

Teaching an Electrical Circuits Course Online

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Motivation

- Allow students to get ahead or stay on schedule in the curriculum
- Allow students to take class while on internships, co-ops, REUs
- Provide same quality of instruction as the on-campus course



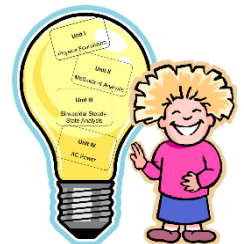
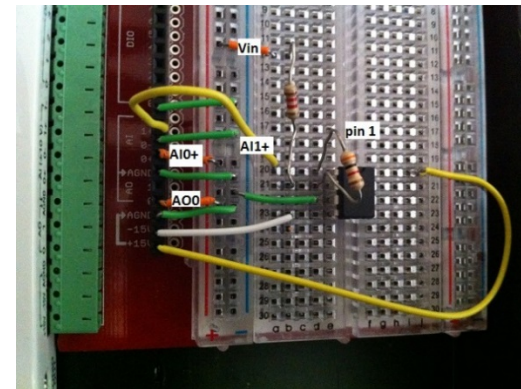
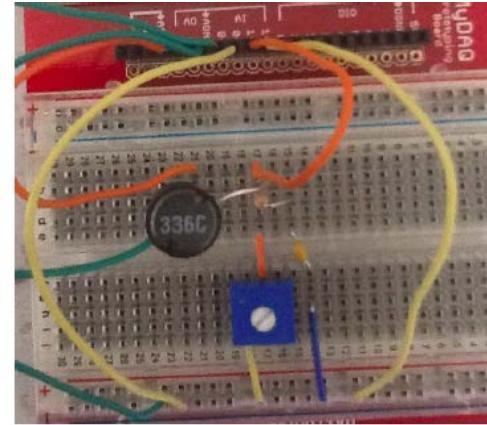
Course Overview

- Electrical systems course for non-majors
- Sophomore-level course
- Semi-synchronous
- DC and AC circuits
- KCL, KVL, Thevenin/Norton
- Operational Amplifiers
- Phasor Analysis
- AC Power
- Integral lab component
- Summer 2013/14



Lab Assignments

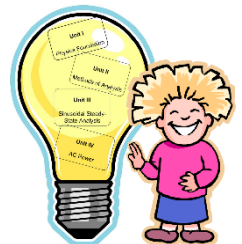
- Prelab - Analytical and Simulation using MultiSim
- Ni myDAQ – power supply, multimeter, function generator, oscilloscope
- Breadboard, resistors, capacitors, inductors, op amps, voltage regulator



Comparison to On-campus Course

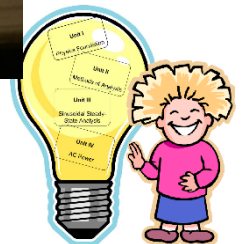
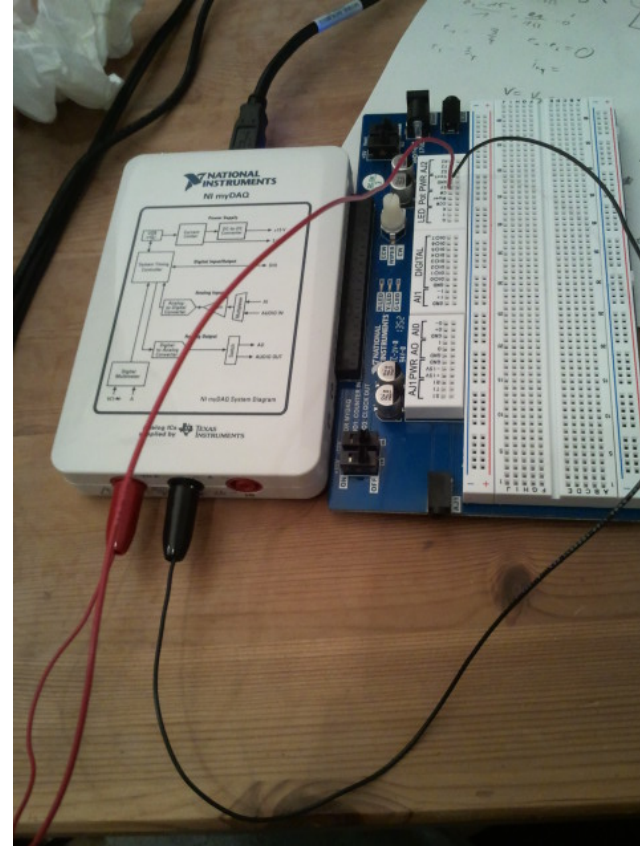
- Same Syllabus
- Same Calendar
- Same Lab Manual
- 3 - 50 minute lectures
- 1 - 150 minute lab
- partial lecture notes
- 3 midterms
- 2 lab practicals
- 10 quizzes
- 10 homework assignments (MasteringEngineering)

Midterms	36%
Final Exam	26%
Homework	10%
Labs and Memos	15%
Lab Practical Test	5%
Quizzes	5%



Course Expectation Meeting

- Be more focused, disciplined, and independent
- Level of difficulty
- Scale on-campus course by 1.5
- Test of Online Learning Success (ToOLS) self-assessment
- Textbook
- Study Guide
- Lab Manual
- Lab Kit
- NI myDAQ



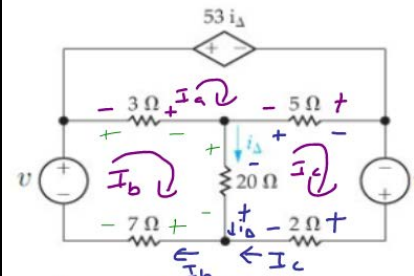
Instructor Interaction

- Piazza message board for anonymous posts
- Weekly Google Hangouts to review quizzes, exams, homework
- Moodle learning management system for quizzes, exams, discussion board

Homework 3 - Problem 4.40

Hello all,

Here is help with Homework 3, Problem 4.40 that we discussed during tonight's hangout.



4 equations
4 unknowns
 I_a, I_b, I_c, i_Δ

mesh-current method

$$\text{constraint: } i_\Delta = I_b - I_c$$

$$\text{KVL @ } I_a: 53i_\Delta + 5(I_a - I_c) + 3(I_a - I_b) = 0$$

$$\text{KVL @ } I_b: -V + 3(I_b - I_a) + 20(I_b - I_c) + 7I_b = 0$$

$$\text{KVL @ } I_c: -V + 2I_c + 20(I_c - I_b) + 5(I_c - I_a) = 0$$



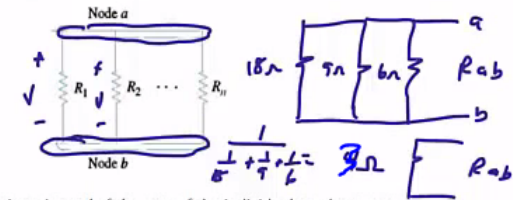
Online Lecture Videos on YouTube

- Same lecture and notes used in the face to face class but there was no opportunity to stop and ask questions
- Benefit of rewinding and watching multiple times
- Still include partial lecture notes

Therefore the equivalent resistance is always larger than the largest individual resistor.

$$R_{eq} = R_1 + R_2 + \dots + R_n$$

When two elements connect at a single node pair, they are said to be in **parallel**. Elements in parallel have the same **voltage**.



The equivalent resistance is reciprocal of the sum of the individual conductances. Therefore the equivalent resistance is always smaller than the smallest individual resistor.

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n} \right)^{-1}$$
$$G_{eq} = G_1 + G_2 + \dots + G_n$$



The special case for 2 parallel resistors is $R_{eq} = R_1 R_2 / (R_1 + R_2)$

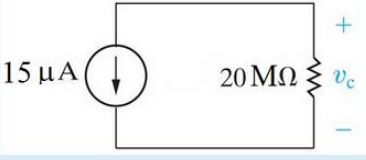
Concept Question:



Concept Quizzes

- Weekly on Moodle
- Typically 10 questions
- Multiple Choice
- Random Questions
- Timed
- Assessed students mastery of prior week's concepts

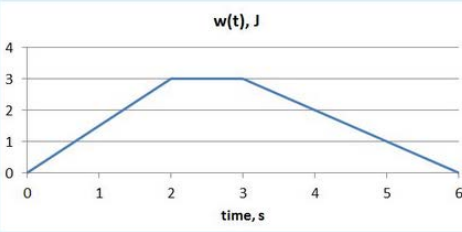
Use Ohm's Law to find v_c in the following circuit.



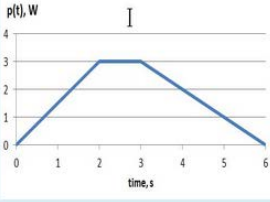
Select one:

- a. -300 V
- b. -30 V
- c. 300 V
- d. 3.0 V
- e. 30 V
- f. -3.0 V

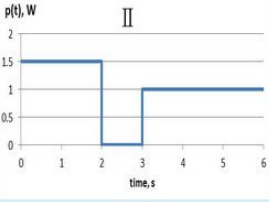
The following figure shows the energy transferred to a circuit element. Which of the figures shows the power associated with the circuit element?



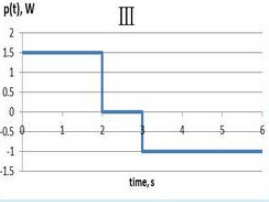
w(t), J



p(t), W I



p(t), W II



p(t), W III



Online Homework

- MasteringEngineering
- No time limit
- Fill in the blank but many opportunities to get hints and help
- 3 to 6 tries to arrive at the correct answer
- Students could work through out the week

The op amp in the circuit in the figure is ideal. (Figure_1)

Figure 1 of 1

The circuit diagram shows an ideal op-amp configured as a non-inverting amplifier. The non-inverting input is connected to a voltage divider consisting of a 1.6 kΩ resistor and a 6.4 kΩ resistor. The inverting input is connected to a feedback network consisting of a 50 kΩ resistor and a 12 kΩ resistor. The output is connected to a 10 kΩ load resistor. The op-amp is powered by a 5 V supply and a -5 V supply.

Part A
Find the minimum value of σ for which the op amp does not saturate.
 $\sigma_{\min} =$
Submit My Answers Give Up

Part B
Find the maximum value of σ for which the op amp does not saturate.
 $\sigma_{\max} =$
Submit My Answers Give Up

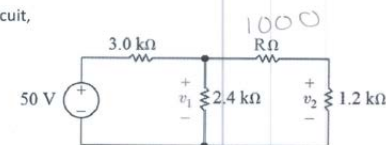
Part C
Find i_o when $\sigma = 0.275$.
Express your answer with the appropriate units.
 $i_o =$



Exams

- Exams were handwritten and scanned and uploaded to Moodle
- Typically 4 to 5 open ended questions that involved hand calculations

For the following circuit,



c. (5 pts). Use the voltage divider to find v_1 .

~~$\frac{2.4 \times 10^3}{7.600} (50)$~~ $\frac{2.4k\Omega(1k+1.2k)}{3k + 2.4k\Omega(1k+1.2k)}(50)$ 13.84 V
15.79 V

d. (5 pts). Use the voltage divider to find v_2 .

$V_2 = \frac{1.2}{1+1.2}(V_1) = 7.55 V$

3



Pre-labs & Labs

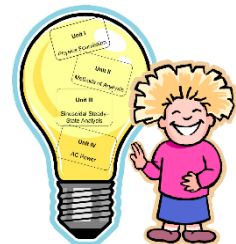
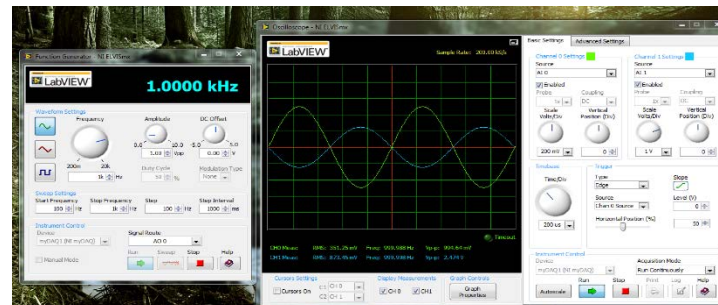
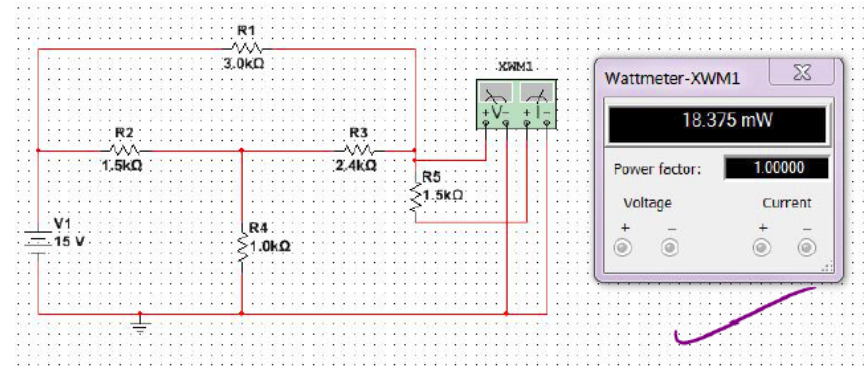
- Lab manual with images of circuits
- Supplemental lab videos on NI website on Multisim and using myDAQ
- Supplemental videos on using a breadboard, building circuits, and using lab equipment

3. 2a) $P = +V_o i$
 $= (483.87 \text{ mV})(403 \mu\text{A})$
 $= 195 \mu\text{W}$ ✓

2b) $P = -V_o i$
 $= -(3.75 \text{ V})(3.125 \text{ mA})$
 $= -11.71875 \text{ mW}$ ✓ 28.1 mW

2c) $P = -V_o i$
 $= -(4.29 \text{ V})(3.99 \text{ mA})$
 $= -17.1181 \text{ mW}$ ✓ 33 mW

Superposition does not work for the power of a single element because it is not made up of the sum of the power absorbed/delivered by all of the elements. It can be used for overall power.

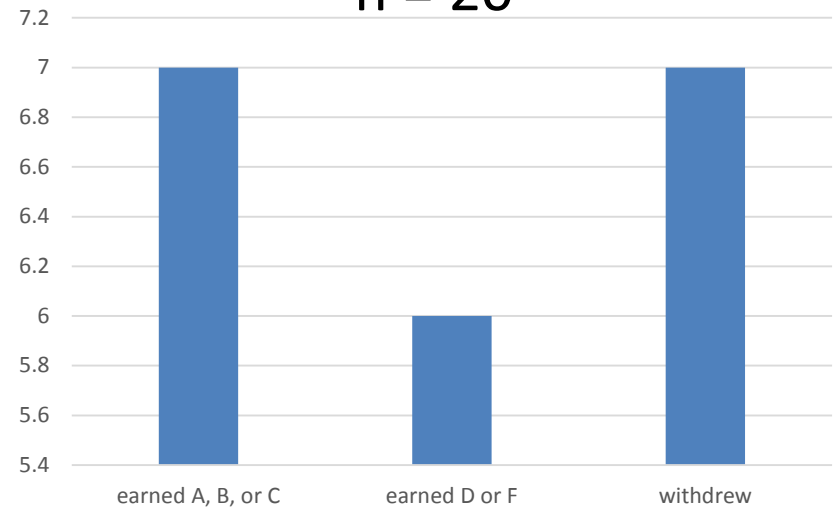


Results

- 28% of students rated the course a 9 or higher with respect to difficulty
- 71% of the students thought the labs were the most difficult part of the online course

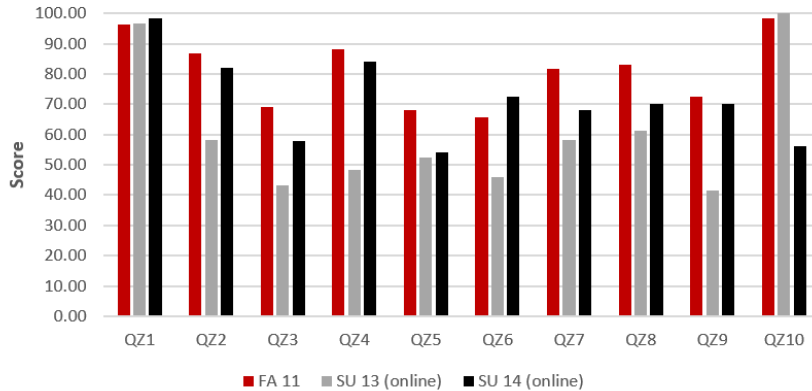
Grade Results

n = 20

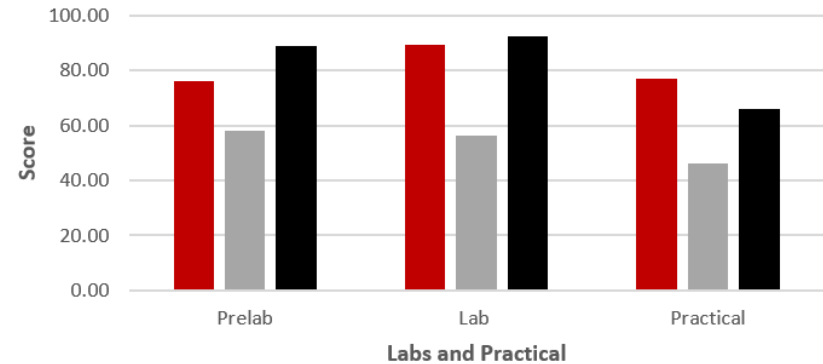


Comparison to Face to Face Classroom

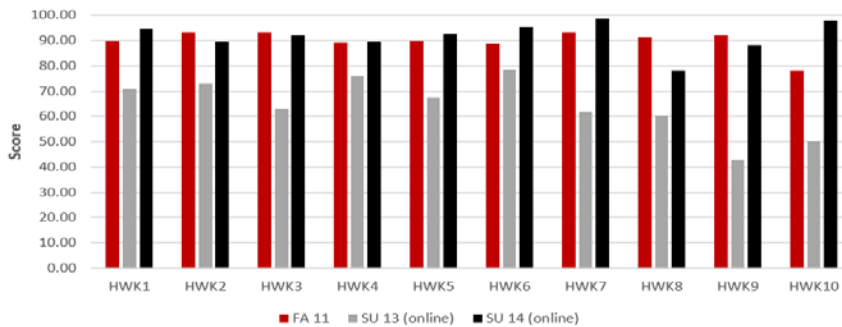
Quiz Comparison
Average (80.97, 60.60, 71.31)



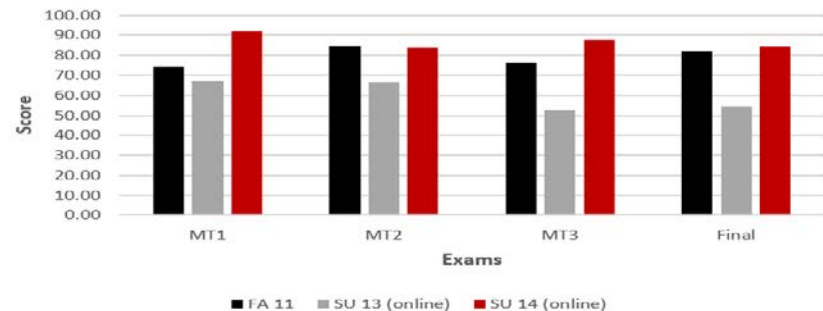
Lab Comparison



Homework Comparison
Average (89.9, 64.28, 91.57)



Exam Comparison
Average (79.29, 60.27, 86.88)



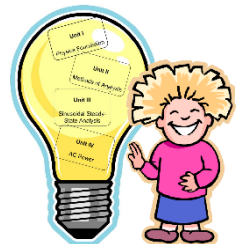
Qualitative Results

- Debugging and building circuits own their own was the biggest challenge
- No real time help was challenging
- Hard to communicate circuit problems electronically
- One student felt that there was actually more interpersonal interaction with the professor
- Timed quizzes were too difficult for new material
- Engagement increased by 50%



Conclusions and Recommendations

- Similar level of engagement but sometimes more for online course
- Respond to all questions in all formats within 24 hours
- Use screen sharing software for questions and problem solving
- Piazza encouraged students to engage with each other
- Randomize component values and questions on quizzes, practicals and exams
- More lab review at expectation meeting
- Make attendance mandatory at virtual office hours



More information

- Carlotta A Berry
 - berry123@rose-hulman.edu
- Course Study Guide
 - <http://www.rose-hulman.edu/~berry123/Courses/ES203.html>
- Video Lectures
 - goo.gl/KXKx2M

