April 27, 2011 Physics 122 Prof. E. F. Redish

- **Theme Music:** **Maynard Ferguson**
  High Voltage
- **Cartoon:** **Pat Brady**
  Rose is Rose

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Outline

- Go over Quiz 9
- Recap Foothold ideas
- Foothold ideas for circuits (Kirchoff's principles)
  - Ohm's law
  - Flow rule
  - Loop rule
- Examples

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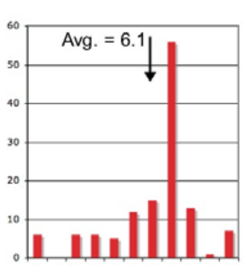
Quiz 9

	9.1	9.2	9.3	9.4
a	77%	2%	73%	16%
b	0%	14%	18%	58%
c	2%	83%	5%	6%
d	2%	0%	2%	6%
e	2%	0%	1%	3%
bc	0%	0%	2%	12%
cd	17%	0%	0%	0%



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Foothold Idea: Local Neutrality

- Most matter is made of of an equal balance of two kinds of charges: positive and negative.
- Since the electric force is <u>very</u> strong, mostly the + and - charges overlap closely and cancel each other.
- Small imbalances in the cancellation leads to:
  - polarization forces
  - potential drop across a resistance
  - observed electric forces.

Foothold ideas: Currents

- Charge is moving: How much? $I = \frac{\Delta q}{\Delta t}$
- How does this relate to the individual charges? $I = q\,n\,A\,v$
- Constant flow means pushing force balances the drag force $ma = F_e - bv$ $a = 0 \quad \Rightarrow \quad v = F_e/b$
- What pushes the charges through resistance? Electric force implies a drop in *V*! $F_e = qE$ $E = -\frac{\Delta V}{L}$

Units of power

- Since the units of work (energy) is the Joule, the unit of power is the Joule/second.
  - 1 Watt = 1 Joule/second (definition)
- Our analysis shows that current x voltage = power.
- 1 Watt = 1 Ampere x 1 Volt

$$P = I\Delta V$$

Electric circuit elements

- *Batteries* —devices that maintain a constant electrical pressure difference across their terminals (like a water pump that raises water to a certain height).
- *Resistances* —devices that have significant drag and oppose current. Pressure will drop across them.
- *Wires* — have very little resistance. We can ignore the drag in them (mostly – as long as there are other resistances present).



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Foothold ideas (Kirchoff's Rules)

- Flow Rule
  - The total amount of current flowing into any point in a network equals the amount flowing out (no significant build-up of charge anywhere).
- Potential Rule
  - Following around any loop in an electrical network the potential has to come back to the same value (sum of drops = sum of rises).
- Ohm's Rule
  - When a current I passes through a resistance R, there is a voltage drop across the resistor of an amount $\Delta V = IR$

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Very useful heuristic

- The Constant Potential Trick (CPT)
  - Along any part of a circuit with 0 resistance, then $\Delta V = 0$, i.e., the voltage is constant since in any circuit element

$$\Delta V = IR$$

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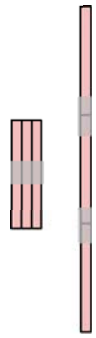
What happens when we combine resistors?

- Consider increasing the width or the length of a resistor.
  - Analogy with air flow
  - Using the equation for resistance
  - Analyze in terms of potential drops and current flow



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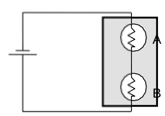
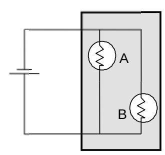
Series and Parallel Rules

- In series, the current through each element is the same.
- In parallel, the pressure drop across each element is the same.

$$\Delta V = \Delta V_A + \Delta V_B$$
$$IR_{eff} = IR_A + IR_B$$
$$R_{eff} = R_A + R_B$$



$$I = I_A + I_B$$
$$\frac{\Delta V}{R_{eff}} = \frac{\Delta V}{R_A} + \frac{\Delta V}{R_B}$$
$$\frac{1}{R_{eff}} = \frac{1}{R_A} + \frac{1}{R_B}$$



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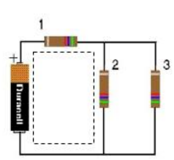
Sample Problem

- The circuit diagram shown at the right contains a 1.5 Volt battery and three identical 50 Ω resistors. Find the current in and voltage drop across each of the resistors.



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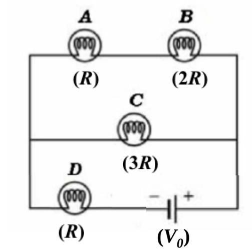
Sample Problem

- How do the currents in resistors A and B compare?
- How do the voltage drops across resistors A and B compare?
- How does the current in and voltage drop across resistor C compare to those in A and B?
- Find the current in resistor D.



$I_0 = V_0/R$

Sample Problem

- Identical batteries are connected in different arrangements to the same light bulb. Rank these arrangements on the basis of bulb brightness from the highest to the lowest.