ECE 3510

Introduction to Feedback Systems
Spring 2021 Class Syllabus

Instructor: Arn Stolp

Office: I don't expect to use my office or office phone: MEB 2262, (801) 581-4205

Phone: **(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.

Office hours: My "office hours" are the Zoom sessions at class time and 1 hour after each class. Otherwise, text me. Start text with "ECE 3510" and your question.

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

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.

The Class:

I plan to teach most, if not all, of the class this semester as a "flipped" class.

Lectures: Watch video lectures before the Zoom session on the same subject.

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 watching on schedule is important. I will link to them in Canvas "assignments". The lectures are also available at: ece.utah.edu/~ece3510/ECE3510lect_S21.html .

Zoom Sessions: M, W & F 10:45 -11:35 am

Attendance is a required for at least the first 10 minutes of each session so that I can make class announcements. I may also cover new material and examples not in the regular video lectures. These are also problem and review sessions and your primary chance to ask questions and get help, it's highly likely that you will never see me in person this semester. Together, the video lectures and the Zoom sessions make a "flipped" class. I intend to record these sessions and publish them on Canvas.

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.

Homework, homework, and more homework: 100 pts.

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.

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.

Please scan your homework to a pdf file and turn it in to Canvas by 11:59pm on the due date.

Virtual Handouts:

To make things a little easier for you, I will group class notes and homework assignments into weekly packets and link to them from Canvas "assignments". Lab assignments will be linked separately. All of the "handouts" for, homework, labs, notes, etc. are also available on the class web site; ece.utah.edu/~ece3510/ .

Midterms: 300 pts.

You will take three 50-minute midterms throughout the semester. They will cover material up to the time of the test. Exams are normally closed book, closed notes, but will have to be a little different this semester. More information to come. My exams are designed to see if you learned concepts and problem solving strategies and whether you can work with them, sometimes in new and different ways. I want to find out how much you *know*, not how quickly you can find a similar example. Don't try to memorize specific problems. Exams also cover what you learn in the labs.

Final: Wednesday, 5/5/21 10:30 - 12:30 pm 180 pts.

The final will be comprehensive with greater emphasis on the last material. Zoom review Tuesday, 3:30 - 5:30 pm .

Labs: MEB 2365 70 pts.

Due to the severity of covid-19 issues, all labs will be available on line at this time. They will be a combination of zoom videos and simulations. There will probably be an in-person option as well, pay attention to announcements on canvas.

Grades:

	Pts
Homework:	100
Labs:	70
Midterms:	300
Final:	180
Total:	650
Cheating:	-650

% 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.

ECE 3510

A. Stolp

Tentative

01/15/21

Spring 2021 COURSE SCHEDULE

Week		Date	lect	Topics	Books Bodson	Nise
1	M	01/18		Martin Luther King Day		
	W	01/20	1	Introduction to Feedback Systems, Block diagrams	1.1	1.1 - 6
	F	01/22	2	Transfer functions and signals, The Laplace transform of signals	2.1	2.1
2	M	01/25	3	The Laplace transform, Relationship between pole locations and signal shapes	2.1	2.2
	W	01/27	4	Inverse of Laplace transforms using partial fraction expansions	2.2 - 3	2.2
	F	01/29	5	Martin Luther King Day		
3	M	02/01	6	Transfer functions, Interconnected systems, Feedback system		
	W	02/03	7	Systems, Circuits, BIBO stability	3.2	2.4
	F	02/05	8	Responses to step inputs, % overshoot, effect of zeros	3.3	4.1 - 4.5
4	M	02/08	9	Responses to sinusoidal inputs, sinusoidal steady-state	3.4	4.6 - 8
	W	02/10	10	Effect of initial conditions, State-space advantages	3.5 - 6	3.5
	F	02/12	11	Electrical analogies of mechanical systems	notes	3.1 - 3
5	M	02/15		Presidents Day		
	W	02/17	12	Electrical analogies of mechanical systems		
	F	02/19	13	Stability and Performance of Control Systems	4.1	6.1
	M	02/22		Exam 1		
	W	02/24	14	Control system characteristics	4.1	7.1
	F	02/26	15	Steady-state error and integral control	4.2	7.2 - 5
7	M	03/01	16	Routh-Hurwitz stability test	4.3	6.2 - 5
	W	03/03	17	Root-locus introduction, main rules RL1	4.4	8.1 - 5
	F	03/05	18	Root-locus main rules, examples fill in from screen	4.4	8.5 - 7
8	M	03/08	19	Root-locus additional rules, examples fill in from screen	4.4	9.1 - 3
	W	03/10	20	Root-locus design, PI, Lag, PD, Lead	4.4	9.4 - 5
	F	03/12	21	PID, Lag - lead, Catchup and Review		
9	M	03/15	22	Feedback design for phase-locked loops, discussion of PLL lab		
	W	03/17		Exam 2		
	F	03/19	23	Variations of Root Locus	notes	

					Books	
					Bodson	Nise
10	M	03/22	24	Pole dominance, Physical realization,	notes	9.6
	W	03/24	25	PID tuning	notes	
	F	03/26	26	Ladder Logic & Programmable Logic Controllers (PLCs)	notes	
11	M	03/29	27	Ladder Logic & Programmable Logic Controllers (PLCs)	notes	
	W	03/31	28	Frequency-Domain Analysis of Control Systems, Bode plots	5.1	10.1 - 2
	F	04/02	29	Bode Plots complex poles & zeros, ζ, ω_n	5.1	10.2
12	M	04/05	30	Bode Plots to Transfer functions	5.1	10.13
	W	04/07	31	Bode Plots to Transfer functions, Gain and phase margins	5.1, 3	10.7
	F	04/09	32	Nyquist Criterion of stability, introduction		
13	M	04/12		Exam 3		
	W	04/14	33	Nyquist Criterion of Stability, poles on the jω axis	5.2	10.5
	F	04/16	34	Gain, phase and delay margins	5.3	10.6-7, 12
14	M	04/19	35	Relation to transient response, Frequency-Domain Design	5.3	10.8, 11
	W	04/21	36	Discrete-time Signals and Systems	6.1	13.1 - 2
	F	04/23	37	The z-transform	6.1	13.3
15	M	04/26	38	Properties of the z-transform	6.2	13.3
	W	04/28		Problem Session, 10:45		
	T	05/04		Review 3:30		
	W	05/05		Final Exam, 10:30 -12:30		

ECE 3510 Spring Semester, 2021

01/17/51

Week	Month	Mon	Tue	Wed	Thur	Fri
1	Jan	18 Martin Luther King Day	19 First Day of Classes	20	21	22 Last day to add or drop simply
2		25 Hw1	26	27	28 Hw2	29 Last day to add or drop Hw3a Sat
3	Feb	1	2 Hw3b Sat	3	4	5 Hw4
4		8	9 Hw5	10	11	12 Hw6
5		15 Presidents Day	16	17 3510 Exam 1	18	19
6		22	23	24	25	26
7	Mar	1	2	3	4	5
8		8	9	10	11	12 3510 Exam 2
9		15	16	17	18	19 Last day to withdraw
10		22	23	24	25	26
11		29	30	31	1	2
12	April	5	6	7 3510 Exam 3	8	9
13		12	13	14	15	16
14		19	20	21	22	23
15		26	27 Last Day of Classes	28 Reading Day ECE 3510 prob ses	29 Finals begin	30
16	May	3	4 ECE 3510 reveiw 3:30	5 ECE 3510 10:30	6 Freedom	7

ECE 3510 Spring Semester, 2021