

## ECE 203 – Spring 2008

### Engineering Electromagnetics Waves (3)

**Lecture Time:** Spring 2008, Monday-Wednesday-Friday at 10:10-11:00 pm

**Location:** Whitaker Lab 207

**Problem Solving Session (Optional):** TBD

**Office Hours:** Monday at 3:30-5:00 pm

Tuesday at 3:30-5:00 pm

**Instructor:** Prof. Nelson Tansu  
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#### **Required Reading Textbook:**

1. S. M. Wentworth, *Applied Electromagnetic*, Wiley (2007).
2. Nelson Tansu, *Additional Lecture Notes on EM Theory and Waves*.

#### **Recommended Elementary/Intermediate Textbook:**

1. U. S. Inan, and A. S. Inan, *Electromagnetic Waves*, Prentice Hall (2000). *Useful EM textbook for ECE 203-level.*
2. D. Cheng, *Fundamental of Engineering Electromagnetics*, Prentice Hall (2003). *Nice and concise treatment of elementary EM theory.*
3. N. Rao, *Elements of Engineering Electromagnetics*, Prentice Hall (2005). *About the same level with Cheng's EM book.*
4. D. Griffiths, *Introduction to Electrodynamics*, Prentice Hall (1999). *An alternative method of treatment of EM theory for physics undergraduate students.*
5. D. H. Staelin, Ann. W. Morgenthaler, J. A. Kong, *Electromagnetic Waves*, Prentice Hall (1994). *Useful textbook for ECE 203-level, comparable with textbook by Inan and Inan.*
6. N. Ida, *Engineering Electromagnetics*, Springer (2003).

### **Additional Advanced Textbooks:**

#### **Fundamentals**

1. J. A. Kong, *Electromagnetic Wave Theory*, EMW (2002).
2. C. Balanis, *Advanced Engineering Electromagnetics*, Wiley (1989).
3. J. D. Jackson, *Classical Electrodynamics*, Wiley (1999).

#### **Applications – Optoelectronics / Photonics**

4. E. Rosencher, and B. Vinter, *Optoelectronics*, Cambridge (2002).
5. J. Liu, *Photonic Devices*, Cambridge (2005).
6. S. L. Chuang, *Physics of Optoelectronics Devices*, Wiley (1995).
7. R. Boyd, *Nonlinear Optics*, Academic Press (2003).

#### **Computational EM**

8. A. Taflov, S. C. Hagness, *Computational Electrodynamics: The Finite-Difference Time-Domain Method*, Artech (2005).

### **Course Abstract:**

The ECE 203 course is a continuation of ECE 202, which is an Introduction to Electromagnetics (EM) I. The first introductory electromagnetics course ECE 202 covers the electrostatic and magnetostatic, with emphasis of introducing the general concepts of Gauss' Law, Ampere's Law, Faraday's Law, and absence of magnetic monopole. Several relevant concepts of importance discussed previously in ECE 202 are vector analysis / calculus, and boundary value problems.

In the ECE 203, we will emphasis on the Electromagnetic Waves. Instead of analyzing a static condition of the EM problems, we will develop the theory of how time-varying EM waves moves in media. The dynamical property of EM waves is governed by Maxwell's equation. We will present the relevance of EM theory in the modern applications, in particular in wireless communications, optical communications, photonics, optoelectronics, nanophotonics, and biotechnology.

After starting with a brief review of electrostatic and magnetostatic, we will present how time varying EM waves and Maxwell's equation are derived. This will be followed by the analysis to understand how EM waves travels in unbounded media. The reflection, transmission, and refraction of EM waves will then be analyzed at planar interfaces. The transfer of EM energy using several waveguides such as parallel-plate, dielectric slab, and cylindrical waveguides will also be analyzed. The confinement of EM energy will be discussed in the context of cavity resonators. The antennas and radiation of EM energy will also be analyzed. Introductory computational EM methods will also be presented. Several applications based on wireless communications, photonic and optoelectronics devices, and transmission lines will be given. Advanced special topics on negative refractive index materials, meta-materials, and transfer matrix approach will also be presented, if time permits.

### **Intended Levels:**

The ECE 203 course is intended for intermediate- and upper-level undergraduate (sophomore/junior/senior) in engineering (Electrical and Computer Engineering, Material Science Engineering, and other related engineering) and applied physics areas, who are intending to understand the Maxwell's classical electromagnetic waves, and apply the

EM wave theory in solving problems related to waveguiding (dielectric and metallic waveguides), antenna, computational EM technique.

**Prerequisites:**

1. Physics: Students should have the knowledge of the classical Newtonian mechanics, classical electromagnetic theory, and wave theory from general physics courses (PHY 11 and PHY 21)
2. Mathematics: Students should have the knowledge of calculus, differential equations, linear algebra, geometry, vector analysis, and vector calculus.
3. Electrostatic and Magnetostatic Background (from ECE 202):
  - a) Coulomb's and Gauss' Laws
  - b) Ampere's Law
  - c) No Magnetic Monopoles
  - d) Faraday's Law
4. Computing: Students should have the knowledge of one of the programming or numerical programs (ie. MatLab, MathCad, Mathematica, Maple, C language, Fortran language, or other numerical programs).

**The course will cover all the chapters in the textbook with the following topics:**

1. Review of Vector Analysis / Calculus, Electrostatic & Magnetostatic (ECE 202)  
The review of the ECE 202 materials will be responsibility of the students. If you do not feel comfortable with ECE 202 materials, please see me during office hours. These materials include the Topics 1 till 8 in ECE 202, up to Magnetostatic II (Magnetic Properties of Materials, Self and Mutual Inductances, Magnetic Forces, and Magnetic Energy).
2. Time-Varying Electromagnetics and Dynamic Fields
3. Maxwell's Equation
4. Plane Waves and Waves in Unbounded Medium
5. Reflection, Transmission, and Refraction of Waves at Planar Interfaces (Conductors, Dielectric, Lossless and Lossy Media)
6. Waveguides
7. Antenna
8. Applications: Photonic Devices, Transmission Lines, Microwave Engineering
9. Special Topics (negative index, meta materials, and other interesting research topics)

**Structure of the Course Grading:**

The structure of the course will consist of weekly homework assignments, two midterm exams, and a final exam with the following proportion toward the final grade:

1. Problems – 30 % (approximately 10-11 homework sets)
2. Midterm Exam I – 30 %
3. Final Exam – 40 % (scheduled by the Registrar Office)

**The purposes of this course:**

1. You would be able to differentiate the electrostatic and magnetostatic phenomena, with the time-varying electromagnetic phenomena (as well as the equations).

2. You would be able to understand the development of Maxwell's Electromagnetics equations.
3. You would be able to understand how EM waves propagate in Unbounded Media.
4. You would be able to understand the phenomena of reflection and transmission of EM waves at the interfaces of two materials.
5. You would be able to understand how EM waves propagate in waveguides (rectangular and cylindrical).
6. You would be able to understand the radiation of EM waves via antenna.
7. You would be able to solve the EM problems using numerical / computational approach.

**Homework and Exam Policy:**

1. Homework is given on every Monday, and due on the following Monday before class. (a week later)
2. No late homework is accepted, unless there is a medical emergency or permissions given in advance.
3. Working together in homework is encouraged, but not copying.
4. Academic Dishonesty will be subject to disciplinary action by Lehigh University.

**Accommodations for Students with Disabilities:**

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.