Power of Light Lab

Directions and Suggestions for Teacher

Purpose:

This lab is designed to give students hands-on experiences with the connection between voltage and power for an object of fixed resistance. I highly recommend doing a live part to this virtual lab that mirrors as closely as possible what is done in this program. The real life object will most likely deviate from the ideal as its resistance increases with temperature.

Virtual Part:

(https://thephysicsaviary.com/Physics/Programs/Labs/OhmsLawWithPredictionsLab/)

This lab can easily be paired with a live lab that mimics the virtual lab. It is important to give the students a hands-on experience as frequently as possible.

Measuring Voltage:

Students click on the switch on the power supply to turn the supply on. The voltage will display on a digital readout on the supply. Students can change the value of the voltage by clicking on the knob located on the right side of the supply. By varying which side of the knob they click on, they can raise or lower the voltage.

Measuring Current:

Students should use the analog meter that is connected in series with the lightbulb to estimate the current flowing through the circuit. Students should make sure they record their current in Amps regardless of what it is measured in using the meter.

Calculating Power:

Students calculate power by multiplying voltage by current. If they are in standard units, the calculated power will be in Watts.

This lab was created by Frank McCulley for thephysicsaviary.com.

Working Through the Lab:

Students will be changing the voltage of the power supply for each trial. A nice range of voltages should be used. I would suggest students do at least 8 different voltages to get a good looking graph.

The program will randomize the resistance of the filament inside the lightbulb, so all students will get different results. Students should not refresh the website while working or it will generate new values and thus make all the old data irrelevant. Below is a sample of what potential data might look like.

Data:

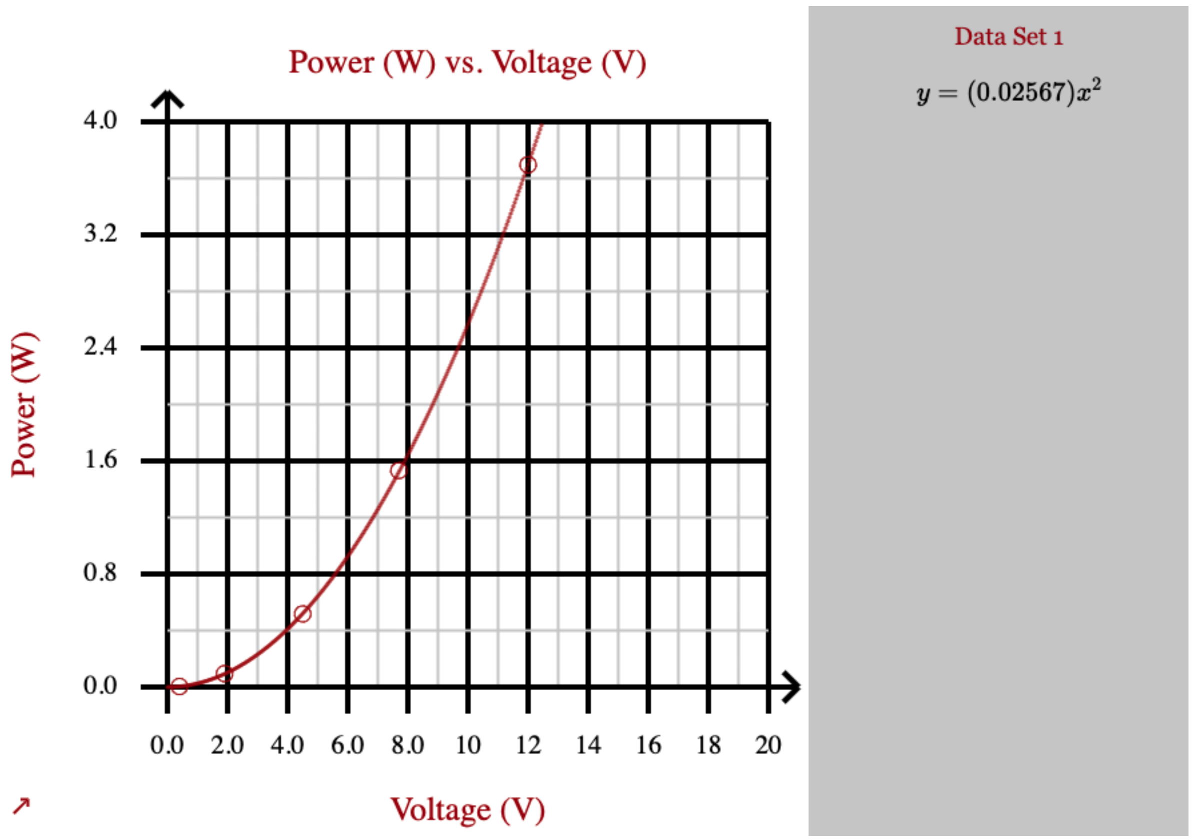
Voltage (V)	Current (A)	Power (W)
0.4	**0.010**	**.004**
1.9	**0.050**	**0.095**
4.5	**0.115**	**0.5175**
7.7	**.199**	**1.532**
12	**.308**	**3.696**

Graphing Data:

(https://www.thephysicsaviary.com/Physics/Programs/Tools/Graphing/)

Once students have finished collecting data, they should graph it and find a relationship between the variables. The voltage in Volts is the independent variable and should be placed on the x-axis and the power in the circuit in Watts should be on the y-axis. This graph should come out to be a squared graph.

I prefer always having the students transfer their graph onto their lab sheet by hand.



Equation:

For this graph students get a squared relationship between the variables. This indicates to them that a larger voltage will cause an increase in power. Doubling the voltage will cause the power to quadruple.

The equation for a squared relationship is given below.

$$y = Ax^2$$

We want to continue to emphasize to them the idea that each of these letters has real physical significance. Looking at the axes, they should see that the y is the power and the x is the voltage. So the equation becomes:

$$\text{Power} = (\text{graph constant})(\text{Voltage})^2$$

We then want students to think about the significance of the graph constant. We can prompt them by asking what other things about the circuit played a role in terms of determining the power measured by the meter. Hopefully a few of the students will realize that the resistance of the filament in the lightbulb would have an effect on the current and therefore the power. At this point you can tell them that the graph constant in this equation is equivalent to the Resistance of the filament so that the final equation becomes:

$$P = RV^2$$

Checking their work:

Once the students have reached the point where they have graphed and created an equation, they will then be able to check their work. They should simply hit “Finished” on the program to be brought to a form they can fill out to see if they did everything correctly. Remind students that they all will be getting different answers and that they shouldn’t worry if their answers differ from those of their classmates.

Make sure to stress that they should have graphed the voltage in Voltage and the power in Watts. They will be entering their value from their graph as the graph constant. They will then use their equation to make a prediction on how much power would be used if they used a voltage for which they didn’t collect data on. Finally, they will be asked to calculate the voltage that would be needed to create a desired power..

Create a graph with voltage (V) of the supply on the x-axis and the power (W) of the bulb on the y-axis.

Enter the graph constant for your graph.

Then use the equation for your graph to find power of this bulb if supply had a voltage of 18.7 V

Finally, find the voltage that would be required to create a power of 39.5 W.

Enter Your Answer Below

Don't Enter Units

Name:

Graph Constant:

Power for a voltage of 18.7 V (W):

Voltage needed to create a power of 39.5 W (V):

Return Submit

I would normally offer a small amount of extra credit added to the lab grade if they get all their answers correct. I would have them show me their completion certificate so I could record that they earned the extra credit. If a student doesn’t get everything correct, you can have them redo the lab by refreshing their page if time permits.

Live Part:

I would have the students complete a live part that is almost identical to the virtual part they have just completed realizing full well that they will not get the same graph type. I want them to realize that the results we get will only happen if the resistance of the object they are running the current through has a consistent resistance for the entire lab. This will introduce students to the idea that resistance can vary in complicated ways with the temperature of the object.

I have frequently used a power supply and incandescent lightbulb just like the one pictured in the virtual lab. Since I only had one power supply, I would have each lab group make one measurement of voltage, current and power and then we would combine data together as a class to get our results.

As an alternative setup, you could have students use different numbers of batteries to create different voltages and hook the batteries up to a high value resistor. This will generate small currents that you will easily be able to measure with a digital meter. With small currents, the temperature of the resistor will not change significantly and you will get results similar to what we saw in the virtual lab.

Conclusion:

I personally like to have students write out a conclusion by hand after they are done with the entire lab (live part and virtual part). Some things you can have students include in the conclusion.

1. **Restatement of the purpose.**
    a. This is a great way to open the conclusion
    b. It helps to reinforce the reason we were doing the lab.
2. **Brief Summary of the steps**
    a. I don't want too much here but I do want students to transition from the purpose to the results with a sentence or two summary of the steps.
    b. This part of the conclusion should paint with a very broad brush what type of data we were collecting and what remained constant when collecting data.
3. **Results**
    a. I want students to clearly state what type of relationship existed between the two variables we were examining.
    b. I want them to clearly explain what this means in simple to understand terms.
    c. Basically, they will be making sense of the equation they have discovered in the lab.
4. **Error**
    a. They should talk about their percentage of error from the lab (you can have them do this for the live part or the virtual part or both).
    b. They should brainstorm at least one possible source of that error and how it can be minimized if they redid the lab.
5. **Limitations to the model**
    a. Whenever possible I want them to think about when the mathematical model for the lab would break down and no longer apply.
    b. For instance, with this lab, the number one reason for our model to fail would be that resistance of the object will change with temperature. With an incandescent light bulb, the temperature is going to change by a significant amount and this will cause the model to fail.

Going Further

If you have the time, you could challenge the students with the following types of things.

1. The number one thing that I would do if I had extra time with this lab is to have students run the live part for a variety of different objects. Some that change temperature significantly and some that don't. This will cement the idea that our model works best when the temperature is fairly constant.

2. You could have students do some research on a thermistor and how we can use the idea of resistance changing with temperature to electronically determine temperature.