

**South Dakota School of Mines & Technology**  
**Antennas for Wireless Communications, Spring, 2025**  
**EE 583-M01 (3-0) 3 credits**

### **Instructor Information**

**Instructor's Name-** Thomas Montoya

**Instructor's Contact Information-** (605) 394-1219, [Thomas.Montoya@sdsmt.edu](mailto:Thomas.Montoya@sdsmt.edu), EEP 314

**Instructor Office Hours-** 9-10 am MWF & 4-5 pm MF, or when available (open door policy).

As I do not always notice voicemails in a timely fashion, e-mails or in person are the preferred contact methods. Unless I am traveling or it arrives at night, I typically respond to e-mails the same day.

### **Course Information**

**Course Start/End Dates-** 1/13/2025 to 5/9/2025

**Course Meeting Times and Location-** MWF from 3-3:50 pm in EEP 208

**Course Delivery Method-** The course will be delivered in-person for lectures, quizzes, and exams. The syllabus and a link to my web page <http://montoya.sdsmt.edu> will be posted on D2L. The course web page will be used for posting assignments, examples, solutions, etcetera. E-mail will be used to notify students of course-related information and events (**check daily**). Your [first.last@Mines.sdsmt.edu](mailto:first.last@Mines.sdsmt.edu) address will be used for these e-mails.

### **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). **Notes:** Students enrolled in EE 583/583L will be held to a higher standard than those enrolled in EE 483/483L.

**Course Prerequisites-** EE 382 Applied Electromagnetics

**Course Corequisites-** EE 483L or EE 583L

### **Student Learning Outcomes**

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

- A. Apply, calculate, or produce fundamental parameters or quantities of antennas (e.g., radiation patterns, radiation intensity, directivity, ...).
- B. Apply or use the Friis Transmission Equation and Radar Range Equation.
- C. Use EM software to design and model antennas.
- D. Calculate magnetic and electric vector potentials given electric or magnetic current densities, respectively.
- E. Calculate the total and far-field electric and magnetic fields from the magnetic and/or electric vector potentials.
- F. Analyze and calculate antenna quantities and parameters for commonly used antennas (e.g., linear dipole, loop, microstrip, and Yagi-Uda).
- G. Design and analyze linear antenna arrays with uniform spacing and amplitude.

**Course Topics-** See course description and tentative course schedule.

## Course Materials

### Required Textbook(s) and Materials

Antenna Theory: Analysis and Design (Fourth Edition), Balanis, Wiley, 2016, ISBN 1-118-64206-6.

### Technology Equipment and Skills Needed for the Course

The course requires use of a computer and scientific calculator (capable complex number operations). Software needed/used in the course will include a pdf reader (Acrobat), D2L, MATLAB, NEC-2 (provided), and Microsoft Office. Skills required include the ability to navigate D2L and internet, upload/download files (e.g., text and pdf files), use MS Office programs, communicate via email, use MATLAB, and use Zoom (possibly).

## Course Grading

### Coursework

- Course instruction will be delivered in lectures. Assignments will be posted to <http://montoya.sdsmt.edu>.
- Instructor course notes are posted to course webpage, a 3-ring binder is suggested (2.5" or above).
- Bring notes, text, and calculator to every class. Most quizzes will be unannounced and require a calculator and may be open book/notes (no borrowing, no smartphones, no computers).
- To aid grading, homework shall meet the following specifications (example on course web page):
  - (a) Use the front (i.e., single-sided) of 8.5" × 11" engineering graph paper or plain white paper (NO pages torn from spiral notebooks) for assignments. Hardcopy only!
  - (b) At the top of **each** page put date, course number, your name, and page numbering (i.e., page  $x$  of  $y$  or  $x/y$  formats in upper right-hand corner). Ensure problems & pages are in order.
  - (c) All work exceeding one page should be stapled - no paper clips, folded corners, or folders.
  - (d) Write-out problem numbers & descriptions, copy/draw figures, and **show all** work so it can be understood without the text. No work (i.e., "magic" answer) → no credit.
  - (e) Writing/figures/graphs must be legible and large enough to read → illegible = no credit.
  - (f) Reference equations derived in the text (e.g., equation number and/or page number). Fundamental equations (e.g., Maxwell's equations, Ohm's Law ...) are excluded from this requirement.
  - (g) Use notation, especially for vectors, and conventional engineering units & prefixes (i.e., MKS) as given in class and text. For example,  $\vec{E} = \hat{a}_\theta 10 \text{ kV/m}$  and  $100 \text{ MHz}$  **NOT**  $\vec{E} = \hat{\theta} 100 \text{ V/cm}$  and  $10^5 \text{ kHz}$ . Answers with incorrect notation and/or without applicable units are incomplete/incorrect.
  - (h) Answers should be boxed/double underlined, in **decimal** format if numeric (no fractions) with variables, values & units (if any) included. Also, use lead zeros for fractional answers. For example, " $V_x = 0.4 \text{ V}$ " **not** " $V_x = .4$ " or " $V_x = 2/5 \text{ V}$ ". Typically, 4-6 significant digits are used.
  - (i) Work problems sequentially in a **single** vertical column with subparts clearly labeled, e.g., a), b) ... Leave space (~1/2") between consecutive parts of a problem, and draw a line across the page at the end of each problem if there is more than one. No 'checker boarding.'
  - (j) **No more than two** problems on any single page.

### Attendance Policy

Attendance is required. Notify instructor in advance (when possible) if you will be absent from class.

## Late/Make-up Assignment Policy

- Homework (HW) is due at the beginning of class on specified days (up to 20% penalty for being late w/out doctor's note, etcetera). Hardcopy format. If you know you will be missing a class, it may be turned in early. HW will **not** be accepted or graded after solutions are posted on the course web page.
- Missed quizzes will **not** be made up. If you know that you will be missing a class for a school-related activity (athletic travel, conference, etcetera), you may stop by the day before and ask to take a quiz early (if available).
- Make-ups for exams only allowed for school-sponsored events, documented illness, ...
- If 2/3 of quizzes and 2/3 of HW are completed at a **passing** level, the lowest HW grade and lowest two quiz grades will be dropped (no questions asked). If not, **all** quizzes and HW will count (no drops). The drops are meant to cover any absences, including those due to illness, interviews, trips...

## Academic Integrity

South Dakota Mines is committed to academic honesty and scholarly integrity. The South Dakota Board of Regents ([BOR Policy 2.9.2](#)) provides a comprehensive definition of “Academic Dishonesty”, which include cheating and plagiarism. All Instructors at South Dakota Mines are required to report allegations of academic misconduct to the Student Conduct Officer. [BOR Policy 3.4.1](#) provides detailed information regarding key definitions, policy information, prohibited conduct, and the Student Conduct process adhered to at South Dakota Mines. Any student suspected of violating academic integrity standards will be reported in accordance with the process outlined on the South Dakota Mines [website](#).

- Students are encouraged to discuss homework with classmates in general terms. However, copying, plagiarism ... is not acceptable and will be penalized (e.g., grade of zero).

## Grading and Assessment

Student learning is assessed by a combination of exams, quizzes, and homework.

Description	Percent
Three (3) Hourly exams @ 15% each	45%
Quizzes	20%
Homework	15%
Final exam	20%
<b>Total</b>	<b>100%</b>

**Special Note Regarding Final Exams:** Per South Dakota Mines Policy ([II-6-2](#)), if you are scheduled to take three or more final/last exams on the same day during finals week, you may request that the middle exam(s) of the day be rescheduled. ***You are required to make this request of your Instructor(s) at least 30 days prior to the last day of regular classes.***

**Grading Scale-** 100 > A > 90, 89 > B > 80, 79 > C > 70, 69 > D > 60, F < 60.

## Academic Freedom Statement

Academic Freedom is the cornerstone upon which higher education is built. Academic freedom, as defined by [BOR Policy 1.6.1](#), is fundamental to the advancement of truth, development of critical thinking, promotion of civil discourse, and contribution to the public good. Each course includes the freedom to discuss relevant matters and present various scholarly views in the classroom, as determined by the subject-matter expertise of the instructor. Students are encouraged to develop the capacity for critical thinking and to pursue the truth, debate ideas, express and evaluate their opinions, and draw conclusions. Students are

free to take reasoned exception to the 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.<sup>1</sup>

<sup>1</sup>*Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".*

### **Complaint Process**

While we hope that every student has a meaningful and positive experience at South Dakota Mines, should a concern arise, students are encouraged to first attempt to resolve their concern directly with the person or office directly involved. Following that attempt, should the concern remain unresolved, students are encouraged to reach out to the Dean of Students office at [DeanOfStudents@sdsmt.edu](mailto:DeanOfStudents@sdsmt.edu) or 605.394.2416. Additionally, students may access the [online form](#) to submit their complaint, appeal, or grievance.

### **Grade Appeal Policy**

In alignment with [BOR Policy 2.9.1](#), students who wish to appeal their final course grade shall first discuss the matter with the course instructor. If the concerns are unresolved following that discussion, students may utilize the [online form](#) to submit "Appeal – Academic" for a "Grade Dispute".

### **Opportunity for All - Student Success Services and Support**

Students are provided a one-stop source for information regarding all the services and supports to ensure success. Visit the [Opportunity Center](#) page to learn more.

### **South Dakota Board of Regents Required Syllabus Statements**

The following statements may be found online in South Dakota Board of Regents Academic Affairs Council Guideline [2.7.3.A\(1\)](#):

- Freedom in Learning
- Americans with Disabilities Act
- Academic Dishonesty and Misconduct
- Acceptable Use of Technology
- Emergency Alert Communications

### **Electronic Devices Policy**

Please silence/turn off your cell phone before class starts. No text messaging or headphones in class. You may use a laptop/tablet in class for purposes of note taking (NOT allowed for exams or quizzes). No other use of any other electronic/computer media, other than calculators, is allowed during class time.

**Topics/Course Schedule:** Selected topics from Chapters 1-6, 9, 10, 11, and 14, supplemented by notes. See attached tentative schedule.

<b>Class   Date</b>	<b>Tentative Topics/Activities</b>	<b>Reading/Text</b>
1   1/13/25 2   1/15/25	<b>Antennas-</b> Intro, types of antennas, radiation mechanism, methods of analysis, history	<ul style="list-style-type: none"> <li>• 1.1 - 1.3</li> <li>• 1.3 - 1.5</li> </ul>
3   1/17/25 <b>1/20/25</b> 4   1/22/25 5   1/24/25 6   1/27/25 7   1/29/25 8   1/31/25	<b>Fundamental Parameters of Antennas-</b> Intro; radiation pattern(s); power density, intensity; directivity; numerical techniques; gain; antenna efficiency; beamwidth; directivity; beam efficiency; bandwidth; polarization; input impedance; antenna radiation efficiency, effective length, & effective area; maximum directivity & effective area; Friis transmission & radar range equations	<ul style="list-style-type: none"> <li>• 2.1 - 2.3</li> <li><b>Holiday</b></li> <li>• 2.3 - 2.6</li> <li>• 2.6 - 2.12</li> <li>• 2.12 - 2.14</li> <li>• 2.14 - 2.16</li> <li>• 2.17 - 2.18</li> </ul>
9   2/3/25 10   2/5/25	<b>Radiation Integrals &amp; Aux. Potential Functions-</b> Intro, vector potentials for electric & magnetic currents, far-field radiation	<ul style="list-style-type: none"> <li>• 3.1 - 3.4</li> <li>• 3.4 - 3.6</li> </ul>
11   2/7/25 12   2/10/25 13   2/12/25	<b>Numerical Electromagnetics Code (NEC)-</b> Introduction, background, and usage	<ul style="list-style-type: none"> <li>• Notes</li> <li>• Notes</li> <li>• Notes</li> </ul>
14   2/14/25	<b>Exam #1-</b> Covers material from Chapters 1, 2, and 3	
<b>2/17/25</b>	<b>Holiday</b>	
15   2/19/25 16   2/21/25 17   2/24/25 18   2/26/25	<b>Linear Wire Antennas-</b> Introduction; infinitesimal & small dipoles, region separation, finite length dipole, half-wavelength dipole	<ul style="list-style-type: none"> <li>• 4.1 - 4.2</li> <li>• 4.3 - 4.4</li> <li>• 4.4 - 4.5</li> <li>• 4.5 - 4.6</li> </ul>
19   2/28/25 20   3/3/25 21   3/5/25	<b>Yagi-Uda arrays-</b> Introduction, background, design	Notes, 10.3.3
22   3/7/25	<b>Folded Dipoles-</b> Introduction, background, design	Notes, 9.6
<b>3/10 – 3/14</b>	<b>Spring Break</b>	
23   3/17/25 24   3/19/25 25   3/21/25	<b>Matching Techniques-</b> T-Match, modified T-Match, Gamma match, Modified Gamma match, Omega match, other matches/baluns	<ul style="list-style-type: none"> <li>• Notes</li> <li>• Notes</li> <li>• Notes, 9.8</li> </ul>
26   2/24/25 27   2/26/25	<b>Log-periodic dipole arrays (LPDAs)-</b> Introduction, background, design	<ul style="list-style-type: none"> <li>• Notes, 11.4</li> <li>• Notes, 11.4</li> </ul>
28   3/28/25	<b>Exam #2-</b> Covers material from NEC to matching techniques	
29   3/31/25 30   4/2/25 31   4/4/25	<b>Microstrip Antennas-</b> Introduction; rectangular patch, quality factor, bandwidth, & efficiency; input impedance	<ul style="list-style-type: none"> <li>• 14.1</li> <li>• 14.2, notes</li> <li>• 14.4 - 14.5</li> </ul>
32   4/7/25 33   4/9/25	<b>Loop Antennas-</b> Introduction, small circular loop, circular loop with constant and nonuniform current	<ul style="list-style-type: none"> <li>• 5.1 - 5.2</li> <li>• 5.3 - 5.4</li> </ul>
34   4/11/25 35   4/14/25 36   4/16/25	<b>Helical Antennas-</b> Introduction, normal mode, axial mode, design, matching	<ul style="list-style-type: none"> <li>• 10.3.1, Notes</li> <li>• Notes</li> <li>• Notes</li> </ul>
<b>4/18 – 4/21*</b>	<b>Holiday (* Governor gave Monday as holiday last year)</b>	
37   4/23/25 38   4/25/25	<b>Arrays: Linear, ... -</b> Introduction, two-element arrays, $N$ -element linear array: Uniform Amplitude & Spacing	<ul style="list-style-type: none"> <li>• 6.1, Notes</li> <li>• 6.2 - 6.3</li> </ul>
39   4/28/25	<b>Exam #3-</b> Covers material from LPDAs to helical antennas	
40   4/30/25 41   5/2/25	<b>Arrays: Linear, ... cont.-</b> $N$ -element linear array: Uniform Amplitude & Spacing, $N$ -element linear array: Directivity	<ul style="list-style-type: none"> <li>• 6.3 - 6.4</li> <li>• 6.4 - 6.5</li> </ul>
	<b>Final Exam- Thursday, May 8, 2023 from 3 - 4:50 pm, EEP 208</b>	