Mesh & Nodal Analysis

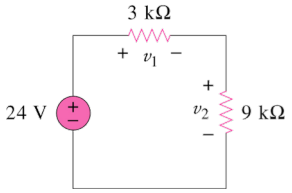
EGR 220, Chapter 3
Feb 11, 2020

Overview

- Use Ohm's Law, KVL & KCL for simultaneous equations with…
- Nodal Analysis
  - One equation per node
  - Solve for node voltages
- Mesh Analysis
  - One equation per loop
  - Solve for loop currents (not necessarily the same as element currents)

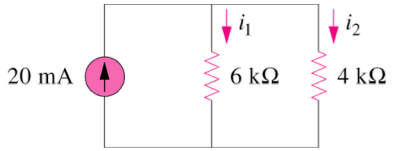
Recap Voltage Divider: Series R

- Solve for v_1 and v_2
  - Think about which resistor will have the larger V drop

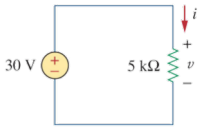


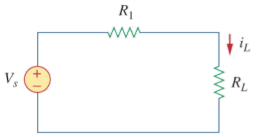
Recap Current Divider: Parallel R

- Solve for i_1 and i_2
  - Think about which R will carry the larger current



Write Expressions for I, using Ohm's Law & "V_{drop}"





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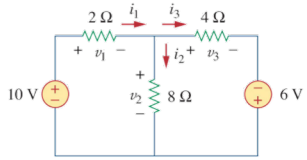
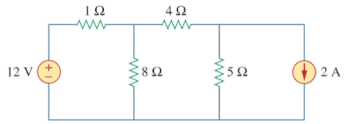


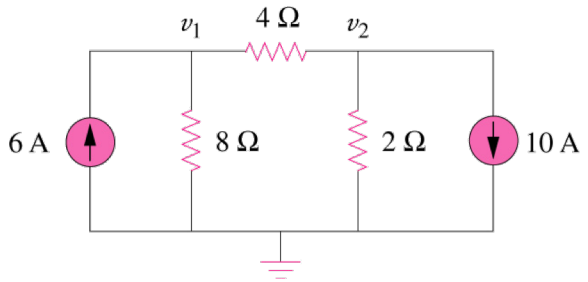


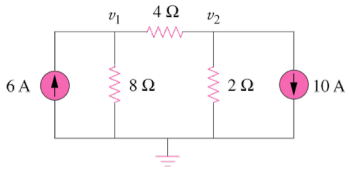
Nodal Analysis

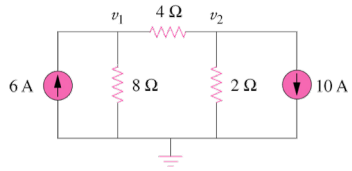
- Apply Kirchhoff's ***current*** law to solve for nodal ***voltages***
  1) Label diagram (nodes, all directions)
     - Initial labeling is arbitrary *but must be consistent!*
  2) Obtain equations using KCL and substituting in Ohm's law
  3) Solve equations for nodal voltages
     - Substitutions, linear algebra (matrices), Matlab
     - Note, negative answers indicate polarity is opposite your initial assumptions and are not incorrect
- Solution often requires iteration, as first attempt may not work.

Nodal Analysis

- How do we find v_1, v_2 and power dissipated in the resistors?

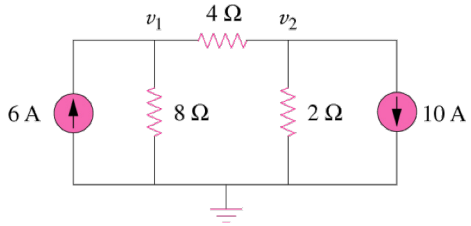






Concept Check: Voltage *Across*

- v_1, v_2 are voltage values relative to what?
- What is the voltage across the 4Ω resistor?



Mesh Analysis

- Apply Kirchhoff's ***voltage*** law to solve for loop (mesh) ***currents***
- Other law(s), expression(s) to use?
- Process?

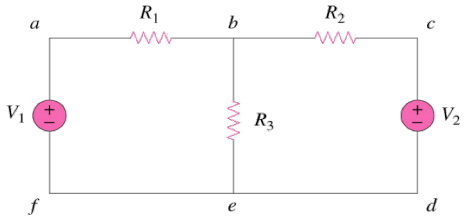
1)

2)

3)

Mesh Analysis Warmup

- How do we find (and label) *i* through R_3?
- Mesh currents versus element currents (linearity for resistor behavior; superposition of sources)



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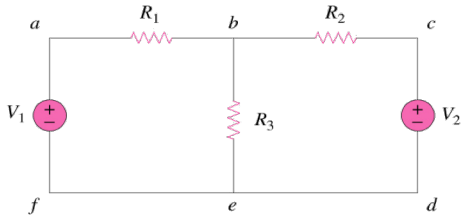
Mesh Analysis Warmup

If we draw loop currents to be opposing through R_3...



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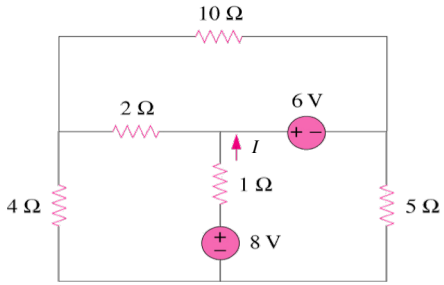
Mesh Analysis

- How do we find I_1, I_2, I_3 and I?
- Set up equations
- (*be able to write equations in matrix format*)



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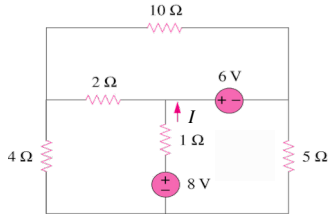
Mesh Analysis

- Write equations for I_1, I_2, I_3 **and** ***I***



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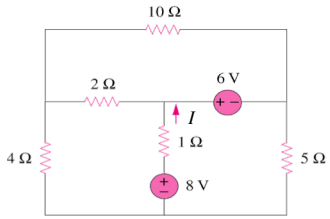
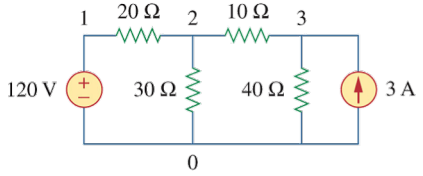
Use Matlab to solve…

```
>> R = [7  2  1; 2  12  0; 1  0  6]

R =  7     2     1
     2    12     0
     1     0     6

>> V = [8; 6; 2]

V =  8
     6
     2

>> I = inv(R) * V

I = 1.0256
    0.3291
    0.1624
```



Practice Circuit Analysis 1

- Find all currents and voltages



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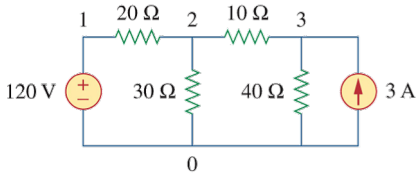
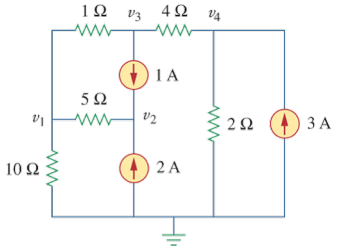
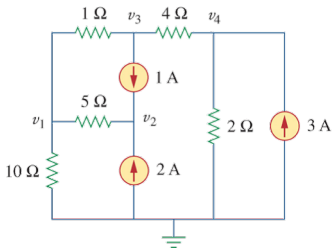


Discussion Circuit Analysis

- How can you find the voltages indicated?
- Compare ability to use nodal analysis vs. mesh analysis.

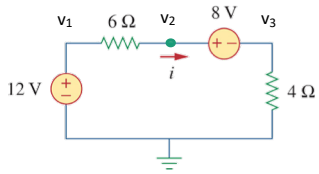


- How to find the voltages indicated?

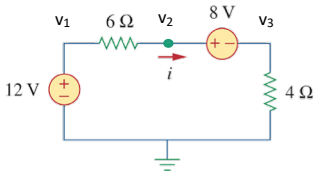


Practice Circuit Analysis 2

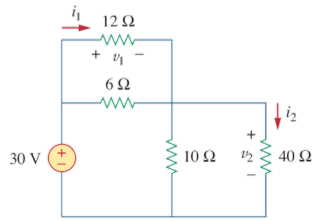
- Find all currents and voltages



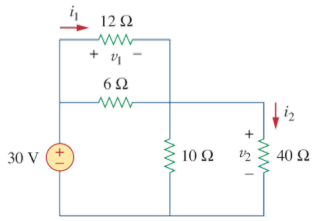
- Find all currents and voltages



Practice Analysis

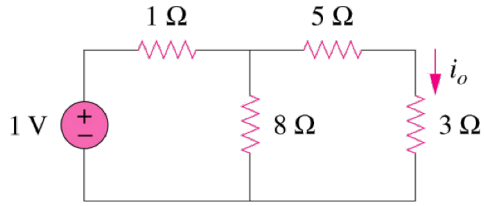


Practice Analysis

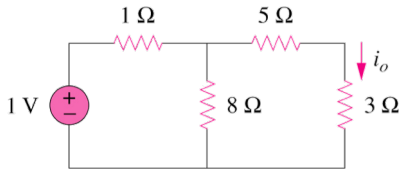


Practice Analysis (posted)

- How would we apply the tools learned so far?
  - KCL → Nodal analysis
  - KVL → Mesh analysis
  - Current or voltage divider with R_{eq}?



Practice Analysis



Analysis Tools

- Ohm's law
- KVL: Kirchhoff's voltage law
- KCL: Kirchhoff's current law
- Equivalent resistance
- Current divider
- Voltage divider
- Mesh analysis
- Nodal analysis

→ Exam 1 Through Mesh & Nodal ←

- *Next core theorem:* Thevenin Equivalent Circuit

Important Notes

- Read the text book!
  - We have limited in-class time
- Check out the applets link
  - on webpage from the first week of class
- Homework
  - show and develop clear thinking
  - ***learn*** from the homework

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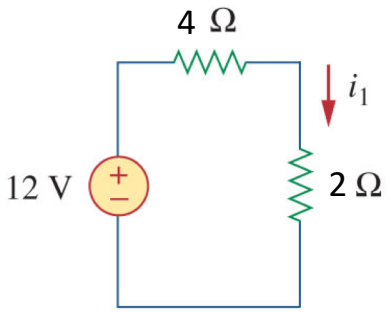
Lab 3: Linearity



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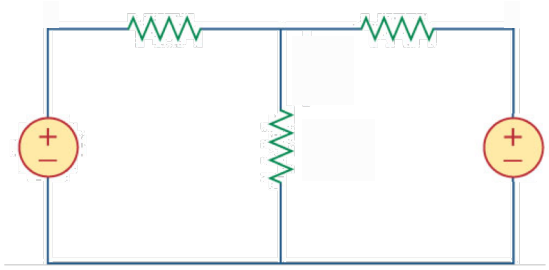
Lab 3: Superposition



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Lab 3 Preview

- Design your own lab – to verify Superposition and Linearity in circuits
- Read the chapter to begin learning these analysis methods
- Use ***simple*** circuits from the chapter to get ideas for your circuits, to build and test in the lab
- Pre-lab – design your lab experiment
  - Design it for 1 ¾ hour, allow time for mistakes and learning as you go, in our 2 ½ hour lab time.

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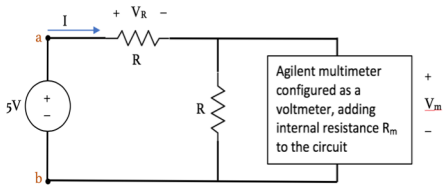
Lab 2 Experiments – Find $R_{Multimeter}$

R = 10MΩ



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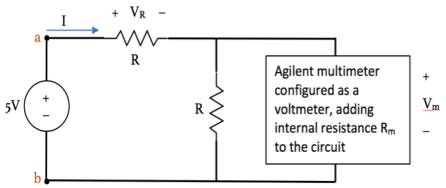
Lab 2 Experiments – Find $R_{Multimeter}$

R = 10kΩ



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