UNIVERSITY OF UTAH
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

ECE 5324/6324 **ANTENNA THEORY AND DESIGN** Spring 2013

Instructor: O. P. Gandhi Office: MEB 4508

1. This is an engineering course which deals with the basic theory of antennas as well as the practical aspects of their design. We will use the textbook, *Antenna Theory and Design*, by W. L. Stutzman and G. A. Thiele, Third Edition, John Wiley & Sons, 2013. The prerequisite for the course is ECE 3300 (Fundamentals of Electromagnetics and Transmission Lines).

2. We will cover important aspects of the material covered in Chapters 1-11 of the textbook. Topics such as design of broadcast antennas, design of antenna arrays, design of shaped antennas such as corner reflectors, V- and rhombic antennas, and design of microwave antennas including wireless antennas and microstrip patch antennas will be discussed. Also discussed will be broadband antennas (Chap. 7), antenna synthesis (Chap. 10) and antenna considerations for communications systems and radar .

3. The students will be asked to run design problems using the NEC antenna code for calculating the radiation patterns of various antennas and antenna arrays.

4. A feature of the course would be one or two required research reports on the state-of-the-art on new emerging applications of antenna engineering for which each student will submit a 6-8 page report by April 5, 2013.

5. By Monday March 4, the students will form groups of 2-3 students to undertake one of the following tasks as a part of this class.

   a. Design, fabrication and testing of a dual/triple band microstrip antenna for wireless communications.
   or
   b. Visit to an antenna installation in the Salt Lake Valley. The purpose of this visit with the engineer at that installation would be to understand an antenna system in depth.

   Upon completion of Task a or b, the group will write short written reports (no more than 6-8 pages each).

   Both the research reports and the above-defined Tasks a or b are important parts of the course and will count for a total of 20% of the overall grade.

6. Detailed objectives of the course are given on the accompanying sheet.

7. Homework, typically two or three problems, will be assigned during each class period. The homework will be due as follows:

Homework Assigned	Due in ECE 5324/6324 Drop-In Box
Mondays	following Fridays by 5:00 p.m.
Wednesdays	following Mondays by 5:00 p.m.
Fridays	following Wednesdays by 5:00 p.m.

A student may miss two homework assignments during the semester without any loss of credit. Two additional homework assignments (four homework problems) during the semester may also be turned in late, by no more than three days, without any loss of credit. If all of the assignments are turned in, we will ignore the two assignments with the worst grades in counting the total score for the homework.

Homework is important and will count 12% toward the grade in the course.

8. There will be two 50-minute open-book midterm examinations during the semester. Each examination will cover material in the text, lectures, and homework assignments. Whereas Midterms I and II will be based on the material covered during each of the five week periods, the two-hour final examination will be based half on material covered after Midterm II and half on the earlier parts of the course.

9. The course grade will be based on the following:

Homework	12 percent
Research Report/s	8 percent
Group project	12 percent

Midterm I	(Wednesday , February 20, 2013)	18 percent
Midterm II	(Friday, March 29, 2013)	18 percent
FINAL EXAM	(Friday, April 26, 10:30 a.m.-12:30p.m.)	32 percent

I will grade on the curve with the median of the class between B and B+.

10. I would like to encourage you to come and talk to me on any problems with the homework or course material. My office hours are:

MWF 2:00-3:00 p.m.

For appointments at other times, please call me at 581-7743. You may also send me e-mail at gandhi@ece.utah.edu regarding questions pertaining to the class.

11. The e-mail address of the TA is as follows:

The TA may also be contacted for help with the homework or class materials.

Semester Breaks

Martin Luther King Jr. Day Holiday	Monday, January 21
President's Day Holiday	Monday, February 18
Semester Break	Sun-Sun, March 10-17

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EE 5324/6324 ANTENNA THEORY AND DESIGN

SPECIFIC OBJECTIVES

It will be the objective of this course to train a student to:

AM, FM, TV, and Short-Wave Antennas

1. Design a short monopole antenna together with a feeding arrangement and to calculate the radiation pattern and intensity of such a radiator.
2. Understand the radiation pattern of linear antennas of different lengths and the method of determining their equivalent driving point impedances.
3. Design typical broadcast antennas of one or more elements, including the ground and mutual impedance effects and the feeder arrangement/s for such antennas.
4. Understand the antennas used for mobile communication systems and their feed point impedance and radiation characteristics.
5. Design antenna arrays of horizontal or vertical elements together with the required feeder system to obtain a prescribed directivity.
6. Calculate the radiation pattern of general antenna arrays of linear elements (arbitrary locations and half lengths) driven by prescribed currents (magnitudes and phases).
7. Calculate the radiation patterns of loop antennas and Yagi Uda Arrays.
8. Synthesize antenna arrays for specified radiation patterns.

VHF, UHF, and Microwave Antennas

9. Calculate the radiation patterns of corner reflector antennas, folded dipoles and monopoles, V- and rhombic antennas, helical antennas, etc.
10. Understand broadband antennas such as spiral and log periodic antennas.
11. Understand and work problems based on slot antennas, turnstile, rectangular and circular apertures, horn and parabolic radiators.
12. Understand and design microstrip antennas and antenna arrays using rectangular and circular patch antennas.

13. Design a radar antenna to provide a prescribed "viewing" range for a given transmitter power.
14. Design transmitting and receiving antennas in order to obtain a required path loss for a communication link.

Typical Texts

1. W. L. Stutzman and G. A. Thiele, “Antenna Theory and Design,” 2nd Edition, John Wiley, 1998.
2. J. D. Kraus and R. J. Marhefka, “Antennas for All Applications,” Third Edition, 2002.
3. S. R. Saunders, “Antennas and Propagation for Wireless Communication Systems,” John Wiley & Sons, 1999.
4. R. C. Johnson and H. Jasik, Editors, “Antenna Engineering Handbook,” McGraw-Hill, 1984.
5. C. A. Balanis, “Antenna Theory: Analysis and Design,” Third Edition, John Wiley, 2005.
6. L. V. Blake and M. W. Long, “Antennas: Fundamentals, Design, Measurement,” Third Edition, Scitech Publishing, 2009.

FREQUENCY ALLOCATIONS FOR BROADCASTING

Radio Broadcasting

AM 535-1605 kHz
(interchannel spacing = 10 kHz)

Short wave (for international broadcasting) 5.95-26.1 MHz

FM 88-108 MHz

(100 channels each 200 kHz wide)

Channel 201 -- 88.1 MHz

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Channel 300 -- 107.9 MHz

Commercial broadcasting on channels 221 (92.1 MHz) to 300.

Noncommercial educational broadcasting on channels 201 through 220 (91.9 MHz).

Television Broadcasting

Low VHF 54-88 MHz

High VHF 174-216 MHz

UHF/HDTV 470-890 MHz

Numerical designation of TV channels is given in Table 1.

Wireless Communications

Cellular telephones	820 - 850 MHz (TX)
PCS	1850 - 1890 MHz 1930 - 1970 MHz 2130 - 2150 MHz 2180 - 2280 MHz
Wi-Fi (wireless PCs)	2412-2462 MHz (802.11 b/g) 5150-5350 MHz (802.11a) 5725-5805 MHz (802.11a)
Mobile (via satellites)	1645 MHz

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up to 10 GHz projected for the future

Table 1. Numerical designation of ground-based television channels.

Channel Number	Band Megahertz	Channel Number	Band Megahertz	Channel Number	Band Megahertz
2	54-60	29	560-566	57	728-734
3	60-66	30	566-572	58	734-740
4	66-72	31	572-578	59	740-746
5	76-82	32	578-584	60	746-752
6	82-88	33	584-590	61	752-758
7	174-180	34	590-596	62	758-764
8	180-186	35	596-602	63	764-770
9	186-192	36	602-608	64	770-776
10	192-198	37	608-614	65	776-782
11	198-204	38	614-620	66	782-788
12	204-210	39	620-626	67	788-794
13	210-216	40	626-632	68	794-800
14	470-476	41	632-638	69	800-806
15	476-482	42	638-644	70	806-812
16	482-488	43	644-650	71	812-818
17	488-494	44	650-656	72	818-824
18	494-500	45	656-662	73	824-830
19	500-506	46	662-668	74	830-836
20	506-512	47	668-674	75	836-842
21	512-518	48	674-680	76	842-848
22	518-524	49	680-686	77	848-854
23	524-530	50	686-692	78	854-860
24	530-536	51	692-698	79	860-866
25	536-542	52	698-704	80	866-872
26	542-548	53	704-710	81	872-878
27	548-554	54	710-716	82	878-884
28	554-560	55	716-722	83	884-890
		56	722-728		

The standards for TV transmission in the U. S. as defined by the FCC are:

Channel width: 6 MHz

Polarization of radiation: horizontal