ECE 3510

Introduction to Feedback Systems
Spring 2023 Class Syllabus

Instructor: Arn Stolp
Office: MEB 2262
Phone: U of U: 581-4205
Cell: (801) 657-7766 **Always TEXT FIRST & start text with "ECE 3510"**. This is the best way to contact me. I may call back from (385) 429-3439 (a google voice number). Do not initiate contact on the 385 number.
E-mail: arnstolp@ece.utah.edu. I don't check my e-mail as often as I should, so text me if you send me email that I need to read. Subject should start with "ECE 3600". DO NOT use other email addresses.
Office hours: My "office hours" will likely be problem sessions after the end of class. Otherwise it's catch me if you can. To increase your chances, talk to me after class. I'm usually around between 12:20 a.m. & 3 p.m. M,W & F. If I'm not in my office, check the lab.
DO NOT send messages via Canvas. I don't have the time to monitor them.

Web Site: http://www.ece.utah.edu/~ece3510/

Required books and lab supplies:
Textbooks: Introduction to Feedback Systems, by Marc Bodson, available free at http://www.ece.utah.edu/~bodson/ifs/
Control Systems Engineering, 3rd , 4th or 5th ed. by Norman S. Nise
Ring binder for the Bodson text and additional materials to be handed out in class.
Lab notebook (bound or spiral) and standard ECE lab supplies

Prerequisites: C- or better in ECE 2260

Introduction:

When you're walking down the sidewalk, how do you actually stay on the sidewalk? "Duh, I watch where I'm going", you say. Well, that's feedback. You use your vision to detect which way the sidewalk leads as well as which way you are moving and adjust your direction to minimize the difference between the two. The sidewalk direction is the input, you are the system, and your movement direction is the output. Detecting your direction and using that information to adjust your direction is feedback.

Your body uses feedback control systems to automatically regulate your internal temperature, heart-rate, blood sugar, etc. etc.. Without feedback systems you'd be dead by this afternoon! Feedback is important stuff! Any system that uses a sensor to regulate or control what the sensor is measuring is a feedback system. Engineers use this concept extensively.

This class will introduce you to some of the basics of feedback and control systems and the math used to analyze, design, and stabilize these systems.

I teach concepts and the use of those concepts to solve problems, not formulas and memorization. The hands-down easiest way get a good grade in this class is to *learn* those concepts.

This class consists of:

Lectures: M, W & F 10:45 -12:05 am. WEB 2230

Lectures set the direction and tone of the class and cover more than the written material. You will be held accountable for everything discussed in the lectures, so your attendance is important.

Supplemental Example / Problem Sessions: time and place to br determined

We cover a lot of material in this class and there is rarely enough lecture time to cover everything in the reading assignments, to work as many examples as most students would like, or to answer your questions in detail. These supplemental sessions will make the class much easier to follow with less outside reading and study time.

Textbook:

The main textbook was written by Dr. Marc Bodson, who taught this class for many years. The secondary textbook is an older edition of a popular control-systems textbook which you will have to buy on-line.

Handouts:

There will be a number of handouts for, homework, labs, notes, etc.. I may hand these out before class or may have to download them from the class web site; http://www.ece.utah.edu/~ece3510/.

Homework, homework, and more homework: 14%

I will assign a lot of homework, it will be your main study tool. As such, I'll give you all the numeric answers so that you can check your work immediately. In fact, you'll have to self-correct your homework. If you can't get the answer, check the web site for corrections, study some more, come to the problem session, or ask for help, or see the posted solutions (outside my office). Sometimes I even post solutions before the homework is due. So, you might ask, "Why is it handed in and 'graded'?". Well, to answer a question with a question, "Would you even do it otherwise?"

Your homework should be neat and clear and show all your work. For most problems the grader will simply check to see that you've done it and that your paper shows the necessary work to get the answer. Only a few problems will be checked in greater detail. You may collaborate with others to learn how to do the homework, but will need to hand in your own work. Copying or allowing another student to copy your work is considered cheating.

You will probably learn more from doing the homework than any other part of this class. If you thoroughly understand the homework, you will know what the class is about, and the exams should give you no trouble.

You will need to scan your homework, create a .pdf file, and turn that in on canvas by 11:59 pm of the due date. Solutions will be posted in my office window. Most graded material will be returned on Canvas.

Midterms: (300 exam pts) 43.75%

You will take three 50-minute midterms throughout the semester. They will cover material up to the time of the test. All exams are closed book, closed notes, no phones, tablets or computers allowed. These exams will usually be in two parts, a no calculator, no reference material part where I ask for items that you should have committed to memory, and a part with *some* reference material where I will ask you to solve problems that may require your calculator. This part is designed to see if you learned concepts and problem solving strategies and whether you can work with them, sometimes in new and different ways. Don't try to memorize specific problems. Exams also cover what you learn in the labs. Exams will be returned in class. If you miss class, come to my office.

Final: Friday, 4/28/23 10:30 - 12:30 pm (180 exam pts) 26.25%

The final will be comprehensive with greater emphasis on the most recent material. It may also be in two parts. There will be a zoom review session. Listen for details in class.

Labs: MEB 2365 16%

Lab will be held every week, beginning the second week and including the last week of class. Many of the subjects covered in lab aren't covered anywhere else in class, so make sure you pay attention and read the lab instructions. You will have to keep a laboratory notebook as a requirement of the lab. Your lab TA will either collect and grade these notebooks or ask you to scan them and submit on canvas.

Labs are **not optional.** For each lab that you miss or fail (< 60% score), your final grade will suffer a **half letter drop** (5% of possible points). Be sure to make-up any labs you miss or fail.

Grades:

Homework:	14%
Labs:	16%
Exams:	70%
Total:	100%
Failed lab:	-5%
Cheating:	-100%

% of total	Grade
> 93	A
90-93	A-
87-90	B+
83-87	B
80-83	B-
77-80	C+
73-77	C
70-73	C-
67-70	D+
63-67	D
60-63	D-
< 60	E

If you want any deviations from the normal requirements, you will need to see me before the work would normally be due and get an agreement *in writing*. You'll need to turn in your copy of the agreement with your final, so I'll remember to grade you properly.

Disclaimer:

All information provided here is subject to change due to external factors or unintended typos or errors.

ECE 3510 Spring Semester 2023 Likely HW Due-Dates (canvas date will overide) 01/08/23

Week	Month	Mon	Tue	Wed	Thur	Fri	Sat
1	Jan	9	10	11	12	13 Hw1 Identify Feedback Systems	14
2		16 Martin Luther King Day	17	18 Hw2 Laplace	19	20	21 Hw3a Inverse Laplace
3		23	24 Hw3b Inverse Laplace	25	26	27 Hw4 Systems & Transfer functions	28
4		30	31	1 Hw5 Circuits -> H(s), Step response	2	3	4 Hw6 Review of Steady-State AC
5	Feb	6	7 Hw7 Sinusoidal Response	8 Exam 1	9	10 Hw8 Electrical Analogies of Mech. Linear	11
6		13	14 Hw9 Electrical Analogies of Mech. Trans. Rot. & Fluids	15	16	17 Hw10 Control System Characteristics	18
7		20 Presidents Day	21	22 RL1 Root Locus by Hand	23	24	25 RL2 Basic rules
		27	28 RL3 Additional rules	1	2	3	4 RL4 Departure Angles etc.
8	Mar	6 Spring Break	7	8	9	10	11
9		13	14 RL5 MATLAB SISO tool	15 Exam 2	16	17 RL6 Root Locus Design	18
10		20 RL7 Root Locus Design	21	22	23 RL8 Unconventional Root Locus Plots	24	25
11		27 RL9 Physical Realization	28	29 FC1 PID tuning	30	31	1 FC2 Programmable Logic Controller, Ladder Logic
12	April	3 BP1 Bode Plots, simple & w/complex poles & zeros	4	5	6 BP2 Bode Plots to Transfer functions	7 Exam 3	8
13		10	11 BP3 Bode GM, PM, DM, Bode Design	12	13	14 AF1 Amplifier Feedback, Zin, Zout	15
14		17 AF2 Amplifier Feedback	18	19	20 ME Design Day, Union Build.	21 Z1 z-transforms	22 DD Design day
15		24 Z2 Inverse z-transforms	25 Z3 Digital Control	26 Reading Day	27 Finals ECE 3510 Review	28 3510 Final 10:30 AM	29
16	May	1	2	3	4 Freedom	5	6

ECE 3510 Spring Semester 2023 Likely HW Due-Dates (canvas date will overide)

ECE 3510

A. Stolp

Tentative

01/08/23

Spring 2023 COURSE SCHEDULE

Week		Date	lect	Topics	Books Bodson	Nise
1	M	01/09	1	Syllabus, etc. Servo, Introduction to Feedback Systems, Block diagrams	Ch.1	Ch.1
	W	01/11	2	Transfer functions and signals, The Laplace transform of signals	2.1	2.1
	F	01/13	3	The Laplace transform, Relationship between pole locations and	2.1	2.2
2	M	01/16		Martin Luther King Day		
	W	01/18	4	Inverse of Laplace transforms using partial fraction expansions	2.2	2.2
	F	01/20	5	Inverse Laplace, Properties of signals (bounded, converge)	2.3	2.2
3	M	01/23	6	Transfer functions, Interconnected systems, Feedback system	3.1	2.3, 5.1-2
	W	01/25	7	Systems, Circuits, BIBO stability	3.1 - 2	2.4
	F	01/27	8	Responses to impulse and step inputs, 1st & 2nd order	3.3	4.1 - 4
4	M	01/30	9	Responses to step inputs, % overshoot, effect of zeros	3.3	4.5 - 7
	W	02/01	10	Responses to sinusoidal inputs, sinusoidal steady-state	3.4	4.1 - 8
	F	02/03	11	Effect of initial conditions, State-space advantages	3.5-6,	Ch.3
5	M	02/06	12	Electrical analogies of mechanical systems	notes	2.5 - 9
	W	02/08		Exam 1		
	F	02/10	13	Electrical analogies of mechanical systems	notes	2.5 - 9
6	M	02/13	14	Stability and Performance of Control Systems	4.1 - 3	6.1
	W	02/15	15	Steady-state error and integral control	4.1 - 5	Ch. 7,
	F	02/17	16	Routh-Hurwitz stability test	4.5.1	6.2
7	M	02/20		Presidents Day		
	W	02/22	17	Root-locus introduction, main rules, RL1	4.6.1	8.1 - 4
	F	02/24	18	Root-locus main rules, examples		
8	M	02/27	19	Root-locus additional rules, examples	4.6.2	8.1 - 4
	W	03/01	20	Root-locus additional rules, examples	4.6.3	8.5 - 7
	F	03/03	21	Root-locus design, PI, Lag, PD, Lead, Example 1	notes	9.1- 4
9	S	03/04		Spring Break		
	Su	03/12				

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Week		Date	lect	Topics	Books Bodson	Nise
10	M	03/13	22	Root-locus design, PID, Lag - lead, Catchup and Review	4.6.5	9.1- 4
	W	03/15		Exam 2		
	F	03/17	23	Feedback design for phase-locked loops, discussion of PLL lab	4.7,	notes
11	M	03/20	24	Variations of Root Locus	notes	notes
	W	03/22	25	Pole dominance, Physical realization,	notes	9.6
	F	03/24	26	PID tuning and Relay logic	notes	notes
12	M	03/27	27	Ladder Logic & Programmable Logic Controllers (PLCs)	notes	notes
	W	03/29	28	Frequency-Domain, Bode plots, basic examples	5.1	10.1 - 2
	F	03/31	29	Bode Plots complex poles & zeros, ζ, ω_n	5.1	10.2
13	M	04/03	30	Bode Plots to Transfer functions	5.1	10.13
	W	04/05	31	Bode Plots to Transfer functions, Gain and phase margins	5.3	10.7,12
	F	04/07		Exam 3		
14	M	04/10	32	Relation to transient response, Frequency-Domain Design	5.2 - 3	10.8
	W	04/12	33	Amplifier Feedback & freq response, Op Amp compensation, Zin, Zout	notes	notes
	F	04/14	34	Discrete-time Signals and Systems	6.1	13.1 - 2
15	M	04/17	35	The z-transform and properties	6.1	13.3
	W	04/19	36	Properties of the z-transform	6.2 - 3	13.3
	Th	04/20		ME Design Day, Union Build.	0	0
	F	04/21	37	Inverse z-transform	6.3	13.3
16	M	04/24	38	Digital control	Ch.7	Ch.13
	T	04/25		Last Day of Classes		
	W	04/26		Reading Day		
	Th	04/27		Finals ECE 3510 Review		
	F	04/28		3510 Final 10:30 AM		
17	M	05/01				
	T	05/02				
	W	05/03				
	Th	05/04		Freedom		

ECE 3510 Spring Semester, 2023 01/08/23

Week	Month	Mon	Tue	Wed	Thur	Fri
1	Jan	9 L1 Syllabus, etc. Servo, Introduction to Feedback Systems, Block diagrams	10	11 L2 Transfer functions and signals, The Laplace transform of signals	12	13 L3 The Laplace transform, Relationship between pole locations and signal shapes
2		16 Martin Luther King Day	17	18 L4 Inverse of Laplace transforms using partial fraction expansions	19	20 L5 Inverse Laplace, Properties of signals (bounded, converge)
3		23 L6 Transfer functions, Interconnected systems, Feedback system	24	25 L7 Systems, Circuits, BIBO stability	26	27 L8 Responses to impulse and step inputs, 1st & 2nd order
4		30 L9 Responses to step inputs, % overshoot, effect of zeros	31	1 L10 Responses to sinusoidal inputs, sinusoidal steady-state	2	3 L11 Effect of initial conditions, State-space advantages
5	Feb	6 L12 Electrical analogies of mechanical systems	7	8 Exam 1	9	10 L13 Electrical analogies of mechanical systems
6		13 L14 Stability and Performance of Control Systems	14	15 L15 Steady-state error and integral control	16	17 L16 Routh-Hurwitz stability test
7		20 Presidents Day	21	22 L17 Root-locus introduction, main rules, RL1	23	24 L18 Root-locus main rules, examples
8		27 L19 Root-locus additional rules, examples	28	1 L20 Root-locus additional rules, examples	2	3 L21 Root-locus design, PI, Lag, PD, Lead, Example 1
9	Mar	6 Spring Break	7	8	9	10
10		13 L22 Root-locus design, PID, Lag - lead, Catchup and Review	14	15 Exam 2	16	17 L23 Feedback design for phase-locked loops, discussion of PLL lab
11		20 L24 Variations of Root Locus	21	22 L25 Pole dominance, Physical realization,	23	24 L26 PID tuning and Relay logic
12		27 L27 Ladder Logic & Programmable Logic Controllers (PLCs)	28	29 L28 Frequency-Domain, Bode plots, basic examples	30	31 L29 Bode Plots complex poles & zeros, damping fact., nat. freq.
13	April	3 L30 Bode Plots to Transfer functions	4	5 L31 Bode Plots to Transfer functions, Gain and phase margins	6	7 Exam 3
14		10 L32 Relation to transient response, Frequency-Domain Design	11	12 L33 Amplifier Feedback & freq response, Op Amp compensation, Zin, Zout	13	14 L34 Discrete-time Signals and Systems
15		17 L35 The z-transform and properties	18	19 L36 Properties of the z-transform	20 ME Design Day, Union Build.	21 L37 Inverse z-transform
16		24 L38 Digital control	25 Last Day of Classes	26 Reading Day	27 Finals ECE 3510 Review	28 3510 Final 10:30 AM
17	May	1	2	3	4 Freedom	5

ECE 3510 Spring Semester, 2023

MERRILL ENGINEERING BUILDING (BLDG. 064)

SECOND FLOOR PLAN