NORTH CAROLINA STATE UNIVERSITY
DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

MAE/ECE 535: DESIGN OF ELECTROMECHANICAL SYSTEMS

DR. GREGORY D. BUCKNER

SUMMER 2025

Moodle Site: https://wolfware.ncsu.edu/courses/my-wolfware/ **E-mail:** gbuckner@ncsu.edu
Discussion Board: on Moodle site

COURSE DESCRIPTION

A practical introduction to electromechanical systems with emphasis on modeling, analysis, and design considerations. Provides theory and practical tools for the design of electric machines (standard motors, linear actuators, magnetic bearings, etc). Involves some self-directed experimental work and culminates in an industry-sponsored design project.

COURSE TOPICS

Electric and magnetic field theory, magnetic circuit analysis, electromechanical energy conversion, generalized machine theory, modeling and simulation, design considerations.

COURSE OBJECTIVES

Students completing this course will be able to:

1. Understand the fundamentals of electromagnetism (Maxwell's equations) and apply them to standard problems;
2. Apply magnetic circuit analysis to predict the electromagnetic characteristics of electric machines; utilize finite element analysis to predict magnetic fluxes, forces, and torques in electric machines;
3. Understand the fundamentals of permanent magnetism and select permanent magnet materials for specific applications;
4. Understand the principles of electromechanical energy conversion and apply these principles to predict forces and torques in electric machines;
5. Develop nonlinear dynamic models of electric machines, simulate these systems using MATLAB and Simulink, and analyze their performance and response characteristics;
6. Explain the fundamentals (machine topology, etc.) and basic operating characteristics (torque, speed, efficiency, etc.) of common electrical machines;
7. Design, model, simulate, and analyze the dynamics of common (dc motors, induction motors, etc.) and unique (railguns, active magnetic bearings, etc.) electric machines

COURSE NOTES (REQUIRED)

- **Print**: Buckner, G.D., ***Course Notes: MAE/ECE 535 Design of Electromechanical Systems***, available via the NCSU Bookstores (anthony_sanders@ncsu.edu, 919-515-3868)
- **Digital**: https://ladbookstore.com/products/principles-of-automatic-control-2025

WEBASSIGN ACCESS (REQUIRED)

- Access code must be purchased for homework and exams (http://www.webassign.net)

REFERENCE TEXTS (NOT REQUIRED; BOTH PRINT AND DIGITAL ("ALL-IN") VERSIONS AVAILABLE)

- Sadiku. Elements of electromagnetics, (any recent edition). Oxford University Press.
- Fitzgerald, Kingsley, and Umans. Electric machinery, (any recent edition). McGraw-Hill.

GRADING (YOUR CHOICE… FINAL EXAM IS OPTIONAL)

	Option 1	Option 2
Homework	25%	33.33%
Midterm Exam	25%	33.33%
Design Project	25%	33.33%
Final Exam	25%	

GRADING SCALE (REQUIRED %)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-
98	92	90	88	82	80	78	72	70	68	62	60

OTHER

- Lecture videos are accessible via the course Moodle site (https://wolfware.ncsu.edu/). These lectures were recorded during the spring semester of 2025; due dates and deadlines discussed in these videos obviously do not apply to the summer semester. The schedule on the next page lists recommended dates for viewing lectures, plus dates for exams, homework submissions, and project submissions.

- This course deals extensively with the fundamentals of problem solving… **attention to homework is highly recommended**.

- **Late homework will not be accepted**.

- Academic dishonesty rules, as outlined in the NCSU Code of Student Conduct, will be strictly enforced. **Any suspected act of academic misconduct will be immediately referred to the NCSU Office of Student Conduct.**

- Students are encouraged to work in small groups and use additional reference materials for the solution of homework assignments and design projects. However, **copying and submitting the work of other students as your own is a violation of the NCSU Code of Student Conduct, and will be treated as such.**

- Note: copying figures, equations, or text from other sources without properly referencing these sources is **plagiarism: a violation of the NCSU Code of Student Conduct that will be referred to the NCSU Office of Student Conduct.**

- Any student with a disability who is registered with the University Office of Student Disability Services should schedule an appointment with Dr. Buckner at the beginning of the semester to discuss academic accommodations.

- Video copies of each lecture are accessible via the course Moodle site

- Online class evaluations will be available for students to complete during the last three weeks of the semester

TENTATIVE SCHEDULE

Week	Topics	Optional Textbook Reading	Archived Lecture Date	Key Dates
May 14	**Introduction**		1/7	
	Course objectives, overview, and policies			
	Fundamentals of Electromagnetism: Maxwell's Equations	S 4.1-4.10		
May 19	Static electric fields: Coulomb's law, Gauss's law,	S 6.5	1/9, 14	
	visualizing fields and potentials, capacitance	S 5.1-5.8	1/16	
	Electric currents: Ohm's law, Continuity Equation		1/21	
	Static magnetic fields: conservation of flux,	S 7.1-7.2	1/23	
May 27	Biot-Savart's law, Lorentz's force equation,	S 7.3-7.6	1/28	
	Ampere's law	S 8.1-8.2	1/30, 2/4	HW #1
	Faraday's law, inductance	S 9.1-9.3	2/6, 13	Due
June 2	**Demonstration Project Assigned**			
	Summary of Maxwell's equations	S 9.5		
	Magnetic Circuit Theory	F 1.1-1.3,	2/18	
	Magnetic circuits: theory and applications	S 8.10		
June 9	**Finite Element Analysis for EM Circuits**	S 15.5	2/25	HW #2
	Introduction to FEA	FEMM		Due
	2D using FEMM	User's Man	2/25	
June 16	3D using ANSYS Maxwell		3/4	
	Permanent Magnets	F 1.5-1.6		
	Magnetic hysteresis, coercivity, load lines, flux leakage	S 3.1-3.6	3/21	Demo
June 23	**In-class Demo Presentations**		3/6-20	Due
June 30	**Design Projects Assigned**		3/25	HW #3
	Midterm Exam Review		3/25	Due
	Be sure exam proctors are registered with EOL			
July 3	**Midterm Exam**			Midterm Exam
July 7	**Electromechanical Energy Conversion**			
	Work, energy, co-energy, calculating forces and torques in EM machines	F 3.1-3.6	4/3, 8	
	Generalized Machine Theory		4/15	
	Forces and torques in standard rotating machines	F 4.1-4.11		
July 14	**Common Electric Machines**		4/17, 19	
	Induction, DC, reluctance motors	F 5,6,7,8		
	Modeling and Simulation			
	Modeling and simulation of EM systems	F 3.8-3.9	4/8,10	
	Nonlinear analysis: Simulink			
July 21	**Design Considerations for Electric Machines**		4/22	
	Iron Losses, Copper Losses, Flux Saturation			
	Conclusion			
	Course Topic Review, Key Takeaways			Design
July 25	**Design Projects Due**			Project Due
July 29	**Final Exam (Optional)**			Final Exam