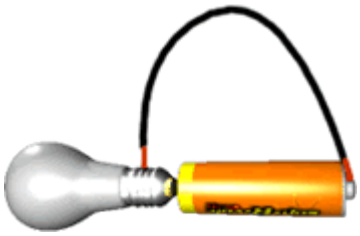
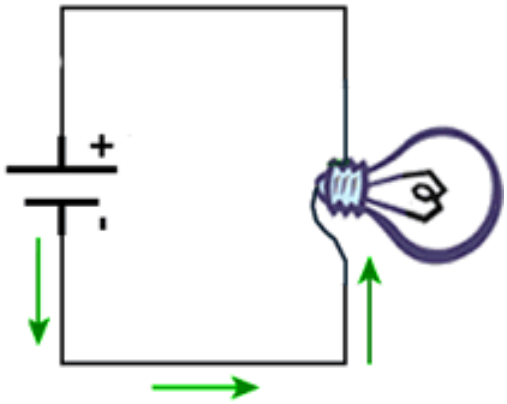
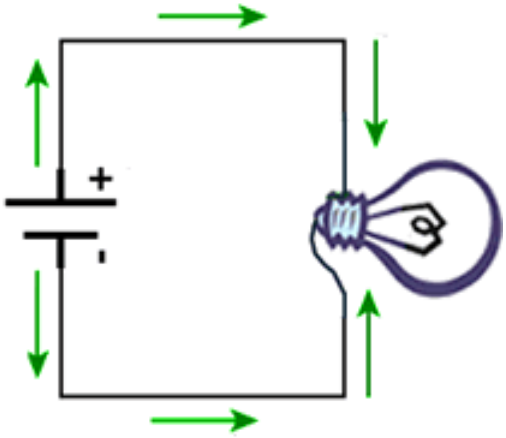
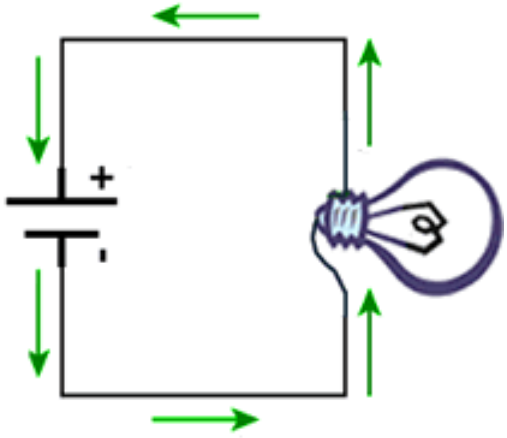
Practice 1.1: The Bulb Challenge

Predict	Picture	Test It
A. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
B. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
C. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
D. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
E. Will this circuit make the bulb light? Explain.		Try it. Explain your observations

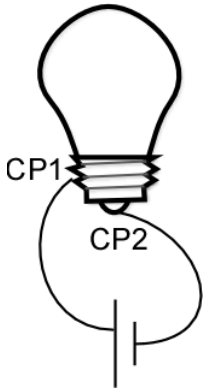
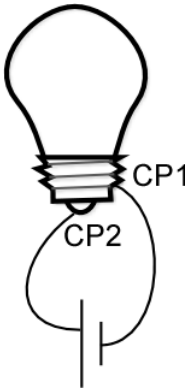
Predict	Picture	Test It
F. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
G. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
H. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
I. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
J. Will this circuit make the bulb light? Explain.		Try it. Explain your observations
K. Will this circuit make the bulb light? Explain.		Try it. Explain your observations

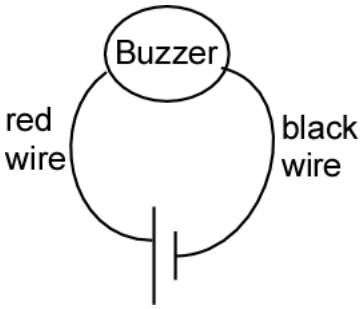
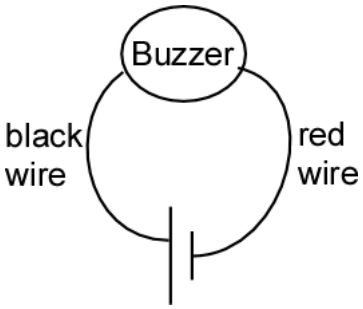
Practice 1.2: Flow Challenge

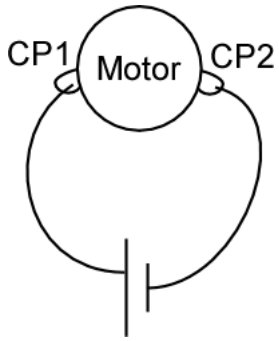
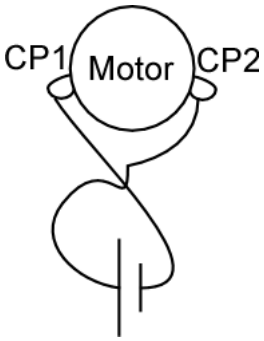
1. Four students draw the flow of current or "electricity" in a one-bulb circuit as shown below. The arrows represent the direction of the current. Which diagram(s) do you think is/are correct? Explain your reasoning.

A. 	B. 
A is correct/wrong because:	B is correct/wrong because:
C. 	D. Draw a diagram of your own idea, if different from A, B or C
C is correct/wrong because:	D is correct/wrong because:

2. After reading "Reading Page: What is Charge,? What is current?" Draw the direction of electron current flow in the following circuits. Also state how the device would work.

<table>
<tr>
<td>A. Draw the electron current flow for the circuit below:
 
</td>
<td>B. Draw the electron current flow for the circuit below:
 
</td>
<td>How are circuits A and B different from each other?

Will the bulbs in A and B work differently? If so, how?</td>
</tr>
<tr>
<td>C. Draw the electron current flow for the circuit below:
 
</td>
<td>D. Draw the electron current flow for the circuit below:
 
</td>
<td>How are circuits C and D different from each other?

Will the buzzers in C and D work differently? If so, how?</td>
</tr>
<tr>
<td>E. Draw the electron current flow for the circuit below:
 
</td>
<td>F. Draw the electron current flow for the circuit below:
 
</td>
<td>How are circuits E and F different from each other ?

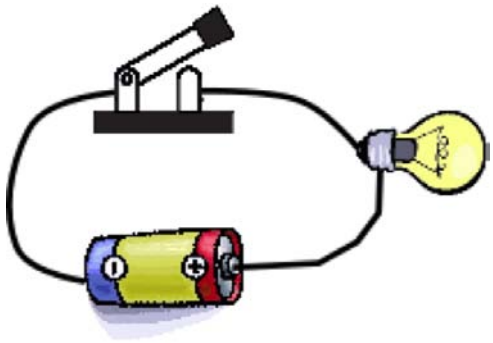
Will the motors in E and F work differently? If so, how?</td>
</tr>
<tr>
<td colspan="3">G. In all the circuits above, what determines if there is flow of current in the circuit - the device or the battery? Explain.

In all the circuits above, what determines the direction of electron flow in the circuit- the device or the battery? Explain.</td>
</tr>
</table>

Practice 1.3: Circuits With a Switch

1. Paige builds the circuit shown below:

   - Make a schematic drawing of this circuit using the symbols used for the three elements that make up this circuit.



a) In the circuit drawn, does the light bulb light? Explain.

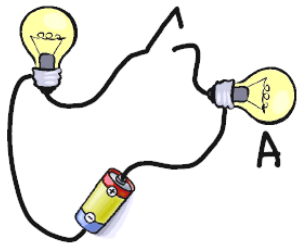
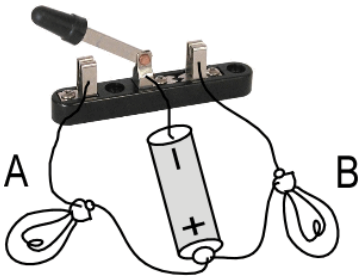
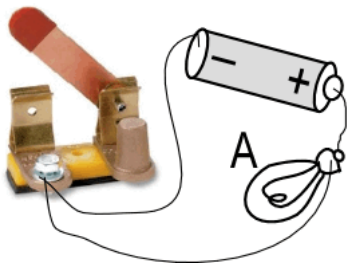
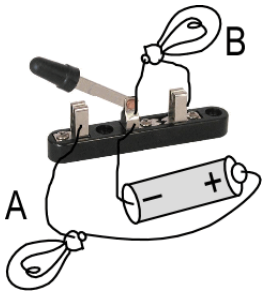
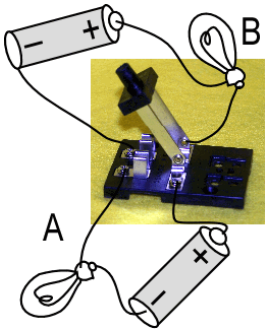
b) Explain what will happen to the light bulb when the switch is closed.

c) Why does the light bulb glow when current passes through it?

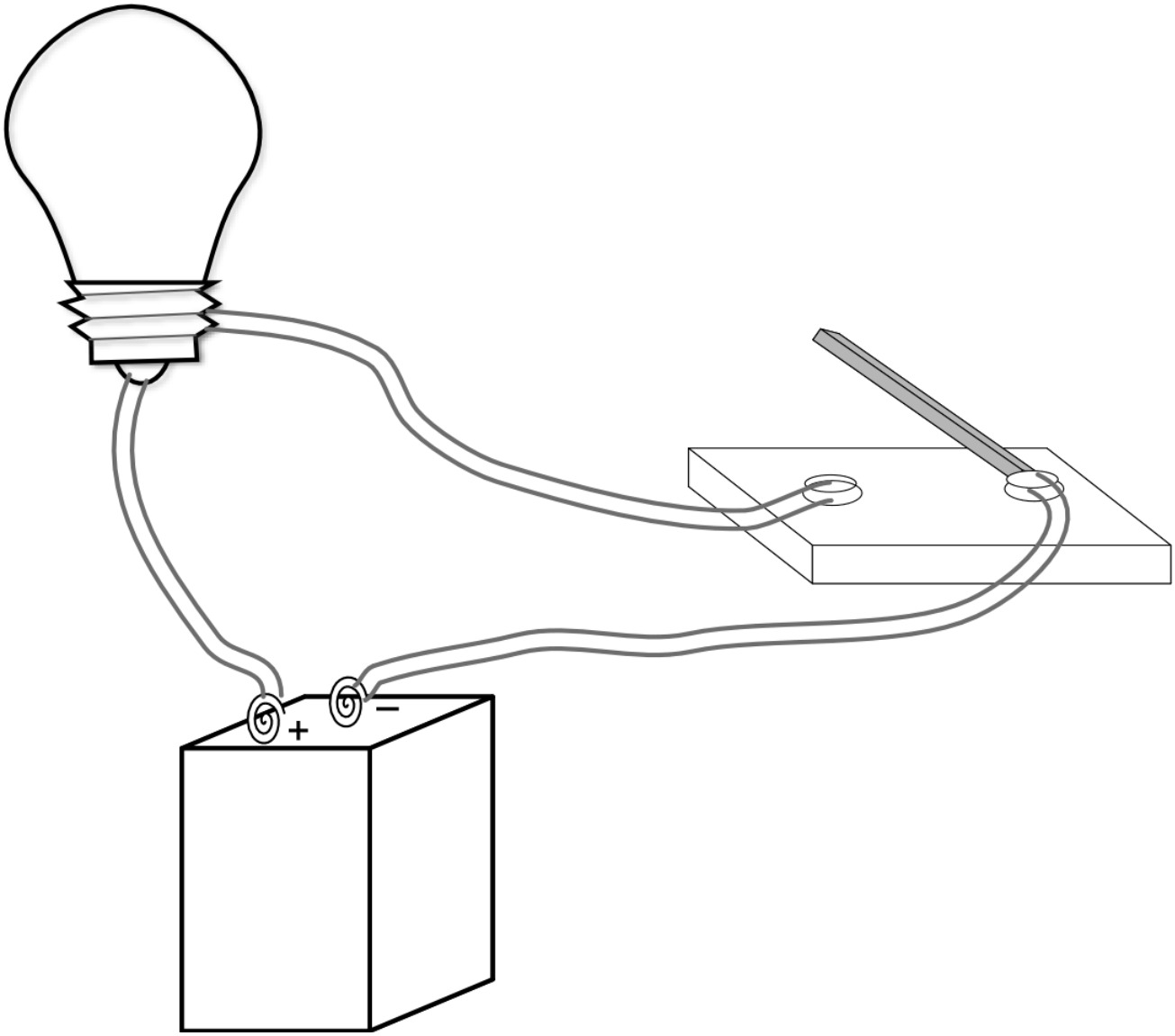
d) Show the direction of the current in the circuit (when it is flowing).

2. How do you think a three-way bulb (one that has three different levels of brightness when you click the switch) works?

3. Five circuits are shown below. Make a schematic drawing of each circuit using the symbols for each element in the circuit.

Circuit	Schematic drawing of circuit	Does the bulb "A" light up?
A. 		Prediction, when switch is: Open: Closed: Test, when switch is: Open: Closed:
B. 		Prediction, when switch is: Open: Closed left: Closed right: Test, when switch is: Open: Closed left: Closed right:
C. 		Prediction, when switch is: Open: Closed: Test, when switch is: Open: Closed:
D. 		Prediction, when switch is: Open: Closed left: Closed right: Test, when switch is: Open: Closed left: Closed right:
E. 		Prediction, when switch is: Open: Closed: : Test, when switch is: Open: Closed: :

4. In the picture below draw in and label all details of the devices in the circuit. Describe what happens in various parts of the circuit. You may use cartoon-like balloons if you wish. (Note that the wires are drawn as tubes).



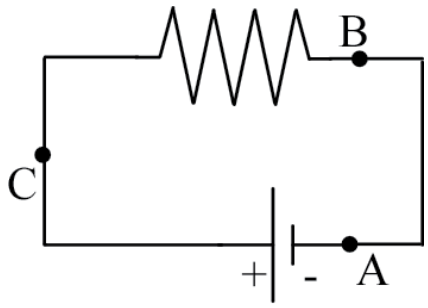
Practice 1.4: Comparing Currents in Circuits

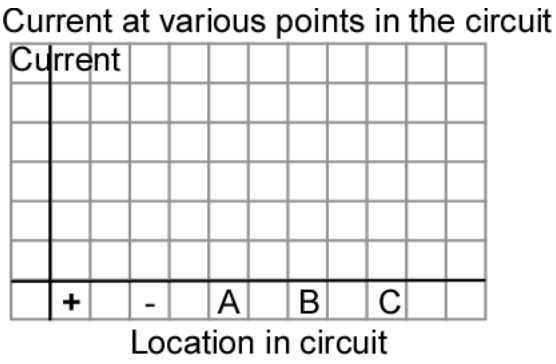
1. In the circuit shown,

   i) Draw the direction of flow of electrons (electron current).

   ii) Compare the amount of current that flows at B and at C to that at A. Explain.

   iii) Graph the current at different locations in the circuit in the graph.





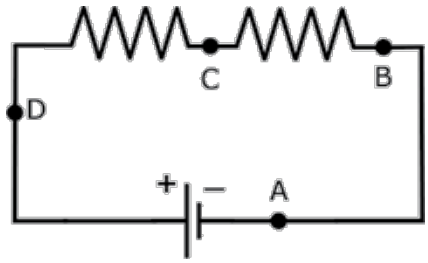
2. In circuits 2(a) and 2(b) below,

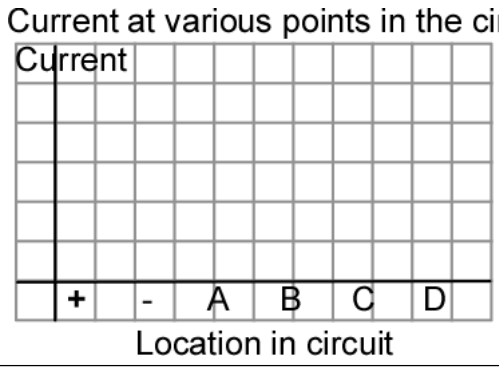
   i) Draw the direction of flow of electrons (electron current).

   ii) Within each circuit, compare the current at B, C, and D to the amount at A. Explain.

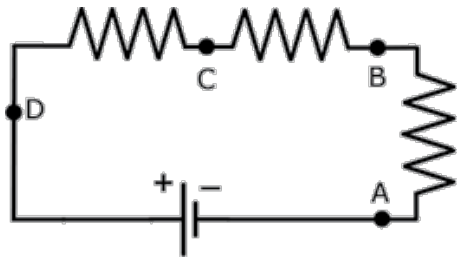
   iii) Graph the current at different locations in the circuit in the graphs below each circuit.

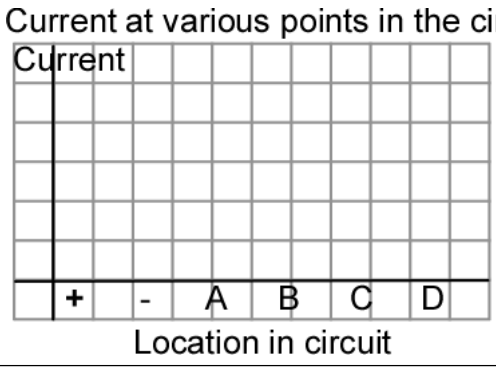
2(a)





2(b)

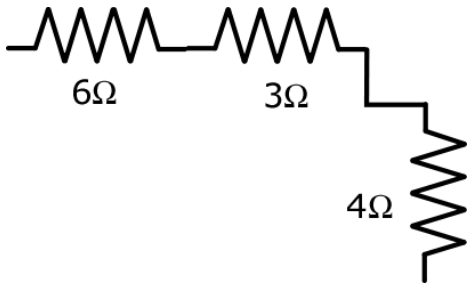




Practice 1.5: Circuit Challenge - Series Circuit Design

1. The resistances of three resistors are R_1 = 2 Ω, R_2 = 3 Ω, and R_3 = 5 Ω. What would a multimeter read if you connected them in series and measured the combined resistance?

2. Calculate the total resistance of the string of resistors.



3. Suppose that you have a box with several 3 Ω resistors. Design the following circuits:

3A. Design a circuit made of only 3 Ω resistors that has a total resistance of 6 Ω. Draw it.
3B. Design a circuit made of only 3 Ω resistors that has a total resistance of 9 Ω. Draw it.
3C. Design a circuit made of only 3 Ω resistors that has a total resistance of 12 Ω. Draw it.
3D. Design a circuit made of only 3 Ω resistors that has a total resistance of 18 Ω. Draw it.

4. Suppose that you had a box with several 2 Ω, 3 Ω, and 5 Ω resistors. Design the following circuits (some circuits may have more than one design):

4A. Design a circuit made of any mix of 2 Ω, 3 Ω, and 5 Ω resistors that has a total resistance of 4 Ω. Draw it.
4B. Design a circuit made of any mix of 2 Ω, 3 Ω, and 5 Ω resistors that has a total resistance of 6 Ω. Draw it.
4C. Design a circuit made of any mix of 2 Ω, 3 Ω, and 5 Ω resistors that has a total resistance of 7 Ω. Draw it.
4D. Design a circuit made of any mix of 2 Ω, 3 Ω, and 5 Ω resistors that has a total resistance of 8 Ω. Draw it.

Practice 1.6: Calculating Resistance

(Unit conversions you might need: 100 cm = 1 m; 10 mm = 1 cm)

1. A 2000 cm-long wire is made of iron and has a cross-sectional area of 0.003 cm^2. Calculate its resistance.

2. Calculate the resistance of a 25,000 cm long wire made of copper, which has a radius of 0.2 cm.

3. Calculate the length of a wire made of tungsten that has a cross-sectional area of 0.24 cm^2 and a resistance of 300 Ω.

4. The resistance of a 100 cm-long wire of cross sectional area 0.015 cm^2 is 400 Ω. Calculate the resistivity of the material of this wire.

5. Calculate the cross-sectional area of a silver wire that has a resistance of 50 Ω and is 15 m long.

6. What happens to the resistance of a wire if its length doubles?

7. What happens to the resistance of a wire if its radius doubles?

Practice 1.7: Ohm's Law Problems

Ohm's Law: V = IR. Pictures of blank multimeters and sheets of graph paper are included in the Appendix.

Veronica's Data	
Voltage (V)	Current (A)
1.2	0.05
2.4	0.1
3.5	0.15
4.8	0.2
6.2	0.25
7.2	0.3
8.4	0.35
9.4	0.4
10.8	0.45
12.1	0.5
13.2	0.55

I. Using Ohm's Law:

1. Veronica measures the current produced in a one-resistor circuit when she applies various voltages to the resistor.

   a) Draw the circuit, including two multimeters, properly connected to measure voltage and current.

   b) The data she obtains is given in the table. Make a graph and use the slope to figure out the resistance of the resistor.

2. A current of 0.25 A flows when a light bulb of resistance 60 Ω is connected to a battery. Draw a circuit diagram. Calculate the voltage of the battery.

3. A light bulb of resistance 40 Ω is connected to a 6 V battery. Draw a circuit diagram. How much current flows through the bulb?

4. A light bulb in a desk lamp has a resistance of 260 Ω. How much current flows through it when it is connected to a 110 V outlet?

II. Ohm's Law and Traveling Overseas

Note: Some modern appliances are "smart." They have a automatic sensor that adjusts 220 V down into 110 V. The problems below are written about appliances that are not smart.

5. If I took my iron that draws a current of 7 A on a 110 V line to Germany, where the line voltage is 220 V, how much current would it draw? What do you think would happen to the iron?

6. While on her concert tour in the US, my Austrian friend Andrea brought along a small electric fabric-steamer. The steamer draws a current of 4.2 A on a 220 V line in Austria. If she plugged it into an electrical line in the US, where the household voltage is 110 V, how much current would the steamer draw? How well do you think it will perform?

7. The U.S. uses a household voltage of 110 V. However, electric stoves and dryers are wired with 220 V lines. Which would cause less damage -- plugging a 110 V-rated curling iron into a 220 V outlet, or a German-made 220 V-rated curling iron into a 110 V outlet? Explain. (Note: 110 and 220 V outlets are made in different shapes so that appliances cannot be accidentally interchanged.)

II. Measurements in Circuits

8. A bulb has a resistance of 70 Ω. It is connected to a battery of voltage 6.2 V. Calculate the current flowing through it. Draw the circuit. Use a picture of the blank multimeter to show how you would measure the <u>voltage difference</u> across the bulb	9. A 12 V battery is connected to a resistor of resistance of 9000 Ω. Calculate the current flowing through it. Draw the circuit. Use a picture of a blank multimeter to show how you would measure the <u>current through</u> the resistor.
	

10. A 5 Ω resistor has 2.6 A flowing through it when it is connected to a battery. Calculate the voltage of the battery. Draw the circuit. Use a picture of a blank multimeter to show how you would measure the <u>voltage difference</u> across the resistor.	11. A bulb that has a resistance of 750 Ω, and is connected to a 4.5 V battery. Calculate the current flowing through the bulb. Draw the circuit. Use a picture of a blank multimeter to show how you would measure the <u>current through</u> the bulb.
	

Practice 1.8: Series Circuit Picture and Graph Problems

1. In circuits P and Q, all batteries produce the same voltage and all resistors have the same amount of resistance. The current at point C in circuit Q is 3 A, as shown.

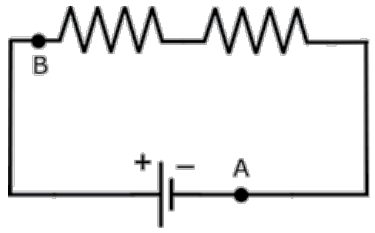
a) Draw the direction of flow of electrons in both circuits (electron current).

b) How much current flows at D in circuit Q? Explain.

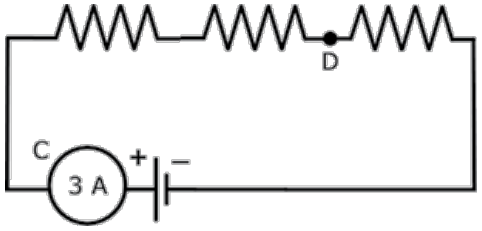
c) Would you expect the current at A in circuit P to be more or less than that at C? Explain.

d) By comparing the two circuits, figure out how much current flows at point A in circuit P. Explain.

P.



Q.



2. In circuits R and S, both batteries produce the same voltage.

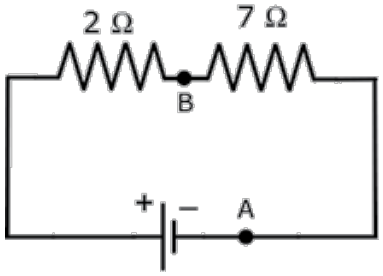
(a) Draw the direction of flow of electrons in both circuits (electron current).

(b) In circuit R, compare the currents at A and B to each other. Explain your reasoning.

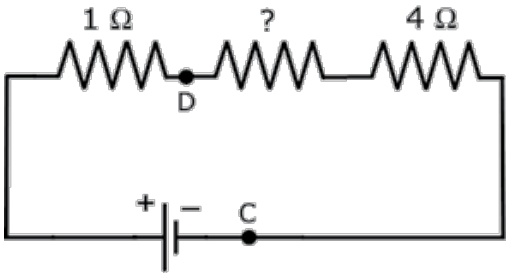
(c) In circuit S, compare the currents at C and D to each other. Explain your reasoning.

(d) If the current at A in circuit R is to be the same as the current at C in circuit S, what value must the middle resistor in S have? Explain.

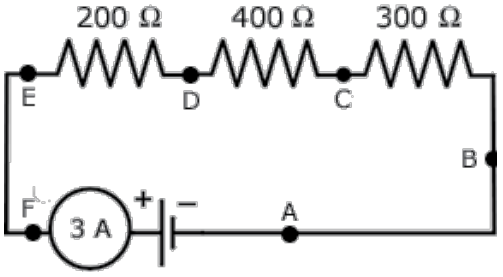
R.



S.



3. Angie builds a circuit with three resistors as shown below. She measures a current of 3 A at F. Draw the direction of flow of electrons (electron current). What would a voltmeter read if Angie connects it between



a) B and C? Explain your reasoning.

b) C and D? Explain your reasoning.

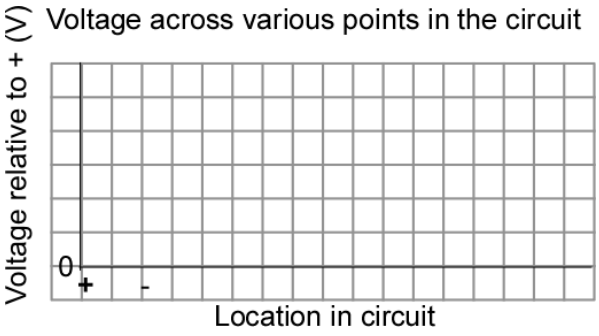
c) D and E? Explain your reasoning.

d) C and E? Explain your reasoning.

e) E and F? Explain your reasoning.

f) F and A? Explain your reasoning.

g) Draw a position-voltage graph.



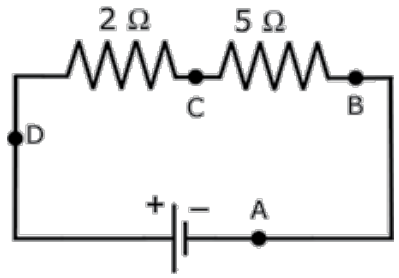
4. In circuits M and N,

a) Draw the direction of flow of electrons (electron current).

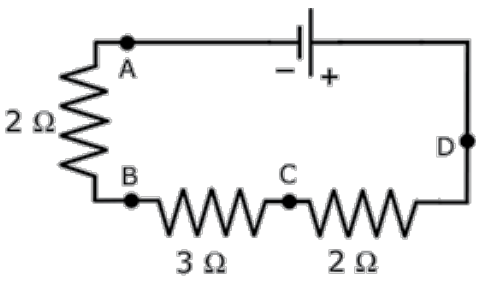
b) Within each circuit, compare the amount of current that flows at B, C, and D to the amount that flows at A. Explain your reasoning.

c) Calculate the voltage across the 5 Ω resistor in circuit M (battery voltage = 12 V).

M.



N.



Practice 1.9: Ohm's Law for Series Circuits Word Problems

1. Three identical Christmas bulbs are connected in series to a 12 V battery. If one bulb in the circuit has 3 A flowing through it.

   a) How much current flows through the other bulbs? Give a reason for your answer.

   b) Calculate the resistance of each bulb.

Diagram:

2. A current of 0.15 A flows in a series circuit with four identical Christmas bulbs, each of resistance 300 Ω. Calculate the voltage of the battery.

3. A series circuit has two bulbs connected to a 6 V battery. The first bulb has a resistance of 3 Ω, while the second has a resistance of 4 Ω.

   a) How much current flows in the circuit?

   b) Calculate the voltage across each of the resistors.

Diagram:

4. Sarah connects four resistors in series. Three are marked 100 Ω, 150 Ω, and 300 Ω. She does not know the resistance of the fourth resistor. She connects the series to a 110 V power source, and an ammeter in the circuit reads a current of 0.14 A. Calculate the resistance of the fourth resistor.

Diagram:

5. A series circuit has three bulbs of resistance 3, 8 and 9 Ω. When the bulbs are connected to a battery, a current of 3 A flows through the circuit.

a) Draw a diagram of the circuit. Would you expect the current through each of the bulbs to be different? Explain.

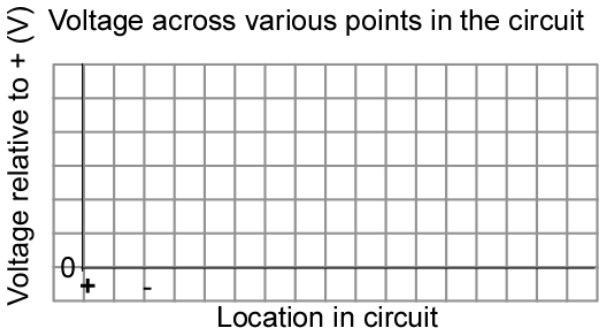
Diagram:

b) Calculate the voltage of the battery.

c) Would you expect the voltage across each of the bulbs to be different? Explain.

d) Calculate the voltage across each of the bulbs using Ohm's law.

e) Mark various positions on the graph as A, B, C .... and draw a voltage vs. position graph for this circuit



6. A series circuit has three bulbs of resistance 30, 55 and 90 Ω (when hot). When the bulbs are connected to a battery of voltage 6 V, a current flows through the circuit.

a) Calculate the total (or equivalent) resistance of the circuit.

Diagram:

b) Would you expect the current through each of the bulbs to be different? Explain.

c) Calculate the current through each bulb.

d) Use the picture of the <u>blank multimeter</u> to measure the current through the 55 Ω resistor.

e) Would you expect the voltage across each of the bulbs to be different? Explain.

f) Calculate the voltage across each of the bulbs using Ohm's law.

Additional Problems: (Note: See appendix for additional pictures of blank multimeters)

7. Two bulbs with resistances of 2 Ω and 3 Ω are connected in series across a 12 V battery.

   a) How much current does the 2 Ω bulb draw? How much current does the 3 Ω bulb draw? How much current is drawn from the battery?

   b) A third bulb of resistance 5 Ω is added in series to the circuit in (a). How much current is drawn by the three bulbs now? How much current does the battery have to supply?

8. A current of 6 A flows in a series circuit with four identical bulbs when it is connected to a 18 V battery. Calculate the total resistance in the circuit. Also calculate the resistance of each bulb.

9. Becky connects two bulbs in series and then hooks them up to a 20 V battery. The first bulb has a resistance of 6 Ω, while the second has a resistance of 3 Ω.

   a) How much current will Becky measure in the circuit?

   b) Figure out how much voltage is dropped across each of the resistors.

10. A series circuit has two bulbs of resistance 9 Ω and 4 Ω connected to a 8 V battery.

   a) Calculate the total resistance.

   b) Calculate how much current flows in the circuit.

   c) Draw a diagram of the circuit; use the picture of the blank multimeter and connect it appropriately to measure the current in the circuit.

   d) Calculate the voltage across each of the resistors.

   e) Use the picture of the blank multimeter to measure the voltage cross the 4 Ω resistor.

   f) Draw a voltage vs, position graph for this circuit.

11. A series circuit has three bulbs of resistance 4, 7 and 9 Ω (when hot). When the bulbs are connected to a battery, a current of 1.2 A flows through the circuit.

   a) Calculate the total (or equivalent) resistance of the circuit.

   b) Calculate the voltage of the battery.

   c) Would you expect the voltage across each of the bulbs to be different? Or not? Explain your reasoning.

   d) Calculate the voltage across each of the bulbs using Ohm's law.

   e) Use the picture of the blank multimeter to measure the voltage cross the 9 Ω resistor.

   f) Would you expect the current through each of the bulbs to be different? Explain.

12. A bulb with resistance 20 Ω can only have 0.1 A flowing through it (or it will blow). You only have a 6 V battery with which to light the bulb.

   a) If you connected the bulb to the battery, would it survive?

   b) If you had a choice of resistors that you could use in this circuit, design a circuit so that you could get the bulb to light (but not blow) using this battery. Be specific – draw the circuit, say what kind of circuit it is, and give the values of all the elements of the circuit.

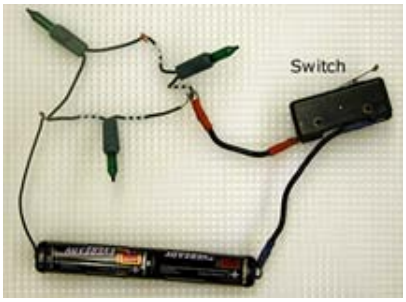
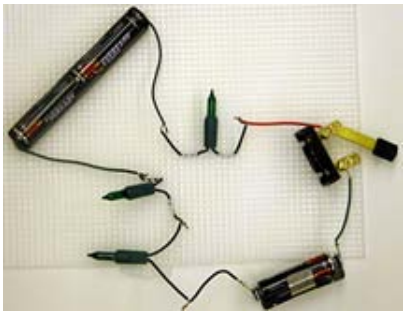
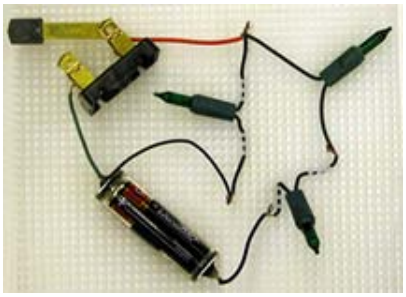
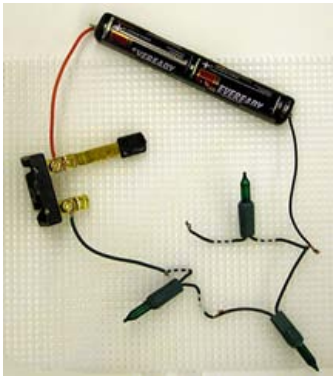
Practice 1.10: Designing Series and Parallel Circuits

In the following problems, all bulbs are similar, and the same battery is used. Test your circuits after you design them!

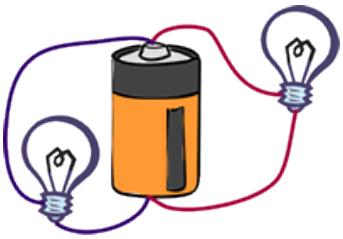
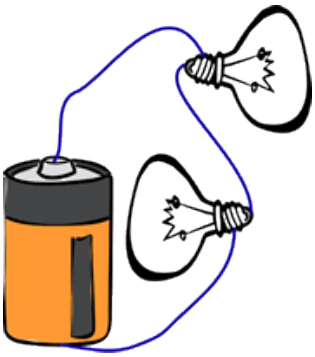
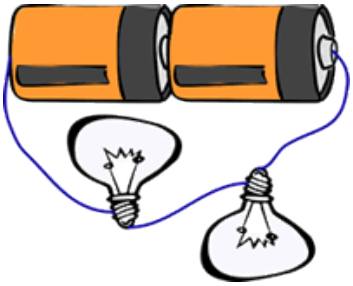
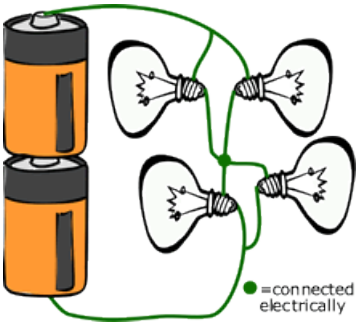
1. Design a circuit to have four bulbs, all very dim. Draw a circuit diagram. Explain why it has the features required.	2. Design a circuit to have four bulbs, all very bright. Draw a circuit diagram. Explain why it has the features required.
3. Design a circuit to have four bulbs, all medium bright. Draw a circuit diagram. Explain why it has the features required.	4. Design a circuit to have four bulbs, three of them dim and one of them very bright. Draw a circuit diagram. Explain why it has the features required.
5. Design a circuit to have four bulbs, two of them medium bright and two of them very bright. Draw a circuit diagram. Explain why it has the features required.	6. Make up your own design:

Practice 1.11: Recognizing Circuits

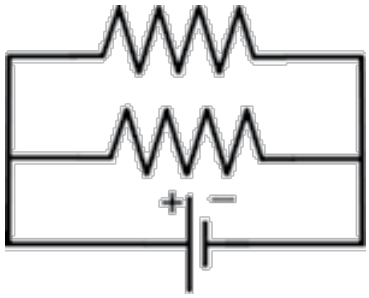
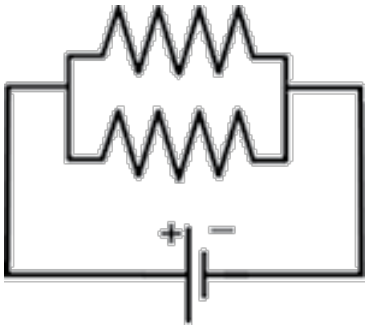
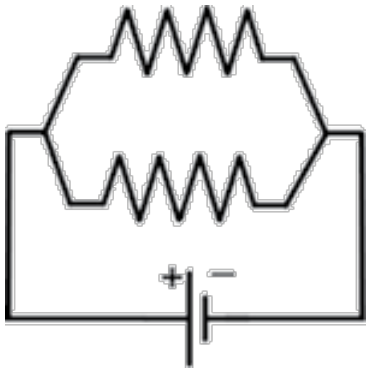
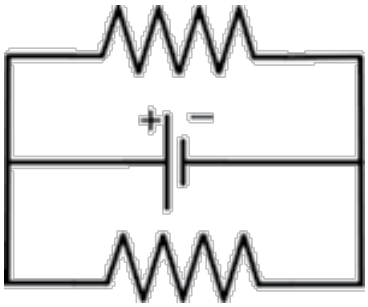
1. In the circuits below, all bulbs are similar.

Picture of circuit	**Draw a circuit diagram:**	**What is the brightness of the bulbs ...**
1A. 		When the switch is open? Explain When the switch is closed? Explain
1B. 		When the switch is open? Explain When the switch is closed? Explain
1C. 		When the switch is open? Explain When the switch is closed? Explain
1D. 		When the switch is open? Explain When the switch is closed? Explain

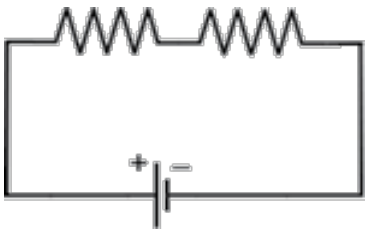
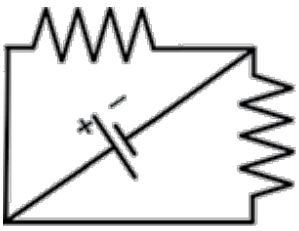
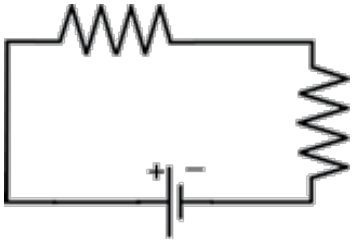
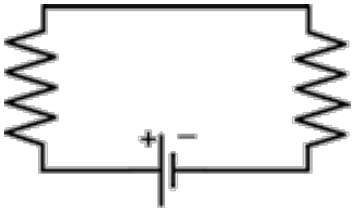
2. In the circuits below, all bulbs are similar.

	Describe the circuit in words:	**Draw a circuit diagram using symbols:**	**Compare the brightness of the bulbs within each circuit:**
2A. 			
2B. 			
2C. 			
2D. 			

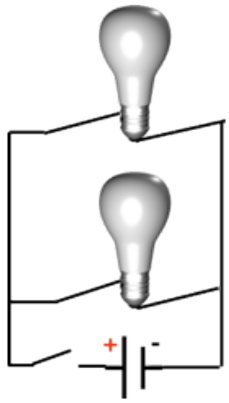
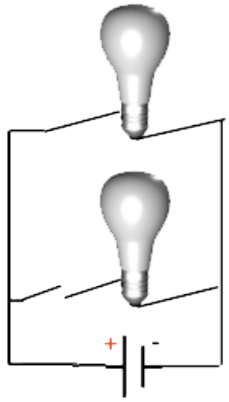
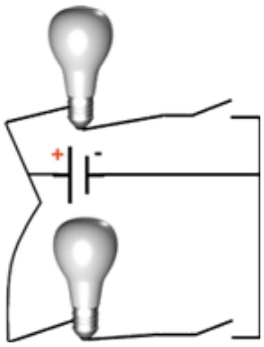
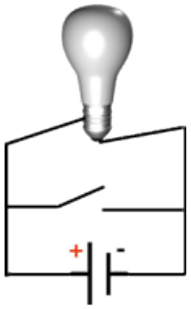
3. In the four circuits 3A – 3D, all batteries produce the same amount of voltage, and all bulbs are similar. Compare circuits B, C and D to circuit A, and describe your similarities and differences. Factors you could use for comparison may include, for example, voltage, bulb brightness, flow of current in the various branches, etc.

3A. 	3B. 
3C. 	3D. 

4. In the four circuits 4A-4D, all batteries produce the same amount of voltage, and all bulbs are similar. Which ones among the four circuits are similar and which one(s) are different? Explain.

4A. 	4B. 
4C. 	4D. 

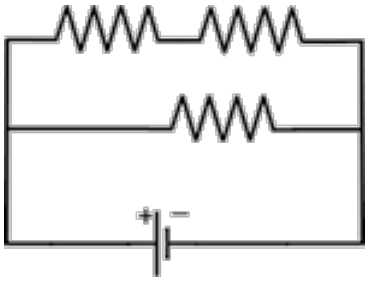
5. In the circuits below, all bulbs are similar. Explain the reasoning behind all your answers.

5A. What happens in this circuit When the switch is open? When the switch is closed?	
5B. What happens in this circuit When the switch is open? When the switch is closed?	
5C. Describe the different on/off possibilities in this circuit.	
5D. What happens in this circuit When the switch is open? When the switch is closed?	

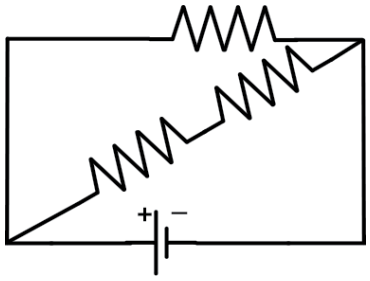
Additional Problems:

6. In circuits 6A-6E below, all batteries produce the same voltage, and all bulbs are similar. Which circuits are equivalent to each other? Explain your reasoning.

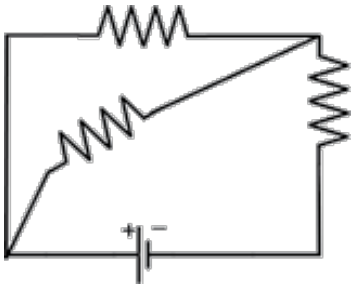
6A.



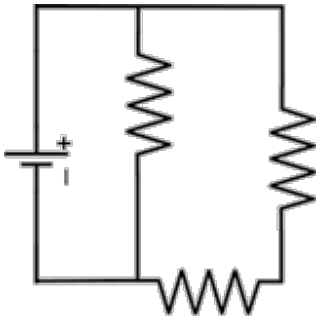
6B.



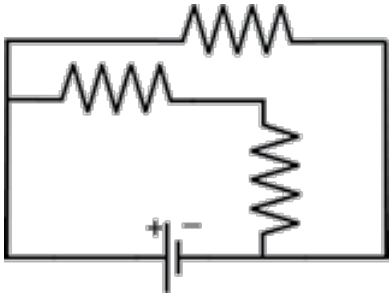
6C.



6D.



6E.



6F.

7. Draw a new circuit in box 6F above so that it is electrically similar to 6C. Explain.

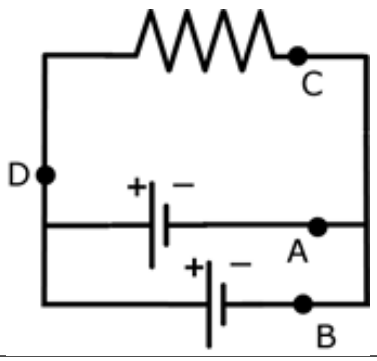
8. In circuits P and Q below, all batteries produce the same amount of voltage and all resistors have the same value.

a) Draw the direction of flow of electrons (electron current) in both circuits.

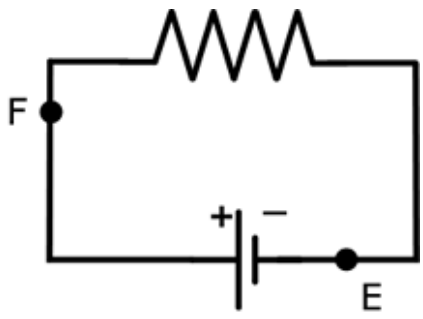
b) Compare the amount of current that flows at A in circuit P to the current at B, C, and D. Explain your reasoning.

c) Compare the amount of current that flows at E and F in circuit Q to the current at A in circuit P. Explain your reasoning.

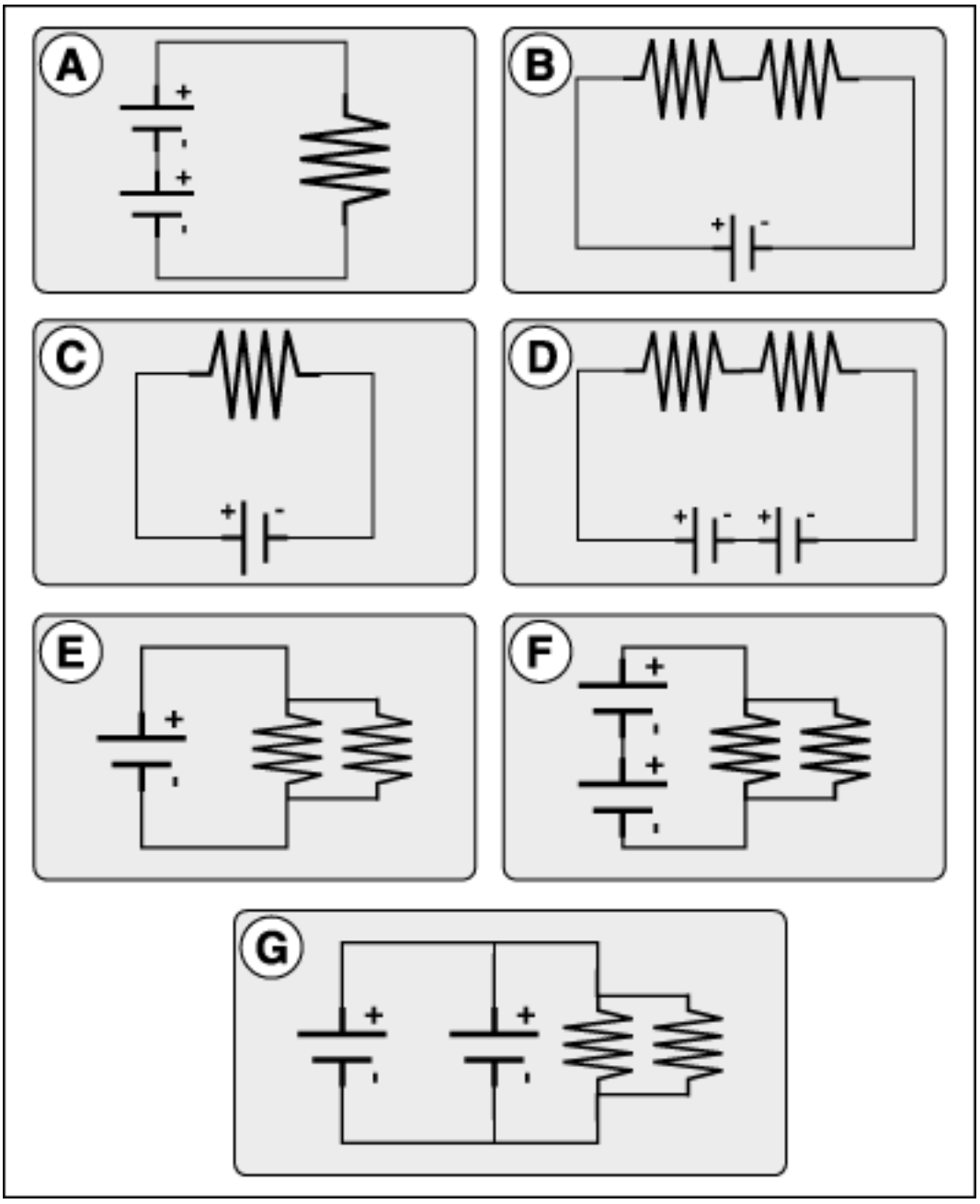
P.



Q.



9. A flashlight manufacturer wants to design a flashlight for use in emergency kits. The flashlight should last as long as possible. His engineers come up with the designs shown below. Compare the currents they will draw from each battery and order them in sequence from the one that exhausts the batteries first (the hungriest circuit) to the one that makes the batteries last the longest (the least hungry circuit).
Present data or arguments to support your answers.



The most hungry: ____ ____ ____ ____ ____ ____ ____ The least hungry

10. In circuits M, N and P below, all batteries produce the same voltage, and all resistors have the same value of resistance. (Hint: use numerical values to help you answer the questions).

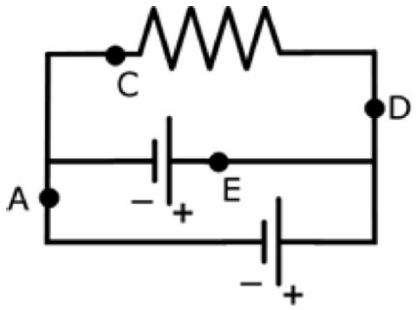
a) Draw the direction of flow of electrons in each circuit (electron current).

b) In circuit M suppose that the current at C is 6 A. Compare the current at point A, D and E to the current at C. Explain your reasoning.

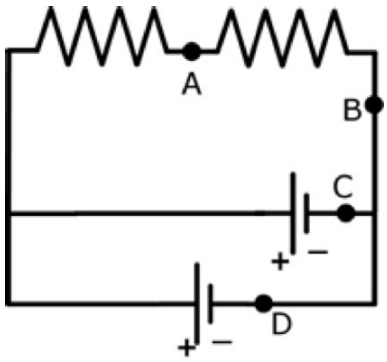
c) In circuit N, what would the current be at A? Then compare the current at B, C and D to the current at A. Explain your reasoning.

d) In circuit P what would the current be at A? Then compare the current at A, B and D to the current at C. Explain your reasoning.

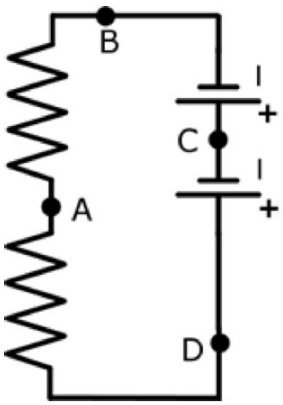
M.



N.



P.



Practice 1.12: Parallel Circuit Problems

1. Kara connects two bulbs with resistances of 20 Ω and 30 Ω in parallel across a 120 V wall outlet.

Diagram:

a) Draw a diagram in the box on the right.

b) How much current does the 20 Ω bulb draw? How much current does the 30 Ω bulb draw?

c) How much current is drawn from the outlet?

d) A third bulb of resistance 50 Ω is added in parallel to the circuit. How much current is drawn by this bulb?

e) How much current does the outlet have to supply now?

f) If the circuit with the three resistors has a 15 A fuse, will the fuse blow?

2. A parallel circuit has two bulbs of resistance 4 and 10 Ω (when hot). When the bulbs are connected to a battery, a current of 1.5 A flows through the 10 Ω resistor.

Diagram:

a) Draw a diagram in the box on the right.

b) Would you expect the voltage across each of the bulbs to be different? Or not? Explain your reasoning.

c) What is the voltage of the battery?

d) What is the voltage across each of the bulbs?

e) Calculate the current through the 4 Ω bulb.

f) If the circuit is connected to a 4 A fuse, will the fuse blow?

3. Two light bulbs in a floor lamp are connected in parallel. Each has a resistance of 200 Ω.

a) Draw a diagram.

Diagram:

b) If the two bulbs are connected to a household 110 V line, how much current would each bulb draw? How much current would both (together) draw?

c) If the two bulbs were connected to a 220 V line, how much total current would each draw now? Both together?

4. A parallel circuit has three resistors of 450, 724 and 916 Ω. When the resistors are connected to a battery, a current of 0.012 A flows through the 450 Ω resistor.

a) Calculate the voltage across the 450 Ω resistor.

b) What is the voltage of the battery?

c) Would you expect the voltage across each of the resistors to be different? Or not? Explain.

d) What is the voltage across each of the resistors?

e) Would you expect the current through each of the resistors to be different? Explain your reasoning.

f) Calculate the currents through the 724 and 916 Ω resistors.

g) Use the picture of a blank multimeter to draw how you would measure the voltage difference across the 916 Ω resistor.

Additional Problems: (Note: See appendix for additional pictures of blank multimeters)

5. An electric iron has a resistance of 15 Ω, and a microwave has a resistance of 12 Ω. If both of them were plugged into the same 110 V circuit and turned on at the same time, calculate the total current drawn.

6. An electric radio draws a current of 1.8 A, and a toaster oven has a resistance of 12 Ω. If both of them were plugged into the same 110 V circuit and turned on at the same time, calculate the total current drawn.

7. The fuse on my kitchen line is rated at 15 A. What would happen if I turned on my iron, which draws 5 A, at the same time that my sister turned on a microwave that draws 8 A? Explain your reasoning.

8. The fuse on my bedroom line is rated at 10 A. What would happen if I turn on my curling iron, which draws 5 A, at the same time that my brother irons a shirt with an iron that draws 7 A?

9. A parallel circuit has three bulbs of resistance 4, 6 and 12 Ω (when hot). When the bulbs are connected to a battery, a current of 0.7 A flows through the 4 Ω resistor.

a) Would you expect the voltage across each of the bulbs to be different? Or not? Explain.

b) Calculate the voltage difference across the 4 Ω resistor

c) What is the voltage of the battery?

d) What is the voltage across each of the bulbs?

e) Would you expect the current through each of the bulbs to be different? Explain your reasoning.

f) Calculate the currents through the 6 and 12 Ω bulbs.

g) Use the picture of a blank multimeter to draw how you would measure the current through the 6 Ω bulb.

10. Two light bulbs are connected in parallel. Each has a resistance of 260 Ω.

a) If Sashi connects the resistors to a 110 V line, calculate how much current would both of them together draw. How much does each one draw?

b) If Hakim connects the two resistors to a 220 V line instead, calculate how much current each would draw now.

11. Four resistors with resistances of 125, 52, 24 and 87 Ω are connected in parallel.

a) Haibo finds a 16 V battery, and connects the four resistors in parallel across the battery. How much current does the 24 Ω bulb draw? How much current does the 87 Ω bulb draw? How much current is drawn from the battery?

b) Show how you would measure the battery current (use the picture of a blank multimeter).

Calculating Equivalent Resistance:

12. You work in an electrical store that is running low on resistors. You know that customers will ask for different resistors. Suppose all you had is one resistor each of resistance 2, 3 and 4 Ω.

a) Connecting them in series, what different combinations of resistors can you make up? Calculate your values. (You can use less than three resistors).

b) What different combinations of resistors can you make up by connecting them in parallel?

13. Dana finds a box with four resistors: 120 Ω, 200 Ω, 180 Ω and 80 Ω.

a) By combining them, what is the largest resistance she can make? Calculate its value. Draw a picture of how she had to connect them.

b) What is the smallest resistance she can obtain? Draw a picture.

14. Robby is working on his science olympiad project and needs two resistors, of resistance 10 Ω and 160 Ω. All he can find in his mom's basement, though, is a box of 20 Ω resistors. Help him hook resistors up to obtain the values he needs. Draw diagrams of how they must be connected.

15. Yoshi finds four resistors with resistances of 3 Ω, 5 Ω, 6 Ω and 2 Ω and connects them in parallel. Calculate the total resistance of the circuit. If he connects them to a 6 V battery, how much current must the battery supply?

Practice 1.13: Power and Energy Problems

Conversions: 1 watt = 1 joule /sec 1 kilowatt-hour = (1000 watts) x 1 hour

1. A hair dryer draws a current of 10 A when connected to a 110 V line. How many watts of power does it consume?

2. A light bulb in a desk lamp uses 60 W of electrical power when connected to a 110 V line. How much current does it draw?

3. A Christmas light bulb draws 0.5 A of current with a voltage of 4 V across it. How much power does the bulb consume?

4. When 25 Christmas bulbs are connected in a series string, each with 4 V across it and 0.5 A flowing through it, how much power would the string consume?

5. A traveler buys a 60 W light bulb in Germany, where the household lines operate at a voltage of 220 V. If she uses the bulb in the US, where the line voltage is 110 V, how much power will the bulb consume? How does this compare with the bulb's power consumption in Germany?

6. A 60 W bulb runs on a line voltage of 110 V.

   a) Calculate its resistance.

   b) Optional: take an ordinary 60 W bulb and measure its resistance using a multimeter. What did you measure? Was it different from what you calculated? Why do you think it was different?

7. A bulb consumes a power of 75 W when it carries a current of 1.5 A. Calculate its resistance.

8. A small night-light that consumes 4 W of power operates 8 hours a day.

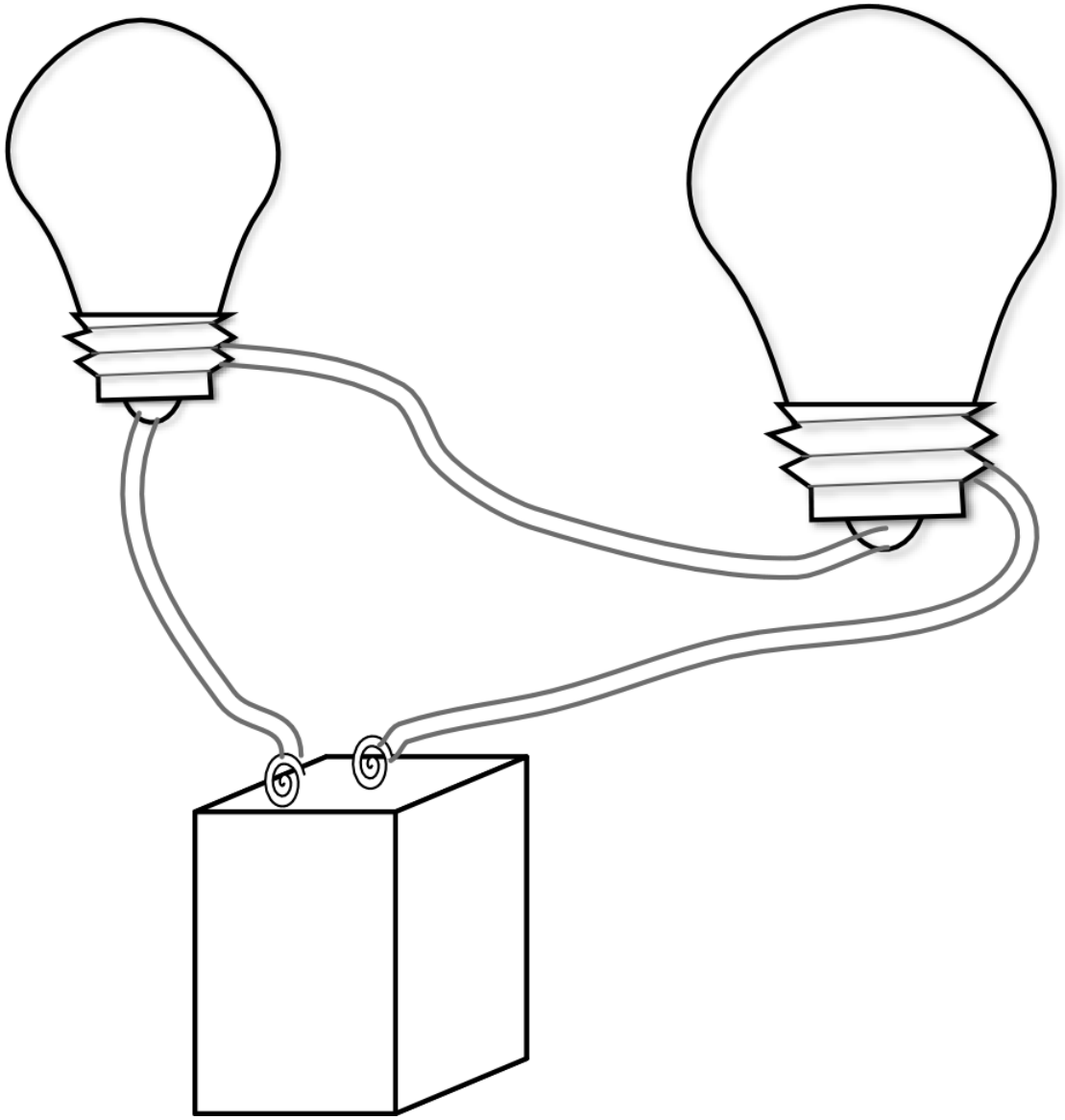
   a) How much energy does it consume in joules (per day)?

   b) In kilowatt-hours (per day)?

   c) How much energy does it consume in kilowatt-hours in a year (365 days)?

9. My microwave has a power rating of 700 W. I use it for about 45 minutes every day. I have four lights in my kitchen, each of which has a 75 W bulb. I have them turned on for five hours every day. Compare the energy in kilowatt-hours used by the microwave and the lights. If I wanted to reduce my electricity bill, where do you think I should try to save energy -- the lights or the microwave?

10. In the picture below, a section of the filament of the large bulb has become skinnier from use. Draw in details of all parts of the devices in the circuit, focusing on ideas that have to do with power. You may use cartoon-like balloons, if you wish.



Additional Problems:

11. A small night-light that consumes 4 W of power operates all day for a year. What is its energy consumption in kilowatt-hours? If energy costs 11 cents /KWH, how much does it cost annually to pay for the night light?

12. A flashlight uses 2 AA batteries in series, each rated at 1.5 V each. If the flashlight bulb draws 400 milliamps (mA) of current, how much power does it use?

13. A Christmas bulb has a resistance of 2 Ω. If it has a voltage of 6 V across it, how much power does it consume?

14. A stove is rated at a power of 800 W and has a resistance of 60 Ω. How much current does it draw?