ITT Technical Institute

ET1310

Solid State Devices

Onsite Course

SYLLABUS

Credit hours: 4.5

Contact/Instructional hours: 56 (34 Theory Hours, 22 Lab Hours)

Prerequisite(s) and/or Corequisite(s):

Prerequisites: ET1210 DC-AC Electronicsv or equivalent

Course Description:

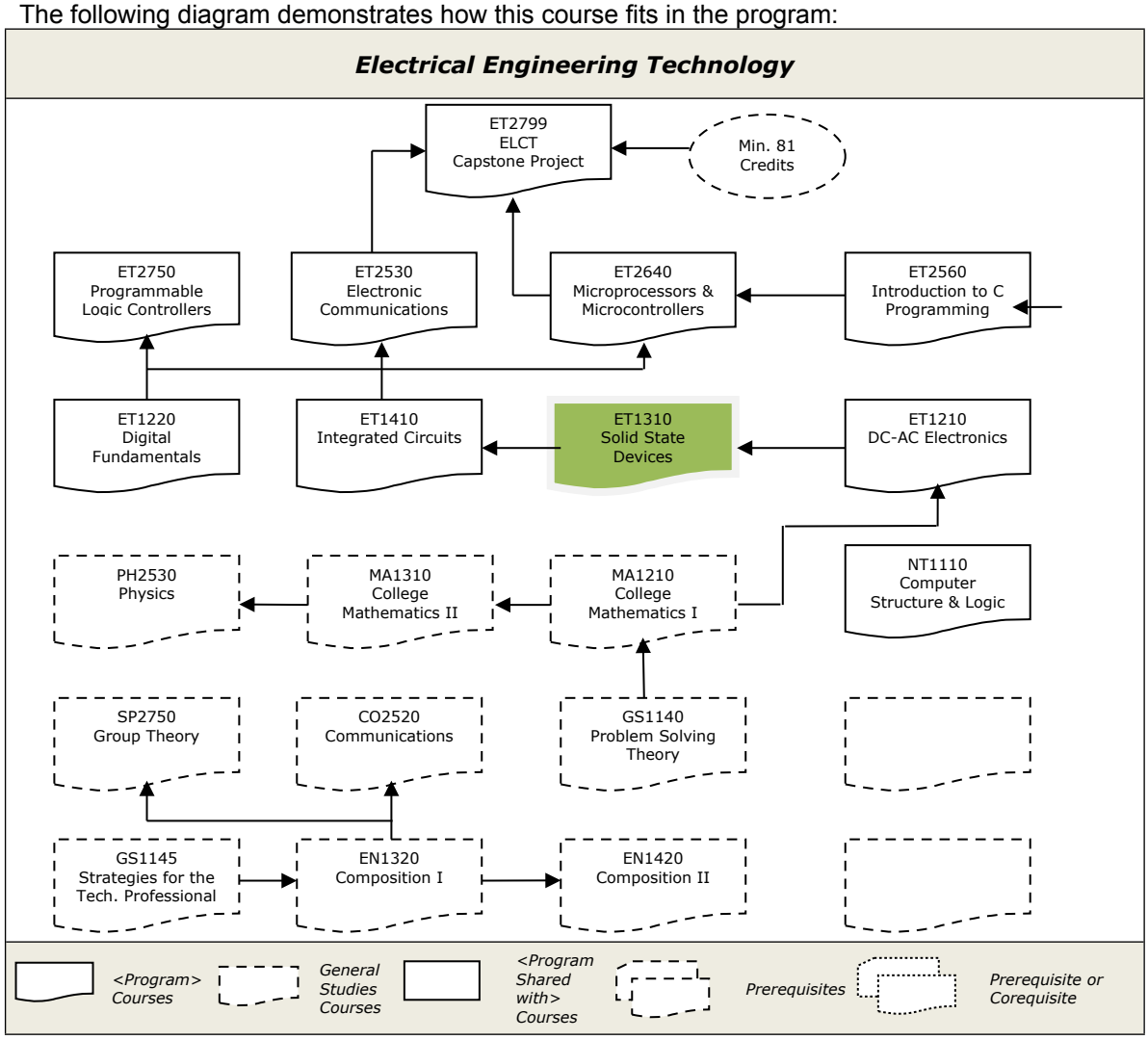
In this course, students study a variety of electronic devices, such as semiconductors, diodes, transistors and amplifiers. Bias circuits and methods and switching applications are discussed. Students analyze circuits and troubleshoot a power supply.

Where Does This Course Belong?

In general, this is a third-quarter course in the Electrical Engineering Technology program in the School of Electronics Technology. This course is required for the Electrical Engineering Technology program. This program covers the following core areas:

1. *Analog and digital electronics*
2. *Computer and networking*
3. *Electronic communications systems*
4. *Microprocessors and programming*
5. *Control systems*
6. *General education*

The following diagram demonstrates how this course fits in the program:



NOTE: Refer to the catalog for the state-specific course information, if applicable.

Course Summary

Major Instructional Areas

Unit 1
The Atomic Structure of Semiconductors
The PN Junction
Biasing the Semiconductor Diode
Diode Characteristics
Unit 2
Rectifiers
Rectifier Filters and IC Regulators
DC Power Supply
Unit 3
Diode Limiting and Clamping Circuits
Special Purpose Diodes
Diode Data Sheet
Troubleshooting
Unit 4
Structure of Bipolar Junction Transistors
BJT Bias Circuits
Data Sheet Parameters and AC Considerations
Transistor Packages and Terminal Identification
Common- Emitter Amplifiers
Unit 5
Common-Collector Amplifiers
Common-Base Amplifiers
Unit 6
Bipolar Junction Transistor as a Switch
Troubleshooting
Unit 7
Structure of Field Effect Transistors
JFET Characteristics
JFET Biasing
Unit 8
MOSFET Characteristics
MOSFET Biasing
Unit 9
FET Linear Amplifiers
FET Switching Circuits
Unit 10
Capacitively Coupled Amplifiers
RF Amplifiers
Transformer-Coupled Amplifiers
Direct-Coupled Amplifiers
Class A and Class B Power Amplifiers

Course Objectives

Upon completion of the course, students should be able to:

1. Discuss the basic atomic structure of semiconductors and the characteristics of a *pn* junction.
2. Describe the basic diode characteristics and the operations of diodes.
3. Describe the basic construction and operation of bipolar junction transistors (BJTs) and explain

the operation of the four basic BJT bias circuits.
4. Discuss transistor parameters and characteristics and use them to analyze a transistor circuit and explain how a transistor can be used as a switch.
5. Describe and analyze the operations of common-emitter, common-collector, and common-base amplifiers and identify various types of transistor package configurations.
6. Troubleshoot a power supply using accepted techniques and various faults in transistor circuits.
7. Describe the basic classifications for field-effect transistors (FETs) and the construction and operation of junction field-effect transistors (JFETs).
8. Describe three bias methods for JFETs and explain how each method works.
9. Explain the operation of metal-oxide semiconductor field-effect transistors (MOSFETs).
10. Discuss and analyze MOSFET bias circuits.
11. Describe the operation of FET linear amplifiers and discuss two switching applications of FETs.
12. Describe and analyze the operation of multistage, RF, and power amplifiers.

Learning Materials and References

Required Resources

Textbook Package	New to this Course	Carried over from Previous Course(s)	Required for Subsequent Course(s)
Floyd, T. L., and Buchla, D.M. (2005). *Fundamentals of Analog Circuits*. (Custom 2nd ed.). Boston, MA: Pearson Custom.	■		■
Buchla, D.M. (2011). *Laboratory Exercises for Fundamentals of Analog Circuits*. (Custom 2nd ed.). Boston, MA: Pearson Custom.	■		■
Buchla, D.M. (2011). *Multisim Circuit Files for Fundamentals of Analog Circuits* CD. (Custom 1st ed.). Boston, MA: Pearson Custom.	■		■
Other Items	**New to this Course**	**Carried over from Previous Course(s)**	**Required for Subsequent Course(s)**
National Instruments Multisim and Ultiboard 11		■	
ELCT Student Toolkit		■	

Technology Requirements

The following requirements are for NI Multisim and Ultiboard 11.0:

- Windows XP; Windows Vista; or Windows Vista, the 64-bit version; Windows 7, both 32- and 64-bit versions
- Pentium 4 class microprocessor or equivalent (Pentium III class minimum)
- 512 MB of memory (256 MB minimum)
- 1.5 GB of free hard disk space (1 GB minimum)
- Open GL®-capable 3D graphics card recommended (SVGA resolution video adapter with 800 x 600 video resolution minimum, 1024 x 768 or higher preferred)
- NI LabVIEW 8.6.x or 2009 is required to develop custom instruments based on LabVIEW for use in Multisim

(-From National Instruments Multisim System Requirements web page)

Recommended Resources

Books, Professional Journals

- Streetman, B., & Banerjee, S. (2006). *Solid state electronic devices*. (6th ed.). Upper Saddle River, NJ: Prentice Hall.
- Kano K. (1998). *Semiconductor devices*. Upper Saddle River, NJ: Prentice Hall.

Professional Associations

- Institute of Electrical and Electronics Engineers (IEEE): http://www.ieee.org/index.html
- Electronics Technicians Association (ETA): http://www.eta-i.org/

ITT Tech Virtual Library (accessed via Student Portal)
School of Electronics Technology> Recommended Links>

- Articles and Books>

    - All About Circuits: LESSONS IN ELECTRIC CIRCUITS, Volume III – Semiconductors and Volume VI – Experiments.
    - Basic Electronics, Chapter 7
- Components>
    - Fairchild Semiconductor
    - National Semiconductor
    - Texas Instruments
- Dictionaries>
    - Electronics Dictionary
    - Semiconductor Glossary
- Online magazines and journals>
    - SOLID STATE TECHNOLOGY
- Reference resources>
    - Educypedia: Electricity and Electronics
    - Electronics Learning Resources on the WWW
- Product and Data Sheet Directories>
    - Semiconductor Datasheets on the Web

School of Electronics Technology> Tutorial Links>

- Wisc-Online: Online Learning Object Repository> Learning objects> Technical>
    - Electronics - Solid State

Books> Ebrary

- Cathey, J. (2002). *Schaum's outline of electronic devices and circuits.* (2nd ed.). New York, NY: McGraw-Hill.

Books> CRCNetBase

- Whitaker J. (2005). *The electronics handbook* (2nd ed.). Chapter 7. New York, NY: CRC Press.

Other References

- How Semiconductors Work
  http://www.howstuffworks.com/diode.htm (accessed on 06/29/11)
  Web site contains articles about doping silicon, diodes, and transistors.
- How Transistors Work
  http://www.howstuffworks.com/transistor.htm (accessed on 06/29/11)

Web site contains articles about transistor applications to radio and computers

- Discrete Semiconductor Circuits
  http://www.allaboutcircuits.com/vol_6/chpt_5/index.html (accessed on 06/29/11)
  Web site contains circuits and experiments using diodes and transistors.

NOTE: All links are subject to change without prior notice.

Information Search

Use the following keywords to search for additional online resources that may be used for supporting your work on the course assignments:

- Circuits
- Circuit boards
- Semiconductors
- Rectifier
- Diode circuits
- Bipolar junctions
- BJT
- JFET

- D-MOSFET
- Thevenin model
- Voltage-divider rule

Course Plan

Suggested Learning Approach

In this course, you will be studying individually and within a group of your peers. As you work on the course deliverables, you are encouraged to share ideas with your peers and your instructor, work collaboratively on projects and team assignments, raise critical questions, and provide constructive feedback.

Use the following advice to receive maximum learning benefits from your participation in this course:

DO	DON'T
▪ Do take a proactive learning approach. ▪ Do share your thoughts on critical issues and potential problem solutions. ▪ Do plan your course work in advance. ▪ Do explore a variety of learning resources in addition to the textbook. ▪ Do offer relevant examples from your experience. ▪ Do make an effort to understand different points of view. ▪ Do connect concepts explored in this course to real-life professional situations and your own experiences.	▪ Don't assume there is only one correct answer to a question. ▪ Don't be afraid to share your perspective on the issues analyzed in the course. ▪ Don't be negative about the points of view that are different from yours. ▪ Don't underestimate the impact of collaboration on your learning. ▪ Don't limit your course experience to reading the textbook. ▪ Don't postpone your work on the course deliverables – work on small assignment components every day.

Course Outline

Unit 1: SEMICONDUCTORS, PN JUNCTION, AND DIODES

Unit Duration: *Onsite: 1 week*
Outside Prep Time: *4 hrs.*

Upon completion of this unit, students are expected to:

- Describe the basic atomic structure of semiconductors.
- Compare differences between N-type and P-type semiconductive materials.
- Explain how the depletion region is formed in a *pn* junction.
- Explain forward bias and reverse bias of a diode.
- Interpret a diode characteristic curve and identify the reverse bias region, forward bias region, knee, and Barrier potential.
- Demonstrate how to test a diode using a multi-meter.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 1, pp. 2-5, and Chapter 2, pp. 48-62 • Lab manual, "Summary of Theory" section of Experiment 2, The Diode Characteristic, p. 19	Assignments	Unit 1 Homework 1: Semiconductors, PN Junctions, and Diodes	2%
	Labs	Unit 1 Lab 1: Using DMM to Test a Diode	1%
		Unit 1 Lab 2: Generating Diode I-V Characteristic Curve	1%

Unit 2: DIODE CIRCUITS AND APPLICATIONS

Unit Duration: *Onsite: 1 week*
Outside Prep Time: *4 hrs.*

Upon completion of this unit, students are expected to:

- Explain the operation of half-wave, center-tapped full-wave, and full-wave bridge rectifier circuits.
- Explain the operation of rectifier filters and IC regulators.
- Explain the operation of a basic power supply.
- Discuss practical applications for rectifiers, rectifier filters, and IC regulators.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 2, pp. 62-83 • Lab manual, "Summary of Theory" section of Experiment 3, Rectifier Circuits, p. 27	Quizzes	Unit 2 Quiz 1	2%
	Assignments	Unit 2 Homework 1: Diode Circuits and Applications	2%
	Labs	Unit 2 Lab 1: Rectifier Circuits	2%

Unit 3: SPECIAL PURPOSE DIODES AND DIODE TROUBLESHOOTING

Unit Duration: *Onsite: 1 week*
Outside Prep Time: *4 hrs.*

Upon completion of this unit, students are expected to:

- Explain the operation of diode-limiting and diode-clamping circuits.
- Discuss practical applications for diode-limiting and diode-clamping circuits.
- Compare the characteristic curve of a Zener diode with that of a rectifier diode.

- Explain how a Zener diode is used as voltage regulator.
- Explain how a varactor diode is used as a variable capacitor.
- Explain the basic operation of a light-emitting diode.
- Explain the basic operation of a photodiode.
- Discuss practical applications for Zener diodes, varactor diodes, LEDs, and photodiodes.
- Define the parameters found on a diode data sheet.
- Apply troubleshooting techniques to determine symptoms of failure of a basic power supply.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 2, pp. 83-104 • Lab manual, "Summary of Theory" section of Experiment 4, Diode Limiting and Clamping Circuits, p. 33 • Lab manual, "Summary of Theory" section of Experiment 5, Special-Purpose Diodes, p. 39 •	Quizzes	Unit 3 Quiz 2	2%
	Assignments	Unit 3 Homework 1: Special-Purpose Diodes and Diode Troubleshooting	2%
	Labs	Unit 3 Lab 1: Diode Limiting and Clamping Circuits	1%
		Unit 3 Lab 2: Special-Purpose Diodes	1%

Unit 4: BIPOLAR JUNCTION TRANSISTORS, COMMON-EMITTER AMPLIFIER

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:

- Describe the basic construction of bipolar junction transistors (BJTs).
- Draw the schematic symbol for npn and pnp BJTs.
- Identify the various transistor package configurations.
- Explain how the base, collector, and emitter currents are related.
- Define DC beta.
- Use Kirchhoff's voltage law to analyze sum of voltage drops around a closed-loop BJT circuit.
- Interpret a BJT characteristic curve and explain how the DC load line is constructed.
- Define the Q-point of the DC load line.
- Define cutoff and saturation of a BJT and locate the cutoff and saturation points on the characteristic curve.
- Differentiate between base bias, collector feedback bias, voltage divider bias, and emitter bias circuits.
- Define the parameters found on a BJT data sheet.
- Explain the purpose of coupling and bypass capacitors in BJT amplifier circuits.
- Explain the operation of a common-emitter (CE) BJT amplifier.
- Identify the equivalent ac circuit of a CE BJT amplifier.
- Calculate dynamic emitter resistance, input resistance, output resistance, and voltage gain for a CE BJT amplifier.

- Explain the difference between the AC and DC load lines.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 1, pp. 17-18 and pp. 20-24, and Chapter 3, pp. 124-158 • Lab manual, "Summary of Theory" section of Experiment 8, The Common-Emitter Amplifier, pp. 59-60	Quizzes	Unit 4 Quiz 3	2%
	Assignments	Unit 4 Homework 1: Bipolar Junction Transistors, Common-Emitter Amplifiers	2%
	Labs	Unit 4 Lab 1: Common-Emitter Amplifier	2%

Unit 5: COMMON-COLLECTOR AND COMMON-BASE AMPLIFIERS

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:

- Explain the operation of a common-collector (CC) BJT amplifier.
- Identify the equivalent ac circuit of a CC BJT amplifier.
- Calculate input resistance, output resistance, and current gain for a CC BJT amplifier.
- Explain the operation of a Darlington pair circuit.
- Explain the operation of a common-base (CB) BJT amplifier.
- Identify the equivalent ac circuit of a CB BJT amplifier.
- Calculate input resistance, output resistance, and voltage gain for a CB BJT amplifier.
- Compare CE, CC, and CB BJT amplifiers in terms of voltage gain, input resistance, and output resistance.
- Discuss practical applications for CE, CC, and CB BJT amplifiers.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 3, pp. 158-167 • Lab manual, "Summary of Theory" section of Experiment 9, The Common-Collector Amplifier, pp. 65-66	Exams	Unit 5 Exam 1	8%
	Assignments	Unit 5 Homework 1: Common-Collector Amplifier	2%
	Project	Unit 5 Project Proposal	1%
	Labs	Unit 5 Lab 1: Common-Collector Amplifier	2%

Unit 6: USING BJT AS A SWITCH AND BJT TROUBLESHOOTING

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:

- Explain BJT conditions during cutoff and saturation states.
- Explain how a BJT is used as a switch.
- Calculate collector current and minimum base current in the saturation state.
- Understand basic techniques used to troubleshoot transistor bias circuits and individual transistors.
- Discuss practical applications for BJT switches.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)

• Floyd, Chapter 3, pp. 168-182 • Lab manual, "Summary of Theory" section of Experiment 10, Transistor Switches, p. 71	Quizzes	Unit 6 Quiz 4	2%
	Assignments	Unit 6 Homework 1: Using BJT as a Switch and BJT Troubleshooting	2%
	Labs	Unit 6 Lab 1: Transistor Switches	2%

Unit 7: JUNCTION FIELD-EFFECT TRANSISTORS

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:

- Describe the basic construction and operation of n-channel and p-channel junction field-effect transistors (JFETs).
- Draw the schematic symbol for n-channel and p-channel JFETs.
- Interpret the drain characteristic curve and identify the ohmic, constant current, and breakdown regions.
- Define transconductance (gm), shorted drain current (IDSS), gate-reverse current (IGSS), input capacitance (Ciss), cutoff voltage (VGS(off)), and pinch-off voltage (VP).
- Calculate transconductance (gm) and input resistance.
- Differentiate between self-bias, voltage-divider bias, and current-source bias circuits.
- Interpret the transconductance curve and understand how it relates to the drain characteristic curve.
- Discuss practical applications for JFETs.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 4, pp. 202-220 • Lab manual, "Summary of Theory" section of Experiment 12, JFET Biasing, pp. 83-84	Quizzes	Unit 7 Quiz 5	2%
	Assignments	Unit 7 Homework 1: Junction Field-Effect Transistors	2%
	Labs	Unit 7 Lab 1: JFET Characteristics and Biasing	2%

Unit 8: METAL OXIDE FIELD-EFFECT TRANSISTORS

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:

- Describe the basic construction and operation of n-channel and p-channel depletion metal-oxide semiconductor field-effect transistors (D-MOSFET).
- Describe the basic construction and operation of n-channel and p-channel enhancement metal-oxide semiconductor field-effect transistors (E-MOSFET).
- Draw the schematic symbol for n-channel D-MOSFETs, p-channel D-MOSFETs, n-channel E-MOSFETs, and p-channel E-MOSFETs.
- Explain the difference between depletion mode and enhancement mode.
- Interpret the D-MOSFET and E-MOSFET transfer characteristic curves.
- Understand MOSFET handling precautions.
- Differentiate between voltage divider with self-bias, source bias, and current-source bias circuits for D-MOSFETs.
- Differentiate between drain-feedback and voltage divider bias circuits for E-

MOSFETs.
- Discuss practical applications for MOSFETs.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 4, pp. 220-228 • Lab manual, "Summary of Theory" section of Experiment 14, JFET Applications, p. 95	Quizzes	Unit 8 Quiz 6	2%
	Assignments	Unit 8 Homework 1: Metal Oxide Field-Effect Transistors	2%
	Labs	Unit 8 Lab 1: FET Amplifiers	2%

Unit 9: FIELD EFFECT TRANSISTOR AMPLIFIERS AND SWITCHING CIRCUITS

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:
- Explain the operation of a common-source (CS), common-drain (CD), and common-gate (CG) FET amplifier.
- Calculate voltage gain for CS, CD, and CG FET amplifiers.
- Calculate the input resistance for FET amplifiers using various bias circuits.
- Discuss practical applications for CS, CD, and CG FET linear amplifiers.
- Explain the difference between an analog switch and a digital switch.
- Explain the operation of a JFET analog switch, MOSFET analog switch, solid-state relay, discrete MOSFET switch, and IC switching circuit.
- Discuss practical applications for FET switches.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Floyd, Chapter 4, pp. 228-246 • Lab manual, "Summary of Theory" section of Experiment 13, FET Amplifiers, p. 89	Exams	Unit 9 Exam 2	8%
	Assignments	Unit 9 Homework 1: Field-Effect Transistor Amplifiers and Switching Circuits	2%
	Labs	Unit 9 Lab 1: JFET Applications	2%

Unit 10: MULTI-STAGE AMPLIFIERS

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *4 hrs.*

Upon completion of this unit, students are expected to:
- Understand the analysis of cascaded amplifier stages using the Thevenin model and voltage divider rule.
- Calculate overall voltage gain, input resistance, and output resistance of a two-stage amplifier.
- Explain how multistage amplifiers are designed to avoid unwanted oscillations and noise.
- Describe the characteristics of RF amplifiers.
- Discuss practical applications for high-frequency RF amplifiers.
- Describe the characteristics of transformer-coupled amplifiers, tuned amplifiers, and mixers.
- Discuss practical applications for transformer-coupled amplifiers, tuned amplifiers, and mixers.

- Describe the characteristics of direct-coupled amplifiers.
- Describe the characteristics of Class A and Class B power amplifiers.

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	Activity/Deliverable Title	Grade Allocation (% of all graded work)
• Floyd, Chapter 1, Cascaded Stages section, pp. 24-31, and Chapter 5, pp. 264-307 • Lab manual, "Summary of Theory" section of Experiment 17, Class B Push-Pull Amplifiers, pp. 115-116	Quizzes	Unit 10 Quiz 7	2%
	Assignments	Unit 10 Homework 1: Multi-Stage Amplifiers	2%
	Labs	Unit 10 Lab 1: Class B Push-Pull Amplifiers	2%

Unit 11 – COURSE REVIEW, PROJECT, AND FINAL EXAM

Unit Duration: *Onsite: 1 week* ***Outside Prep Time:*** *2 hrs.*

READING ASSIGNMENT	GRADED ACTIVITIES / DELIVERABLES		
	Grading Category	Activity/Deliverable Title	Grade Allocation (% of all graded work)
No reading assignment	Final Exam	Final Exam	15%
	Project	Project (ePortfolio)	9%
	Student Professional Experience	Student Professional Experience Project (ePortfolio)	5%

Evaluation and Grading

Evaluation Criteria

The graded assignments will be evaluated using the following weighted categories:

Category	Weight
Assignments	20%
Quizzes	14%
Labs	20%
Exams	16%
Project	10%
Student Professional Experience	5%
Final Exam	15%
TOTAL	**100%**

Grade Conversion

The final grades will be calculated from the percentages earned in the course, as follows:

Grade	Percentage	Credit
A	90–100%	4.0
B+	85–89%	3.5
B	80–84%	3.0
C+	75–79%	2.5
C	70–74%	2.0
D+	65–69%	1.5
D	60–64%	1.0
F	<60%	0.0

Academic Integrity

All students must comply with the policies that regulate all forms of academic dishonesty, or academic misconduct, including plagiarism, self-plagiarism, fabrication, deception, cheating, and sabotage. For more information on the academic honesty policies, refer to the Student Handbook and the Course Catalog

(End of Syllabus)