**Portland State University**
**General Physics Workshop**
**Problem Set 2** 

# Resistance, Current, Voltage

**Equations and Relations:**

Coulomb's law: $F = k\frac{|q_1||q_2|}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$

$k = 8.99 * 10^9\ Nm^2 / C^2$

$\varepsilon_0 = \frac{1}{4\pi k} = 8.85 * 10^{-12} C^2 / Nm^2$

magnitude of an electron's charge:
$e = 1.6 * 10^{-19} C$

Electric Field: $E = \frac{F}{q_0}$

Electric field of a point charge: $E = k\frac{|q|}{r^2}$

Electric flux: $\Phi = EA\cos\theta$

Gauss's law: $\Phi = \frac{Q}{\varepsilon_0}$

Electric Potential: $E = -\frac{\Delta V}{\Delta s}$

Electric Potential of a point charge: $V = \frac{kq}{r}$

Electric current: $I = \frac{\Delta Q}{\Delta t}$

Ohm's law: $V = IR$

Resistance of a wire: $R = \rho\left(\frac{L}{A}\right)$

Temperature dependence:

$R = R_0[1 + \alpha(T - T_0)]$

Electrical power: $P = IV = I^2 R = \frac{V^2}{R}$

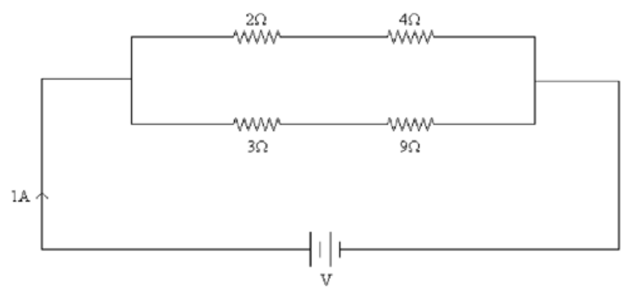
Resistance:

$R_{series} = R_1 + R_2 + R_3 + ...... = \sum_i R_i$

$\frac{1}{R_{parallel}} = \sum_i \frac{1}{R_i}$

1. Four resistors of 20 Ω, 40 Ω, 60 Ω, and 80 Ω are connected across a DC voltage source. If the current through this circuit is 0.5 A, what is the voltage applied to this circuit?

2. Four resistors of values 2 Ω, 4 Ω, 3 Ω, and 9 Ω are connected across a DC source with voltage V as shown in Figure. If the total current through this circuit is 1 A, what is the value of the voltage V?



3. The length of a certain wire is doubled and at the same time its radius is also doubled. What is the change in the resistance of this wire?

   - *Think of a wire of Length L as two wires half the length (L/2) in series. Why must the resistance of the wire be proportional to the length?*
   - *Think of a wire with cross section A as two wires with half the cross section (A/2) in parallel. Why must the resistance of the wire be inversely proportional to the cross section?*

4. Two light bulbs, one rated 25 W at 120 V and another rated 40 W at 120 V, are arranged in two different circuits.

(a) The two bulbs are first connected in parallel to a 120 V source. Determine for each bulb
   i. the resistance, and
   ii. the current through it in this circuit.

(b) Now with the bulbs connected in series with the 120 V source, determine for each bulb
   i. the resistance
   ii. the current through it in this circuit.

(c) Rate the following bulb conditions according to the brightness of each (1 = brightest, 4 = dimmest):
   ____ 25 W bulb in the parallel circuit
   ____ 40 W bulb in the parallel circuit
   ____ 25 W bulb in the series circuit
   ____ 40 W bulb in the series circuit

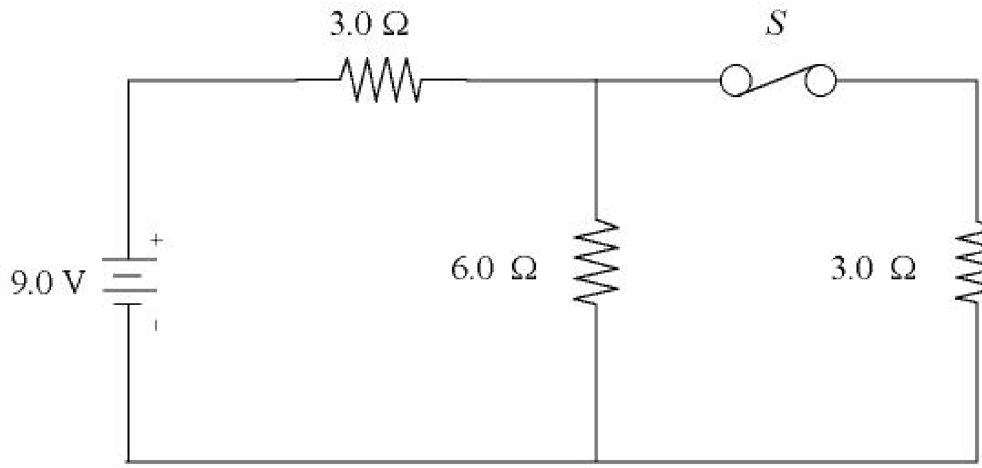
(d) Calculate the total power dissipated by the two bulbs in for the parallel circuit, and again for the series circuit.

- *Draw a circuit diagram for two light bulbs and a switch connected to a single battery so that.*
  - *(a) the switch turn both light bulbs on and off*
  - *(b) one bulb stays light even after the other bulb burns out.*

- *Why do most Ammeters have a  fuse to protect them from large currents, while voltmeters usually won't have one?*

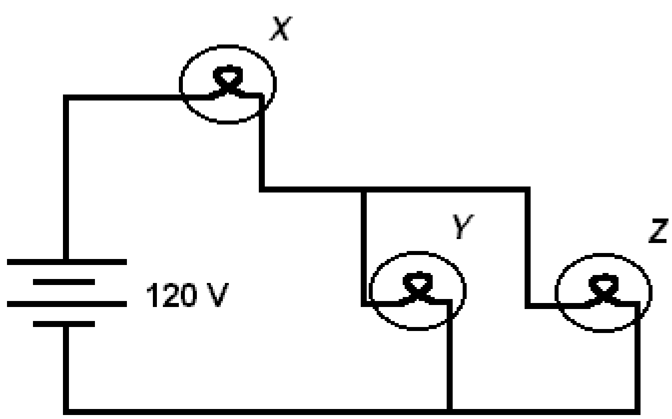
- *Why are some appliances (electric stoves, dryers) supplied with 240 V and others (Light bulbs, TV) are connected to 120 V?*

5. Light bulbs of fixed resistance A=3.0 Ω and B=6.0 Ω, a C=9.0 V battery, and a switch *S* are connected as shown in the schematic. *S* is closed.



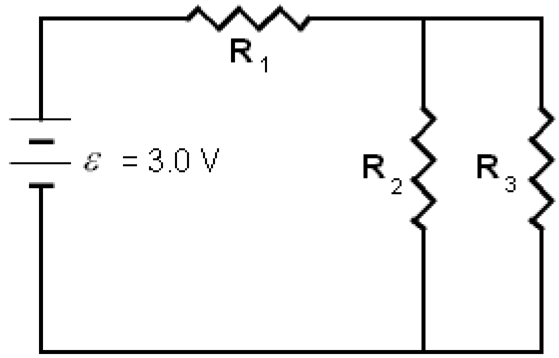

(a) Calculate the current in bulb *A*.
(b) Which light bulb is brightest? Why?
(c) *S* is then opened. Indicate for each bulb (*A*, *B*, and *C*) whether it's brightness will increase, decrease, or remain the same. Explain your answer.

6. In the circuit shown, *X*, *Y*, and *Z* represent three light bulbs, each rated at 60 W. Assume that the resistances of the bulbs are constant and do not depend on the current.




(a) What is the resistance of each bulb?
(b) What is the equivalent resistance of the three light bulbs when arranged as shown?
(c) What is the total power dissipation of this combination when connected to a 120-V source, as shown?
(d) What is the current in bulb *X*?
(e) What is the potential difference, $V_X$, across bulb *X*?
(f) What is the potential difference, $V_Z$, across bulb *Z*?

7. For the circuit shown ($R_1$=$R_3$=10Ω, $R_2$=20Ω), use Ohm's law and Kirchhoff's rules to find:
(a) the potential difference across each resistor, and
(b) the current through each resistor.

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8. A 30-m-long extension cord is made from two #19 gauge (diameter is 0.912 mm) copper wires. (One wire carries current *to* an appliance while the other carries current *from* it.)
   (a) What is the resistance of each wire.
   (b) If the copper wire is to be replaced by an aluminum wire of the same length, what is the minimum diameter so that the new wire has a resistance no greater than the old?

   (Resistivity: $\rho_{copper} = 1.67 \times 10^{-8}$ Ω·m, $\rho_{aluminum} = 2.65 \times 10^{-8}$ Ω·m)

Additional Questions

1. Why is a person who touches a van de Graaff generator not electrocuted even though there may be a potential difference of hundreds of thousands of volts between him/her and the ground?

2. When riding the MAX home last week, you overheard someone say to his girlfriend, "The power ratings printed on all my appliances really depend on their resistance. The more resistance I have, the less current I draw and the less power I use. Therefore if I leave all my appliances on, the resistances will be additive. With a higher total resistance I'll draw less current. Then, since $P = VI$, I'll use less power and save on my electricity bills!" Why is this further proof not to trust a stranger's physics reasoning? (The fact a true physicist could never get a girlfriend does not count.)