EE 483 *Antennas for Wireless Communications*
EE 483L *Antennas for Wireless Communications Lab*

CATALOG DATA:

EE 483 Antennas for Wireless Communications Credits: 3. Introduction to antenna design, measurement, and theory for wireless communications including fundamental antenna concepts and parameters (directivity, gain, patterns, etc.), matching techniques, and signal propagation. Theory and design of linear, loop, and patch antennas, antenna arrays, and other commonly used antennas. Students will design, model, build, and test antenna(s).

Prerequisites: EE 382

Corequisites: EE 483L

Notes: This course is cross-listed with EE 583.

EE 483L Antennas for Wireless Communications Lab Credits: 1. Laboratory to accompany EE 483.

Corequisites: EE 483

Notes: This course is cross-listed with EE 583L.

TEXTBOOK:

Antenna Theory: *Analysis and Design* (Fourth Edition), Balanis, Wiley, 2016, ISBN 1-118-64206-6.

COORDINATOR:

Dr. Thomas P. Montoya, Associate Professor

GOALS:

The objective of this course is to introduce students to the basic concepts of antenna design, measurement, and theory. In particular, they are introduced to fundamental antenna concepts and parameters (directivity, gain, patterns, etc.), the theory and design of some common antennas (e.g., linear, loop, patch, linear arrays, Yagi-Uda), matching techniques, and signal propagation. By the end of the course, the students should be able to design, model, build, and test simple antennas.

CLASS SCHEDULE:

Lecture: 3 hours per week.

Laboratory: scheduled weekly labs; lab projects will be scheduled as required.

TOPICS:

1. Antennas
    a. Types of antennas
    b. Radiation mechanism
    c. Describe some methods of analysis
    d. History of antenna development

2. Fundamental Parameters of Antennas
    a. Radiation patterns
    b. Radiation power density
    c. Radiation intensity, directivity, and gain
    d. Antenna radiation efficiency
    e. Bandwidth and beamwidth
    f. Polarization
    g. Input impedance
    h. Effective length and area
    i. Friis Transmission Equation
    j. Radar Range Equation
3. Radiation Integrals and Auxiliary Potential Functions
    a. Magnetic vector potential $\overline{A}$ for electric current density $\overline{J}$
    b. Electric vector potential $\overline{F}$ for magnetic current density $\overline{M}$
    c. Total and far-field electric and magnetic fields from $\overline{A}$ or $\overline{F}$
4. Numerical Electromagnetics Code (NEC)
    a. Introduction
    b. Modeling rules (e.g., segmentation)
    c. Usage- input commands and input file structure
    d. Interpreting output data
5. Linear Wire Antennas
    a. Infinitesimal dipole (fields, gain, radiation resistance, …)
    b. Small dipole (fields, gain, radiation resistance, …)
    c. Finite-length dipole (fields, gain, radiation resistance, …)
    d. Half-wavelength dipole (fields, gain, radiation resistance, …)
6. Log-periodic dipole array (LPDA)
    a. Background
    b. Design
    c. Feeding/matching techniques
7. Yagi-Uda Dipole Arrays
    a. Design
    b. Feeding/matching techniques- folded dipole, T-Match, modified T-Match, Gamma match, Modified Gamma, …
8. Microstrip Antennas (patches)
    a. Theory and design of rectangular patches- transmission line model
    b. Theory and design of rectangular patches- cavity model
    c. Quality factor, Bandwidth, efficiency, and input impedance
9. Loop Antennas
    a. Small circular loops (fields, gain, radiation resistance, …)
    b. Circular loop with constant current (fields, gain, radiation resistance, …)
    c. Circular loop with nonuniform current (fields, gain, radiation resistance, …)
10. Helical Antennas
    a. Normal mode

   b. Axial mode
11. Arrays: Linear, …
   a. Two-element array
   b. Design of *N*-element linear arrays with uniform amplitude and spacing- broadside, end-fire, passed/scanning, and Hansen-Woodyard end-fire
   c. Directivity of *N*-element linear arrays with uniform amplitude and spacing

COMPUTER USAGE:

Students use the computer program called the Numerical Electromagnetics Code (NEC) to model/simulate and analyze antennas. Also, computer mathematical packages such as MATLAB, MathCad, MS Excel, ... are used to analyze, design, and present results for antennas and related data and/or measurements.

COURSE LEARNING OBJECTIVES (CLO) FOR LECTURE:

Upon completion of this course, students should demonstrate the ability to:

A. Apply, calculate, or produce fundamental parameters or quantities of antennas (e.g., radiation patterns, radiation intensity, directivity, …).
B. Apply or use the Friis Transmission Equation and Radar Range Equation.
C. Use EM software to design and model antennas.
D. Know how to calculate magnetic and electric vector potentials given electric or magnetic current densities, respectively, and calculate the total and far-field electric and magnetic fields from the magnetic and/or electric vector potentials.
E. Analyze and calculate antenna quantities and parameters for commonly used antennas (e.g., linear dipole, loop, microstrip, and Yagi-Uda).
F. Design and analyze linear antenna arrays with uniform spacing and amplitude.

COURSE LEARNING OBJECTIVES (CLO) FOR LABORATORY:

Upon completion of this course, students should demonstrate the ability to:

A. Use EM software to design and model antennas.
B. Design, build, match, and/or test commonly used antennas (e.g., linear dipole, loop, microstrip, and Yagi-Uda).
C. Measure important antenna parameters (e.g., impedance, reflection coefficient, VSWR, radiation pattern, …) using modern test equipment (e.g., vector network analyzer).

RELATION OF COURSE LEARNING OBJECTIVES TO STUDENT OUTCOMES (SO):

These course learning objectives fulfill the following student outcomes for the B.S. EE program:

1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public, health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3) An ability to communicate effectively with a range of audiences.
4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions

in global, economic, environment, and societal contexts.

5) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

The following tables indicates the relative strengths of each course objective in addressing the program's student outcomes listed above (on a scale of 0 to 4 where 4 indicates a strong emphasis)

Lecture

CLO \ SO	1	2	3	4	5	6	7
A	4	2					
B	4	2					
C	4	2					2
D	4						
E	4	3					
F	4	3					2

Laboratory

CLO \ SO	1	2		3	4	5	6	7
A	4	2						2
B	4	4					3	2
C	4	3					3	2

PREPARED BY:

Thomas P. Montoya, Date: January 15, 2004
Revised June 17, 2016, January 9, 2017, AND January 9, 2018 by Thomas P. Montoya.
Revised January 12, 2020 by Marilyn Maxvold AND Thomas P. Montoya.
Revised January 5, 2022 by Thomas P. Montoya.
Last Revised January 9, 2025 by Thomas P. Montoya.