EE 483/483L Antennas for Wireless Communications
Spring 2009, 2-2 (4 credit hours)

Instructor: Dr. Dimitris E. Anagnostou, Office: PE-319 (Electrical Engineering/Physics Building), danagn@sdsmt.edu , http://anagnostou.sdsmt.edu

Lecture Room: 10 - 10:50am (MWF), Chem – Chem Eng. 303

Office Hours: 10:50-11:50AM (MWF) or by appointment

TA: Mr. Ahmad Gheethan, Office: PE-213, ahmad.gheethan@mines.sdsmt.edu

Text: Balanis C., "*Antenna Theory*: *Analysis and Design*" 3rd Ed., Wiley, 2005, (ISBN: 047166782X). Students are encouraged to keep the textbook.

Suggested References: Stutzman W., Thiele G., "Antenna Theory and Design" (Wiley, 1997)
Kraus J, Marhefka R., "Antennas for all Applications" (McGraw-Hill, 2001)
Balanis C., "Advanced Engineering Electromagnetics" (Wiley, 1989)

EE 483/483L Course Description: 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). (Design content- two (2) credits).

Prerequisite(s): EE382

WWW: Email and the page http://anagnostou.sdsmt.edu will be used for course-related communication. Ensure your @mines.sdsmt.edu email is listed on WebAdvisor.

ADA: Students with special needs or requiring special accommodations, contact the instructor and/or the campus ADA coordinator, Jolie McCoy, at 394-1924.

Grading:

2 Hour Exams @ 10%/each	20 %
Homework	25 %
Labs / Projects	25 %
Quizzes / Other Assignments	10 %
Final Exam (required)	20 %
Total	**100 %**

Tentative Grading Scale: The minimum percentage necessary for each letter grade is as follows: 100 > A > 90, 89 > B > 80, 79 > C > 70, 69 > D > 60, F < 60. The instructor reserves the right to adjust this scale at the end of the semester (to the students' advantage), based on the student's overall course percentage and on the difficulty of course assignments and examinations.

Labs/Projects: Assignments will be announced as they come up during the semester. Most laboratory/project work will take place in the Computer Labs and in EP127.

Reading Assignment: Students individually or in groups will be required to read a paper from a related scientific journal or chose an antenna-related topic and write a report and/or present it in class. Topics and papers will be distributed in class.

Students can work on a topic of their own interest after getting approval from the instructor. The report **must** be in IEEE format, which can be obtained from: http://www.ieee.org/web/publications/authors/transjnl/index.html , or from: http://www.ieee.org/portal/cms_docs/pubs/transactions/TRANS-JOUR.DOC .

Software: Computational Electromagnetic Design software (ADS-Momentum and/or IE3D) is available to all students and will be used.

Tentative Course Schedule

Antennas for Wireless Communications, EE 483, Spring 2009

Class	Date(s)	Topics	Reading/ Text Sections
1	F-1/16	Introduction	Intro
-	M-1/19	MLK Day – No class	
2	1/21	Vector analysis, types of antennas, radiation mechanism, wire antenna current distribution	App VII, 1.1-1.4
3	1/23	Fundamental Parameters	2.1-2.4
4	M-1/26		2.5-2.8
5	1/28		2.8-2.11
6	1/30		2.12-2.16
7	M 2/2		2.17-2.18
8	2/4		ADS see results
9	2/6	Radiation Integrals & Aux. Potential Functions	3.1-3.2
10	M-2/9		3.3-3.4
11	2/11		3.5
12	2/13		3.6
-	M-2/16	President's Day – No Class	
13	2/18		3.7-3.8
14	2/20	Exam I (Closed book, closed notes)	
15	M-2/23	Linear Wire Antennas	4.1-4.2
16	2/25		ADS inf/smal dip.
17	2/27		4.2-4.4
18	M-3/2		4.4-4.5
19	3/4		4.5-4.6 ADS λ/2
-	F-3/6	Spring Break – No Class	
-	M-3/9	Spring Break – No Class	
-	3/11 Mid	Spring Break – No Class	
-	3/13	Spring Break – No Class	
20	M-3/16	Arrays: Linear, 2D, Binomial, Chebyshev	6.1, notes
21	3/18		6.2-6.3
22	3/20		6.4 –6.5, 6.7
23	M-3/23		6.8-6.10, ADS
24	3/25	Microstrip Antennas	14.1, 14.2
25	3/27		14.2, ADS
26	M-3/30	Microstrip Antennas and Arrays	14.2 & notes, 14.4, 14.5
27	4/1	Matching Networks with ADS	Notes / ADS
28	4/3	Loop Antennas	5.1-5.4
29	M-4/6		5.6-5.8
30	4/8	Exam II (Open book, Closed notes)	
-	4/10	Easter Break – No Class	

-	M-4/13	Easter Break – No Class	
31	W-4/15	Matching Techniques and Matching Networks	Notes, 9.8.3
32	4/17	Yagi-Uda Arrays / LPDAs	Notes, 10.3.3
33	M-4/20	Introduction to Apertures and Horns	Ch 12, Ch. 13
34	4/22	Signal Propagation in Wireless Communications	Notes
35	4/24		Notes
36	M-4/27		Notes
37	4/29	Modern Antenna designs for Wireless Communications	Notes
38	5/1	Review / Catch up	
May 6th 2009		**EE483 Final Exam, 9-10:50am, Ch-Ch. Eng. 303**	

Homework, exam and attendance policies:

- Homework is due before class begins. Late homework will not be accepted. For full credit, show all your work (include code for plots, units, intermediate stages, etc.). Include the equations you used. If you use equations derived elsewhere, reference them (e.g., source, eq. number and/or page). Box or double underline your answers. Use conventional engineering units (i.e. μF, mV, GHz, etc). All pages should be in order, numbered, and stapled (NO paper clips / folded corners).
- Exam dates are fixed. There will be absolutely no changes to these dates.
- Attendance is not required but students are responsible for all the material we cover.
- Do not contact the instructor if you miss a lecture. If you miss an exam for good and valid reason, inform the instructor as soon as possible to schedule a make-up exam.
- All laboratory/project assignments must be completed at a passing level to pass.
- Unless otherwise specified, all coursework is to be individually completed. See *The Student Code of Conduct* for SDSM&T.

Electronic Devices Policy: Students must **turn off** their cell phone, ipod and any other electronic device **before class starts**. No text messaging in class. No headphones. If you wish to use a laptop for note taking, you may; however, you are required to download DyKnow and join *EE483* to activate. Any attempt to circumvent the DyKnow monitoring system will be considered a form of cheating and a breach of academic integrity. According to "Policy Governing Academic Integrity" in the SDSM&T Undergrad Catalog, the instructor has discretion of how acts of academic dishonesty are penalized, subject to the appeal process, and that "Penalties may range from requiring the students to repeat the work in question to failure in the course" (72-73). No other use of any other electronic/computer media is allowed.

Integrity Policy: You are expected to do your own work (as an individual or as a team as the case may be); however, one can learn by consulting with others. If you receive help from others, acknowledge that assistance appropriately. Understand the significant difference between consulting or asking someone a question versus outright copying or plagiarism. **If individuals or teams turn in assignments that are clearly not their own work, all parties involved can expect to receive no credit for that assignment**. In addition, i**f teams fail to demonstrate teamwork, all parties involved can expect to receive no credit for that assignment.**

Freedom In Learning: Students are responsible for learning the content of any course of study in which they are enrolled. Under Board of Regents and University policy, student

academic performance shall be evaluated solely on an academic basis, not on opinions or conduct in matters unrelated to academic standards. Students should be free to take reasoned exception to the data or views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled. Students who believe that an academic evaluation reflects prejudiced or capricious consideration of student opinions or conduct unrelated to academic standards should contact the dean of the college which offers the class to initiate a review of the evaluation.

Suggested laboratory and project report guidelines:

(a) Laboratory/project work should be in ink in a bound logbook unless otherwise specified.

(b) On cover, put a typed/word-processed label with: **EE483L**, **Antennas for Wireless Communications**, **Spring 2009**, and **your name**. Optional- it is a good idea to put some contact information on the cover or inside the front cover in case you misplace your logbook.

(c) Make a **Table of Contents** on the first page- include lab number (if applicable), description/title, date(s), and page(s) (both start and finish).

(d) Mistakes should be neatly crossed out (i.e., don't scribble out, white out, etc.)

(e) Use only the front side of pages (hard to read otherwise).

(f) Each page in logbook should be numbered (prefer top right hand corner).

(g) **Goal**- another person should be able to duplicate the lab/work without outside references. For example, partner(s), equipment list (include description, brand & model #s), dates, block/circuit diagrams of test set-up ... should be included, as applicable. Comments, conclusions, summaries, … are always valuable in meeting this goal, and, therefore, expected

(h) Answers/measurements/solutions should be boxed or double underlined, with the variables, values and units (if any), included. Answers without applicable units are incomplete.

(i) Leave a space (e.g., 1/2") between consecutive parts of a lab.

(j) Writing/figures/graphs must be legible (e.g., size and neatness)→ unreadable = no credit.

(k) Diagrams/figures/plots/graphs should be of a good size (e.g., 3" × 5"), and may contain colors. As applicable, they should be titled (at bottom), labeled (i.e., names / units on axes), scaled (i.e., numbers on axes), and clearly drawn. Tables should also be titled (at top).

(l) Diagrams/figures/plots/graphs/tables may be done using computer software and affixed (pasted or taped) on pages in the logbook. The bottom should be oriented toward the bottom or right hand side of the page. These items should be formatted fit logbook pages without needing to be folded over (limited exceptions for large and/or complicated drawings/tables).

(m) Do not insert loose material or multiple pages in logbook, e.g., don't insert multiple pages stapled together.

Course objectives: 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.

Student Learning Outcomes

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

1. Apply, calculate, or produce fundamental parameters or quantities of antennas (e.g., radiation patterns, radiation intensity, directivity, …).

2. Apply or use the Friis Transmission Equation and Radar Range Equation.

3. Use EM software to design and model antennas.

4. Calculate the magnetic ($\overline{A}$) and electric ($\overline{F}$) vector potentials given the electric ($\overline{J}$) or magnetic ($\overline{M}$) current densities, respectively, for simple problems.

5. Calculate the far-field electric and magnetic fields from $\overline{A}$ or $\overline{F}$.

6. Calculate antenna quantities and parameters for linear dipole, loop, and microstrip antennas.

7. Design, analyze, match, and test commonly used antennas (e.g., linear dipole, loop, microstrip, and Yagi-Uda).

8. Design and analyze linear antenna arrays with uniform spacing and amplitude.

9. Measure important antenna parameters (e.g., impedance, reflection coefficient, VSWR, radiation pattern, …) using modern test equipment (e.g., vector network analyzer).

Follow-Up: EE 692 – Advanced Antenna Engineering
EE 692 – Advanced Electromagnetics
EE 692 – Computational Electromagnetics
EE 692 – Advanced Microwave Engineering
PHYS 521 – Electromagnetism
MES 692 – Printed Electronics