Measuring Magnetic Forces in a Circuit

A REEL Power [tm] (Renewable Energy Education Lab) Lesson

LESSON OVERVIEW

This lesson demonstrates how to measure the magnetic forces generated by the voltage and current flowing through a circuit composed of a solar panel and two different resistor values.

LEARNING OUTCOME

Students learn that electricity (voltage and current) creates a magnetic force as it flows through a circuit. The power source for the circuit can be a solar panel, wind turbine, fuel cell or battery. A magnetic compass is used to observe the magnetic force under several circuit configurations.

Students come to understand that:

1. The deflection of a magnetic compass needle is directly proportional to the voltage and current flowing though the circuit.

2. Magnetism and current flow are part of the same force that makes up electricity.

STUDENT ACTIVITIES

Students setup the equipment to measure the magnetic force created by an electrical current flowing through a circuit using a conventional magnetic compass. They modify the setup to change resistor values in the circuit to create different conditions for magnetic measurement.

During the course of the lesson, students measure and record voltage, current, resistance, power and energy with the ***Smart Meter – Data Logger [tm].*** Students are also charged with displaying the recorded data on the classroom computer and explaining the differences in readings. This is followed by printing out plots

of the data on a printer or downloading data files gathered on the computer to be included in reports about the lesson.

GRADE-LEVEL APPROPRIATENESS

This lesson is appropriate as an introduction to solar and magnetic energy data interpretation for students in grades 5-8.

LESSON TIME

This lesson should take between 30 minutes to 45 minutes depending on discussion time about the experiment.

SAFETY

No particular safety issues are deemed present in this lesson; however, particular attention to the setup and execution of the lesson is always prudent in order to avoid unintentional mistakes and the resultant possible harm to those involved.

REQUIRED MATERIALS

Qty	Description
1	Solar Panel
1	***Smart Meter – Data Logger*** ***tm***
1	USB cable
6	Clip leads
1	Magnetic compass
1	10 ohm resistor
1	Classroom Windows PC computer with **REEL Power** **tm** software (MACs must have Parallel's "Desktop 3.0 for Windows")
1	Printer (optional)

PRELIMINARY STEPS

1. Install the graphical software on the classroom computer.
2. Install a fresh 9-volt battery in the ***Smart Meter – Data Logger*** ***tm***
3. Refer to the ***Smart Meter – Data Logger*** ***tm*** **Tutorial** for extra help.

EQUIPMENT SETUP

1. Setup the equipment as shown in Figure 1 below. Wire the opposite side of the solar panel so that all three modules are in parallel in order to produce maximum current. You can use clip leads or the wires with looped ends to hookup the modules as shown in Figure 1. Then attach a clip lead from the left-most negative (-) post to the Black Input terminal on the ***Smart Meter – Data Logger*** *tm* and another clip lead from the left-most positive (+) post to the Red Input terminal on the ***Smart Meter – Data Logger*** *tm*.

2. Also add a 10 ohm resistor to the Output terminals – the polarity doesn't matter.

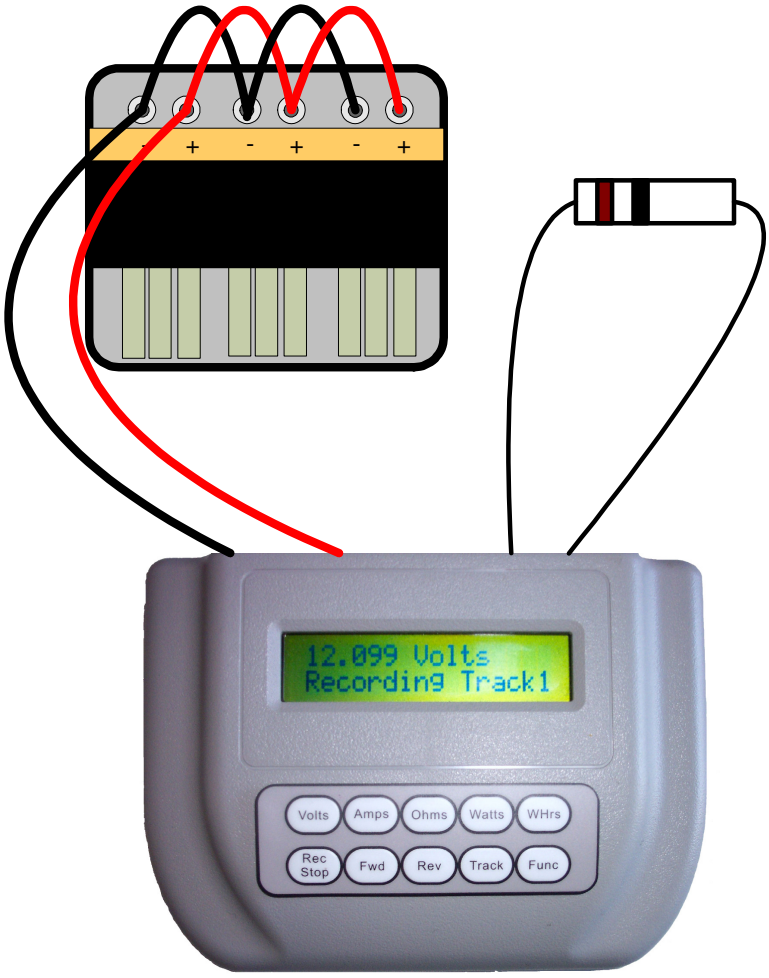


Figure 1 – Initial Equipment Setup

TEACHING THE LESSON

1. Find an appropriate location to place the solar panel where it can receive the maximum amount of sun.

2. Place the magnetic compass over one of the wires that are connected between the solar panel and the ***Smart Meter – Data Logger*** [tm] as shown in Figure 2 below. Align the compass pointer so that it points to North.

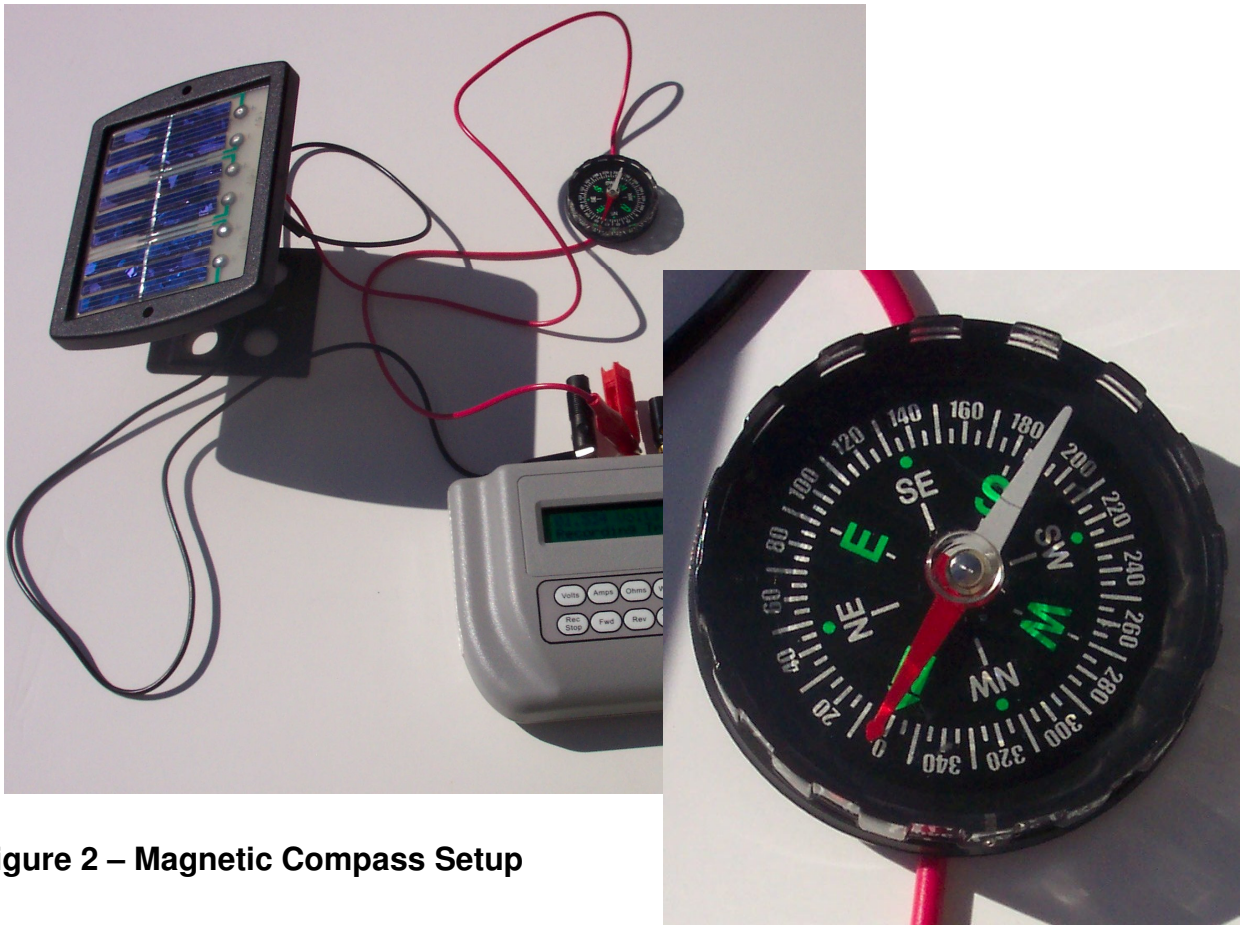


Figure 2 – Magnetic Compass Setup

3. Set the switch on the ***Smart Meter – Data Logger*** [tm] to ON.

4. Push the **Track** key until **Set Sample Time** is displayed. Use the **Fwd** or **Rev** keys to set the sample time to 1 second. Once 1 second is displayed, don't push any keys for 3 seconds. The Sample Time is set when the bottom line on the LCD is blank.

5. Push the **Rec-Stop** key. The bottom line of the LCD should display **Recording Trackx** followed by other messages. Note what Track number is being recorded.

6. Temporarally block the sun from shining on the solar panel and notice how the compass needle deflects as in Figure 3. There is not much of a deflection because the solar panel cannot produce much current and, consequently, not much magnetic energy; however, the concept can still be shown.

Figure 3 – Compass Needle Deflected When Current is Removed

7. Push the **Rec-Stop** key again to halt the recording.

DISCUSSING THE LESSON OUTCOME

1. In the classroom plug in a USB cable between the ***Smart Meter – Data Logger*** [tm] and the classroom computer and set the switch to the USB position so that it receives power from the computer's USB port. Set the power switch to the USB position and verify the sign on message on the LCD screen.

2. Click on the **REEL Power** [tm] icon to bring up the software menu. Then click on the **MPP Auto Trac – Data Logger** icon.

3. On the computer adjust the voltage (vertical) scale on the **REEL Power** [tm] software to 2.5 volts maximum.

4. Adjust the time (horizontal) scale on the **REEL Power** [tm] software to show a red line marching across the bottom of the plot area.

5. Push the **Track** key until the **View Trackx Data** message is displayed. Keep pushing the **Track** key until the correct Track number is selected. The computer should begin displaying the data plots for the previous day's data. The data should look like Figure 2 below (although your data may not be as consistent due to weather related issues like clouds blocking the sun, etc.). Adjust the horizontal plot until a similar display is shown.

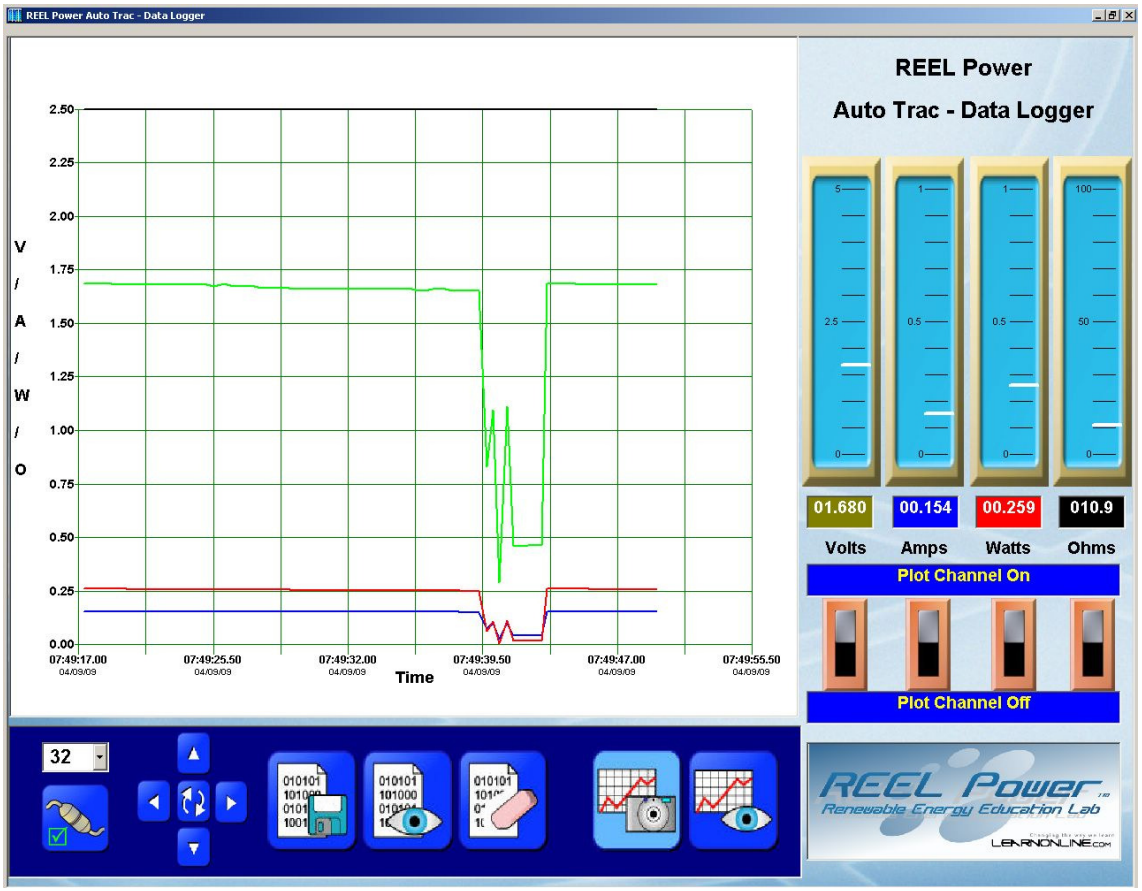
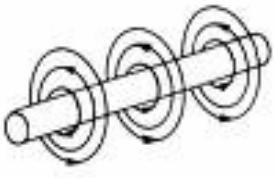


Figure 4 – Plot of Solar Panel Output for Compass Defection Experiment

6. Notice the dip in voltage (green line) and current (blue line) when the solar panel is shaded from the sun. This reduced current caused the needle to deflect since the magnetic lines of force were greatly reduced. Magnetic lines of force are created around a wire when a current flows through it. When the current is removed the lines of force also disappear. This is what caused the magnet needle to deflect.



TEACHER GUIDELINES AND TIPS

1. Repeat the experiment with either a larger solar panel or just a battery instead of a solar panel. A fully charged battery will produce much more current and will cause the magnetic compass to deflect even further.

2. If you use a battery you will have to remove it from the circuit to remove the current flow.

Caution:

When using a battery or more powerful solar panel be careful not to touch the 10 ohm resistor. It will get hot!

3. If possible have students either photograph the compass needle deflections or make a drawing of a compass and have them mark where the needle started and then deflected.