ECE 454: Antennas
Spring Semester 2026

Meeting Time/Place: TR 12:30 pm – 1:50 pm / 2015 ECEB

Text: *Antenna Theory and Design*, 3rd Edition (2012), W. L. Stutzman and G. A. Thiele

References: Will be placed on reserve in the Engineering library as needed.

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Office Hours: ECEB 5032 Tuesday and Thursday 2-3 p.m., and by appointment (made via e-mail). You can also ask Dr. Mitchell questions via e-mail – please don't assume the reply will be immediate!

Course Web Site: https://courses.grainger.illinois.edu/ece454/sp2026/index.html

Gradescope: **RVV5Z6**

Goals: In this course, students will develop an understanding and working knowledge of fundamental antenna theory. This includes the ability to analyze and design basic antennas, characterize and classify antenna behaviors, and determine what kinds of antennas and antenna characteristics are necessary to achieve desired communication or radar system performance.

Prerequisites: ECE 350 (Lines, Fields, and Waves) or permission; 3 credits.

Estimated Course Schedule for ECE 454

Mtg.	Date	Topic	Related Reading	Problems
1	1/20 T	Course Introduction and Motivation; Maxwell's Equations		
		Theoretical Foundations of Antennas		
2	1/22 R	Electromagnetic Fields & Power Radiated by an Antenna	Ch. 1, 2.1-2.2	2.2-2, 2.2-3, 2.3-2,
3	1/27 T	Hertzian Dipole Antennas	2.3	2.3-3, 2.3-4, 3.4-1
4	1/29 R	Hertzian Dipole Antennas / Duality	2.3, 3.4	3.4-2, 3.4-4, 3.4-7
5	2/3 T	Small Loop Antennas	3.4	3.4-10, 3.4-11
		Guided and Unguided Wave Descriptions of Antennas		
6	**2/5 R***	Antenna Input Impedance and Efficiency	2.4-2.8	2.4-1, 2.4-8, 2.4-9
7	2/10 T	Antenna Radiation Patterns and Characteristics	2.4-2.8	2.4-10, 2.5-1, 2.5-2
8	2/12 R	Antenna Directivity, Gain, and EIRP	2.4-2.8	2.5-3, 2.5-5, 2.5-9
9	2/17 T	Link Budgets with Antenna Parameters / Antenna Noise	4.1-4.4	2.7-1, 2.7-2, 2.8-4
10	2/19 R	Antenna Reciprocity and Measurements	13.1-13.5	4.4-1, 4.4-8, 4.4-14, 4.4-15
		Antenna Array Fundamentals		
11	**2/24 T***	Array Factor	8.1-8.6	8.2-4, 8.2-5, 8.3-1
12	2/26 R	Linear Arrays	8.1-8.6	8.3-7, 8.3-12, 8.5-1
13	3/3 T	Mutual Coupling in Arrays/ Phased Arrays and Scanning	8.7, 8.8-8.11	8.7-1, 8.8-1, 8.8-4
		Resonant Antennas		
14	**3/5 R***	Dipoles and Folded Dipoles	3.1-3.3, 6.1-6.2	3.1-2, 3.2-4, 3.2-5
15	3/10 T	Ground Planes, Monopoles and Image Theory	3.3	3.3-2, 6.1-2, 6.1-8
16	3/12 R	**Midterm Exam on Material from Lectures 1-13**		
17	3/24 T	Antennas and Imperfect Ground Planes	6.7	6.2-2, 6.7-5, 6.8-1
18	3/26 R	Loop Antennas	6.8	6.8-6, 11.2-2
19	3/31 T	Microstrip Antennas	11.1-11.2	11.2-7
20	4/2 R	Microstrip Antennas	11.1-11.2	
		Aperture Antennas		
21	**4/7 T***	Radiation from Aperture and Huygens' Principle	9.1	9.3-4, 9.3-8
22	4/9 R	Rectangular Apertures/Apertures and Gain	9.2-9.3	9.3-11, 9.4-19(a)
23	4/14 T	Horn and Reflector Antennas	9.4-9.6	9.6-4, 9.6-15
24	4/16 R	Reflector Antennas	9.6-9.7	
		Broadband Antennas		
25	**4/21 T***	Log Periodic Antennas and Other Broadband Antennas	7.4-7.8	7.4-1, 7.6-1
26	4/23 R	Frequency Independent Antennas	7.6	7.6-3, 7.8-2
27	4/28 T	Ultrawideband Antennas	7.10	7.8-4, 7.8-5
28	4/30 R	Arrays Revisited	8.8-8.11	
29	**5/5 T***	**Course Review and Evaluation**		

Policies and Announcements

Grading:	Problem Sets	15%
	Midterm Exam	25% (Thursday, March 12, in class)
	Antenna System Design Project	25%
	Final Exam (Cumulative)	35% (Monday, May 11, 1:30-4:30 p.m.)

Student Integrity: Students are expected to conduct themselves according to the University's policies on academic integrity (see https://studentcode.illinois.edu/). Violation of these rules will be handled according to University policy.

AI Use: Generative AI tools, such as ChatGPT, Co-pilot, and Gemini, are not permitted for any stage or phase of work in this class. Use of these tools in this course will be considered academic dishonesty and a violation of the University of Illinois Student Code.

Any work written, developed, created, or inspired by artificial intelligence (AI) is considered plagiarism and will not be tolerated. While these tools will find their place in our workforces and personal lives, for this class their use hinders the learning process and therefore is not allowed.

Problem Sets: Problem sets are due on the meeting after a section is completed as noted on the previous page with **bold*** dates. Each problem is worth 10 points. **Late problem sets will not be accepted unless under exceptional circumstances approved by the instructor. Exceptional circumstances include illness or related quarantine, as confirmed by proper notification to Dr. Mitchell.** If you wish to have a problem grade reconsidered, please submit the homework and a **written** description explaining in detail why you think a correction should be made.

Problem Set Solutions: *Problem set solutions will not be posted*. The responsibility is yours to make sure you find out how to solve the problems by getting help before they are due and/or asking about them after they've been handed in and graded.

Exams: The midterm and final exams will be **open notes/open homework**. The final exam will be cumulative. If you wish to have a problem grade reconsidered, please submit the exam and a **written** description explaining in detail why you think a correction should be made.

Design Project: The antenna system design project gives you an opportunity to apply knowledge you've gained in the course in a real-world scenario. You will have a choice of two possible projects (A and B). IMPORTANT: For the written report required for the project, spelling, grammar, and organization count. Spell-checking is a good first step, but it does not replace proof-reading. More details on the specifications, evaluation criteria, and grading scheme for the projects will be provided on **April 14th**.

Important Project Dates

Tuesday, April 14	Project Specifications Distributed
Thursday, April 16	Student Commitment to Project Due
Thursday, April 30	Project Due

Antennas
Spring 2026

Course Goals

The goals of this course are (a) to develop students' analytical and intuitive understandings of antenna physics, and (b) to introduce students to a large variety of antenna structures of practical interest related to recent developments in wireless communication and radar systems. The course culminates with an antenna system design project where students leverage their knowledge of antennas to specify and synthesize a practical antenna communication system.

Instructional Objectives

A. By the time of the Midterm Exam (after 13 lectures), students should be able to do the following:

1. Demonstrate understanding of the concepts of time-dependent and time-harmonic three-dimensional vector fields in Cartesian and spherical systems, and carry out conversions from one system to the other (1).
2. Demonstrate understanding of source-field relationships and understand how to compute the field due to arbitrary electric source distributions (1).
3. Be able to quantify the fields radiated by Hertzian dipoles and small loop antennas (1).
4. Understand and apply the concept of duality between dipoles and loop antennas (1).
5. Demonstrate understanding of the concepts of antenna impedance, efficiency, pattern, directivity, gain, side lobe level, forward backward ratio, effective isotropically radiated power, and polarization, and be able to compute fields and power radiated by an antenna and characterize its state of polarization given the above parameters (1).
6. Understand and apply the concepts of reciprocity and antenna effective aperture, and compute power received by an antenna in function of the antenna's properties and the characteristics of the illuminating field (field strength, polarization, direction of incidence) (1).
7. Be able to compute an antenna link budget, i.e., compute power received in function of the characteristics of the transmitting and receiving antennas and their relative orientation relative to each other (1,2).
8. Demonstrate understanding of the concepts of antenna noise, S/N (signal to noise) ratio, and G/T (gain over antenna temperature) ratio, and compute these figures of merit in function of the field illuminating the receiving antenna and its environment (1,2).
9. Understand and apply the concepts above to design and analyze antenna measurement systems (1,2).
10. Understand and apply the concept of an antenna array factor, and compute array factors of arbitrary array configurations (1).
11. Be able to design linear cophasal arrays with a minimum number of elements with a given main beam direction and half-power beamwidth or beamwidth between first nulls (1.2).
12. Understand and apply the concept of pattern multiplication, using it for the computation of array factors of non-uniformly excited linear arrays (e.g., a binomial array) and two-dimensional arrays (1,2).
13. Demonstrate an understanding of the effects of mutual coupling in arrays and possible methods to address this coupling (1,2,7).
14. Extend the concepts inherent in one-dimensional arrays to multidimensional arrays (1,2,7).
15. Understand and apply the concept of phased array scanning in one-dimensional and multidimensional arrays (1,2).

B. By the time of the Final Exam (after 29 lectures), students should be able to do all of the items listed under A, plus the following:

16. Be able to quantify the fields radiated by resonant antennas such as dipoles of arbitrary length, folded dipoles, loop antennas, slot and line sources (1).
17. Understand and leverage in designs the effect of the presence of a perfectly conducting ground plane on the fields radiated by arbitrarily oriented wire antennas, and compute these fields as well as the input impedance of vertical monopoles (1,2).
18. Demonstrate an understanding of the effects of imperfect ground planes on antenna performance (1).
19. Understand the operational principles and basic properties of microstrip antennas, and be able to dimension a simple microstrip antenna given the desired resonant frequency (1,2,4).
20. Demonstrate an understanding of Huygens' principle and its relationship to radiation from simple apertures (1).
21. Calculate and compare the gain and other radiation characteristics of simple apertures (1).
22. Design and analyze simple horn antennas (1,2,4).
23. Design and analyze simple reflector antennas, including planar reflectors, corner reflectors, and parabolic reflectors (1,2,4).
24. Design and analyze log periodic antennas consisting of linear dipole antennas (1,2,4).
25. Understand the physical origins of the characteristics of frequency independent antennas (1).
26. Understand the physical origins of the characteristics of ultrawideband antennas (1).
27. Identify characteristics of broadband antennas that make them more or less suitable for transmission of high frequency pulses (1,6).
28. Write clear, organized documentation for an antenna system design that **explains** design tradeoffs and **justifies** design choices (1,2,3).

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