MEC 411 Control System Analysis and Design

FALL 2018

Instructor: **Noah D. Machtay, Ph.D., P.E.,** 146 Heavy Engineering Building, 2-9014
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(emails will generally be answered within 2 business days)

Office Hours:	MWF 7:30-8:30AM, TuTh 1:15-2:15PM, HE146		
Lecture:	MF	1:01-2:21pm, Frey 104	
Monday Lab:	Mon	10:00am -1:00pm,	HE139
Tuesday Lab:	Tue	10:00am -1:00pm,	HE139
Wednesday Lab:	Wed	10:00am -1:00pm,	HE139
Thursday Lab:	Thu	10:00am -1:00pm,	HE139

Attendance policy: Lectures are required – there will be no make-ups for announced or ***unannounced*** in-class assignments. When scheduled, lab sessions are absolutely mandatory. Students who are late for or miss a lab session will receive a grade of zero for that lab report.

Recommended Text: Franklin, "Feedback Control of Dynamic Systems," 6th Edition, Pearson Prentice Hall 2010. ISBN: 0-13-601969-2.

Assignments: Homework problems have been assigned for the duration of the semester, and have been posted along with their solutions. Homework is not graded, due to the prevalence of website selling solutions to homework sets. Homework is assigned solely for the benefit of the student, so that they may practice the principles discussed during lecture, evaluate their understanding, and, in part, prepare for examinations. There will also be a number of laboratory reports that must be completed and submitted. Assignments are due and must be submitted as specified on Blackboard, through the Blackboard system; it is each group member's responsibility to ensure that their reports are properly submitted through Blackboard before the deadline; late submissions will result in a grade of zero for the assignment.

Lab work: Students will form into lab groups of 3. Lab groups are responsible for conducting experiments and design projects as instructed, and preparing and submitting reports as a group. It is each student's responsibility to ensure that the group functions well and achieves the assigned goals. Students found to be making insufficient contributions to their group's work will be removed from the group, and will receive a grade of zero for all lab and/or design work, at the sole discretion of the instructor.

Exams: *Two midterm exams and a final exam.* Midterm 1: 10/15/2018, Midterm 2: 11/19/2018, Final as scheduled by registrar. No make-up exams will be given. Exams will be closed book/closed notes.

Grading: *1st midterm: 15%, 2nd midterm: 15%, Lab and Design reports: 30%, Final: 30%, Participation: 10%.*

Cell phone and electronic device policy: Cellular phones or other communication devices are not permitted in lectures or labs, and are especially prohibited from exams. If you are found to be in possession of such a device during an exam, you will be ejected from the exam and will receive a grade of zero. Audio or video recording or photography during lectures is strictly prohibited, and anyone found in violation will be ejected from the course with a failing grade. Students may not use personal electronic devices during lectures, exams, or lab sessions – this includes but is not limited to cell phones, laptop computers, cameras, music devices, etc.

Course Objectives: This course will cover the analysis and design of feedback control systems. Topics include system modeling; transfer function; block diagram and signal-flow graph; sensors, actuators, and control circuit design; control system characteristics and performance; stability analysis; root locus method; Bode diagram; PID and lead-lag compensator design, time permitting. A preexisting understanding of calculus up to and including differential equations and Laplace transforms is ***essential*** (see prerequisites) as these tools are intrinsic to the study of control system analysis and design.
Prerequisites: AMS 361 or MAT 303, MEC 262, MEC316.

Excused absences for religious observance: From the university policy statement regarding religious holidays, students will be expected to notify their professor in advance, but definitely before the final date of the 'add/drop' period of their intention to be out for religious observance. Notification of intention to be out for a religious holiday MUST be made through the CEAS Undergraduate office, who will verify and evaluate the notification, and provide the instructor with ap-

propriate instructions; you must include your name, SBID#, and the course number when contacting CEAS in regards to your absence.

Statement on Academic Dishonesty

Academic dishonesty is an extremely serious offense and will not be tolerated in any form. Academic dishonesty in general is the presentation of intellectual work that is not originally yours. Examples include, *but are not limited to*, copying or plagiarizing class assignments including homework, reports, designs, and other submitted materials; copying or otherwise communicating answers on exams with other students; bringing unapproved aids, either in physical (written) or electronic form to an exam; obtaining copies of an exam prior to its administration, etc. Academic dishonesty violates both the ethical and moral standards of the Engineering profession and all infractions related to academic dishonesty will be prosecuted to the fullest via the CEAS CASA committee. For you, the honest student, academic dishonesty results in lower class curves, hence a depression in your GPA and class standing, while cheapening the degree you earn. Please note that failing to provide proper citations in a paper or report constitutes plagiarism and will be prosecuted accordingly. [1]

Allowed Calculators

For both security and uniformity in this class **only** the following calculators will be allowed to be used on the midterm and final exams. There will be no exceptions. This list of calculators is identical to that allowed for the *National Council for Examiners for Engineering and Surveying* (NCEES) Fundamentals of Engineering (FE) exam that many of you will take in your senior year, as well as the Professional Engineering (PE) exam that you may take several years from now. The sooner you become comfortable on one of these calculators, the better. If you have any questions on this policy please feel free to contact me. The NCEES policy on calculators can be found here:

http://www.ncees.org/Exams/Exam-day_policies/Calculator_policy.php

Casio:	All **fx-115** models. Any Casio calculator must contain **fx-115** in its model name.
Hewlett Packard:	The **HP 33s** and **HP 35s** models, but no others.
Texas Instruments:	All **TI-30X** and **TI-36X** models. Any Texas Instruments calculator must contain either **TI-30X** or **TI-36X** in its model name.

Approximate Course Schedule, subject to revision:

Topic 1	Introduction, Course Objectives, Open vs. Close-Loop Systems
Topic 2	Review of Mathematical Models, Linear vs Non-linear Systems
Topic 3	Laplace Transforms, Laplace Domain vs Time Domain, Overdamped vs Underdamped Systems
Topic 4	Transfer Functions, Block Diagram, Signal Flow Graph, Three Term PID Controller
Topic 5	Transient vs Steady State Response, Control of Transient Response
Topic 6	Control System Performance, Rise Time, Settling Time, Percent Overshoot, Peak Time, Parameter Selection
Topic 7	Stability, Routh-Hurwitz Stability Criterion
Topic 8	Control System Characteristics, Sensitivity, Noise Attenuation, Disturbance Rejection
Topic 9	Stead State Error, Test Inputs, Simplification of Linear Systems
Topic 10	Root Locus Analysis, Root Locus Analysis for Multi-Parameter Systems
Topic 11	Frequency Response, Fourier Transforms, Frequency vs Time vs Laplace Domain
Topic 12	Bode Diagrams, Combined Log-Magnitude Phase Plot
Topic 13	Stability in the Frequency Domain, The Nyquist Stability Criterion, Gain and Phase Margin
Topic 14	Compensator Design (Cascade, Feedback, Load, and Input Compensators), Phase Lead and Phase Lag Compensators

[1] Dr. Jon Longtin, Department of Mechanical Engineering, Stony Brook University

Course Learning Objectives
1. Ability to analyze differential equations using Laplace transforms and model the behavior of physical systems using differential equations.
2. Ability to represent a control system using block diagrams, signal flow graphs, and transfer functions.
3. Ability to identify system performance characteristics used for parameter selection.
4. Ability to analyze system behavior using the Root Locus method.
5. Understanding of the functionality of PID controllers.
6. Familiarity with frequency response, the construction and analysis of Bode diagrams, stability in the frequency domain, and compensator design.
7. Understanding of the use and application of technology including oscilloscopes, waveform generators, multimeters, power supplies, and MATLAB software.

Grading Policy:

Undergraduate:	
100-95 = A	
94-90 = A-	
89-87 = B+	
86-84 = B	
83-80 = B-	
79-77 = C+	
76-74 = C	
73-70 = C-	
69-65 = D+	
64-60 = D	
<60 = F	

Note: All grades are TRUNCATED, not rounded.

University required statements:

"STUDENT ACCESSIBILITY SUPPORT CENTER (SACS) STATEMENT (must be the following language)
If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or at sasc@Stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential. Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website: https://ehs.stonybrook.edu/programs/fire-safety/emergency-evacuation/evacuation-guide-people-physical-disabilities and search Fire Safety and Evacuation and Disabilities.
ACADEMIC INTEGRITY STATEMENT (must be the following language as approved by the undergrad council):
Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/uaa/academicjudiciary/
CRITICAL INCIDENT MANAGEMENT (must be the following language as approved by the undergrad council):
Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures."