Name(s):_____

Maximum Power Point (Student Handout)

(The Principles of Optimizing Photovoltaic Cell Power Output)

Part 1: Investigating How a Photovoltaic (PV) System Works

Take a look at the animation of a PV system with your partner(s) at:
http://www.greenspec.co.uk/html/design/materials/pvcells.html
Work all the way through and answer the questions below together when you are finished.

Part 1

1. What are the major parts of the photovoltaic system? (Also include the job of each part you list).

2. What does the energy output of a solar (PV) cell depend upon?

   _____

   _____

   _____

3. Experiment with the "Energy Output" segment of the animation? Which direction and tilt combinations produce the highest output for the PV cell?

   _____

   _____

4. Why is it important to find out the highest power output for a PV cell?

   _____

   _____

Part 2 (Experimenting with a Photovoltaic Cell: How Can We Obtain Maximum Power?)
In this part of the activity you will be measuring the voltage and current produced by a photovoltaic cell under various conditions. While conducting these experiments, think about which conditions help the cell produce the most power! (Power=Current x Voltage)

STEP 1: Set up your model PV system:

1) Lay the solar panel on a clean surface, silicon side down. Wire the panel to the multimeter as shown in Figure 1 below.

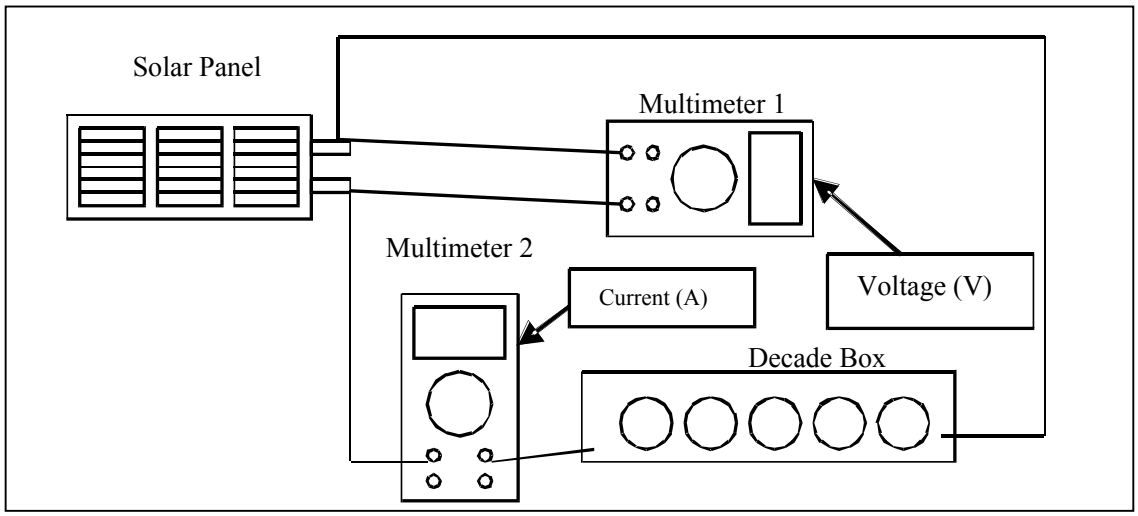
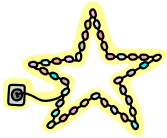


Figure 1. Diagram of a PV panel wired in series with a multimeter.

a) Clip one end of a wire with alligator clips to one of the metal tabs on the back of the solar panel. Connect the other end of the wire to the red lead of the multimeter and to one arm of a 100 ohm (_) resistor at the same time. Take a second wire with alligator clips and clip one end to the second arm of the same resistor and to the black lead of the multimeter. Attach the other clip to the second metal arm on the solar panel.



Great job! Take a look at the following question and get ready to collect some data!

What purpose do you think the resistor serves?

_____

_____

b) Turn the solar panel over and turn on the multimeter. (To get a proper reading you should be using the 200mA DC setting for current and the 20V DC setting for voltage). Measure the current (I). What is it?

_____

c) Measure the voltage (V). What is it?_____

STEP 2: Find out how the "tilt" (angle) and direction of a PV panel affect its power output:

1. Obtain a gnomon stand from you teacher and use the compass to face it towards the sun. Use a compass to find the direction in which you are facing and list that in Table 1.

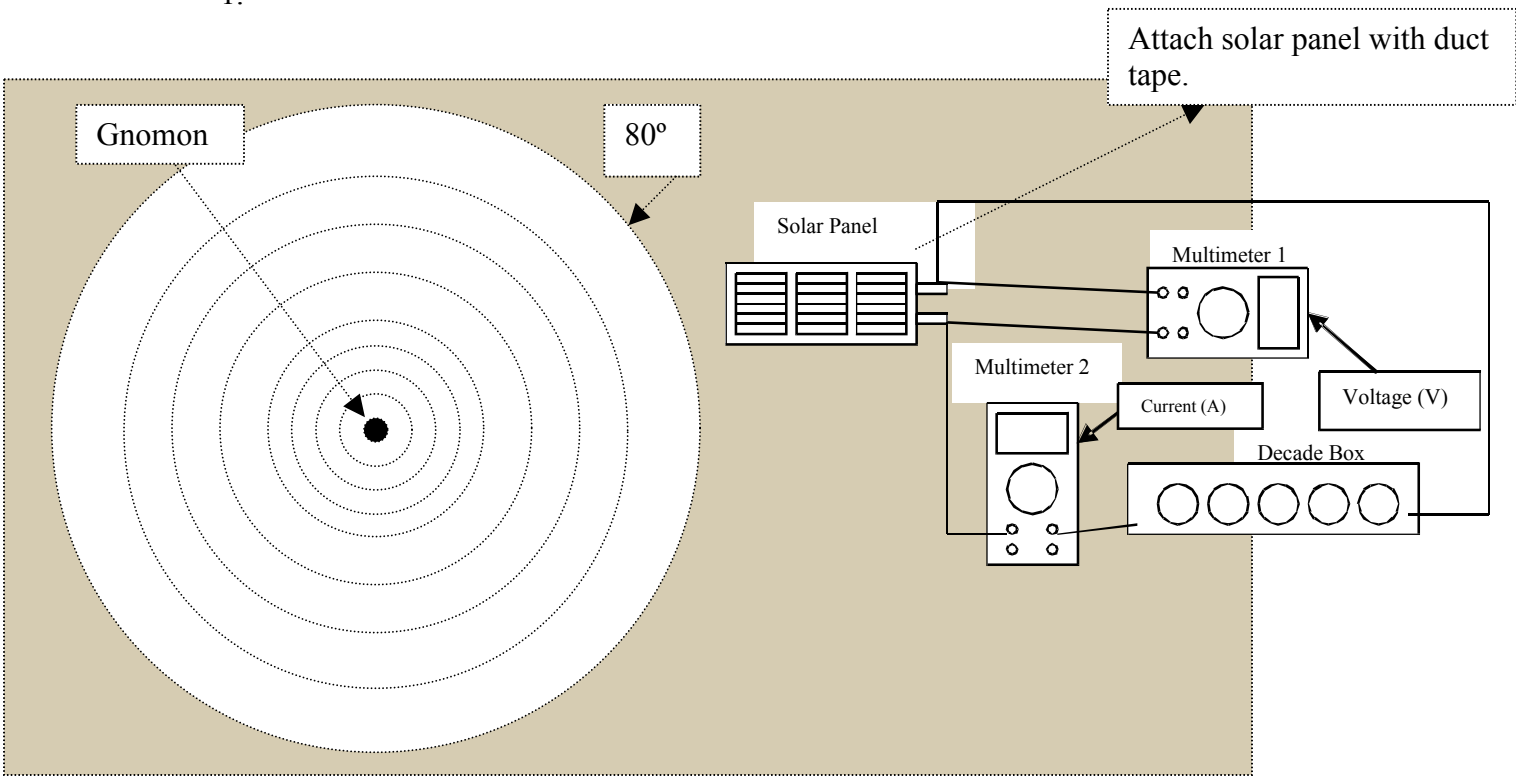


Figure 2. Gnomon Stand with Solar Panel Attached.

a) Tilt the gnomon stand so that the tip of the gnomon's shadow falls upon the circle for each angle and measure the current and voltage. Record your data in Table 1 and calculate the power output of the cell for each angle.

Table 1.

Direction (N, S, E, W)		**Resistance**	
Angle of Incidence (in degrees)	**Current (amps)**	**Voltage (V)**	**Power (watts)**
10			
20			
30			
40			
50			
60			
70			
80			

b) At what angle and direction does the cell produce the most power? Why do you think this is so?

_____

_____

c) Do you think that conducting this experiment at a different time during the day would affect your results? If so, why?

_____

_____

d) How do you think that conducting this experiment during the different seasons would affect your results?

_____

_____

e) Before you move on to the next part, try wiring your group's resistor in series and measure the current (mA) and voltage (V) for several different angles. Calculate the power in watts and record your data in the table below. This will be shared with your class later.

Table 2.

We used a ____ (_) resistor in our trial	Angle Of Incidence (degrees)	Voltage (V) "volts"	Current (A) "amperes"	Power (W) "watts"

f) **STEP 2:** Based upon your observations and evidence, what are the **best conditions** for gaining the most power from a PV cell?

g) What are some of the **limits** of using PV panels to make electricity?

h) What are some **obstacles** to using PV panels to do work like powering automobiles?

Part 3 (Graphing and Analyzing Your Class's PV Panel Data)*
**Adapted from Solar Kit Lesson #11, "Power Maximum: An Electrical Determination" of School Power Naturally's Solar Education for NY.*

In this section, you will use the data that you gathered to create 2 graphs. The graphs will be your tools to find the "Maximum Power Point" (MPP) for your PV panel!

1) Remember Ohm's law as you are working through this section:

Ohm's law: Voltage (V) = Resistance (Ω) x Current (A)

2) Plot current versus voltage to obtain the panel's **I-V curve**. Plot current (A) on the *y*-axis and voltage (V) on the *x*-axis. Label and show the scale of each axis.

Remember that electric power is measured in watts (W) where:

Power (W) = Voltage (V) x Current (A)

3) Calculate the output power for each resistance value and enter the values in Table 1.

4) Plot power versus voltage to obtain the panel's **power curve**. Plot power (W) on the *y*-axis and voltage (V) on the *x*-axis. Label and show the scale of each axis.

5) From the power-voltage graph, what is the value of maximum power and what is the voltage at maximum power?

6) From both graphs, what is the current at maximum power? (From the maximum power point on the power curve, trace upward parallel to the *y*-axis until you intersect the I-V curve. Trace left parallel to the *x*-axis until you reach the *y*-axis.)