Introduction to Circuit Theory

Overview

- Basic concepts
  - Electrical energy
  - Energy storage – 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
- Knowledge building
- Labs
- Exams
- Course webpage & syllabus
  - www.science.smith.edu/~jcardell/Courses/EGR220
- Lab 1 (tomorrow) & Prelab DUE

Course Admin

- Print out slides before each class to bring to class
- For solving circuit problems together.
Basic Concepts

- What is 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?

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>

Ohm’s Law

- Ohm’s Law: \( V = \frac{10V}{2 \cdot 10^{-3} A} = 5000 \Omega \)
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

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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 = \frac{dQ}{dt} )</td>
<td>Ampere, A</td>
</tr>
<tr>
<td>Voltage</td>
<td>( V = \frac{\text{Work}}{Q} )</td>
<td>Volts, ( V = \frac{J}{C} )</td>
</tr>
<tr>
<td></td>
<td>( V = IR ) (Ohm’s Law)</td>
<td></td>
</tr>
<tr>
<td>Resistance</td>
<td>( R )</td>
<td>Ohm, ( \Omega )</td>
</tr>
<tr>
<td>Power</td>
<td>( P = VI )</td>
<td>Watt, ( W = \frac{J}{C\cdot s} = J/s )</td>
</tr>
</tbody>
</table>

- **Units** – always know and use the units

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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*

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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
- Kirchhoff’s circuit laws
  - Current law
  - Voltage law
  - 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

Second Attempt (Revision):
- 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 ink.

Signature: ____________________________

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.
- New solve the problem (if your actual solution varies from your solution plan, make a note of this).
- Be sure to indicate any assumptions and provide references and an evaluation if appropriate.
- Work the problem to the end and provide a numerical answer with units (unless this is not applicable).

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 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.
Knowledge Building
- Start in a few weeks in lab time
- Ongoing work mostly outside of class
- Be thinking about knowledge questions related to electricity that interest and motivate you to investigate

Passing the Course
- Each student must complete each lab and hand in a lab memo to pass the EGR 220
- Each student must have an average exam score $\geq 60\%$ to pass EGR 220.

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
(a) APPLICATION: apply math, science & engineering knowledge
  - (a)1: Solve problems with advanced math skills.
  - (a)2: Apply fundamental principles.
(b) EXPERIMENTATION: design and conduct experiments; analyze and interpret data
  - (b)2: Analyze data and draw conclusions.
(g) COMMUNICATION: communicate effectively
  - (g)1: Writing.
  - (g)3: Graphical representation.
(k) MODERN TOOLS: for engineering practice
  - (k)1: Ability to use modern tools for measurements.
Possible Outcome

- Depending upon your own knowledge building work, you might...
  
  (c) DESIGN: design a system, component, or process to meet desired needs within realistic constraints
  
  (c)2: Generate, evaluate, and select potential design concepts in response to stated design requirements.
  
  (c)3: Develop, test, and iteratively refine a design to meet desired needs and requirements.

Master Tutor Hours

- Emma Rocco
- Meet in circuits lab, 143 Ford Hall
- Three 2-hour blocks
  
  - Saturday:
  
  - Sunday:
  
  - Monday:
  
  - Tuesday:
  
  - Wednesday:

Office Hours

- Tuesday: 1 – 2 pm
- Wednesday: 9:30 – 10:30 am
- In my office... 352 Ford Hall

Circuits Labs

- Building and experimenting with circuits & learning how to use standard electrical lab equipment
- Knowledge building
  
  - Some KB will involve building and experimenting with circuits
  
  - Your KB work might lead you to designing your own circuit
- Lab time is used for exams
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
- Your memo will have the following elements
  - Informative title
  - Objective: in your own words.
  - Results
  - Concise discussion
  - 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
Breadboards – for building circuits

Lab 1: Measure Across or Through?
Lab 1: Measure Across or Through?

Welcome to Circuit Theory!

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