UNITED STATES AIR FORCE ACADEMY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ECE 215S Syllabus - Spring 2025

Overview

Understanding complex systems like the F-35, hypersonic weapons, and GPS is essential for leaders in the world's most advanced military. Regardless of your academic discipline or career field, ECE215S will equip you with the tools to analyze these systems and tackle technical challenges as they arise (because they will!), preparing you for success in the Air Force, Space Force, and beyond.

Instructors

Dr. Kaitlin Fair (Course Director)	2E36E	kaitlin.fair@afacademy.af.edu
Lt Col Matt Booth	2E36A	matthew.booth@afacademy.af.edu
Ms. Vanessa Rosario (Lab Tech)	2E36B	vanessa.rosario@afacademy.af.edu

Course Goals

In ECE215S, cadets will explore the principles of electrical and computer engineering to support well-informed decision-making. By the end of the course, cadets will be equipped to develop systems-level solutions for air, space, and cyberspace operations while addressing real-world constraints.

Course Prerequisites

CompSci 110 and Math 142. Can be co-requisites; chat with your instructor if an issue.

Course Materials

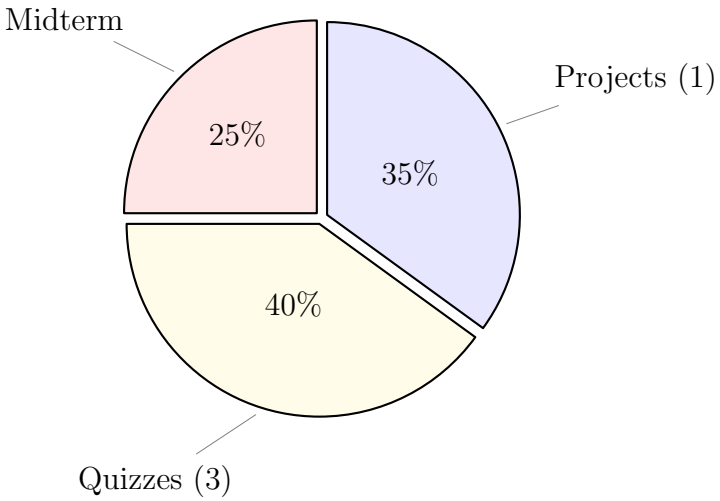
All readings will be provided electronically.

Course Communication

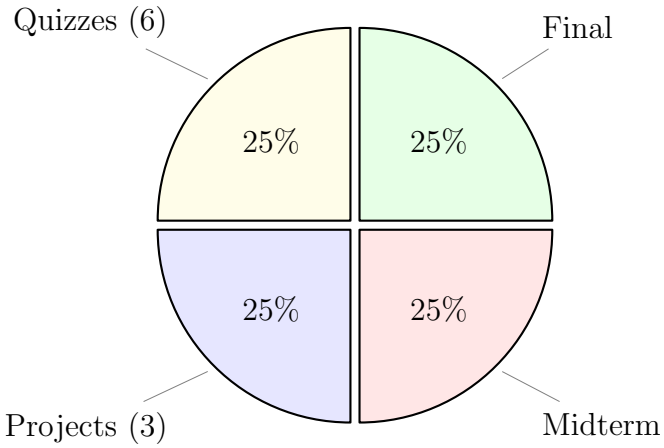
- **Gradescope** Cadets will be enrolled in the course on Gradescope. All Quizzes, Projects, and examinations will be submitted, graded, and/or returned through Gradescope.
- **Teams** Most communications regarding the course will be through Teams, including any due dates and schedule changes.
- **Email** Communications that require formal documentation should be submitted via email such as SCAs and notifications of bedrest.

The grade breakdown for the course at Prog and for your final grade are shown below. A number in parentheses indicates the number of items for that graded event.

Prog Grade Weighting



Final Grade Weighting



Grade Scale

F	D	C-	C	C+	B-	B	B+	A-	A
$\leq 60\%$	70%	73%	77%	70%	83%	87%	90%	93%	100%

This course will utilize an alternative grading format. The intent is that your grades will be fairer, more accurate, and more meaningful. This grading format should also improve your learning and retention of concepts taught throughout the semester.

This course will focus on specific learning objectives, which are key concepts required to succeed in this course and retain knowledge for future academic and professional endeavors. The Learning Objectives section of this syllabus details all learning objectives for this course. Your mastery (i.e. understanding) of each learning objective will be assessed with quizzes, projects, and examinations (midterm and final).

Quizzes Quizzes will be given to ensure you are mastering learning objectives at an appropriate pace for success in ECE215S. Key things to know:

- Quizzes will consist of several problems. Material will be covered during lectures and through assigned reading.
- Some objectives may be covered in multiple problems across multiple quizzes to improve your retention of the concept.
- Grading for quizzes will utilize an alternative grading system:
  - For each quiz problem, you may earn a 1 (correct with at most trivial math errors) or 0 (incorrect) for each problem.
  - If you receive a 0 on a quiz problem, you will be provided meaningful feedback on how to improve your understanding of that learning objective. The correct answer will not be provided.
  - If you receive a 0, you have the opportunity to improve your score within one week of the returned, graded quiz *if and only if* you have submitted your assessment problems with clear effort by the original due date.
  - To change your score from a 0 to a 1, you must demonstrate full understanding of the objective by making changes to correct your quiz problem and submitting the correction with a shareable link through a regrade request on Gradescope.
  - If you do not complete a submission by the deadline for a quiz problem or you clearly did not put effort into your submission, you can earn a retake. To earn a retake, you can read a scientific publication or article chosen by your instructor, give a 3-5 minute summary of the paper to the class, and facilitate a meaningful discussion with your instructor and/or classmates regarding the paper. *Please, put in effort and submit your quiz answers on time!* Also take special note of the absences policy and adhere to due dates!
  - Each quiz problem will be worth 1 point. A quiz with 3 problems will therefore be worth a total of 3 points.
  - The final quiz score for the course will be based on the number of quiz problems given throughout the semester. Example: if there are a total of 20 quiz questions across 6 quizzes for the entire semester and you scored a 1 for 18 quiz questions and 0 for 2 quiz questions, your quiz grade for the course is therefore $\frac{18}{20} = 90.0\%$

  - Be sure to seek help from your instructor early if you worry you may receive a score of 0.

- Ungraded practice problems will be provided with answers to prepare for your quizzes.
- Quizzes will be individual effort.
- You may only use a calculator and class resources to complete your quiz. Search engines, ChatGPT, or other AI assistants are not allowed during quizzes.
- Quizzes will be assigned, submitted, graded, and returned via Gradescope.
- Check Gradescope for official deadlines.

Projects Projects will solidify your understanding of learning objectives through engineering applications. Key things to know:

- Projects will be completed as a group with group sizes detailed within each Project Assignment.
- Projects will be scored similar to quizzes, where you will receive a score of 1 (correct with at most trivial math errors) or 0 (incorrect).
- To earn a 1, all specifications listed in the instructions must be completed correctly as laid out in your Project Assignment.
- If you receive a 0, you have the opportunity to improve your score by correcting your original submission within one week of the returned, graded project *if and only if* you have submitted your project with clear effort by the original due date.
- There will be dedicated work day(s) during lecture periods for each project; however, work outside of class will be required to complete the projects.
- Projects will be assigned, submitted, graded, and returned via Gradescope.
- There are no restrictions regarding resources used to complete your labs. Be cautious that ChatGPT is known to provide incorrect methodology and answers to engineering problems - be sure to use generative AI tools responsibly (i.e. as a learning tool, not as a way to complete your project).
- Check Gradescope for official deadlines.

Examinations Your midterm and final represent a culmination of your learning throughout this course. Key things to know:

- The midterm and final are one-time examinations. As such, there will be no retakes offered.

- Each problem within the midterm and final will receive one of the following scores:
  - 1: The correct mathematical framework is chosen, given data is correctly used in the terms of the framework, and solutions are neat, organized, and easy to grade. Only trivial (simple math) errors are present, if any. Understanding of concepts is therefore evident.
  - .5: The correct mathematical framework is chosen, but the given data is *incorrectly* used in the terms of the framework. Solutions are neat, organized, and easy to grade. Partial understanding of concepts is therefore evident.
  - 0: The correct mathematical framework is *not* chosen, solutions are *not* neat, organized, and easy to grade, or no work completed for the problem. An understanding of concepts is therefore *not* evident.
- Your score for each examination is the number of points earned out of points possible. Example: if there are ten problems on the final and you earn a 1 on eight problems, a 0 on one, and a .5 on one, you would earn an 8.5/10, i.e. 85% on your final exam.
- The midterm and final examinations are individual effort.
- The midterm will be a take-home examination. It will be assigned, graded, and returned via Gradescope.
- The final will occur during finals week as scheduled by the registrar. It will be handwritten and submitted directly to the final exam proctor.
- Your instructor will detail resources allowed prior to each examination.

Learning Objectives

The learning objectives for this course are listed in the order in which they are covered throughout the semester and organized by course block. Mastery of all learning objectives will be assessed by respective quiz and exam questions.

Obj	Description
Block 1 - Resistive Circuits Analysis and Power Distribution	
1	I can calculate the voltages, currents, and power associated with devices in a simple DC-powered circuit using tools such as KVL, KCL, voltage and current dividers, Ohm's Law, and the power equation.
2	I can determine appropriate circuit breaker values for adequate system protection.
3	I can calculate the voltages, currents, and power associated with devices in a simple AC-powered circuit using tools such as KVL, KCL, voltage and current dividers, Ohm's Law, and the power equation.
4	I can calculate the RMS values (current and voltage) of an AC signal and understand the relationship between DC-equivalent and average power values.
5	I can compute the reactive and apparent power values for an AC-powered circuit.
6	I can calculate the efficiency of a system modeled as an electrical circuit.
7	I can calculate a transformer's turns ratio, input voltages and currents, and output voltages and currents.
8	I can calculate the efficiency, source voltage, and current of a power transmission system with one or more transformers.
9	I can calculate the efficiency, source voltage, and current of a power transmission system with one or more power converters.
10	I can calculate the efficiency, source voltage, and current of a power transmission system with AC and DC busses.
11	I can use a decision matrix to quantitatively compare various measures of merit.
Block 2 - Signal Processing	
12	I can graph a given sinusoidal signal (to include DC voltages) in the time and frequency domains and calculate the signal's bandwidth.
13	I can identify types of ideal filters and their associated cutoff frequency(ies).
14	I can determine the output of an ideal filter given an input sinusoidal signal or signal spectrum.
15	I can model capacitors and inductors as complex resistors.
16	I can calculate voltage and power in an AC-powered circuit containing resistors, capacitors, and/or inductors using tools such as voltage dividers, Ohm's Law, and the power equation.
17	I can determine the filter type and gain of simple series circuits containing a resistor, capacitor, and/or inductor.
18	I can calculate the output of a filter given a sinusoidal input signal and the filter magnitude and phase responses.
19	I can implement signal conditioning to avoid aliasing and clipping and to ensure maximum compatibility of the dynamic ranges between two devices.

Obj	Description
20	I can calculate the ADC sampling rate, voltage resolution, and digital output using the ADC operational parameters and input.
21	I can calculate the ADC bit rate to estimate the memory required for a given recording duration or determine how long it takes to fill a memory card of a specified size.
22	I can relate digital inputs to digital outputs using tools such as fundamental digital logic gates (AND, OR, NOT), truth tables, and Sum of Products (SOP) and Product of Sums (POS) Boolean expressions.
23	I can model Moore and Mealy Finite State Machines (FSMs) using tools such as state transition diagrams, transition tables, and combinational and sequential logic circuits.
	Block 3 - Communication Systems, Radar, and Electronic Warfare
24	I can describe the four types of wireless communication channels, advantages and disadvantages to each, and respective communication types.
25	I can explain the three basic types of modulation and the motivation behind modulating signals.
26	I can determine an Amplitude Modulation (AM) system output and modulation index in both time and frequency domains.
27	I can create a block diagram for envelope detection and/or synchronous demodulation of an AM signal.
28	I can describe the basic operation of dipole, monopole, and parabolic dish antennas.
29	I can calculate the signal wavelength, antenna size, max antenna gain, and basic gain pattern for dipole, monopole, and parabolic dish antennas
30	I can convert linear power ratios and values to decibels and vice versa.
31	I can calculate the maximum line-of-sight (LOS) distance between two terrestrial objects.
32	I can use the Friis and Line-of-Sight equations to calculate the maximum communication distance between a transmitter and receiver.
33	I can calculate signal-to-noise ratio (SNR) and understand how it affects wireless communications.
34	I can calculate the range from a radar to a target.
35	I can use the radar range equation to calculate the power received by the antenna from a target and the maximum detection range from the antenna to the target.
36	For pulse Doppler radar, I can calculate the range resolution and use the Doppler equation to calculate a target's velocity.
37	I can apply the Friis and RADAR equations in conjunction with SNR to analyze a jamming scenario.
38	I can explain frequency hopping and spread spectrum anti-jamming techniques.

Block 1: This block reviews basic circuit theory and introduces you to signal fundamentals and power systems. You will learn to analyze signal and power system requirements, evaluate the capabilities of system components, and design a system to meet stated requirements. The block material will culminate in a group project focused on designing a power distribution system. For each lesson read the appropriate material and attempt practice problems ***before*** coming to class.

Block 1 - Resistive Circuits Analysis and Power Distribution		
Lesson	**Topics**	**Notes**
1	Course Overview	
2	Objective 1	Quiz 0 Due
3	Objective 1	
4	Objective 1	
5	Objective 2	
6	Objectives 3-4	Quiz 1 Due (Objs 1-2)
7	Objective 5	
8	Objective 6	
9	Objectives 6-7	
10	Objectives 7-8	Quiz 2 Due (Objs 3-6)
11	Objective 9	
12	Objectives 10-11	
13	Project 1 Workday	Quiz 3 Due (Objs 7-11)
14	Project 1 Workday	

Block 2: This block introduces you to analog-to-digital conversion, digital logic, state machines, and digital information transmission. You will complete the block with a group project focused on designing a data handling system. For each lesson read the appropriate material and attempt practice problems ***before*** coming to class.

Block 2 - Signal Processing		
Lesson	**Topics**	**Notes**
15	Objectives 12-14	Project 1 Due
16	Objectives 15-16	
17	Objectives 17-18	Quiz 4 Due (Objs 12-14)
18	Lab: Non-ideal filters	
19	Work/Review Day	Quiz 5 Due (Objs 15-18)
20	Objective 19	Mid-term Exam Due (Objs 1-18)
21	Objective 20	
22	Objective 21	
23	Objective 22	Quiz 6 Due (Objs 19-20)
24	Objective 23	
25	Objectives 23	
26	Project 2 Workday	Quiz 7 Due (Objs 22-23)
27	Project 2 Workday	

Block 3: This block introduces several aspects of communications systems. You will study modulation, antennas, radar, and basic electronic warfare concepts. You will complete the block with a group project focused on radar, radio, and electronic warfare. For each lesson read the appropriate material and attempt practice problems ***before*** coming to class.

Block 3 - Communication Systems, Radar, and Electronic Warfare		
Lesson	**Topics**	**Notes**
28	Objectives 24-25	Project 2 Due
29	Objective 26	
30	Objective 27	
31	Objectives 28-29	Quiz 8 Due (Objs 24-27)
32	Objective 30	
33	Objectives 31-32	Quiz 9 Due (Objs 28-30)
34	Objectives 32-33	
35	Objectives 34-35	Quiz 10 Due (Objs 31-33)
36	Objectives 35-36	
37	Objective 37	
38	Objective 38	
39	Project 3 Workday	Quiz 11 Due (Objs 34-38)
40	Project 3 Workday	

1. **Instructor Philosophy**

   As your instructors, we believe learning should be both challenging and rewarding, no matter your academic background. We're here to support your success by fostering an inclusive environment and working alongside you. If you put in the effort and communicate with us, we'll ensure you have the tools and support you need to succeed. If something doesn't feel right, don't hesitate to speak up — we are committed to making this a space where everyone thrives.

2. **Academic Honor**
   Your honor is extremely important. The course's academic security policies are designed to help you succeed in meeting academic requirements while practicing the honorable behavior our country rightfully demands of its military. Do not compromise your integrity by violating academic security or by taking unfair advantage of your classmates.

3. **Extra Instruction**
   EI is one of the best and easiest ways to succeed in this class; EI is recommended and welcomed early and often.

4. **Absences**
   In the event of an absence, communicate with your instructor **beforehand.** Please expect all quizzes, projects, and other submissions to be due as scheduled, regardless of absence type. Should you have extenuating circumstances such as no internet while on approved travel or too ill to complete work while on bedrest, you must communicate an alternate plan with your instructor and ensure that your instructor has approved the alternate plan **before** the deadline for quizzes, projects, or other submissions have occurred. If the original deadline passes and you have not submitted your assignment without an approved extension from your instructor, you will receive a 0 and you will not receive any retake opportunities.

5. **Collaboration**
   Collaboration (not copying) is highly encouraged unless your instructor provides direction otherwise. A good litmus test to distinguish between copying and collaboration is as follows: students must be able to explain every step indicated on their submitted work to be considered collaboration and not copying. All help received on work submitted for grading must be documented in accordance with the course documentation policy below.

6. **Generative AI**
   Your instructors are pro-AI unless noted otherwise (example: quizzes); however, we expect you to use generative AI platforms (ChatGPT, etc) as a tool rather than to complete your assignments for you. Similar to the collaboration policy: a good litmus test is that you must be able to explain every step indicated on your submitted work to be considered responsible use of generative AI. It will become clear quickly if you are using AI irresponsibly: ChatGPT is not very good at math and if you aren't following in class and seeking EI, you should not miraculously have a perfect answer on a quiz. If you utilize generative AI on any assignment, include a documentation statement as outlined in the Documentation Policy.

7. **Documentation**
   In accordance with the Dean's policy for documentation, all ECE assignments must have a documentation statement. The documentation statement should be clearly identified with the word "Documentation." If you did not collaborate, then the statement "Documentation: None," is appropriate. In the instance that you utilize a generative AI platform to assist you on your assignment, your documentation statement should contain the platform you utilized, *how* you used it, and the link to the conversation if available. Example "Documentation: ChatGPT to write a for loop in python. Link here." Assignments without a documentation statement or with an incomplete documentation statement will receive a 0 with retake policies as described in the Grading section.