Process Control Lab
ECH 4323L Section 6151 (Class Number 21217)
Class Periods: Th Period 9-11 (4:05-7:05 PM)
Location: Larsen 310
Academic Term: Spring 2024

Instructor: Spyros A. Svoronos
Phone: 352-392-9101 (O), 352-378-1342 (H landline), I do not carry a cell phone
E-mail: svoronos@ufl.edu
Office Hours: T 4:30-6:00 PM in my office and via Zoom
                            W 5:10-6:15 PM in my office and via Zoom
                            F 5:10-6:15 PM in my office and via Zoom

Zoom: https://ufl.zoom.us/j/6379945549 with passcode: 0

Masking policy: I am considered high risk, as I will be turning 70 this year and have certain health issues. To protect myself I will be wearing a mask consistently. I believe that this precautionary measure is ample to safeguard my health. It's important for me to clarify that my decision to wear a mask should not be misconstrued as a solicitation for you to do the same. My choice to wear a mask should not influence your own decision regarding mask usage.

Teaching Assistant: None

Course Description
The analysis and automatic control of process systems in chemical engineering.

Course Pre-Requisites / Co-Requisites
Corequisite: ECH 4323

Course Objectives
- The student will be able to obtain data from an experimental system and use the data to build approximate open-loop models useful for controller tuning.
- The student will be able to tune a proportional-integral-derivative controller (PID) in a closed loop implemented by an Arduino microcontroller.
- The student will understand the advantages and disadvantages of low pass filtering and will be able to tune such a filter.

Materials and Supply Fees: $30

Relation to Program Outcomes (ABET):

	Outcome	Coverage*
1.	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2.	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	High
3.	An ability to communicate effectively with a range of audiences	
4.	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5.	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6.	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	High
7.	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

Required Textbook: None. Instructor notes are posted in CANVAS.

Spring 2021 Videos: https://uflorida-my.sharepoint.com/:f:/g/personal/svoronos_ufl_edu/EtBnr53oz3NLqlCy4xVmqEgBKKl3l_lEbLdH99V2hRfa7g?e=IAY0Ye

Computer: Laptop computer <u>with at least one available USB port</u> **running Windows** and **Excel** is **required.** Additional software is provided by the instructor.

Additional Requirement: Arduino-based equipment for conducting experiments (provided)

Course Topics

- Modeling a physical temperature-control system of a water-filled container heated by a beverage heater and cooled by computer fans
- Linearizing the model of the temperature-control system
- Directly obtaining a first order plus time delay (FOPTD) transfer function model by fitting parameters to experimental data from step changes

- Directly obtaining a higher order transfer function model by fitting parameters to experimental data from step changes
- Directly obtaining transfer function models by fitting parameters to experimental data from pulse changes
- Designing PI and PID controllers for a FOPTD model using the Cohen-Coon and the minimization of integral-time-absolute-error methods, and experimentally testing their performance.
- Designing PI and PID controllers for FOPTD and higher order transfer functions using the Ziegler-Nichols method and experimentally testing its performance
- Experimentally investigating the effect of the filtering time constant on the performance of PID controllers

Experiments (Weekly Activities):

1. Introduction to class. Explanation of the syllabus,
2. For half of the class: Equipment pickup, software installation and testing, equipment instructions and testing.
3. For the remainder of the class: Equipment pickup, software installation and testing, equipment instructions and testing.
4. Intro to Process Control: Student competition on controlling the can temperature manually.
5. Experiments to validate the energy balance model for the heater effect on the can temperature.
6. Experiments used to build a model of the effect of fan speed on the heat transfer coefficient.
7. Introduction to feedback control and the benefits of integral action.
8. Step change experiments used to build a first order plus time delay (FOPTD) transfer function model.
9. Testing the performance of PI controllers tuned using the Cohen-Coon and ITAE minimization methods applied to the transfer function of Experiment 5.
10. Pulse input testing and use of the data to build a FOPTD transfer function model and a Second Order Plus Time Delay (SOPTD) transfer function model.
11. Testing the performance of PI controllers tuned using the Cohen-Coon and ITAE minimization methods applied to the transfer function of Experiment 7.
12. Experiments to investigate the effect of derivative action and low-pass filtering.
13. Testing the performance of PI and PID controllers tuned by the Ziegler-Nichols method applied to the FOPTD and SOPTD transfer functions of Experiment 7.
14. Student competition on controlling the can temperature with their designed PI or PID controllers.

Attendance Policy

You are expected to show up in class for each week's experiment. Unexcused absences will negatively affect the 5% of your grade that depends on attendance and participation. However, all lab experiments can be conducted at home, so there is no need to fall behind if you must miss a lab class. Note also that most lab experiments include lecturing or Excel work at times during which we wait for an experiment to be completed. I am providing access to recordings of the spring 21 offering of the lab class and accompanying PowerPoint slides, and I intend to follow the same topic coverage.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Course Assessment
- Lab reports 70%
    Each report question (or part of it) will be graded in a scale from 0 to 3, with a 3 earned only for perfect answers. Some assignments involve performing experiments.
- Final Controller Design Contest* 25%
- Class attendance & participation 5%.
    *The final Controller Design Contest plays the role of a final exam.

Detailed Explanation of Grading

1. For each student, Overall Points are calculated as follows:

Overall Points = 0.70 * Lab Report Average + 0.25 * Final Controller Design Contest + 0.05 * Class Participation Grade
where
- Final Controller Design Contest scores are 0-100
- Lab Reports Grade = (Total points earned)/(maximum possible points) *100
- Class participation grade:
    88 if student never misses class (without excuse) and never speaks. This number is multiplied by the fraction of times the student was present in class or had an excused absence. Then the grade is raised according to how frequently a student answers or asks questions. Corrections of lecture errors are especially appreciated.

2. The students are sorted in the order of decreasing overall points. Grades are then decided as follows:

Division between A and A- : Largest gap between two students with 90 >= overall points > 85
Division between A- and B+ : Largest gap between two students with 85 >= overall points > 80
Division between B+ and B : Largest gap between two students with 80 >= overall points > 75
Division between B and B- : Largest gap between two students with 70 >= overall points > 65
Division between B- and C+ : Largest gap between two students with 65 >= overall points > 60
Division between C+ and C : Largest gap between two students with 60 >= overall points > 55
Division between C and C- : overall points > = 50 (no gap here, 50 is C, 49.9 C-)
Division between C- and D+ : Largest gap between two students with 40 >= overall points > 35
Division between D+ and D :   30 +/- 2.5
Division between D and D- :   25 +/- 2.5
Division between D- and E :   20

Basically, a student with overall points (OP) >= 90 is guaranteed an A, a student with OP >= 85 is guaranteed an A-, a student with OP >= 80 is guaranteed a B+, etc. But to avoid the undesired situation where a student with OP 90.1 gets an A while a student with OP 89.9 gets an A-, the students are sorted in decreasing order of overall OP and the division between A and A- is made at the largest gap in OP (in the range 90-85). The table below is an example:

Sorted OP	Gap	Grade
90.1		A
89.8	0.3	A
89.1	0.7	A
88.4	0.7	A
86.3	**2.1**	A-
85.2	1.1	A-

The same procedure is followed for the division between A- and B+, B+ and B, etc.

The class participation grade is designed so that students who attend class regularly will not have an A grade lowered even if they never speak. It helps attending students with lower overall points.

ADDITIONAL INFORMATION

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. 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. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. 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 https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

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 Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

• Your academic advisor or Graduate Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

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: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

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

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

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

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

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. 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. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*: https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: http://www.distance.ufl.edu/student-complaint-process.