

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL & COMPUTER ENGINEERING
Syllabus: ECE4803 Wireless Energy and Sensing

ECE4803 Wireless Power and Sensing

Lecture Meeting: T,Th 5:00-6:15pm in Allen Sustainable Education Room 110

Course Websites: Canvas

INSTRUCTOR INFORMATION:

Instructor	Email	Office Hours & Location
Prof. Gregory D. Durgin	durgin at gatech.edu	TBD in VL 507

COURSE INFORMATION

Description

This course provides a comprehensive overview of wireless power transfer systems, from high-energy power beaming to emerging energy-harvesting radio communications. The course presents a multi-disciplinary treatment that involves antennas, propagation, communications, RF engineering, analog devices, and nanotechnology. Case studies in remote sensing, RFID, telemetry, Internet-of-Things applications, and other fields illuminate these concepts.

Course Goals and Learning Outcomes

Students will develop expertise in the following topics:

- I. **Basic Radiation Theory** – review of antenna theory and wave propagation; basic circuit modeling of antennas in transmit, receive, backscatter modes; wire and aperture antennas; antennas on dielectric objects and metal; piezoelectric materials; surface acoustic wave (SAW) devices.
- II. **Propagation Theory** – Backscatter link budgets; small-scale fading; double fading distributions; multi-antenna systems for backscatter radio.
- III. **RF Energy Harvesting** – Survey of energy-harvesting; battery fundamentals; review of time-harmonic transmission line theory; rectenna theory and design; charge pump theory and design; power optimized waveforms and multisine; RF scavenging; energy-banking systems; super-capacitors.
- IV. **Communications Theory** – Rules for unlicensed spectrum operation; review of AWGN detection; orange noise model for RF readers; matched filter detection in colored noise; binary offset carrier modulation; spread-spectrum systems. Computational platforms for low-energy communications.
- V. **Magnetic and Inductive Systems** – Biot-Savart modeling of coils and loops; circuit modeling of inductively-coupled systems; flux circuit model; classical magnetic materials (diamagnetism, paramagnetism); quantum effect magnetic materials (ferrimagnetism, ferromagnetism, super-paramagnetism); inductive RFID systems; Case Study: magnetostrictive electronic article surveillance (EAS). Case Study: MIT inductive resonant transfer.
- VI. **Far-Field Wireless Power Transfer** – Power exchange between large apertures; high-powered microwave sources

Official Course Goals and Outcomes:

1. describe methods and trade-offs for transferring wireless energy between two points in space
2. calculate link parameters and power levels for different types of wireless energy systems
3. describe how RF and microwave signals are generated
4. describe the power consumption of various radio architectures and their trade-offs
5. design basic circuits that harvest and convert RF power and provide charge management

6. design a basic backscatter communications link
7. describe and calculate attributes of a wireless power beaming link

Graded Components

Assignments	Weight
Homework	20%
Midterm Quizzes (2)	40%
Final Project	40%

Description of Graded Components

Expect 4-5 homework assignments throughout the term, to be turned in during class or by email to the instructor. There will be 2 in-class (or DL proctored) quizzes throughout the term. There is a final term project due at the end of the semester. Projects will be assigned midway through the term and may involve group work. For all assignments and projects, late work is not accepted. Special accommodations can be made for medical emergencies, interviewing, and other important events, but only if sufficient advance notice is given to (and permission granted by) the instructor ahead of time.

The graduate and undergraduate sections of this course will be given different assignments, assessments, and project statements to reflect the different content level and expectations for these student groups.

Grading Scale

This course uses a traditional A (>90.0), B (>80.0), C(>70.0), D(>60.0), F(<60.0) grade scale unless special circumstances require a curve to achieve the recommended course GPA as specified by the ECE course catalog. Traditionally, this course target GPA is 3.50. I do not curve *downward* from the traditional grade scale.

Classroom Management

This class will involve classical delivery of lectures during regularly scheduled times.

COURSE MATERIALS

Course Text:

No formal course text. Notes and papers for reading will be disseminated through T-square. Video captures of topical lectures are available at YouTube™ channel [profdurgin]

Recommended References:

- N. Shinohara, *Wireless Power Transfer via Radiowaves*, Wiley, 2014
D. Dobkin, *The RF in RFID*, 2nd edition, Elsevier, 2013

COURSE EXPECTATIONS & GUIDELINES

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, visit <http://www.catalog.gatech.edu/policies/honor-code/> or <http://www.catalog.gatech.edu/rules/18/>. Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Collaboration & Group Work

It is expected that each student upholds the Georgia Tech honor code when preparing work for this class. Everyone must turn in their own work (or group's work where specified) without contribution from another person or source, whether homework, project, or test. For homework assignments, discussion of topics and concepts are encouraged among students provided all submitted work is still original.

Student Use of Mobile Devices

Students may not use mobile devices during tests other than as calculators. Observations of violations during test periods will be reported to the Office of Student Integrity.

Accommodations for Individuals with Disabilities

If you are a student with learning needs that requires special accommodation, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible to make an appointment to discuss your special needs and to obtain an accommodation letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See <http://www.catalog.gatech.edu/rules/22/> for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Absence Policy

Please review the institute student absence policy at <https://catalog.gatech.edu/rules/4/>