Title of Course

EML 5311 Section:
Class Periods: Fully online
Location: cloud
Academic Term: Spring 2022

An important announcement: Starting in Fall 2021, EML 5311 is – and will be - offered every Fall, not in the Spring. This particular installment is offered as a special service to those MS students who did not know about the change in the schedule of EML 5311 (since it used to be offered every spring) and need to take the course in order to meet requirements or to take the MS exam. Therefore, the course is offered in a "limited offering" sense: there will be no live lectures. Instead, videotaped lectures from Spring 2021 will be made available via canvas. If you are a regular PhD student, I recommend that you wait till Fall 2022 to take this course.

Instructor:

Name: Prabir Barooah
Email Address: please use the messaging service in canvas, not email, to contact me. In an emergency, use pbarooah@ufl.edu
Office Phone Number: 352 294 0411
Office Hours: MW 4-5 pm, in person, in MAE B 324.

Teaching Assistants:

- None

Course Description

The course is meant to provide a graduate-level introduction to control theory, and the application of the theory to the design of controllers for engineering systems. The material will focus on LTI (linear time invariant) systems, with some discussion on how to apply these techniques developed to the control of non-linear systems.

The following is a list of topics that will be covered in the class.

Part A: Classical control design/analysis through frequency-domain techniques

1. Dynamic systems LCCODE (linear, constant coefficient ordinary differential equation) models of dynamic systems, BIBO stability, stabilization through feedback control.

2. Design for stability and tracking setpoints PID compensators, design for transient performance through pole placement.

3. Frequency response Arbitrary signals as sum of sinusoids, Bode plots, asymptotic tracking of constant and sinusoidal references.

4. Control design issues/techniques: Robustness, sensitivity and complementary sensitivity func- tions, tracking requirements, Loop shaping design. Lead/Lag compensators.

5. Putting a factor of safety in the design: Nyquist stability criteria, gain and phase margins.

6. Data-driven modeling: System identification from input-output data.

Part A will span approximately 19 lectures.

Part A is on classical control design techniques. The next part, part B, will use modern control design and analysis techniques that use the so-called state space methods. While classical control uses Laplace and Fourier transforms, modern state space methods operate in the time domain without using trans- forms.

Part B: Modern control design/analysis techniques (main tool: linear algebra)

1. A very brief but intense review of linear algebra: matrices as linear maps between vector spaces, range and null spaces, four fundamental subspaces, span, basis, linear independence, eigenvalues and eigenvectors.
2. Linear systems: LTI and LTV systems, Lyapunov vs. BIBO stability of LTI systems, eigenvalues and Lyapunov equation.
3. State-space design: Controllability and state feedback, Observability and output-feedback. Lu- enberger observer, separation principle.
4. Connections between time domain and Laplace domain: State-space to transfer function and vice versa (of LTI systems), minimal realization, canonical decomposition.
5. From C(s) to C-code Discrete-time systems, sampling and state-space representation, stability. Implementing continuous-time control design through digital computers.
6. Control of nonlinear systems using linear controllers: State-space description of non-linear dy- namic systems, simulations in MATLAB©, equilibrium points, linearization around an equilib- rium point, linearization around a trajectory, controller implementation for nonlinear plant using its linearization.
7. Optimal Control
   (a) The general optimal control problem.

   (b) LQR : The Linear Quadratic Regulator problem, derivation of the ARE and DRE, finite and infinite horizon problems.

Part B will span approximately 24 lectures.

Course Pre-Requisites / Co-Requisites

Since this course is a graduate level introduction to control theory, students are required to have taken an undergraduate level controls course. In particular, the students are expected to have an under- standing of Laplace transforms and transfer functions. The beginning of Part A will therefore mostly be a quick review, slowing down toward the end when we encounter loop shaping and Nyquist criterion. Part B is expected to be new to all, so no familiarity with this material is expected. Familiarity with MATLAB© and Simulink© is also required, as they will be used extensively.

Course Objectives
Obtain a firm background in classical and modern linear control system theory.

Materials and Supply Fees
None

Required Textbooks and Software

The following books are required textbooks for this course.

1. An Introduction to Feedback Control by Prabir Barooah (for Part A). A pdf copy of the book is available (at no charge) through canvas, under Files > Resources > Textbook. note: An old version of this textbook is available in Amazon. Don't buy that version; the one we will use has been updated recently.

2. Linear System Theory and Design by Joao P. Hespanha, Princeton University Press, (for Part B). This book has a second edition, but for this course either edition is fine.

A word of caution: the second textbook (JPH) is a true graduate level textbook while the first one (PB) is meant for undergraduates. Also, we will be using bits and parts of the second textbook that are scattered over it. A combination of these two factors may make the second textbook appear harder to follow.

Attendance Policy, Class Expectations, and Make-Up Policy

There is no attendance policy, since this course will be conducted in a purely virtual format. No late submission is allowed.

Evaluation of Grades

Assignment	***Total Points***	***Percentage of Final Grade***
Homework Sets (8)	100 each	100%
		100%

Grading Policy

Percent	***Grade***	***Grade Points***
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 79.9	C+	2.33
72.0 – 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
UF Graduate Catalog
Grades and Grading Policies

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Click here for guidance on how to give feedback in a professional and respectful manner. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students here.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you

are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see the Notification to Students of FERPA Rights.

Campus Resources:

Health and Wellness

U Matter, We Care:
If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or police.ufl.edu.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling.

Library Support, Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.

Student Complaints Campus

On-Line Students Complaints