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)

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Midterms</td>
<td>36%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>26%</td>
</tr>
<tr>
<td>Homework</td>
<td>10%</td>
</tr>
<tr>
<td>Labs and Memos</td>
<td>15%</td>
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<tr>
<td>Lab Practical Test</td>
<td>5%</td>
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<tr>
<td>Quizzes</td>
<td>5%</td>
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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
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

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

\[ R_{eq} = R_1 + R_2 + \ldots + R_n \]

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 resistance.

\[ R_{eq} = \left( \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n} \right)^{-1} \]

\[ G_{eq} = G_1 + G_2 + \ldots + G_n \]

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

Concept Question:
Concept Quizzes

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

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

<table>
<thead>
<tr>
<th>Grade</th>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td>earned A, B, or C</td>
<td></td>
</tr>
<tr>
<td>earned D or F</td>
<td></td>
</tr>
<tr>
<td>withdrew</td>
<td>n = 20</td>
</tr>
</tbody>
</table>
Comparison to Face to Face Classroom

Quiz Comparison
Average (80.97, 60.60, 71.31)

Lab Comparison
Labs and Practical

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
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• Course Study Guide
  – http://www.rose-hulman.edu/~berry123/Courses/ES203.html

• Video Lectures
  – goo.gl/KXXKx2M