Station 1 *Windmill*

Directions:

1) Students will work together as a team.

2) If your teacher has not assigned roles, decide who on your team will be the:

   a. ***Reader***--This person will read the rest of the directions for Station 1.

   b. ***Windmill Operator***--This person will provide the wind to turn the windmill blades.

   c. ***Multimeter Operator***--This person will read electric current measurements using the multimeter.

   d. ***Multimeter Operator Assistant***--This person will assist the *Multimeter Operator* and verify electric current measurements read by the *Multimeter Operator*.

   e. ***Facilitator***--This person will help make sure each person on the team is working together, doing their job, and keep track of time to complete the Station 1 activity. (If fewer than 5 are on your team, the *Reader* should be the *Facilitator* too.)

3) Observe the system. Do not change anything in the system unless your teacher tells you to do so.

4) Each member of your team should draw a picture of the system and label the important parts of the system. Your teacher may ask you to do this in your science notebook or on a separate handout. Include the following words as labels in your picture:

   cup, wire, alligator clip, axle shaft, generator, multimeter, windmill blade, multimeter lead

5) The multimeter in this system is set to detect and measure electric current in units called milliAmperes (mA). Do not change the setting on the multimeter. The ***Multimeter Operator*** and ***Assistant*** should make sure the multimeter turn-switch is set at the 0.5 mA or 50 mA setting. The 50 mA setting is less sensitive than the 0.5 mA setting.

   Make electric current readings or measurements using the correct scale on the multimeter. The appropriate scale to use is the middle, black-colored scale, with major intervals marked 0, 10, 20, 30, 40, and 50 mA. If the multimeter is set at 0.5 mA, use the same scale, but remember the values of the major intervals are now 0, 0.1, 0.2, 0.3, 0.4, and 0.5 mA.

6) Have the ***Windmill Operator*** simulate wind by blowing into the windmill blades. Gently adjust the windmill system to allow the blades to turn, if necessary.

7) As the ***Windmill Operator*** blows into the windmill blades (the blades should be turning), the ***Multimeter Operator*** and ***Assistant*** should measure the electric current generated. Everyone on the team should record this data.

   If there is time your teacher may ask you to make 3 measurements and find the average.

   Your team may also need to switch between the 0.5 mA and 50 mA settings on the multimeter, depending on how much electric current is generated in your windmill system. See which setting is best to allow your team to measure the electric current generated in your system. Don't forget that the value of the intervals will change on your scale when you change between the 0.5 mA and 50 mA settings on the multimeter. (Review the information in Step 5, if necessary.)

8) Answer all questions on the handout and other questions your teacher may assign. Be sure to explain your answers.

9) Listen for directions from your teacher to move to the next station. <u>Do not take any of the station materials with you when it is time to move</u>. Make sure all materials can be found at the station for the next team.

Station 2 *Solar Cell*

Directions:

1) Students will work together as a team.

2) If your teacher has not assigned roles, decide who on your team will be the:

   a. ***Reader***--This person will read the rest of the directions for Station 2.

   b. ***Solar Cell Operator***--This person will direct the solar cell at a light source.

   c. ***Multimeter Operator***--This person will read electric current measurements using the multimeter.

   d. ***Multimeter Operator Assistant***--This person will assist the *Multimeter Operator* and verify electric current measurements read by the *Multimeter Operator*.

   e. ***Facilitator***--This person will help make sure each person on the team is working together, doing their job, and keep track of time to complete the Station 2 activity. (If fewer than 5 are on your team, the *Reader* should be the *Facilitator* too.)

3) Observe the system. Do not change anything in the system unless your teacher tells you to do so.

4) Each member of your team should draw a picture of the system and label the important parts of the system. Your teacher may ask you to do this in your science notebook or on a separate handout. Include the following words as labels in your picture:

   wire, alligator clip, solar cell, multimeter, light source, multimeter lead

5) The multimeter in this system is set to detect and measure electric current in units called milliAmperes (mA). Do not change the setting on the multimeter. The ***Multimeter Operator*** and ***Assistant*** should make sure the multimeter turn-switch is set at the 0.5 mA or 50 mA setting. The 50 mA setting is less sensitive than the 0.5 mA setting.

   Make electric current readings or measurements using the correct scale on the multimeter. The appropriate scale to use is the middle, black-colored scale, with major intervals marked 0, 10, 20, 30, 40, and 50 mA. If the multimeter is set at 0.5 mA, use the same scale, but remember the values of the major intervals are now 0, 0.1, 0.2, 0.3, 0.4, and 0.5 mA.

6) Have the ***Solar Cell Operator*** direct and hold the solar cell toward a light source and observe the multimeter for any evidence of an electric current being generated. Light sources such as overhead lighting in the classroom or sunlight from a window may be used.

   This station should have a 25 or 40 watt light bulb plugged into a power strip. Use the lighted light bulb as your team's light source for the remainder of this investigation. Use the switch on the power strip to turn the light bulb on and off.

   CAUTION: The light bulb can be hot!

   Have the ***Solar Cell Operator*** move the solar cell <u>slowly</u> towards the light bulb and then pull back <u>slowly</u> away from the light bulb. Observe the multimeter for any evidence of an electric current being generated.

   What did your team discover as the solar cell is moved closer to and farther away from the light bulb?

7) Now have the ***Solar Cell Operator*** hold the solar cell 10 centimeters (cm) from the light bulb. The ***Multimeter Operator*** and ***Assistant*** should measure any electric current generated. Everyone on the team should record this data.

   If there is time, your teacher may ask you to take 2 other measurements at 20 cm and 30 cm from the light bulb.

   Your team may also need to switch between the 0.5 mA and 50 mA settings on the multimeter, depending on how much electric current is generated in your solar cell system. See which setting is best to allow your team to measure the electric current generated in your system. Don't forget that the value of the intervals will change on your scale when you change between the 0.5 mA and 50 mA settings on the multimeter. (Review the information in Step 5, if necessary.)

8) Answer all questions on the handout and other questions your teacher may assign. Be sure to explain your answers.

9) Listen for directions from your teacher to move to the next station. <u>Do not take any of the station materials with you when it is time to move</u>. Make sure all materials can be found at the station for the next team.

Station 3 *Battery and Bulb*

Directions:

1) Students will work together as a team.

2) If your teacher has not assigned roles, decide who on your team will be the:

   a. ***Reader***--This person will read the rest of the directions for Station 3.

   b. ***System Engineer #1*** --This person will design a way to use 2 wires and a battery to light the small light bulb.

   c. ***System Engineer #2***-- This person will design a way to use 2 wires and a battery to light the small light bulb, in a way that's different from Engineer #1's design.

   d. ***System Engineer #3***--This person will design a way to use only 1 wire and a battery to light the small light bulb.

   e. ***Facilitator***--This person will help make sure each person on the team is working together, doing their job, and keep track of time to complete the Station 3 activity. (If fewer than 5 are on your team, the *Reader* should be the *Facilitator* too.)

3) Observe the materials that your team has to make your battery and bulb system. You should have:

   2 wires
   1 "D" size battery
   1 small light bulb

4) Have each ***System Engineer*** on your team design a way that will successfully light the small light bulb. Each ***System Engineer*** should first draw a design (picture) before trying to build the battery and bulb system. ***System Engineers*** will take turns building their systems after they have finished their design (picture). Don't forget that each ***System Engineer*** has different design requirements. If you forget, refer to Step 2 above.

5) Each member of the team should draw a picture of each different system that was successful in lighting the small light bulb. Label the important parts of each successful system. Your teacher may ask you to do this in your science notebook or on a separate handout. Include the following words as labels in your pictures: **wire, bulb, battery**

6) Answer all questions on the handout and other questions your teacher may assign. Be sure to explain your answers.

7) Listen for directions from your teacher to move to the next station. Do not take any of the station materials with you when it is time to move. Make sure all materials can be found at the station for the next team.

Station 4 *Copper Coil and Magnet*

Directions:

1) Students will work together as a team.

2) If your teacher has not assigned roles, decide who on your team will be the:

   a. ***Reader***--This person will read the rest of the directions for Station 4.

   b. ***Magnet Operator***--This person will operate the magnet.

   c. ***Multimeter Operator***--This person will read electric current measurements using the multimeter.

   d. ***Multimeter Operator Assistant***--This person will assist the *Multimeter Operator* and verify electric current measurements read by the *Multimeter Operator*.

   e. ***Facilitator***--This person will help make sure each person on the team is working together, doing their job, and keep track of time to complete the Station 4 activity. (If fewer than 5 are on your team, the *Reader* should be the *Facilitator* too.)

3) Observe the system. Do not change anything in the system unless your teacher tells you to do so.

4) Each member of your team should draw a picture of the system and label the important parts of the system. Your teacher may ask you to do this in your science notebook or on a separate handout. Include the following words as labels in your picture:

   magnet, pencil, alligator clip, copper coil, multimeter, multimeter lead

5) The multimeter in this system is set to detect and measure electric current in units called milliAmperes (mA). Do not change the setting on the multimeter. The ***Multimeter Operator*** and ***Assistant*** should make sure the multimeter turn-switch is set at the 0.5 mA setting. The 0.5 mA setting is the most sensitive setting and is required for this investigation.

6) Find the magnet that is attached to the end of a pencil. Please do not remove the magnet from the pencil.

   Holding the pencil, the ***Magnet Operator*** should slowly move the magnet near the copper coil.

   Explore how the magnet must interact with the copper coil to generate an electric current.

7) As the ***Magnet Operator*** slowly moves the magnet in various ways to interact with the copper coil, the ***Multimeter Operator*** and ***Multimeter Assistant*** should look for evidence that an electric current may be generated.

   Again, work together to discover what interaction(s) between the magnet and copper coil will generate an electric current.

   What interaction(s) between the magnet and copper coil produces an electric current?

   What evidence do you have that an electric current might be generated during an interaction between the magnet and copper coil?

8) Answer all questions on the handout and other questions your teacher may assign. Be sure to explain your answers.

9) Listen for directions from your teacher to move to the next station. Do not take any of the station materials with you when it is time to move. Make sure all materials can be found at the station for the next team.

Station 5 *Coil and Magnet (EM Java Applet)*

Directions:

1) Students will work together as a team.

2) If your teacher has not assigned roles, decide who on your team will be the:

   a. ***Reader***--This person will read the rest of the directions for Station 5.

   b. ***Loop Operator***--This person will test whether changing the number of loops in the coil will have an effect on the electric current generated.

   c. ***Magnet Operator***--This person will test whether changing the strength of the magnet will have an effect on the electric current generated.

   d. ***Loop Area Operator***--This person will test whether changing the area of the loops in the coil will have an effect on the electric current generated.

   e. ***Facilitator***--This person will help make sure each person on the team is working together, doing their job, and keep track of time to complete the Station 5 activity. (If fewer than 5 are on your team, the *Reader* should be the *Facilitator* too.)

3) Make sure the *Pick up Coil* tab (near the top left part of the computer screen) is selected (highlighted in blue). Observe the system on the computer screen. Draw a picture of the system and label the important parts of the system. Your teacher may ask you to do this in your science notebook or on a separate handout. Include the following words as labels in your picture: **copper coil, bar magnet, electrons, light bulb**

4) Each ***Operator*** on your team should take turns changing the variables assigned to him/her. Changing the *number of loops*, *strength of magnet*, and *area of loops* can be done using the control panels on the right side of the computer screen. Discover the following as a team:

   a. What happens to the electric current when the number of loops increases? What happens when the number of loops decreases?
   b. What happens to the electric current when the strength of the magnet is increased? What happens when it is decreased?
   c. What happens when the area of the loops is increased? What happens when the area is decreased?
   d. What are the electrons doing in the wire loops when an electric current is produced?

5) Answer all questions on the handout and other questions your teacher may assign. Be sure to explain your answers.

6) Listen for directions from your teacher to move to the next station. Do not take any of the station materials with you when it is time to move. Before leaving this station, make sure the *Pick up Coil* tab is selected and reset all controls to their initial settings. To do this, click the *Reset All* button near the bottom right of the screen. Select *"yes"* to confirm the resetting.