ECE 4190 & 6190 All Sections
Electric Machines and Drives

Class Location/Time: 223 Riggs Hall and 302 ZGEC at 3:30pm to 4:45 PM Tueday and Thursday

Instructor: **Prof. Christopher S. Edrington** **Email:** cedring@clemson.edu
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Phone: +1-864-656-5925
Office Hours: 11am – 12pm Tuesday and Thursday. Other times by appointment only.

Course Description

Performance, characteristics, and modeling of AC and DC machines during steady-state and transient conditions. Emphasis on the process of energy conversion in machines. Introduction to reference frame approach to modeling and simulating machines as a transition to power electronic-based drives and associated control.

Students are expected to have completed courses comparable to ECE 3210 and ECE 3600 and ECE 3800 before enrolling in this course. Additionally, students are expected to have completed, or be concurrently enrolled in, a course comparable to MATH 4340 when enrolling in this course.

This 4000-level course has a 6000-level counterpart.

Course Outline (referring to 2nd edition Krause text, if you have 3rd edition the chapters may be arranged differently). Note, most of the semester will be spent on Chapter 1, 3, 4 and 5. If time allows we will cover parts of Chapter 6.

1. Basic principles for electric machine analysis (Chapter 1)
2. Reference frame theory (Chapter 3)
3. Symmetrical induction machines (Chapter 4)
4. Synchronous machines (Chapter 5)
5. Theory of brushless dc machines (Chapter 6)

Course Objectives

The main objectives of the course are:

- Provide an indepth knowledge of the energy conversion process
- Provide an indepth knowledge of how to apply the energy conversion process for any type of machine
- Provide indepth knowledge of reference frame theory and how that is relevant to modeling of machines and how it links to control/drive objectives
- Provide an indepth knowledge of the operation and performance of induction machines
- Provide an indepth knowledge of the operation of synchronous machines

- Gain the experience to develop dynamic simulation models of any machine (though specific focus will be on the induction machine)
- Gain the experience of how to take the technical knowledge developed in this course, and the experience gained from simulation and associated results and express that in technical reports

Required and Recommended Materials

1. Required for ECE-6190; Recommended for ECE-4190:- "Analysis of Electric Machinery and Drive Systems, by P.C. Krause, O. Wasynczuk, S.D. Sudhoff, 2nd or 3rd Ed. Wiley-IEEE Press, 2013.
2. Course Notes – Required for ECE-4190 and ECE-6190

Topical Outline

Class Schedule for Spring 2020 is shown below. Classes will be delivered remotely to Charleston from Clemson, SC. The following dates are approximate and are subject to change depending on the pace of the course and how the instructor feels that students are understanding the material.

Weeks 1 - 5: Review Background and Energy Conversion Principals
Week 5: Simulation project on energy conversion due (Project #1, UG and G)
Weeks 6 - 8: Reference Frame Theory
Week 8: Simulation project on Reference Frame Theory due (Project #2 UG and G)
Weeks 9 - 11: Induction Machines
Week 12: Simulation project on Induction Machines due (Project #3, UG and G)
Weeks 12–14: Synchronous Machine
Week 13: Advanced Simulation on Induction Machines due (Project #3A, G only)
Week 15: Simulation project on Synchronous Machines due (Project #4, UG and G)

First Class: Thursday, January 9, 2020
Spring Break: March 18-22, 2019
Last Class: April 25, 2019
Final Exams: April 29 – May 3, 2019

General Course Policies

Attendance:

- Do not to be excessively or consistently late for class, it is disruptive and unprofessional. Continued activity of this sort will result in a grade reduction.

Homework:

- Homework will be due approximately 1 week after it is assigned.
- No late homework will be accepted. Homework is to be handed in at the beginning of class on the day it is due or scanned and sent to me via email the day it is due.
- Simulation homework will be sent to me via email and will always be due by midnight on the due date.
- All graphs, schematics, and tables should be attached to your homework writeup. You should NEVER "hand-draw" a graph for which you have the data.
- Typically, since problems can be challenging, there will be no more than 2 or 3 each assignment for undergraduates. Graduate students can expect a couple more that what I will assign the undergraduates

or I may ask for additional information from graduate students for the same problems I assign the undergraduates.
- The total number of homework points (each problem is 50 points) will be scaled to 100 points.

Quizzes:

- There will be "on the average" one quiz every week. Quizzes will cover theoretical as well as simulation type material that has been addressed during previous lectures. These are typically topical questions and not calculation type questions where you have to work something out. They typically take about 10 minues. Each quiz will be worth 50pts.

Projects:

- The primary source of evaluation is projects.
- There will be 4 projects during the semester for undergraduates.
- There will be 5 projects during the semester for graduate students.
- Project topics will range from purely theoretical/analysis to open-ended design.
- Each project will be worth 100 pts.
- Each project will strictly follow the IEEE Transactions style format.
- Projects will be graded as follows:
  - 50% : format; grammar; spelling; legibility of graphs, plots, charts etc.
  - 50% : theoretical justification, explanation of engineering judgment, solution rationale, and conclusions
  - An upper page limit of 8 pages and lower page limit of 4 pages will be established.
  - Students will be allowed to work in teams of 2 (or 3 depending on class size) and can be a mixture of graduate and undergraduate students. *Teams will not be the same for each project.*
  - Projects will be submitted digitally via email. Failure to do this will result in a 10 pt deduction.
  - Projects are due in my email by midnight on the due date.
  - All project reports must be accompanied by a working simulation. I should be able to run your simulation and get the same exact results that you obtained in your paper.

Regular Exams:

This class will have no regular exam.

Final Exam:

This class will have no final exam.

Make-up Policy:

- There will be no make-up work. If for some reason you will not be present on the day that either a project, homework, or quiz is due, then you must make an arrangement to complete the assignment **before** the due date. In general, unless under extremely mitigating circumstances (death, extreme illness, etc.), this policy will be adhered to. Travel to conferences and other university related events will not fall under this category.

Consulting with Faculty:

- It is strongly encouraged that you discuss any academic questions, in relation to this course, with me.

Miscellaneous Items:

- Out of courtesy to me and your fellow classmates cell phones are to be either muted or in vibration mode during class. There will be no answering of cell phone, conversations on cell phones, or text messaging during class.
- Use of profanity, ethnic, racial, or sexual remarks in my class will not be tolerated and will result in a reduction in your grade.

Grade Distribution:

Projects …….. .70%
Homework ……..…..15%
Quizzes ……..…...15%

Additional Policies

Attendance policy

- Students at Clemson are expected to wait 15 minutes if an instructor is late. Attendance of class is in your best interest. The instructor will not be responsible for missed quizzes, homework assignments or other information imparted that could have been obtained by the student if they had been in attendance. The instructor will not keep role, however, with a class less than 30 students it is very easy to determine if a student is consistently missing. If attendance does become an issue, the instructor reserves the right to have "pop quizzes" or to institute a "roll call" that will affect your overall "quiz grade" score.

Inclement Weather Policy

- Since all homework may be scanned and sent by email, inclement weather will not affect the submission of homework
- Since all projects are to be sent via email, inclement weather will not affect the submission of projects
- Since quizzes are conducted during class time, inclement weather that causes the cancelation of classes will result in the quiz being conducted during the next available class period

Commitment to Diversity

The College of Education is committed to providing all candidates with purposeful, challenging, and diverse experiences. It is through a range of diverse, carefully constructed, and challenging classroom-based instruction and field-based experiences that candidates will recognize the inherent dignity and value of all individuals, promote equity in education, and advocate on behalf of children, families, and communities. http://www.clemson.edu/education/about/diversity-plan/index.html

Accreditation and Assessment Practices:

Clemson University and the College of Engineering, Computing and Applied Sciences are required to collect candidate performance data for national, regional and state accreditation.

Academic Integrity Policy

"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."
Please refer to the "Academic Integrity Policy" http://www.clemson.edu/academics/academic-integrity/index.html

Accommodations for Students with Disabilities

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 this class should let the professor 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, by emailing studentaccess@lists.clemson.edu, or by visiting Suite 239 in the Academic Success Center building. Appointments are strongly encouraged – drop-ins will be seen if at all possible, but there could be a significant wait due to scheduled appointments. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors 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/.

Clemson University 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. This policy is located at http://www.clemson.edu/campus- life/campus-services/access/title-ix/. Clemson University's Title IX Coordinator is located at 110 Holtzendorff Hall, 864.656.3184 (voice) or 864.656.0899 (TDD).

Academic Continuity Plan for this Class

Clemson has developed an academic continuity plan for academic operations. Should University administration officially determine that the physical classroom facility is not available, class will be conducted in a virtual (online) format. The University issues official disruption notifications through email/ www/ test notification / social media. When notified, use one of the following links to navigate for Clemson Canvas, where you will find important information about how we will conduct class:

· Primary access link: www.clemson.edu/canvas
· Secondary access link, if needed: https://clemson.instructure.com/
· You can also use the Canvas Student App.

Our activities for teaching and learning will occur through our Canvas course.
In the event of an E-learning Day, a real-time test of the academic continuity plan will be conducted. Our class will be conducted via Canvas. Detailed instructions will be published at Canvas before an E-learning day.

Emergency Guidelines from Clemson University Police Department
All students and employees should be familiar with the following guidelines. For additional information about safety see http://www.clemson.edu/cusafety/preparedness/.
Evacuation:

- When evacuating buildings, do not use elevators as they may lose power, stranding riders.
- Familiarize yourself with the locations of stairwells and exits.
- Individuals needing assistance evacuating should move to a stairwell away from the hazard, dial 911, and provide the Dispatcher with their exact location and what they need regarding evacuation.
- When evacuating follow the instructions provided by Public Safety personnel to reach a safe place.

To seek "Tornado Safer Places," get to the lowest level of the building time allows, stay away from areas with windows and glass, and put as many walls as you can between yourself and the outside. In public buildings, bathrooms typically have an additional wall.

Active Shooter:

- Always call 911 as soon as you possibly can.
- Run away from the area, if it is safe to do so, time allows and the gunman is not nearby.
- Hide if the gunman is too close to your location. Find a safer place, lock and barricade doors, turn lights out and cell phones off or to vibrate.
- Fight. As a last resort, resolve to fight the intruder with everything you have at your disposal.

A short video prepared and presented by the Department of Homeland Security can be found at the following link: *dhs.gov/video/options-consideration-active-shooter-preparedness-video*.

The following is information regarding UCG safety/security:

- UCG is under the jurisdiction of the Greenville City Policy Department (911 for emergencies) and the Greenville Technical College Police Department (864-250-8911)
- UCG is open from 8:00am to 9:00pm (Monday through Thursday), 8:00am to 5:00pm (Friday); during this time, a Greenville Technical College Safety Officer is on-site at McAlister Square
- The Greenville City Police Department has a "Police Sub-Station" in the Publix on the property at McAlister Square
- UCG has administrative/library and technical support staff on site from 8:00am to 9:00pm (Monday through Thursday), 8:00am to 5:00pm (Friday)
- The Greenville Technical College Safety Officer can be called to escort students to the parking lot after dark if necessary
- There are emergency phones on the second floor of UCG that immediately call Greenville Technical College Dispatch when the headset is picked up
- Each University "store-front" suite and the UCG reception desk all have emergency buttons that instantly call Priority1 Security who calls Greenville Technical College Police to respond if the button is pushed
- UCG has numerous internal and external high definition security cameras and a 1 Terabyte security recording system
- All entrance and exit doors at UCG function the same from 8:00am to 9:00pm (Monday through Thursday), 8:00am to 5:00pm (Friday)
- UCG is also open from 8:00am to 5:00pm on Saturday and the library only from 1:00pm to 5:00pm Sunday.

Copyright Statement

Materials in some of the courses are copyrighted. They are intended for use only by students registered and enrolled in a particular 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 on the Clemson University website for additional information: http://www.clemson.edu/library /

Privacy Policy

This course is designed with your privacy in mind. If, however, you feel that an assignment or technology tool undermines your right to privacy, please contact me immediately. We will work together to determine an alternative assignment that will help you achieve the course learning outcomes.

Student Success Resources

The Graduate School maintains a collection of resources applicable to graduate students, listed here: https://www.clemson.edu/graduate/students/ (visit this page for professional development, governance, the handbook, and thesis/dissertation resources) and here: https://www.clemson.edu/graduate/students/resources.html (for links regarding education, student life, and health and safety).

See Policy - ECE Common Course Syllabus – Spring 2020