Kirchhoff's Laws II & Equivalent Resistance

EGR 220, Chapter 2

February 4, 2020

Class Concepts

- Open & short circuits
- Series and parallel elements
- Kirchhoff's Laws Examples
  - Current law, KCL
  - Voltage law, KVL
- Equivalent resistance
  - Series R_{eq}
  - Parallel R_{eq}

Open Circuits: V & I

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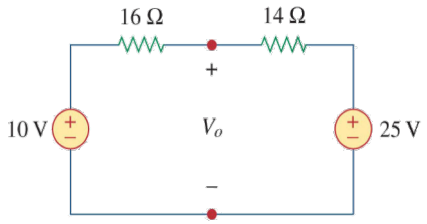
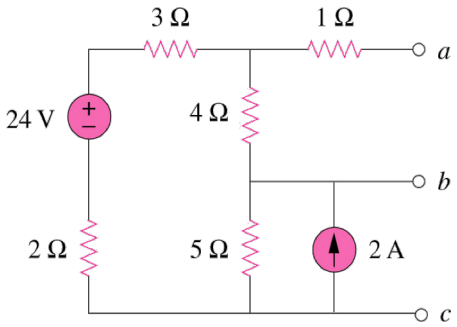
Homework Check-in



Recap: Node, Branch, Series and ||

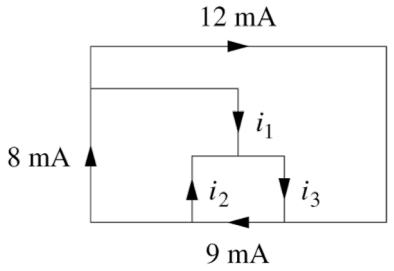
- A branch represents a single element such as a voltage source or a resistor.
- A node is the point of connection between two or more branches.
- Series elements share a node ***exclusively*** (no third element shares the node)
- Parallel elements share the ***same two nodes***

Series, Parallel, Open & Short and other things you notice

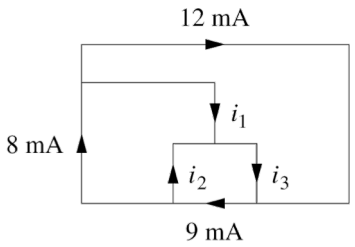


Kirchhoff's Current Law

- Find i_1, i_2 and i_3
  - Label nodes
  - Write KCL eqn's
  - Solve
    - We will use Ohm's law when there are resistors in the circuit diagram



Kirchhoff's Current Law



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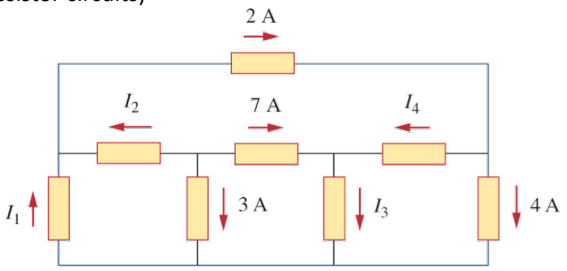
Kirchhoff's Current Law

- From HW 1: Find i_1, i_2, i_3 and i_4
  - Label nodes
  - Write KCL equation and solve (use Ohm's law for actual resistor circuits)



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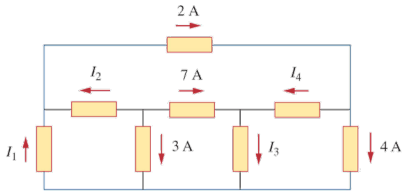

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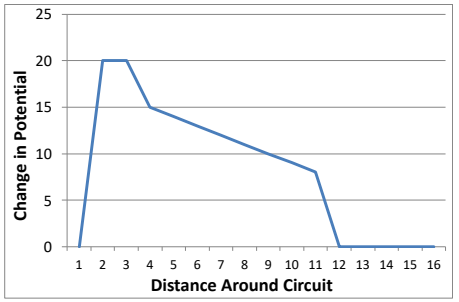
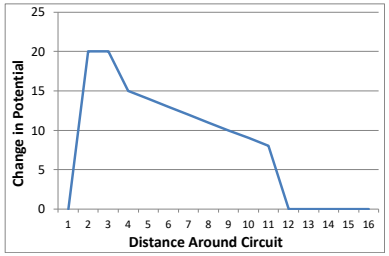
Kirchhoff's Voltage Law, KVL

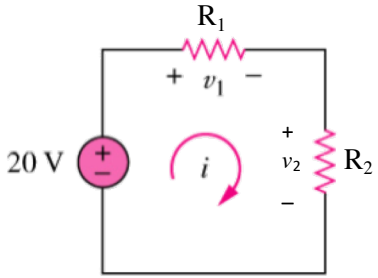
- Draw and label an electrical circuit that is consistent with the graph shown below.





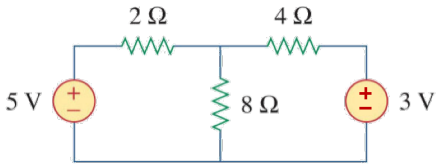
Kirchhoff's Voltage Law, KVL

- The conservation of _____
- Combine Ohm's law with KVL to solve for _____?



Kirchhoff's Voltage Law

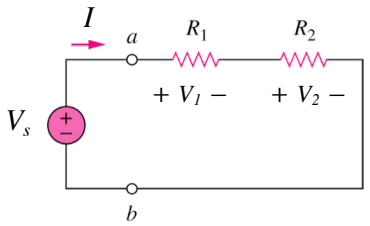
- Apply KVL
  - Label voltages
  - Write KVL eqn's
  - We will solve later with mesh analysis



New Concept: Equivalent Resistance

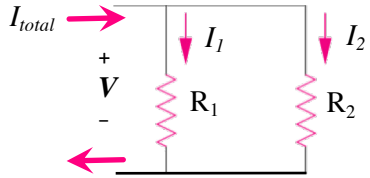
Series Resistors

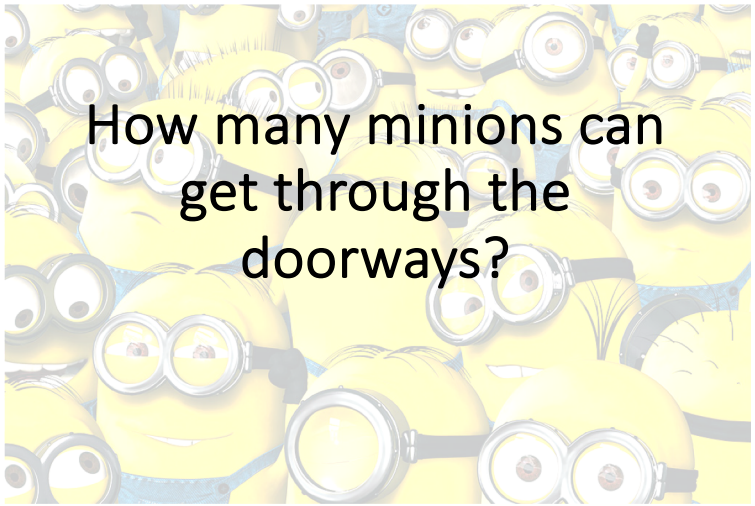
- Find R_{eq} (as a function of R_1 and R_2)

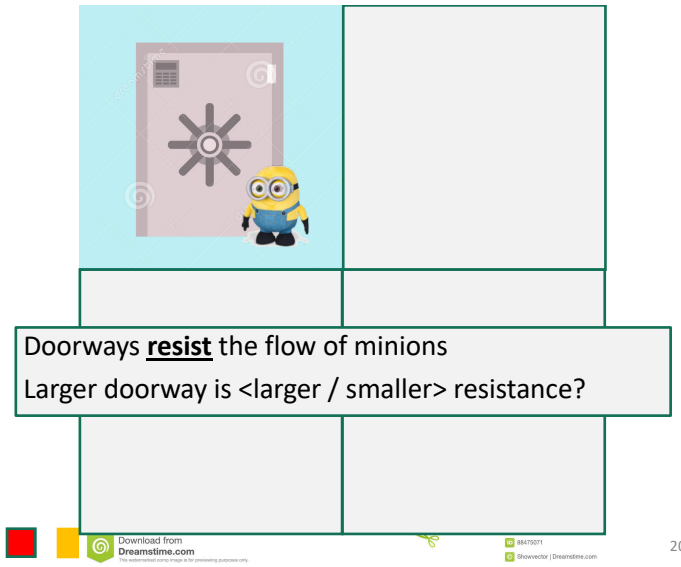


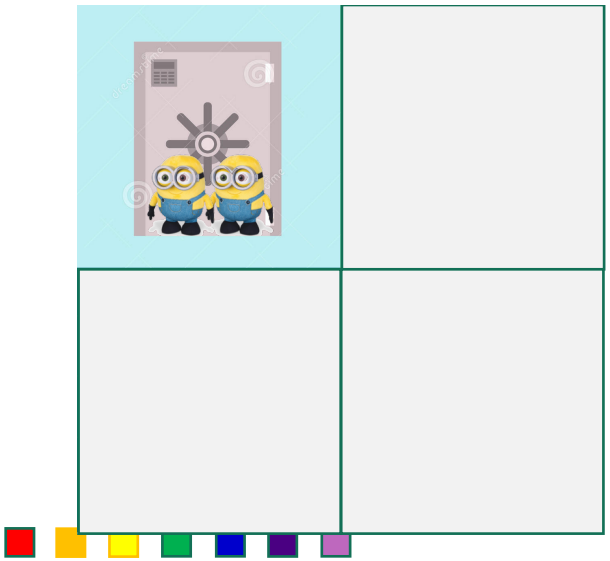
Parallel Resistors

- Find R_{eq} (as a function of R_1 and R_2)









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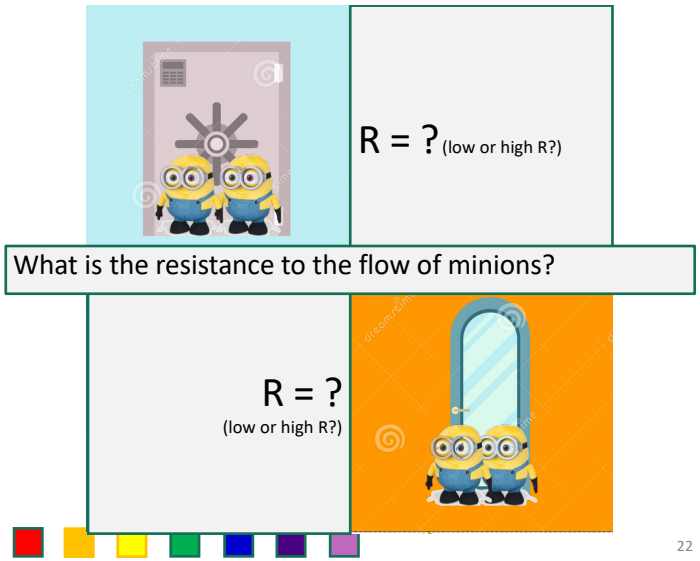

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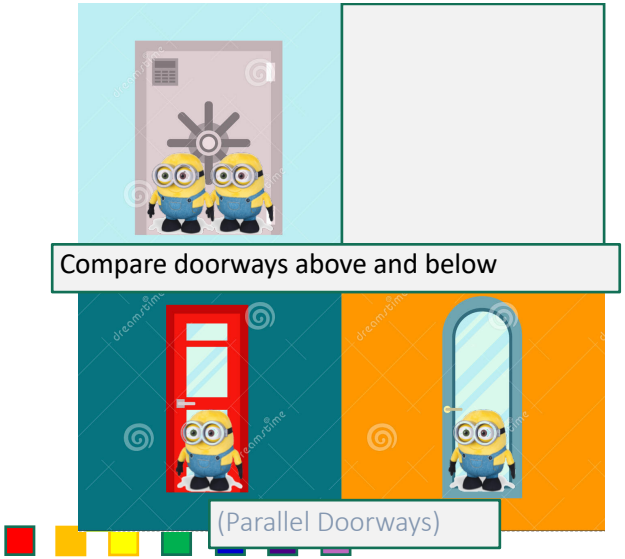

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Resistance = 1 piece

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Resistance = 2 pieces in series

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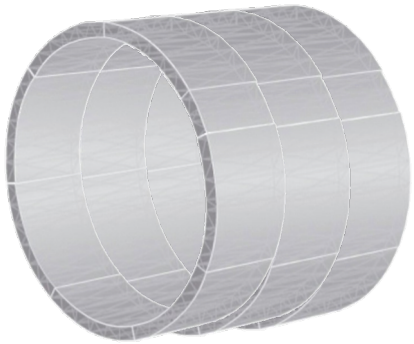
Resistance Increasing



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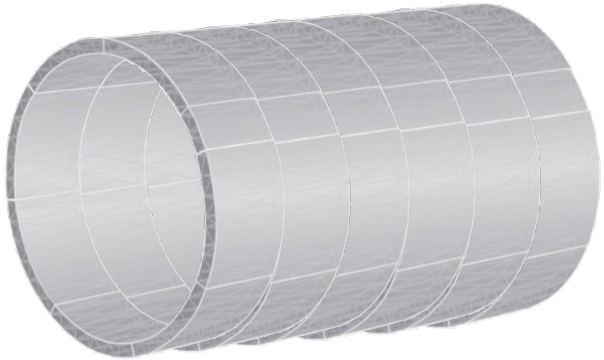
Resistance Increasing More



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Equivalent Resistance

- Combinations of series and parallel resistors
- The same current flows through...
  - Series / parallel resistors?
  - (And the voltage across is divided)
- The same voltage drop is across..
  - Series / parallel resistors?
  - (Current through is divided)

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Equivalent Resistance – Draw …

$R = A\Omega$ $R = \frac{1}{2}A\ \Omega$ $R = 2A\ \Omega$

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Series & Parallel (text def)

- Two or more elements are in series if
  - They exclusively share a single node and
  - Carry the same current.
- Two or more elements are in parallel if
  - They are connected to the same two nodes and
  - Have the same voltage across them.

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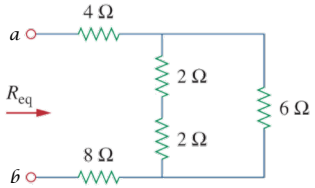
Identify Series and ||Elements, and Find R_{eq}



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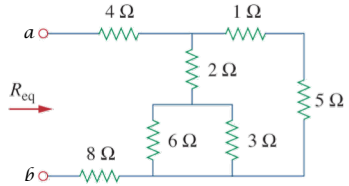
Identify Series and ||Elements, and Find R_{eq}



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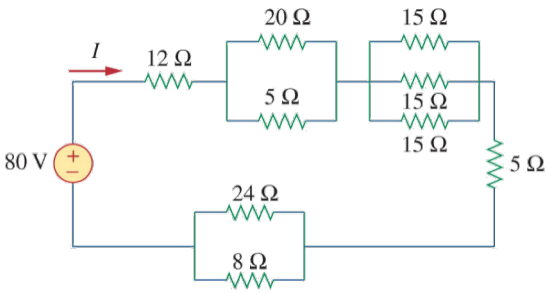
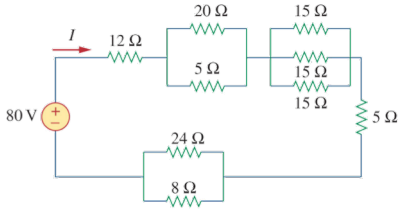
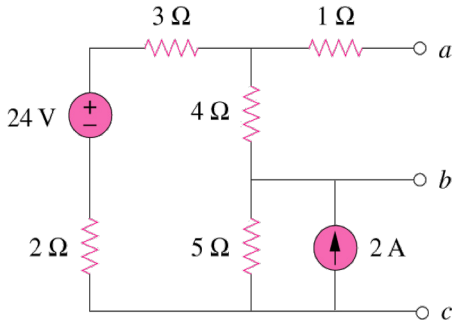
Identify Series and ||Elements, and Find R_{eq}





Different R_{eq} for Different Terminals



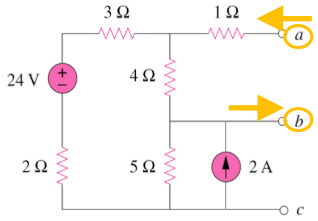
Equivalent Resistance

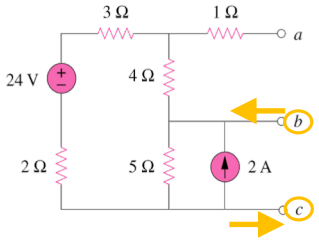
- Equivalent resistance is terminal-dependent

  $V_{drop\ a\text{-}b} = I_{a\text{-}b} * R_{eq}$

  $$R_{eq} = \frac{V_{\text{drop } a-b}}{I_{a-b}}$$

- *The ratio of voltage to current for* **specific** *terminals in a circuit*





New Terminology

- Series elements
  - Share one node exclusively
  - Carry the same current
- Parallel elements
  - Share the same two nodes
  - Have the same voltage drop across
- Equivalent resistance
  - The ratio of voltage to current for the terminals (nodes) of interest

Questions?