EE 381: *Electric and Magnetic Fields*

CATALOG DATA:

EE 381 Electric and Magnetic Fields (3-0) 3 credits. Prerequisites: EE 221/221L with a minimum grade of "C", MATH 225, and PHYS 213/213-A. Fundamentals of field theory (i.e., Maxwell's equations) as applied to static electric and magnetic phenomena. Also, theory and applications of lossless transmission lines are covered.

TEXTBOOK:

Elements of Electromagnetics (Seventh Edition), Sadiku, Oxford, 2018, ISBN 9780190698614.

COORDINATOR:

Dr. Thomas P. Montoya, Associate Professor

GOALS:

The objective of this course is to introduce students to the basic concepts of electromagnetic field theory. In particular, they are introduced to lossless transmission lines, electrostatics, magnetostatics, and the electrical properties of materials. By the end of the course, the students should be able to calculate relevant quantities (e.g., distributed parameters, impedances, voltages, currents, power) for lossless transmission line and simple lossless transmission line circuits in the frequency-domain. For static fields, they should be able to calculate the electric field, electric flux density, and/or electric potential for symmetric electrostatic problems, and the magnetic field, magnetic flux density, magnetic flux, and/or magnetic vector potential for symmetric magnetostatic problems. Also, they should be able to calculate the resistance, capacitance and inductance of simple structures.

CLASS SCHEDULE:

Lecture: 3 hours per week.

TOPICS:

1. Theory and Applications of Transmission Lines:
    a. Types of transmission lines
    b. Lossless transmission lines (frequency-domain)
    c. Lossless transmission line circuits (frequency-domain)
2. Vector Algebra
    a. Vector addition/subtraction, dot, and cross product
    b. Unit and position/distance vectors
    c. Cartesian, cylindrical and spherical coordinate systems
3. Vector Calculus
    a. Differential lengths, areas, and volume
    b. Line, surface, and volume integrals
    c. Del operator, gradient, divergence, curl, and Laplacian
    d. Divergence and Stoke's Theorems
    e. Vector field classification
4. Electrostatics
    a. Coulomb's Law and electric field intensity

   b. Electric flux density and Gauss' Law
   c. Electric potential
   d. Electric energy and energy density
   e. Electric dipole and dipole moment
   f. Electric material properties
   g. Boundary conditions
   h. Resistance and capacitance
   i. Poisson’s and Laplace’s equations and electrostatic boundary-value problems
5. Magnetostatics
   a. Biot-Savart’s Law and magnetic field intensity
   b. Magnetic flux and magnetic flux density
   c. Ampere's Law
   d. Magnetic vector potential
   e. Magnetic energy and energy density
   f. Magnetic force and torque
   g. Magnetic dipole and dipole moment
   h. Magnetic material properties
   i. Boundary conditions
   j. Inductance
   k. Magnetic circuits (time allowing)

COMPUTER USAGE:

Students are encouraged to use computer programs for mathematics and graphing (e.g., MS Excel. MathCad, MATLAB, ...).

COURSE LEARNING OBJECTIVES (CLO):

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

A. Calculate distributed parameters *L* and *C* for simple lossless transmission lines and dependent quantities (e.g., characteristic impedance, phase velocity, and phase constant).
B. Solve frequency-domain problems (e.g., find impedances, reflection coefficients, currents, voltages, and powers) for lossless transmission line circuits.
C. Perform basic vector algebra operations such as addition, dot product, and cross product in Cartesian, cylindrical, and spherical coordinates.
D. Perform basic vector calculus operations such as line, surface & volume integrals, gradient, divergence & curl operations, Laplacians, Divergence & Stoke’s Theorems, and perform vector field classification in Cartesian, cylindrical, and spherical coordinates.
E. Calculate the electric field and electric potential in regions containing point charges and/or line, surface, and/or volume charge densities.
F. Apply Gauss’ Law to problems with spherical, cylindrical, and/or planar symmetry.
G. Calculate the electric potential, field, flux density, capacitance, and resistance of/for structures with spherical, cylindrical, and planar symmetry containing dielectric materials.
H. Apply electrostatic and magnetostatic boundary conditions.
I. Solve Poisson’s and Laplace’s Equations for one-dimensional electrostatic boundary-value problems.
J. Calculate the magnetic field, flux density, flux, and vector potential near wires, surfaces, and/or volumes carrying current(s).

K. Apply Ampere's Law to problems with cylindrical and/or planar symmetry.
L. Calculate the magnetic field, flux density, and inductance of/for simple structures with or without magnetic materials.

RELATION OF COURSE TO DEPARTMENTAL STUDENT OUTCOMES (SO):

These course objectives fulfill the following student outcomes adopted for the B.S. EE degree:

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 table indicates the relative strengths of each course objective in addressing the program's student outcomes listed above (on a scale of 1 to 4 where 4 indicates a strong emphasis).

SO / CLO	1	2	3	4	5	6	7
A	4	2					
B	4	3					
C	4	2					
D	4	2					
E	4	2					
F	4	2					
G	4	2					
H	4	2					
I	4	2					
J	4	2					
K	4	2					
L	4	2					

PREPARED BY:

Larry Meiners, Date: January 25, 2002
Revised by Thomas P. Montoya, Date: September 16, 2008; August 31, 2011; August 19, 2014; August 18, 2017; August 19, 2018; September 10, 2019