

---

## Industrial Controls Systems and Automation

---

**Class Location/Time:** MWF 1:25 PM – 2:15 PM. If instructor is absent for 15 minutes after the start of class, it can be considered cancelled for the day.

**Instructor:** Dr. Apoorva Kapadia

**Email:** akapadi@clemson.edu (You can expect a response within 36 hours excluding weekends and university holidays)

**Office:** 307 Fluor Daniel EIB

**Phone:** 864-656-3946

**Office Hours:** By appointment only. Office Hours will be online for the foreseeable future, until it is determined that in-person meetings are safe again.

**Course Modality:** Traditional (the university reserves the right to convert to online any time)

### Course Description

---

Introduction to control systems specifically related to industrial applications, and manufacturing and production systems. Topics include continuous variable control and the PID paradigm, the Z-transform, digital control, model-predictive control, direct adaptive control, discrete logic control, ladder logic and PLC implementation, and equipment interfacing and industrial networking protocols. **Prerequisite:** ECE 4090 with a C or better

### Course Objectives

---

The goals for this course are to provide the student with an understanding of applied industrial and process control methodologies and a framework for programming controllers in the manufacturing environment. The students will: 1) Learn how to apply mathematics to the analysis of control systems using methods beyond classical linear control, 2) Learn how to adapt control theory for discrete-time systems, and 3) Learn how to create ladder logic algorithms for control needs and implement them on a PLC.

### Required Materials

---

You will need a scientific calculator for this class. Some questions on the homework or the tests, however, may not involve numbers.

**Textbook:** *Industrial Controls and Manufacturing*, Kamen, Academic Press (useful but not mandatory)

**Computer:** Windows or Linux computer required for PLC programming and in the event remote access to the lectures is required.

## Topical Outline

---

- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. <b>The Process Control Problem (1 week)</b> <ol style="list-style-type: none"> <li>a. Motivation</li> <li>b. The Two-Tank Problem</li> <li>c. Continuous Variable Control</li> </ol> </li> <li>3. <b>Introduction to Digital Control (0.5 weeks)</b> <ol style="list-style-type: none"> <li>a. The Z-Transform</li> </ol> </li> <li>5. <b>Direct Adaptive Control (1.5 weeks)</b></li> <li>7. <b>Discrete Logic Control (1.5 weeks)</b></li> <li>9. <b>PLC Implementation – programming and testing on Linux PC or Arduino (3 weeks)</b></li> <li>11. <b>Tests (1 week)</b></li> </ol> | <ol style="list-style-type: none"> <li>2. <b>Control of Continuous Variable Processes (1.5 weeks)</b> <ol style="list-style-type: none"> <li>a. PID Control</li> <li>b. Effect of Disturbances</li> <li>c. Input Delay</li> </ol> </li> <li>4. <b>Model Predictive Control (2 weeks)</b></li> <li>6. <b>Neural Network Controllers (1 week)</b></li> <li>8. <b>Ladder Logic (1.5 weeks)</b></li> <li>10. <b>Equipment Interfacing and Industrial Network Protocols (0.5 weeks)</b></li> </ol> |
|--|---|

## Grading

---

Final grades will be determined by averaging the homework, exams, and the final exam based on the distribution below.

Regular Homework	10%
Graduate work comparing controllers listed in outline topics 4-7.	10%
PLC Programming	20%
2 Midterms Exams	40%
Final Project	20%
-----	-----
Course Grade	100%

90% – 100%	A
80% – < 90%	B
70% – < 80%	C
60% – < 70%	D
0% – < 60%	F

## Additional Policies

---

### Logistics

To keep up with course announcements, you need to check the Canvas site on a regular basis. All the material you need for the course is on the Canvas site. The site contains the homework assignments and due dates, homework answers, upcoming test dates, practice tests, test answers, and much more. Any exams cancelled due to power outages, inclement weather or similar conditions will be held at the next

class meeting unless explicitly stated by me on Canvas. Any assignments due at the time of the class cancellation will be rescheduled for the next class meeting day and will be stated on Canvas.

### **Homework**

Homework assignments will be posted on the Canvas site. The homework assignments should all be scanned and submitted as a PDF by 11:59 PM on the day it is due. Answers for every homework assignment will be posted after the due date. Working the homework problems is essential to the learning of the material in this course; Late homework will not be accepted.

### **Attendance**

Attendance is optional, but strongly recommended. In the event you cannot in-person, attending via Zoom is an option – the links are provided on Canvas. Online only students will have to attend via Zoom.

While on campus, face coverings are required in all buildings and classrooms. Face coverings are also required in outdoor spaces where physical distance cannot be guaranteed. Please be familiar with the additional information on the [Healthy Clemson](#) website, such as the use of wipes for in-person classes. If an instructor does not have a face covering or refuses to wear an approved face covering without valid accommodation, students should notify the department chair. If a student does not have a face covering or refuses to wear an approved face covering without valid accommodation, the instructor will ask the student to leave the academic space and may report the student's actions to the [Office of Community & Ethical Standards](#) as a violation of the Student Code of Conduct. If the student's actions disrupt the class to the extent that an immediate response is needed, the instructor may call the Clemson University Police Department at 656-2222.

For a student who reports testing positive or is being asked to quarantine because of exposure to the virus, it will be up to the student to inform the instructor that they will be moving to online only instruction for at least the next two weeks. Students are directed to use the [Notification of Absence form](#) in Canvas to initiate this notification, which can be found under the "Help" button on the left navigation. (For courses where Canvas is not used, the direct link to the [Notification of Absence form](#) can be found through the [Division of Student Affairs site](#).) Additional communication via email is encouraged; students should follow up with their instructor to develop a continued plan of study for each course. Students cannot be penalized in their grade for needing to move to online instruction.

### **Exam Attendance**

There will be 2 midterm exams. You will need to be present for the exam – if it is not possible, prior permission is to be sought from the instructor. In the event of illness, the instructor must be informed as soon as possible, preferably prior to the exam time. Exam dates will be announced in class. If classes are cancelled on a test day, the test will be rescheduled for the following class day.

### **Questions**

This class works best when there is a conversation running between the instructor and the students. When it comes to applications, there are often nuances that may not be fully covered in the notes. Often, there are multiple solutions for a given problem. Do not hesitate to bring up questions, thoughts or opinions to the instructor. You will be surprised how often your instincts are correct, or at the very least on the right track.

### **General**

We might not have time in class to go over homework and exam solutions. The answers will be placed on Canvas and if there are still questions after you have read them, you can ask for explanations in class or during office hours. Note in particular that you should not skip class immediately after the exam assuming that we will go over the exam and hence cover no new material.

### **Accessibility**

Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing [studentaccess@lists.clemson.edu](mailto:studentaccess@lists.clemson.edu). Students who receive Academic Access Letters are strongly encouraged to request, obtain, and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here:

<http://www.clemson.edu/campus-life/campus-services/sds/>.

### **Title IX Statement**

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. The University is committed to combatting sexual harassment and sexual violence. As a result, you should know that University faculty and staff members who work directly with students are required to report any instances of sexual harassment and sexual violence, to the University's Title IX Coordinator. What this means is that as your professor, I am required to report any incidents of sexual harassment, sexual violence or misconduct, stalking, domestic and/or relationship violence that are directly reported to me, or of which I am somehow made aware. There are two important exceptions to this requirement about which you should be aware:

Confidential Resources and facilitators of sexual awareness programs such as "Take Back the Night and Aspire to be Well" when acting in those capacities, are not required to report incidents of sexual discrimination.

Another important exception to the reporting requirement exists for academic work. Disclosures about sexual harassment, sexual violence, stalking, domestic and/or relationship violence that are shared as part of an academic project, a research project, classroom discussion, or course assignment, are not required to be disclosed to the University's Title IX Coordinator.

This policy is located at <http://www.clemson.edu/campus-life/campus-services/access/title-ix/>. Ms. Alesia Smith is the Executive Director for Equity Compliance and the Title IX Coordinator. Her office is located at 223 Holtzendorff Hall, phone number is 864.656.3181, and email address is [alesias@clemson.edu](mailto:alesias@clemson.edu).

### **Safe Campus**

Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

- a. Ensure you are signed up for emergency alerts (<https://www.getrave.com/login/clemson>)
- b. Download the Rave Guardian app to your phone (<https://www.clemson.edu/cusafety/cupd/rave-guardian/>)
- c. Learn what you can do to prepare yourself in the event of an active threat (<http://www.clemson.edu/cusafety/EmergencyManagement/>)

### **Academic Integrity**

As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity. Further information on Academic Integrity can be found in the [Undergraduate Announcements](#) and in the [Graduate School Policy Handbook](#).

### **Copyright**

Materials in this course are copyrighted. They are intended for use only by students registered and enrolled in this course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Students should be reminded to refer to the Use of Copyrighted Materials and "Fair Use Guidelines" policy in on the Clemson University website for additional information: <https://clemson.libguides.com/copyright>.