# Introduction to Circuit Theory

EGR 220

January 28, 2020

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Course URL:
http://www.science.smith.edu/~jcardell/Courses/EGR220

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## Overview

- Circuit theory's big questions
- Basic concepts
- Ohm's Law
- Course administration
  - Homework
  - Passing the course
  - Labs
- Questions of Understanding

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## Questions to Understand This Field

- Everyone, pair or solo, write down some ***big questions*** for this field.
- What do you need to ask and learn to begin addressing these big questions?
- What do you anticipate using from EGR 220 in other courses, internships, career?
- What will you use from other courses in EGR 220?

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## Big Questions for Circuit Theory

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## Knowledge to Transfer *In* and *Out*

- Transfer in from previous courses

- Transfer out to other courses

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## What do you hope 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

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## Basic Concepts

- What is
  - Electricity
  - Electrical charge
  - Current

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## Basic Concepts

- What is
  - Electricity
  - Electrical 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?

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## Basic Concepts

- What is power?
  - Expression for power:
    - P = dw/dt → A time rate of change
    - P = V*I
    - Unit of the 'Watt'

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## Basic Concepts

- What is power?
  - Expression for power:
    - P = dw/dt → A time rate of change
    - P = V*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"

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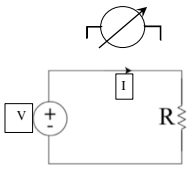
## First Basic Law: Ohm's Law

- *Experiment*: Current $I$ is measured as the voltage $V$ across resistor R is changed.
- What is the relationship between $V$ and $I$?

| Voltage (V) | -10 | -5 | 0 | 5 | 10 |
|---|---|---|---|---|---|
| Current (mA) | -2 | -1 | 0 | 1 | 2 |

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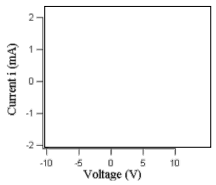
## Ohm's Law

- Ohm's Law: V = _____
  - What is the value of R?
  - What is R, resistance?

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

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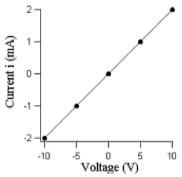


$$R = \frac{v}{i} = \frac{10V}{2 \cdot 10^{-3} A} = 5000\Omega$$



## Voltage DROP; Voltage ACROSS

- Ohm's Law: V = IR
- Think of this as:
  - $V_{drop}$ = IR
  - ΔV = 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 one side of a resistor to the other



## Summary of Terminology

- Basic terminology

| Term | Expression | Units |
|---|---|---|
| • Charge | | |
| • Current | | |
| • Voltage | | |
| • Resistance | | |
| • Power | | |

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



## Summary of Terminology

- Basic terminology

| Term | Expression | Units |
|---|---|---|
| • Charge | Q | Coulomb, C |
| • Current | I = dQ/dt | Ampere, A |
| • Voltage | V = Work/Q<br>V = IR (Ohm's Law) | Volts, V = J/C |
| • Resistance | | R Ohm, Ω |
| • Power | P = VI | Watt, W=(J/C)(C/s) = J/s |

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

## Chapter 1 Summary

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

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## Chapter 2 – Next Class

- Concepts of nodes and branches
- 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)
  - 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

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## 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 tomorrow**

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## Course Admin

- Print out slides before class to bring to class
  - Computer or tablet use ok, but only for working on class slides
- ...For solving circuit problems together.

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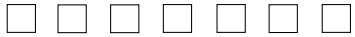
## Course Admin

- 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 each Thursday.





## Homework Cover Sheet

**First Attempt ON YOUR OWN (no consultation with friends, master tutor or others)** [2]

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.



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- 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 statement 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.*

Signature: _____

**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.

[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.





## Passing the Course

- Each student must complete each lab and hand in a lab memo, with your lab partner, to pass EGR 220
- Each student must have an average exam score >= 60% to pass EGR 220.
  - Average of midterms (2 of them) and the final exam





## 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): The student demonstrates resilience, adaptability, and **iterative learning**.

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## Master Tutor Hours

- Master tutor structure → 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

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## Questions of Understanding

1) How are voltage and current inter-related?
   - What do I understand about the theoretical and practical connections between voltage and current?
2) What is voltage?
   - What do I understand about the concept of voltage?
3) How do conservation laws apply to circuit theory?
   - What is my understanding of how conservation laws are used in circuit analysis and design?
4) What does "equivalent" mean for electrical circuits?
   - What is my understanding of how "equivalence" is used to design and analyze circuits?

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## *Examples* for pushing your understanding

1) How are voltage and current inter-related?
   - What is my theory to explain these connections?
2) What is voltage?
   - What am I unsure about, for the concept of voltage?
3) How do conservation laws apply to circuit theory?
   - How can I experiment with conservation laws?
4) What does "equivalent" mean for electrical circuits?
   - Can I design and test two circuits to explore my theory of equivalence?

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## Circuits Labs

- A chance to deepen your understanding of fundamental engineering, and circuits, concepts
- How does this lab improve your understanding of our *Questions of Understanding*?
- Building and experimenting with circuits
- Learning how electricity works
- Learning how to use standard electrical lab equipment
- (Lab time is used for exams also)

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## Circuits Labs

- Select one or more Question Of Understanding to investigate further in each lab
  - Each lab memo explains how your understanding is improving, deepening, … or getting more confused.
- Map your – objectives, experiments, results, learning – to the Questions Of Understanding

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## Wednesday Lab Time

Different uses of lab time

1) Everyone doing lab together
2) Midterm exams

Everyone must be free each Wednesday 1:20–4:00

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## Pre-Lab Questions

- Read through the entire lab handout
- Identify your learning objective(s) and begin work/plan on how this lab will advance your learning objective(s)
  - Include these statements in your pre-lab
- Pre-Lab questions in lab handout
  - Complete the pre-lab questions
- Be neat and professional
- Submit pre-lab to me at 1:20 (start of lab time)
- Every student must complete her own pre-lab (lab memos are done in teams)

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## Lab Memo: What to Hand In

- **Your memo must be a stand-alone document**
  - ***One Memo Per Team***
- 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* **including your learning objective(s)**
  - Results from the laboratory experiments
  - Concise discussion of what you discovered and how you made progress on your learning goal
  - One concise and elegant statement of *what you learned* and *how your understanding is improving, has improved...*

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## One Page Lab Memo Guidelines

- * Include **one statement** demonstrating your growing understanding, that **goes beyond** what is requested directly in the lab handout. *
- Focus on *your* **Q**uestion **O**f **U**nderstanding

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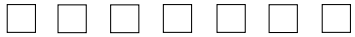
## One Page Lab Memo Guidelines

- * Include **one statement** demonstrating your growing understanding, that **goes beyond** what is requested directly in the lab handout. *
- Focus on *your* **Q**uestion **O**f **U**nderstanding
  - This is for you to demonstrate you are processing and reflecting on the course material and on your quest to better understand circuit theory.
  - New & improved questions often demonstrate your on-going learning, and can be used as part of this statement.
- * Note that this statement *must* demonstrate some *independent thinking and learning*. *



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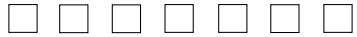
## Course Webpage

- Note this is NOT Moodle
- http://www.science.smith.edu/~jcardell/Courses/EGR220

- Moodle page will be used:
  - Annotated slides (after class) will be posted on Moodle
  - Homework solutions will be posted on Moodle



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## 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*

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## Welcome to Circuit Theory!

- Deepen your understanding of electrical circuits and of engineering science
- 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

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Questions?

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