ENGR 210: Introduction to Circuits and Instruments (Spring 2015)

CASE WESTERN RESERVE UNIVERSITY

Case School of Engineering

Department of Electrical Engineering and Computer Science

Version 20150801

Overview

Meeting Times: MWF from 9:30 - 10:20 AM in Ford Auditorium.

Instructor: Prof. Greg Lee, Glennan 517B, 368-4079 (leegs@case.edu)

Office Hours: MW 10:20 to 11:20 (Immediately after class in the atrium outside the Ford Auditorium and in Glennan 517B)

Summary Description (as listed in the Bulletin):

Modeling and circuit analysis of analog and digital circuits. Fundamental concepts in circuit analysis: voltage and current sources, Kirchhoff's Laws, Thévenin and Norton equivalent circuits, inductors capacitors, and transformers. Modeling sensors and amplifiers and measuring DC device characteristics. Characterization and measurement of time dependent waveforms. Transient behavior of circuits. Frequency dependent behavior of devices and amplifiers, frequency measurements. AC power and power measurements. ~~Noise in real electronic systems.~~ Electronic devices as switches. ~~Digital logic circuits. Introduction to computer interfaces. Analog/digital systems for measurement and control.*~~ *Prerequisite:* MATH 122. Co-requisite: PHYS 122.

***NOTE:**

The above is the official catalog description. This course will not cover the crossed out topics: "Noise in real electronic systems. Digital logic circuits. Introduction to computer interfaces. Analog/digital systems for measurement and control." It is also presented in an "Active Learning" format (see below).

Required Textbook:

J.W. Nilsson and S. Riedel, *Electric Circuits,* 10th ed., Pearson, 2014. ISBN 978-0-13-387590-4*. (It includes access to a required online resource called Mastering Engineering (course ID CWRUENGR210F15).

*NOTE:

The textbook available in the CWRU bookstore is the only supported textbook and is the book students are expected to have. For instance, homework that is late because an alternate book has not arrived will still count as late and any "open book" activities may be restricted to paper books only. While you are free to choose alternate books, you are ultimately responsible for that choice.

Supplemental Material:

You are free to use any other Circuits textbook as a *supplement* to the required textbook.

Daniel Kaplan and Christopher White, *Hands On Electronics: A Practical Introduction to Analog and Digital Circuits*, Cambridge University Press, 2003, ISBN: 978-0-521-89351-0. (Available on-line to CWRU students through the Kelvin Smith Library at http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=2723)

Active Learning

This course is presented in an Active Learning format. Active Learning is an approach to education wherein students engage actively in learning during class. This is an evidence based approach to education which increases students' mastery and retention of material. Active Learning courses develop and reinforce the material prepared before class time during class time when students have access to the instructor and teaching assistants as immediately available resources when material become difficult. Group work is a core activity in this class and **requires attendance**.

Accommodations for Students with Disabilities

Academic accommodations are available to students with documented disabilities. In order to access the accommodations for which you may be qualified, please register with the office of Disability Resources (ESS, Sears 470). The staff there will verify your need for specific accommodations and provide you with a memo to inform me of your needs. Once you have received this memo, please deliver it to me so that you may receive your accommodations. Please be aware that accommodations cannot be implemented retroactively.

Course Outcomes

Students completing ENGR 210 should be able to analyze:

- DC behavior of circuits: independent and dependent sources, Ohm's Law, Kirchhoff's Voltage Law, Kirchhoff's Current Law, node voltage and mesh current methods, operational amplifiers
- Linear properties of circuits: constant of proportionality (gain), Thévenin and Norton equivalent circuits, superposition, maximum power transfer
- Time dependent behavior of first and second order circuits: capacitors and inductors, energy and power, ability to write and solve first and second order circuit differential equations, initial and final values, time constants
- Frequency dependent behavior of RLC circuits: forced sinusoidal steady state response, phasors, frequency response, Bode plots

and should know:

- Laboratory techniques: how to use oscilloscopes and DMMs for circuit measurements, how to use laboratory power supplies and function generators, how to build a circuit from a schematic

ABET Criteria for Program Student Outcomes

This course emphasizes the bolded ABET criteria for student outcomes for program curriculum.

a) an ability to apply knowledge of mathematics, science and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

COURSE GRADING

Basis of Grades

Preparations (20%): *Preparation* assignments will be assigned concurrently with every reading assignment. The *Preparation* problems must be attempted *after* the reading. These assignments will typically be online "tutorial" problems where feedback is provided when incorrect answers are submitted. *Preparation* assignments provide an opportunity for students to practice applying the material so that they are *prepared* for class. Mastery of the material is not expected, but students are better prepared to maximize the benefit of class time having determined what material they do and do not understand.

Online *Preparation* assignments include hints to help indicate how to solve the question. If you cannot solve the question, you may give up and continue to the next problem on the assignment. You will receive credit for completing the assignment, not for solving the problems correctly. When you give up on a problem, you must compose a question related to what you do not understand. You must submit your *Preparation* assignment work as a PDF through Blackboard (with questions included). It is also good practice to bring this work to class. *Preparation* assignments should take no more than two hours to complete.

Again, you receive credit for completing the assignment, not for solving the problems correctly. Two (2) *Preparation* assignments are dropped when calculating the final grade.

Individual Summative Assessments (20 %): There will be individual *Summative Assessments* assigned in this course. Individual Summative Assessments are closed book and allow calculators (internet access is prohibited), but are must be completed individually. It is, however, encouraged to prepare for Individual Assessments in groups.

The score you receive on these assessments will be used to determine your grade. The two (2) lowest *Individual Summative Assessment* grades will be dropped when calculating the final grade.

Group Summative Assessments (20 %): There *Summative Assessments* assigned to groups in this course. The score you receive on these assignments will be used to determine your grade. Group assessments are expected to be complete in a collaborative manner.

The score you receive on these assessments will be used to calculate your grade.

Laboratory (20 %): The laboratory for ENGR 210 is located in the Sally & Larry Sears Design Laboratory (Glennan 313). Labs will be done in groups of two. The final lab includes a practical examination element. Students must attend regular lab sessions, but labs may be completed during open lab hours. Lab reports, one per group, must be completed in a one-week period and submitted through Blackboard by the beginning of the next regularly schedule lab period. The laboratory requires key card access and workstation accounts, which will be provided based on the class roster.

The score you receive on these labs will be used to determine your grade. The lowest two scores for Labs 1-11 will be dropped. Lab 12 cannot be dropped.

Final Exam (20 %): The final exam will be given on the scheduled exam period. The exam is closed book and open notes (a one-sided 8.5x11 inch original, hand-written page of notes) and students must work alone. Calculators will be allowed but must be cleared of all programs and/or data before the exam. MATLAB and other higher level computation programs are not allowed on the final.

The score you receive on the final will be used to determine your grade.

Grading:

A	$Total\_pts \geq 90$	*C*	$Total\_pts \geq 70$
B	$Total\_pts \geq 80$	*D*	$Total\_pts \geq 60$

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COURSE POLICIES

Attendance

Attendance is required. Failure to attend an Active Learning format course negatively impacts everyone and will severely impact your ability to succeed. As per university policy, students with excessive unexcused absences will be dropped from the course and will receive a failing grade.

Late and Missed Assignments Policies

Preparations: Preparation *assignments must be completed before class and your work must be submitted as a PDF through Blackboard with questions. No credit will be given for late submissions.*

Individual Summative Assessments: Individual summative assessments *that are missed cannot be made up without an excused absence approved by the Office of Undergraduate Studies. Absences must be excused* prior *to missing the assessment. Late submissions will not receive a grade.*

Group Summative Assessments: *Group members will determine whether and which group members receive credit for the group summative assessment. In the event of an excused absence approved by the Office of Undergraduate Studies that prevents participation in the group assessment, a makeup Individual Summative Assessment may be allowed. Late submissions will not receive a grade.*

Laboratory: *Laboratory write-ups are due no later than 15 minutes after the lab section starts. You will lose 10% per day for late labs unless arrangements are made with your lab TA. Labs will not be accepted after 7 days.*

Final: *As per University policy, the Final Exam is absolutely required.*

Absences and Make-up Assessments: Excused absences are those consistent with university policy (e.g. sports) or absence approved by the Office of Undergraduate Studies. Absences cannot be excused retroactively (except in extreme cases). Special makeup assessments will be available during the semester for those having excused absences during the original assessment. You must receive permission in advance from Prof. Lee or the TA proctor to participate in makeup assessments.

Grading Clarifications

Any grading clarification/correction must be requested in writing and submitted to the head TA within one week of receiving the grade. The clarification/correction request must include a written description of the requested clarification/correction and specifies the desired result. The written request must be stapled to the complete original graded work.

Dropped Scores

Scores are dropped from *Preparations*, *Individual Summative Assessments* and *Laboratories* when calculating the final grade (scores are not dropped when calculating the midterm grade). The function of dropping scores is **not** to improve your grade but to accommodate any of the many expected and reasonable absences, mistakes, and/or misunderstandings that happen during the semester. Example uses of dropped scores include but are not limited to: missing a due date, technical difficulties submitting at the last minute, and attending extracurricular conferences or student organization events.

Email

All correspondence with the instructor and/or TAs must be conducted using your CWRU email account using either your NetID, your CWRU assigned First-dot-Last, or your SIS indicated preferred addresses only. (CWRU email aliases are not valid alternatives.) Email received from other addresses may not be acknowledged and *will not* receive responses. Further, the turn-around time for email is two business days (e.g., an email received Friday evening may not receive a reply until Tuesday afternoon).

CWRU Student Ethics Policy

Violations of the Student Ethics Policy will be dealt with by failure in the assignment in question, failure in the course, or referral to the academic integrity board as per university policy. The *Definition of Violations* section of the CWRU Academic Integrity Policy is excerpted below with emphasis added.

> **Definition of Violations**
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> All forms of academic dishonesty including cheating, plagiarism, misrepresentation, and obstruction are violations of academic integrity standards. Cheating includes copying from another's work, falsifying problem solutions or laboratory reports, or using unauthorized sources, notes or computer programs. Plagiarism includes the presentation, without proper attribution, of another's words or ideas from printed or electronic sources. It is also plagiarism to submit, without the instructor's consent, an assignment in one class previously submitted in another. Misrepresentation includes forgery of official academic documents, the presentation of altered or falsified documents or testimony to a university office or official, taking an exam for another student, or lying about personal circumstances to postpone tests or assignments. Obstruction occurs when a student engages in unreasonable conduct that interferes with another's ability to conduct scholarly activity. Destroying a student's computer file, stealing a student's notebook, and stealing a book on reserve in the library are examples of obstruction.
>
> http://students.case.edu/groups/aiboard/policy.html

Unauthorized sources include Instructor's Solutions Manuals. All violations will be forwarded to the academic integrity board.

SPRING 2015 TOPIC SCHEDULE[1]

Date	Lecture	Topics	Lab
08/24/2015	1	Course Intro, Passive Sign, Power	
08/26/2015	2	Component Measurement, Kirchhoff	Lab 1
08/28/2015	3	Assign Groups, Summative Assessment 1	
08/31/2015		Series, Parallel, Dependent Sources	
09/02/2015	4	Voltage Divider	
09/04/2015	5	Summative Assessment 2	Lab 2
09/07/2015	6	*Labor Day*	
09/09/2015	7	Wheatstone Bridge, ΔY	
09/11/2015	8	Node Voltage	No Lab
09/14/2015	9	Mesh Current	
09/16/2015	10	Special Cases and comparison of NVM, MCM	
09/18/2015	11	Summative Assessment 3	Lab 3
09/21/2015	12	Source trans, Thévenin and Norton	
09/23/2015	13	Superposition, Max Power	
09/25/2015	14	Summative Assessment 4	Lab 4
09/28/2015	15	OP AMP, Inverting	
09/30/2015	16	OP AMP, Summing	
10/02/2015	17	Summative Assessment 5	Lab 5
10/05/2015	18	OP AMP, non-Inverting	
10/07/2015	19	OP AMP, Difference	
10/09/2015	20	Summative Assessment 6	Lab 6
10/12/2015	21	Inductance	
10/14/2015	22	Capacitance	
10/16/2015	23	Summative Assessment 7	Lab 7
10/19/2015		*Fall Break*	
10/21/2015	24	RL	
10/23/2015	25	RC	No Lab
10/26/2015	26	RL, RC Step Response	
10/28/2015	27		
10/30/2015	28	Summative Assessment 8	Lab 8
11/02/2015	29	RLC Parallel	

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11/04/2015	30	RLC Series	
11/06/2015	31	Summative Assessment 9	Lab 9
11/09/2015	32	Sinusoidal Signals	
11/11/2015	33	AC Equivalents	
11/13/2015	34	Summative Assessment 10	Lab 10
11/16/2015	35	Transformers	
11/18/2015	36	Steady-State Power	
11/20/2015	37	Summative Assessment 11	Lab 11
11/23/2015	38	Low- and High- Pass Filters	
11/25/2015	39	Low- and High- Pass Filters	
11/27/2015		*Thanksgiving Break*	No Lab
11/30/2015	40	Active Low- and High- Pass Filters, Scaling	
11/02/2015	41	Higher Order Op-Amp Filter	
11/04/2015	42	Summative Assessment 12	Lab 12
12/14/2015		Final Exam -- 8:30 AM to 11:30 AM	

NOTES:
1. The dates and order of these topics are approximate and subject to some change in order and emphasis.

LAB INFORMATION

The labs provide the practical experience required for a Circuits and Instrumentation course, including how to build prototypical circuits and perform electrical measurements using modern instrumentation. The emphasis will be upon applying classroom material in practical circuits. There will be a short lecture in Glennan 313 before each lab to discuss lab procedures and circuit.

Lab 1 In this lab you will examine the current and voltage relationships for two components: the resistor and the light emitting diode (LED). You will demonstrate that resistors obey Ohm's law while nonlinear devices, such as LEDs, do not. You will measure the relationships in voltage and current dividers and learn how to analyze circuits using LEDs

Lab 2 In this lab you will develop equivalent circuits for multiple resistors networks and for simple "real-world" batteries. As long as two circuits have the same i-v characteristics either may be used for analysis.

Lab 3 This lab will continue the basic concept of equivalent characteristics based upon i-v characteristics. In this lab you will be given unknown devices which you will characterize by their i-v characteristics.

Lab 4 A potentiometer is a resistor with an additional moveable connection called the wiper. The resistance from the wiper to the other two terminals depends on the position of the wiper producing a variable resistor. One application of a potentiometer is in a bridge circuit. When you are measuring small voltages which is typically encountered when working with sensors it is easier to compare two voltages and determine when they are equal (also called a null) than to directly measure the small voltage. This lab will use a potentiometer in a Wheatstone bridge circuit to measure small resistance changes.

Lab 5 Up to now you have worked with relatively slowly changing electrical voltages and currents. However, when these quantities are changing rapidly you need to use a faster measurement device such as an oscilloscope. In this lab you will learn how to set up and use the oscilloscope to make electrical measurements. This lab will also introduce electronically controlled switches and electromechanical switches called relays. The typical op amp can only control 10-20 mA at a few volts yet you will often need to electronically control up to hundreds of volts at many amperes.

Lab 6 One of the most useful electronic devices is an integrated circuit amplifier called an operational amplifier (abbreviated OP AMP). This circuit can be used to amplify small voltages and currents such as you might get from a sensor. In this lab you will gain experience with inverting and non-inverting amplifiers using the 741 op-amp.

Lab 7 Inductors and capacitors respond to how rapidly electrical quantities are changing. In this lab you will use the oscilloscope to study the time dependent behavior of basic inductors and capacitors, examine how pulses pass through RC and RL networks, and combine op-amps with capacitors to make integrators and differentiators.

Lab 8 The signals from sensors often require signal processing. This can be done using computers but a very inexpensive OP AMPs can also perform many mathematical functions on signal waveforms. In this lab you will use OP AMP as buffer amplifiers, to sum signals, and to compute the difference of signals.

Lab 9 Inductors and capacitors can be combined with OP AMPs to perform complex mathematical functions for manipulating signals from sensors. In this lab you will combine operational amplifiers with inductors and capacitors to make integrators, differentiators, and complex filters.

Lab 10 This lab will consider the power in a simple AC circuit and the practice and implications of power factor correction.

Lab 11 Filters are used to manipulate signals in the frequency domain. One common application of filters is to separate different components of signals. In this lab you will study how filters can be used to separate and direct high and low frequency signal components to the woofers and tweeters in an audio speaker system.

Lab 12 One of the most important applications of circuits is to combine the simple devices you have studied in this class to make more complex and useful devices. In this lab you will examine how ENGR 210 components can be combined to make an infrared remote control similar to those used with many consumer electronics devices.