ECE 405: Electromagnetic Fields and Waves II

Fall 2005

Lecture: MWF 1:50 - 2:40 2205 EB

Instructor:	Ed Rothwell
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Office:	C133 Engineering Research
Office hours:	10:30 - 11:30 MWF 2234 EB

Text:	Fields and Waves in Communications Electronics, S. Ramo, J. R. Whinnery and T. Van Duzer, 3rd ed., Wiley, New York, 1994. (On reserve in Engineering Library).
Web site:	MSU ANGEL system (www.angel.msu.edu)
Course notes:	Posted to ANGEL

Grading:		
	Home work	15%
	Midterm Project	10%
	Semester Design Project	25%
	Final Exam	25%
	Lab	25%

Suggested References (on reserve in the Engineering Library)

Antennas, John D. Kraus, 2nd ed., New York, McGraw-Hill, 1988.
Antenna Theory: Analysis and Design, Constantine A. Balanis, 2nd ed., New York, Wiley, 1997.
Antenna Theory and Design, Warren L. Stutzman and Gary A. Thiele, New York, Wiley, 1998.
Microwave Engineering, David M. Pozar, 3rd ed., Hoboken, NJ, Wiley, 2005.

Class outline ----------

I. EM field equations
VI. Microwave networks and circuits: S-parameters, circuit elements
II. Wave equations
III. Waves in unbounded space: Plane waves, spherical waves
VII. Radiation
VIII. Antenna concepts: Radiated power, impedance, gain, antenna pattern
IX. Transmitting antennas: dipoles, arrays, microwave antennas
X. Receiving antennas
IV. Guided waves: Transmission lines, waveguides, microstrip, fiber optics
V. Confined waves: Cavities

Important Dates:

9/5	Labor Day (no class)
9/22	End of tuition refund period
10/18	Last day to drop a course with no grade reported
11/24-11/25	Thanksgiving break (no class)

Final Exam: Friday, December 16, 2005, 12:45-2:45 PM, 2205 EB

ECE 405 Laboratory Policies

Fall 2005

Lab supervisor: Ed Rothwell

Lab instructor: Jorge Villa
E-mail: villajor@msu.edu
Office hours: TBA

Schedule: Section 1 Tu 11:30-2:20 2234 EB
Section 2 Th 11:30-2:20 2234 EB
Section 3 Tu 3:00-5:50 2234 EB

1. Grade breakdown. Your lab grade will be determined from the following breakdown:

Reports	75%
Performance	25%

   The lab instructor will award your performance grade based on his/her observations of your behavior during the lab period. If you are contributing to your group, then you will receive a full 25%. If you are just standing around doing nothing, you will receive 0%.

2. Make-ups. **ALL** labs must be completed for you to receive a lab grade. If you do not complete an experiment, you will receive a "0" for your lab grade. You must be present during lab to get credit. Make-up labs must be arranged either prior to the absence, or afterward with a doctor's excuse. Attendance will be taken during all labs.

3. Preparation. You are expected to be prepared before coming to lab. Read the lab before coming to class, complete the preliminary exercises, if any, and review any topics you are unsure of. There will NOT be a lecture during the lab period. The instructor will NOT answer questions during the lab period over topics you should know from the lab manual. The instructor's presence during the lab period is to oversee the lab and help you with any mechanical trouble you are having with the equipment. If you do not understand material from the manual, see the instructor **before** the lab period.

4. Data. All data must be taken in PEN. It must be signed and dated by the instructor before you leave the lab.

5. Lab reports. Lab reports are to be handed in at the beginning of the lab period immediately following the period during which the lab was completed. You will be graded on spelling, grammar, organization and writing style, as well as on content. Each group will turn in one report.

All lab reports must be written using Microsoft Word. The lab reports need not be lengthy, but should follow the following outline.

1. **Title page**. Title of lab, names of students, name of instructor, section number, date of lab, date of report (due date).

2. **Goals**. One paragraph outlining the goals of the lab.

3. **Accomplishments**. A summary of your accomplishments -- what you have learned during the lab. Discuss discoveries, difficulties, verifications of theory, etc. Relate these to the goals of the lab.

4. **Discussion**. A discussion of your results, which follow in the next section. You must refer to labeled tables and plots. Include answers to questions posed in the lab manual and discuss error, if appropriate. Include all calculations.

5. **Results**. Include your measured and calculated data. Your data must be in either a properly labeled table or graph, or both. When you refer to these, it must be by table or graph number. See the attached pages for examples of a table and graph. For small amounts of data, use a table. For large amounts of data, or when visualization is important, use a graph. Be sure to include units!

6. **Raw data**. Include at the end of your report the raw data you took in lab, including your instructor's signature. Label this data as APPENDIX 1: RAW DATA.

Parts 2 and 3 above are to get you to think about how the lab experience relates to the class material and how the information gained during the lab has helped your understanding of the class topics.

6. Discussion of error. When you discuss error you may, if you wish, blame the equipment. If you do, you must discuss both the source AND RANGE of the error. For example, if you can read a dial to within 5%, this range of error cannot completely explain a difference of 25% between theory and experiment, unless it is compounded. Remember, the most common cause of error is unfamiliarity with equipment.

7. Be nice. Please treat the equipment kindly. Be nice to sensitive things like connectors, switches and dials. To be safe, there will be no food or drink allowed in the lab.

EXAMPLE OF PROPERLY LABELED PLOT

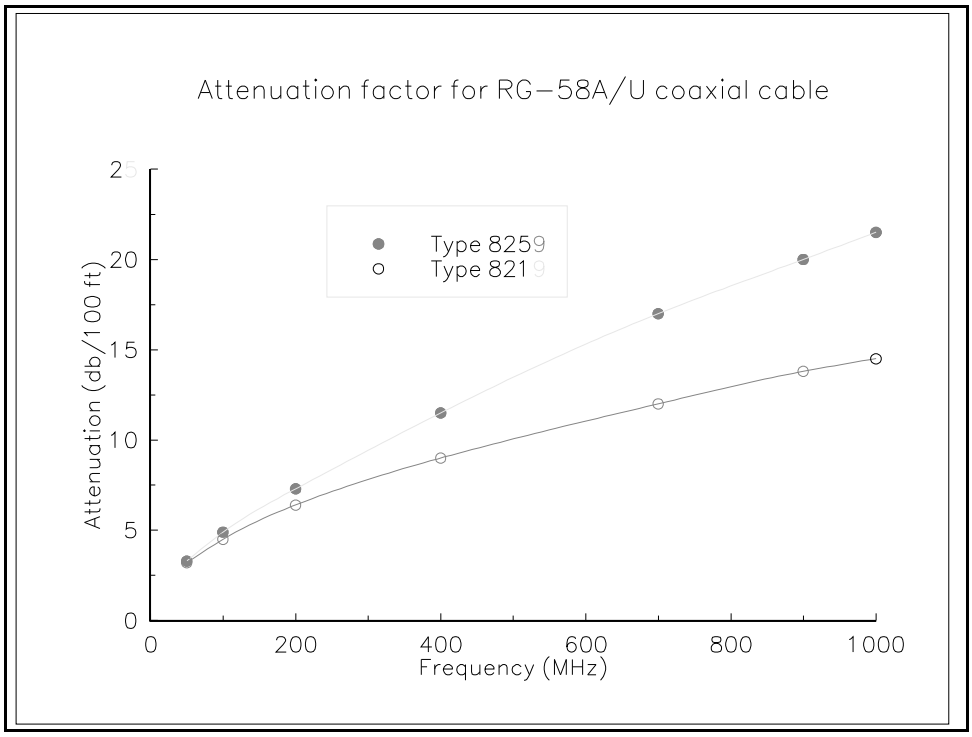

Figure 1.Attenuation factor for RG-58A/U coaxial cable.

EXAMPLE OF PROPERLY LABELED TABLE

Table 1.Properties of various soft ferromagnetic materials.

Material	Initial relative permeability	Coercive force (A/m)	Residual field (Wb/m^2)	Saturation field (Wb/m^2)	density (g/cm^3)
Commercial Iron	150-250	80	0.77	2.15	7.85
Pure iron	10k	4	0.2	2.15	7.85
Silicon-steel	900-1700	35-60	0.62-0.93	1.5-2.0	7.65
Siloctron	1.3k	8-24	1.4	1.5-2.0	7.65
Silicon-iron	400	40	1.2	1.5-2.0	7.65
Deltamax	400-1700	16-32	1.3-1.8	1.35-1.85	8.25
4-79 Mo Perm-Alloy	10k-40k	3-12	0.4-0.55	0.7-0.8	8.74
Supermalloy	50k-120k	0.2-4	0.4-0.55	0.65-0.75	8.77

ECE 405 LABORATORY SCHEDULE

Fall 2005

Note: This schedule is subject to change at the discretion of the ECE 405 instructor. All changes will be announced in class and posted to Angel.

Week	Experiment
9/12	S-parameter measurements using the vector voltmeter
9/19	S-parameters of cascaded 2-port networks
9/26	Introduction to the Agilent 4396B Network Analyzer
10/3	Introduction to CAD of microwave circuits
10/10	Design of microstrip circuits
10/17	Network Analyzer measurements of a branch-line coupler* Antenna pattern measurements*
10/24	Repeat above
10/31	Measurement and calculation of antenna impedances
11/7	Measurement and calculation of antenna impedances (continued)
11/14	X-band waveguide components and measurements
11/21	Thanksgiving break (no lab)
11/28	Microwave cavities
12/5	Open project lab
12/16	Final Exam Date

NOTES:

*Students will alternate these labs

ECE 405 LABORATORY SAFETY CONSIDERATIONS

Fall 2005

This document addresses safety considerations for students participating in the ECE 405 laboratory. Students should review all safety material provided by previous lab supervisors and be aware of the health effects of electrical shock. This document describes specific potential hazards for ECE 405.

Electrical Shock

Any time students use electrical equipment there is a possibility of electrical shock. In the ECE 405 lab there is little potential for shock since most equipment produces low-voltage, high-frequency signals. By using caution and common sense, a high level of electrical safety can be maintained. Whenever using electrical equipment of any kind, students should be on watch for frayed and broken plugs, wires, and connections. Any potential hazards should be **immediately reported to the lab instructor**.

Microwave Exposure

Several ECE 405 experiments involve using signals at microwave frequencies. Power levels employed are well below those which give rise to electromagnetic heating. However, the subtle physiological effects of microwave energy are still uncertain, and students should take care to minimize their exposure to microwave energy. The following guidelines should be sufficient to provide a safe environment.

1. Never look directly into the open end of a waveguide or transmission line.
2. Never radiate EM fields in the direction of yourself or other people.
3. Never perform measurements while anyone is inside the anechoic chamber.

Note that the measurement software has been written so that RF output is turned off at all times when measurements are not being performed. However, students must be aware of the presence of persons inside the anechoic chamber, and make sure that the measurement process is not initiated when the chamber is occupied.

If students have ANY questions regarding safety, they should immediately discuss them with their lab instructor.