECT: Homework Assignment #1

Dr. Bob,

The purpose of this memo is to present the basic results for HW Assignment #1. You assigned a total of two problems: (*enumerate briefly here*).

The answers to problem 1 are: (*give answers here if appropriate*). My sketches appear on p. 2 (*if appropriate*). I obtained the answers using MATLAB file *bob.m*, which appears on p. 3. Sample calculations are presented on p. 4 to demonstrate that the computer code generates the correct results. (*Brief summary of roadblocks, issues, or learning here, if appropriate*).

For problem 2, (*similar to above paragraph*).

If you have any questions on my work, please contact me.

Sincerely,

Ima Student
control_freak@ohio.edu