Introduction to Circuit Theory

EGR 220
September 6, 2018
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Course URL:
http://www.science.smith.edu/~jcardell/Courses/EGR220

Overview

• Basic concepts
  • Electrical energy & static circuits
  • Energy storage & dynamic circuits
    • How does matter store electrical and magnetic energy?
  • Frequency response – how does matter behave with, or ‘respond to,’ high and low frequencies?

• Define an electric circuit

• Chapter 1: Charge & Ohm’s Law
  • Voltage, Current, Resistance, Power
Course Admin

- Read the text book!
- Problem solving and homework
- Labs
- Exams
- Course webpage & syllabus
  www.science.smith.edu/~jcardell/Courses/EGR220
- **Lab 1 & Prelab DUE**

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Course Admin

- Print out slides before each class to bring to class
  - Computer or tablet use ok, but only for working on class slides
- ...For solving circuit problems together.
What do you hope/expect to learn from this course?

- What curiosity do you have about electricity?
- How to use electricity for fun and make our lives better.
- The language of electrical circuits
  - Diagrams, graphs and math... & observation of our world
  - To understand the role of basic circuit elements
  - How to read a circuit diagram
  - How to predict circuit behavior
  - How to apply equations and analysis techniques for circuit analysis

Basic Concepts

- What is
  - Electricity
  - Charge
  - Current
    - What is the relationship (mathematical) between charge and current?
  - Energy
  - Voltage
    - *Always* a potential *difference*
- How does a *voltage drop* relate to energy and work?
Basic Concepts

• What is power?
  • Expression for power:
    • \( P = \frac{dw}{dt} \)
    • \( P = V \times I \)
    • Unit of the ‘Watt’
  • Power is either generated or absorbed by an element.
    • If ‘absorbed’ it can be either dissipated as heat energy or stored in electric or magnetic fields
    • Find, read, know and use the “passive sign convention”

First Basic Law: Ohm’s Law

• **Experiment**: Current, \( i \), is measured as voltage, \( v \), across resistor \( R \) is changed.
• What is the relationship between \( V \) and \( I \)?

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>-10</th>
<th>-5</th>
<th>0</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current (mA)</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

![Diagram of Ohm's Law](image)
Ohm’s Law (Chapter 1)

- Ohm’s Law: $V = ____$
  - What is the value of $R$?
  - What is $R$, resistance?

$$R = \frac{V}{i}$$

Voltage DROP; Voltage ACROSS

- Ohm’s Law: $V = IR$
- Think of this as:
  - $V_{\text{drop}} = IR$
  - $\Delta V = IR$
  - The drop or change in voltage potential as current moves through the resistor
- A voltage value at one node is **always** with respect to a value at a second node
  - *for example*, $V$ from node to ground
  - $V$ from one side of a resistor to the other
Summary of Terminology

• Basic terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Expression</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge</td>
<td>Q</td>
<td>Coulomb, C</td>
</tr>
<tr>
<td>Current</td>
<td>I = dQ/dt</td>
<td>Ampere, A</td>
</tr>
<tr>
<td>Voltage</td>
<td>V = Work/Q</td>
<td>Volts, V = J/C</td>
</tr>
<tr>
<td></td>
<td>V = IR</td>
<td>(Ohm’s Law)</td>
</tr>
<tr>
<td>Resistance</td>
<td>R</td>
<td>Ohm, Ω</td>
</tr>
<tr>
<td>Power</td>
<td>P = VI</td>
<td>Watt, W=(J/C)(C/s) = J/s</td>
</tr>
</tbody>
</table>

• Units – always know and use the units

Chapter 1 Summary

• Basic concepts for circuit theory
• Review basic terminology in text
  • Charge
  • Current
  • Voltage
  • Resistance
  • Energy (work)
  • Power
• Read Chapter 1
  • Find on own: Passive sign convention
Chapter 2 – Next Class

- Read to understand nodes and branches
- Pay close attention to concepts of voltage & current
  - Current is a *flow*, a time rate of change (voltage is not)
  - Voltage is a voltage *drop across* an element (or group of elements)
- Open and short circuits
- Kirchoff’s circuit laws
  - Current law – sum of current flowing into a node = sum of current flowing out of a node
  - Voltage law - voltage summed around a loop = 0V
  - Combining with Ohm’s Law

Course Admin

- Course webpage & syllabus
  
  www.science.smith.edu/~jcardell/Courses/EGR220

- Homework
  - Homework assigned, and then due, each Thursday.
  - Use EGR homework paper.
  - Self-correct your homework each week.
    - Solutions posted each Monday.
  - Hand in with corrections on Thursday.
Homework Cover Sheet

EGR 220 Homework Self-Assessment

First Attempt ON YOUR OWN (no consultation with friends, master tutor or others)

Set up each problem on a new page by doing the following:

- Write a Problem Statement that identifies what information is given (including the circuit diagram, well-labeled) and what you need to find.
- Identify the Problem Type. What concepts, theories or laws will you apply to solve the problem?
- Outline a Solution Plan that identifies the steps or approach required to solve the problem.

Now solve the problem (if your actual solution varies from your solution plan, make a note of this).

- Be sure to indicate any assumptions you make.
- Work the problem to the end, or as far as you can, and provide a numerical answer with units (unless this is not applicable). Try to reach some answer or solution, even if you think it is not correct. Trying here will help you better identify possible, initial misunderstanding.

Work with others – friends and/or master tutors

- … to the extent that you want to do this.

Self-Correction and revision using posted solutions:

- If your solution was incorrect, identify error (concept, math, etc.) and where they occurred. Rework the problem from the point of your first error using a different color of ink.
- If your solution was correct, identify any places where it differs significantly from the posted solution.

Certification

I collaborated with the following people on this homework:

I affirm (1) my collaboration statements is complete and correct; (2) I did not consult with other students before attempting each problem on my own; and (3) I have accurately delineated initial and final attempts using two different colors of pencil/ink.
Passing the Course

• Each student must complete each lab and hand in a lab memo, with your lab partner(s), to pass EGR 220.

• Each student must have an average exam score $\geq 60\%$ to pass EGR 220.
  • Average of midterms (2 of them) and the final exam

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Self-Grading
Circle your self-assigned grade: _______0 1 2 3

0 = Little or no work completed.
1 = A first and second attempt were made on some problems.
2 = A full first and second attempt were made on all problems.
3 = A full first and second attempt were made on all problems. If major revisions were required on problems, your submission also includes a thoughtful yet brief (a few sentences at the most) reflection indicating your initial ideas; how they changed during the revision process; and what knowledge gaps (if any) still remain to be addressed. Make sure your thoughts are legible and easy to read.

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1 To be submitted as a cover page with each homework assignment.
2 You are encouraged to work together to better understand the concepts in the problem sets. However, you will learn more if you first attempt each problem on your own.
ABET Books of Evidence

- Accreditation – ABET
- Student role in department accreditation...
- Book of Evidence
  - A binder in the EGR main office with your work in each category, or ‘outcome’
- Identify, copy and file (in your BoE) course work every semester.

ABET Outcomes for EGR 220

- Student Outcome (1a)
  - (1)a: The student formulates and solves a complex engineering problem that requires mathematical skill and principles from solid mechanics, fluid mechanics, circuit theory and/or thermodynamics...

- Student Outcome (3c)
  - (3)c: The student presents engineering concepts utilizing a graphical representation.
ABET Outcomes for EGR 220

- Student Outcome (6): an ability to **develop and conduct appropriate experimentation**, analyze and interpret data, and use engineering judgment to draw conclusions
  - (6)a: The student **designs an experiment** and carries it out.
  - (6)b: The student demonstrates an ability to make quantitative measurements and **assess sources of error**.
  - (6)c: The student **analyzes data** and **draws conclusions** based on those data.

- Student Outcome (7b) (7)b: The student demonstrates resilience, adaptability, and **iterative learning**.

Master Tutor Hours

- Master tutor structure is in transition
- Community of learners
- Master tutors for all, point-person for EGR 220 is Tani Somolu
- Focus on learning engineering science concepts and principles
- Each evening in the Mechanics Playground
- Can request individual appointments
Circuits Labs

• Building and experimenting with circuits
• Learning how electricity works
• Learning how to use standard electrical lab equipment
• Lab time is used for exams also

Wednesday Lab Time

• Four different uses of lab time
  1) Everyone in the lab together – chaos!
  2) Half of the class for the first half of the time, and the second half for the second half
  3) Half of the class one week for the full time, and the second half the next week
  4) Midterm exams – everyone for the full time
• **Everyone must be free all Wednesdays 1:10 to 4:00**
Pre-Lab Questions

• Read through the entire lab handout
  • Complete the pre-lab questions, and hand in
  • Be neat and professional
    • You are not required to use EGR paper or put problems on separate pages.
    • But, no torn out pages with frayed edges or hard to read, quickly scrawled answers/solutions.

• Your pre-lab must be handed in before you begin your lab at 1:10pm.
  • This means you need TWO copies – one for me and one for yourself.

• Every student must complete her own pre-lab (lab memos are done in teams)

Lab Memo: What to Hand In

• Your memo must be a stand-alone document
• Your memo should be one page (of text)
• Your memo will have the following elements
  • Your names
  • Informative title (not “Lab 1”)
  • Objective: in your own words.
  • Results from the laboratory experiments
  • Concise discussion of what you discovered
  • One concise and elegant statement of what you learned

• ** Note that for full credit, this statement must include more than what is asked for directly in the lab handout. You must demonstrate some independent thinking and learning. **
One Page Lab Memo Guidelines

• One memo per team
• State the **objective** (in your own words)
• **Summarize** what you did
  • Guided by the questions posed in the handout.
• * Include one statement demonstrating your growing understanding, that goes beyond what is requested directly in the lab handout. *
  • This is for you to demonstrate you are processing and reflecting on the course material.

Lab 1: Equipment and Ohm

• Learn and play with the lab equipment
• Test and verify Ohm’s Law

• Measuring voltage and current
  • Measure voltage **across** an element
  • Measure current **through** a branch
    • Break the circuit and insert the ammeter into the flow of the current

• Notice that the lab equipment is part of your circuit
Welcome to Circuit Theory!

- Learn about energy and electricity
- Be comfortable building and testing electrical circuits
- Learn how circuit theory can be used in all other engineering disciplines to model and analyze behavior