FLORIDA ATLANTIC UNIVERSITY

COURSE CHANGE REQUEST
Graduate Programs

UGPC Approval ______
UFS Approval ______
SCNS Submittal ______
Confirmed ______
Banner ______
Catalog ______

Department CEECS

College Engineering and Computer Science

***Current* Course Prefix and Number** EEL 5654	***Current* Course Title** Control Systems 2

*Syllabus must be attached for **ANY** changes to current course details. See Guidelines. Please consult and list departments that may be affected by the changes; attach documentation.*

Change title to:

Change prefix

From: **To:**

Change course number

From: **To:**

Change credits*

From: **To:**

Change grading

From: **To:**

Academic Service Learning (ASL) **

Add ☐ **Remove** ☐

* Review Provost Memorandum
** Academic Service Learning statement must be indicated in syllabus and approval attached to this form.

Change description to:

Change prerequisites/minimum grades to:
Graduate standing

Change corequisites to:

Change registration controls to:

Please list existing and new pre/corequisites, specify AND or OR and include minimum passing grade.

Effective Term/Year for Changes: Spring 2021

Terminate course? Effective Term/Year for Termination:

Faculty Contact/Email/Phone Hanqi Zhuang/zuang@fau.edu/ 297-3413

Approved by		***Date***
Department Chair	Hanqi Zhuang — Digitally signed by Hanqi Zhuang Date: 2020.10.21 15:53:53 -04'00'	
College Curriculum Chair	Francisco Presuel-Moreno — Digitally signed by Francisco Presuel-Moreno DN: cn=Francisco Presuel-Moreno, o=Florida Atlantic University, ou=Ocean and Mechanical Engineering, email=fpresuel@fau.edu, c=US Date: 2020.10.22 11:54:53 -04'00'	
College Dean	M Cardei — Digitally signed by Mihaela Cardei DN: cn=Mihaela Cardei, o=Florida Atlantic University, ou, email=mcardei@fau.edu, c=US Date: 2020.10.25 19:56:06 -04'00'	10/25/2020
UGPC Chair		
UGC Chair		
Graduate College Dean		
UFS President		
Provost		

Email this form and syllabus to UGPC@fau.edu 10 days before the UGPC meeting.

1. Course title/number, number of credit hours	
Control Systems 2 – EEL 5654	3 credit hours
2. Course prerequisites, corequisites, and where the course fits in the program of study	
Prerequisites: Graduate standing	
3. Course logistics	
Term: *Class location and time*:	
4. Instructor contact information	
Instructor's name *Office address* *Office Hours* *Contact telephone number* *Email address*	
5. TA contact information	
TA's name *Office address* *Office Hours* *Contact telephone number* *Email address*	
6. Course description	
Internal stability, stabilization, minimum weighted sensitivity control design, controller design in the presence of unknown disturbances, and model uncertainty.	
7. Course objectives/student learning outcomes/program outcomes	
Course objectives	1) Understanding how to implement controllers digitally 2) Understanding how to analyze and simulate control systems that suffer from nonlinearities 3) Learn about advanced nonlinear control design methods 4) Apply computer-aided-design to Digital Control and Nonlinear Control
Student learning outcomes & relationship to ABET a-k objectives	a) an ability to apply knowledge of mathematics, science and engineering - use of complex variables and complex functions, along with elements of functional analysis b) an ability to design and conduct experiments, as well as to analyze and interpret data – Finding transfer function model from measured time response and frequency response data c) an ability to design a system, component, or process to meet desired needs – Understanding how to interpret time domain and frequency domain design specifications and how to translate it to a feedback controller design d) an ability to function on multi-disciplinary teams – We expose electrical

	engineering students to control models taken from mechanical, aerospace and biomedical engineering. e) an ability to identify, formulate and solve engineering problems – Many of this course's design problems are open ended. f) an understanding of professional and ethical responsibility – N/A g) an ability to communicate effectively – students submit 6 Matlab/Simulink project. Emphasis is on written communication. h) broad education necessary to understand the impact of eng solutions in global and societal context – N/A i) a recognition of the need for and an ability to engage in lifelong learning – N/A j) a knowledge of contemporary issues – N/A k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice – use of Matlab and Simulink

8. Course evaluation method

3 one-hour Exams (each may be up to 18%) 36-54% 3 Homework Assignments (up to 18% each) 54-36% 1 Simulation Project and Brief Presentation 10% Worst Third Exam or Third Homework 5% Selection to the Gallery of Solutions (1% each) 4% Total Maximum Score is 109% as a) the worst score (among the three homework sets and three exams) will be bonus-scored on a scale of 0-5%. You may skip altogether one test or one assignment, or try them all. That is, there are 5% extra credit points added to the 100% base, and b) 1% bonus will be awarded to any solution selected to the Gallery of Best Solutions (there may be 2-3 selections for each homework). There will be a Gallery of Best Projects, as well. In total one may score up to 9 bonus award points. **Projects Information:** In the middle of the semester (near the end of Week 3) a list of projects will be announced and	*Note*: The minimum grade required to pass the course is C.

distributed. Such a list is already tentatively shown in the Course Calendar. As can be seen in the Calendar, for all the lectures done by Dr. Roth on the last week of the semester (Week 6) the material is not included neither in Homework 3 nor in Exam 3. These will be lectures about Control Design subjects that go beyond the scope of the course. In each of these lectures there will be brief presentations (by students) of simulation results that support the lecture material. The individual work on these lectures and simulations will be individually guided by Dr. Roth throughout the last three weeks of the semester. In addition to the brief presentations, students will have to submit a short project report.

9. Course grading scale

Grading Scale:
A= 90-100%, A-=85-89%, B+=80-84%, B=75-79%, B-=70-74%, C+=65-69%, C=60-64%, C-=55-59%, D+=50-54%, D=45-49%, D-=40-44%, F=0-39%.

10. Policy on makeup tests, late work, and incompletes

Makeup tests are given only if there is solid evidence of a medical or otherwise serious emergency that prevented the student of participating in the exam. Makeup exam should be administered and proctored by the College of Engineering Distance Education Office.

Late work is acceptable. Penalty points may be deducted depending how late the work is.

Incomplete grades are given only if there is solid evidence of medical or otherwise serious emergency situation incomplete grades will not be given.

11. Special course requirements

N/A

12. Classroom etiquette policy

University policy requires that in order to enhance and maintain a productive atmosphere for education, personal communication devices, such as cellular phones and laptops, are generally to be disabled in class sessions.
Due to the design contents and the live design software demonstration, the use of laptop computers in class is allowed.

13. Attendance policy statement

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance. Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University-approved activities. Examples of University-approved reasons for absences include participating on an athletic or scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

14. Disability policy statement

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at www.fau.edu/sas/

15. Counseling and Psychological Services (CAPS) Center

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services – individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau.edu/counseling/

16. Code of Academic Integrity Policy Statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys an unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and places high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. For more information, see University Regulation 4.001.

17. Required texts/reading

N/A – Lecture Notes will be posted

18. Supplementary/recommended readings

Reference Material: (Optional reading – no need to purchase)

For the Digital Control material: (any one of the following, and there are many others, including older editions)

1) "Digital Control of Dynamic Systems " by G.F. Franklin, J.D. Powell and M.L. Workman, 3rd Edition, Addison-Wesley 1997.
2) "Digital Control System Analysis & Design" (4th Edition) by C.L. Phillips and T. Nagle, 2014

For the Nonlinear Control material: (here the choices are more limited – any one of the following two is good)

3) "Applied Nonlinear Control" by J.J. Slotine and W. Li, Prentice Hall 1991.
4) "Nonlinear Control" by H.K. Khalil, 2014.

19. Course topical outline, including dates for exams/quizzes, papers, completion of reading

In general, any six-week summer course, with lectures of 3 hours and 10 minutes twice a week, can be hard on any student. Therefore, each of the course's 12 sessions will be broken to three parts with a 10 minute break in between. The three lecture parts, on each session, will have different subjects: Part A (11:30-12:25) of each lecture will be devoted to Digital Control theory, Part B (12:35-1:30) will be devoted to Nonlinear Control theory, and Part C (1:40-2:40) will involve either MATLAB and/or Simulink activities related to the theory parts. In three (out of 12) sessions, Part C will involve one-hour written examinations. The exams will be spaced two weeks apart. On these exam days, the MATLAB/Simulink activities may be inserted into the A and B parts.

Week / Lecture # / Lecture Part	**Recording Date**	**Topics** *Computer activities are shown in italic letters*	**Comments and Deadlines**
		Course Syllabus and Logistics; Brief overview: Sampled-Data Control Systems – Controller's Structure and Control System Timing; The Sampling Theorem; Zero-Order and Higher Order Hold Devices	
		Examples to first and second order nonlinear models: Equilibrium Points; 2nd Order Linear System's Phase Plane Trajectories and Equilibrium Point Classification – Node, Focus, Center, Saddle	
		Simulink: Sampling and Hold of Signals; *Simulink: Simulation of the Logistic Model and other processes*	
		Brief Introduction to Linear Discrete-Time Systems: Difference Equations, Discrete Time Impulse Response; The Z Transform, Discrete-Time Transfer Functions	
		Linearization of first and second order nonlinear systems - Lyapunov's First Theorem; Examples to the linearization method	

		MATLAB CST: Discrete Time Systems and Discrete Time Response; MATLAB CST: Study of discrete-time transient response; Model reduction based on comparison of step response plots; Simulink: Linearization using Trim and Linmod commands applied to model subsystems	HW1 given (Sampling & Hold, Z Transform, Equilibrium Points, Linearization, Stability in the Z plane and Jury's Test, Phase Plane Plots)
		Stability in the Z plane: Jury's Stability Test Mapping from the S plane to the Z Plane: Mapped real and imaginary poles, mapped settling time and damping coefficient	
		Plotting Phase Plane Trajectories; Conservative Nonlinear Second Order Systems; Piecewise Linear Nonlinear Systems – Real and Virtual Equilibrium Points	
		Simulink: Running Simulink from Matlab; Multiple Runs with Phase Plane Plots for Multiple Initial Conditions and Variable Parameters	
		Discretizing of Continuous-Time Processes, Numerical Integration Methods; Examples	HW1 due
		Piecewise Linear Nonlinear Systems – Real and Virtual Equilibrium Points (cont'd); Phase Plane Analysis of various Linear 2^{nd} Order Systems driven by step input	
		Exam 1 (covering HW1 material)	HW2 given (Piecewise-Linear Nonlinearities, Nonlinear Servo Systems, Discretizing of Continuous-Time Processes, Pulse Transfer

			Function, Tracking Errors in Digital Control Loops)
		Hybrid Continuous Time and Discrete Time Control Loops: The Pulse Transfer Function; Examples for Discretization of Hybrid Digital Control Systems	
		Nonlinear Feedback Systems with Saturation and Dead Zone blocks; Relay Servomechanisms: Sliding Mode Effects due to Velocity Feedback	**Projects Assignment to students enrolled in the graduate sections**
		Simulink Analysis of nonlinearities in Servo Systems	
		Application of the discrete time version of the Final Value Theorem to Digital Control Steady-State Errors; Discrete-Time System Type; Examples: Tracking Errors combined with closed-loop stability tests	
		Minimum Time Relay (Bang-Bang) Control; Relay Servomechanisms (continued); More Examples – Systems with Friction, more relay servomechanism examples	
		Simulink and CST demos of discrete time steady state tracking errors; *Simulink demonstration of the Sliding Effect*	
		Digital Controller Design based on the Synthesis of a Closed-Loop Transfer Function; Examples	
		Sliding Mode Control (SMC): Introductory Ideas for First Order Control System: Single and Multi Relay Implementation; Control Smoothing via replacement of relays with high gain amplifiers	
		Case Study: Phase-Locked Loops: Principle and Demonstration; *Simulink simulation of a PLL*	
		Minimum Settling Time Digital Control Design and examples	HW2 due

		Sliding Mode Control of First Order Systems - examples	
		Exam 2 (Covering HW2 material)	HW3 given (Minimum Settling Time Digital Control, Digital Control Design by Closed Loop Synthesis, Sliding Mode Control, Bang Bang Control, Controller Realization, Bode Design of Digital Controllers)
		Discretizing of Analog Controllers; Frequency Domain Design of Digital Controllers; Review of Bode Design in Continuous Time Control Loops; Bode Design and Discretization Examples	
		General Multi-Relay Sliding Mode Control Design Approach; Examples	
		Simulink demonstration of Sliding Mode Control; *SISOTOOL Frequency Domain Design of Digital Controllers*	
		Digital Controller Implementation: Direct Form, Cascade and Parallel Realizations	
		General Single-Relay Sliding Mode Control Design Approach; SMC Design: Control Signal Smoothing	
		More Simulink demonstrations of SMC; *CST Demonstration of Minimum Settling Time Control*	
		W Grade Deadline	
		The last week of the course features extra topics that are not in HW3 and as such are not in Exam 3. These topics are included in the guided projects assigned to the students. Projects presentation times are randomly selected (not	

		necessarily as shown)	
		Project 1: SISO Discrete-Time Pole Placement Controller Design *Pole Placement design examples using Matlab Symbolic Math Toolbox*	
		Projects 2 and 3: Auto-Tuning of PID Controllers *Simulink demonstrations of PID Auto-tuning (Relay tuning, SI closed-loop tuning)*	
		Stability of Continuous-Time Systems with Pure Time Delay – analysis using Bode plots; **Project 4:** Bode Design in the presence of pure time delay; *MATLAB CST: Design of Control Systems with Pure Time Delay using SISOTOOL* [Additional possible project: Bode Design for Systems with RHP Zeros]	
		Project 5: Smith Predictor-Corrector; Examples to loop shaping design using Smith Predictor	HW3 due
		Project 6: The Internal Model Principle and Examples; **Project 7:** Feedforward Control and Examples	
		Exam 3 (covering HW3 material)	