

NORTH CAROLINA STATE UNIVERSITY
DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

MAE/ECE 535: DESIGN OF ELECTROMECHANICAL SYSTEMS

DR. GREGORY D. BUCKNER

SPRING 2026

Classroom: 2207 EBIII

Schedule: TTh 10:15-11:30 am

Moodle Site: <https://wolfware.ncsu.edu/courses/my-wolfware/>

E-mail: gbuckner@ncsu.edu

Office Hours: TTh 4:00-5:30 pm

(also by appointment)

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/design-of-electrical-and-electromechanical-systems>

MÖBIUS ONLINE LEARNING (REQUIRED)

- Access code must be purchased for homework and exams (<https://ncsu.mobius.cloud/>)

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)

	<u>Option 1</u>	<u>Option 2</u>
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

- 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 COURSE SCHEDULE

Dates	Topics	Optional Reading
Jan 13	Introduction Course objectives, overview, and policies	
Jan 15	Fundamentals of Electromagnetism: Maxwell's Equations Static electric fields: Coulomb's law, Gauss's law, visualizing fields and potentials, capacitance	S 4.1-4.10 S 6.5
Jan 20, 22	Electric currents: Ohm's law, continuity equation, Static magnetic fields: conservation of flux,	S 5.1-5.8 S 7.1-7.2
Jan 27, 29	Biot-Savart's law, Lorentz's force equation,	S 7.3-7.6
Feb 3, 5	Ampere's law	S 8.1-8.2
Feb 10, 12	Faraday's law, inductance	S 9.1-9.3, 8.8
Feb 19 (Feb 17 Wellness Day)	Summary of Maxwell's equations Demonstration projects assigned Magnetic Circuit Theory Magnetic circuits: theory and applications	S 9.5 F 1.1-1.3, S 8.10
Feb 24, 26	Finite Element Analysis for EM Circuits Introduction to FEA 2D using FEMM 3D using ANSYS Maxwell	S 15.5 FEMM User's Manual
Mar 3, 5	Permanent Magnets Magnetic hysteresis, coercivity, load lines, flux leakage	S 8.5-8.6
Mar 10, 12	Electromechanical Energy Conversion Conservation of energy, energy and coenergy, force and torque in EM machines	F 3.1-3.6
Mar 12	Design Projects Assigned	
Mar 24, 26 (Mar 16-20 Spring Break)	Generalized Machine Theory Analysis of standard rotating machines using GMT	F 4.1-4.11
Mar 31	Midterm Review	
Apr 2	Midterm Exam	
Apr 7, 9	Common Electric Machines Induction motors, synchronous motors, reluctance motors	F 5,6,7,8
Apr 14, 16	Modeling and Simulation Modeling and simulation of EM systems Nonlinear analysis: linearization and Simulink	F 3.8-3.9
Apr 21, 23	Transient and steady-state dynamics Design Considerations for Electric Machines Iron Losses, Copper Losses, Flux Saturation	
Apr 28	Conclusion Design Projects Due	
Apr 30	Final Exam (Optional)	