

Science 30 Project
LEDs:
A Better Light Bulb?

Student Booklet

2009–2010



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LEDs: A Better Light Bulb?

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Project Overview

Politicians, scientists, and citizens of the world are searching for better ways to use technology to conserve the environment while providing a better life for people in the developing world. Have you noticed some of the different ways of lighting that have been developed recently? You have probably seen the flashlights that you can charge with a hand generator. A good website to visit is *Light up the World* (www.lutw.org). Here you will be able to find out about efforts to bring lighting to people who, up until recently, have had to rely on kerosene lamps and wood fires.

Recently, light-emitting diodes (LEDs) have been introduced to the market. LEDs are advertised as being 10 times more efficient than the more familiar incandescent (tungsten filament) bulbs. In this project, you will investigate and evaluate the efficiency of LEDs. You will research how LEDs and incandescent bulbs work and what they are used for. You will be required to construct simple circuits and use multi-meters and computers to collect and analyze data. This data will be stored and manipulated using a spreadsheet.

Comparing the Energy Efficiency of an LED with an Incandescent Light

Focusing Questions

Some manufacturers claim that the batteries in an LED flashlight will last about 10 times longer than batteries in a regular flashlight. How does the energy efficiency of a LED compare with the efficiency of an incandescent bulb?

Background Information

You need to have a basic background in circuitry and efficiency in order to understand this activity. Your teacher may lead you through the following questions or may have you find the answers yourself.

1. What energy conversions take place in all light bulbs?

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2. Describe what eventually happens to the light energy that leaves the light bulbs in your classroom.

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3. What is the formula for percent efficiency? (Use the Science Data Booklet.)

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4. What type of energy is the “useful” output energy for a light bulb or LED, and what type of energy is considered “waste” energy?

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5. Is $\frac{\text{useful output power}}{\text{input power}} \times 100$ also a legitimate formula for efficiency? Explain.

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6. Name the device that measures voltage and the device that measures current in an electrical circuit. How could the measurements from these devices be used to determine the power used in a simple circuit?

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7. Assume that you had a device that could measure the amount of light energy (useful power output) that is coming from a light bulb or an LED. Briefly describe a method for comparing the efficiency of a battery-operated light bulb and a battery-operated LED.

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8. Draw a circuit diagram that you could use to carry out the method that you described above.

Scoring Guide for Designing a Procedure

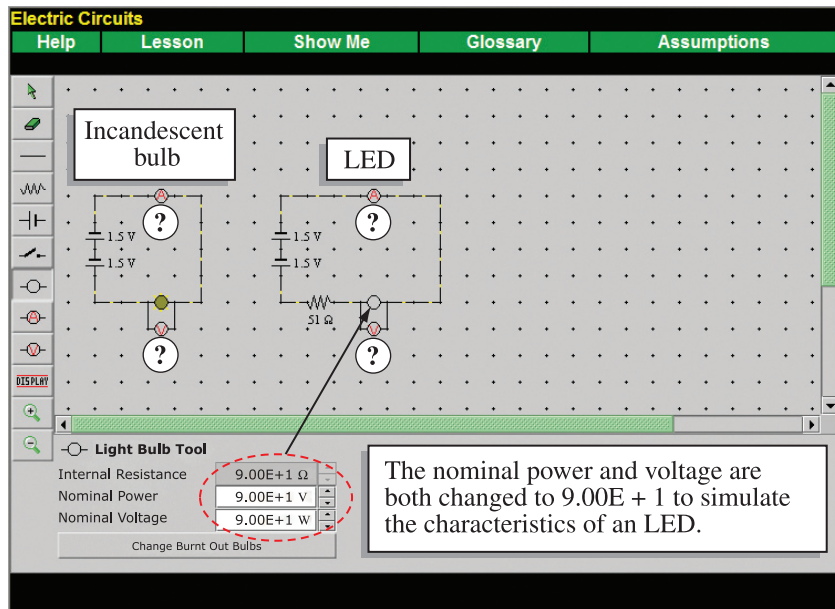
<i>Score</i>	<i>Scoring Descriptions</i>
3 Standard of Excellence	The method is well designed and the circuit drawing is correct and clearly depicted . This is accomplished with minimal assistance.
2 Acceptable Standard	The method will work with minor modifications and the circuit drawing is consistent with the method . This is accomplished with a fair amount of assistance.
1	The method won't work or is impractical and the circuit drawing is incorrect or difficult to decipher . This is accomplished with a great deal of assistance.
0	The performance is not at an appropriate level for a 30-level course.

Procedure 1: Using a Computer Stimulation

1. Locate the “Electric Circuits” software on the Science 30 Textbook CD or click on the icon below to go to the application. Open this application and read through the information in the “Show Me” file to familiarize yourself with the application.



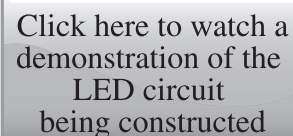
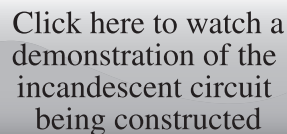
2. Construct the following two circuits on the circuit board.



Note: You need to change the batteries to 1.5 V. Also, change the nominal power and nominal voltage of the LED circuit to 9.00E+1 (90) as shown on the diagram above. For the incandescent bulb, leave the nominal powered voltage at 1.00E+1.

Notice that a 51 Ω resistor has been added to the LED circuit. This keeps it from burning out prematurely and also ensures that the optimum current is supplied to the light.

You will need a password from your teacher to open these demonstrations.



3. Take a screenshot of your circuit and paste it here. (A screenshot can be taken by pressing the “Print Screen” button on the keyboard. This saves the image on the monitor to the clipboard. The image can then be pasted into a Word document.)

Data Collection

Enter the meter reading data from the circuit board into the shaded columns of the spreadsheet. Use this data and the calculations to fill in Table 1.

Open the spreadsheet by clicking on the icon below. Then enter the appropriate formula in cells G2 and G3 to calculate the efficiency of the bulb and LED.



Note that 15 lumens and 35 lumens have been entered for the LED and incandescent bulbs respectively. This is the approximate power output (in terms of light emitted) for these bulbs.

Table 1

	A	B	C	D	E	F	G
1	Type of Bulb	Voltage (V)	Amperage (A)	Power Input (W) $P=VI$	Lumen Rating of the Bulb (Lumens)	Power Output Rating (W) Conversion Factor 1 Lumen = 0.00147 W	Percent Efficiency (%)
2	LED				15		
3	Incandescent				35		

Interpretations

1. How much more efficient is the LED than the incandescent bulb?

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2. Assume that one LED flashlight and one incandescent flashlight of equal brightness have the same type and number of batteries. How much longer would you expect the batteries in the LED flashlight to last? Explain your answer.

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Procedure 2: Constructing the Circuit

Materials

- one incandescent miniature bulb (5 700 mcd and 3 V) and miniature bulb connector base
- one red LED (rated at 2 500 mcd and 20 mA) and 51 Ω resistor
- insulated connecting wires with alligator clips
- two “D” (1.5 V) batteries and battery holder
- switch
- one voltmeter and one ammeter or one multi-meter

1. Using the materials listed above, construct the circuits illustrated in Figure 1 (p. 6).

Note:

- a. A 51 Ω resistor needs to be included in series with the LED light. This will keep it from burning out prematurely and will also ensure that the optimum current is supplied to the light.
- b. The long wire (positive terminal) of the LED light must be connected to the positive post of the battery.
- c. The two 1.5 V cells should be connected in series. The values (lumens) on the table on the previous page are for these conditions.

Hints for Using a Multi-Meter:

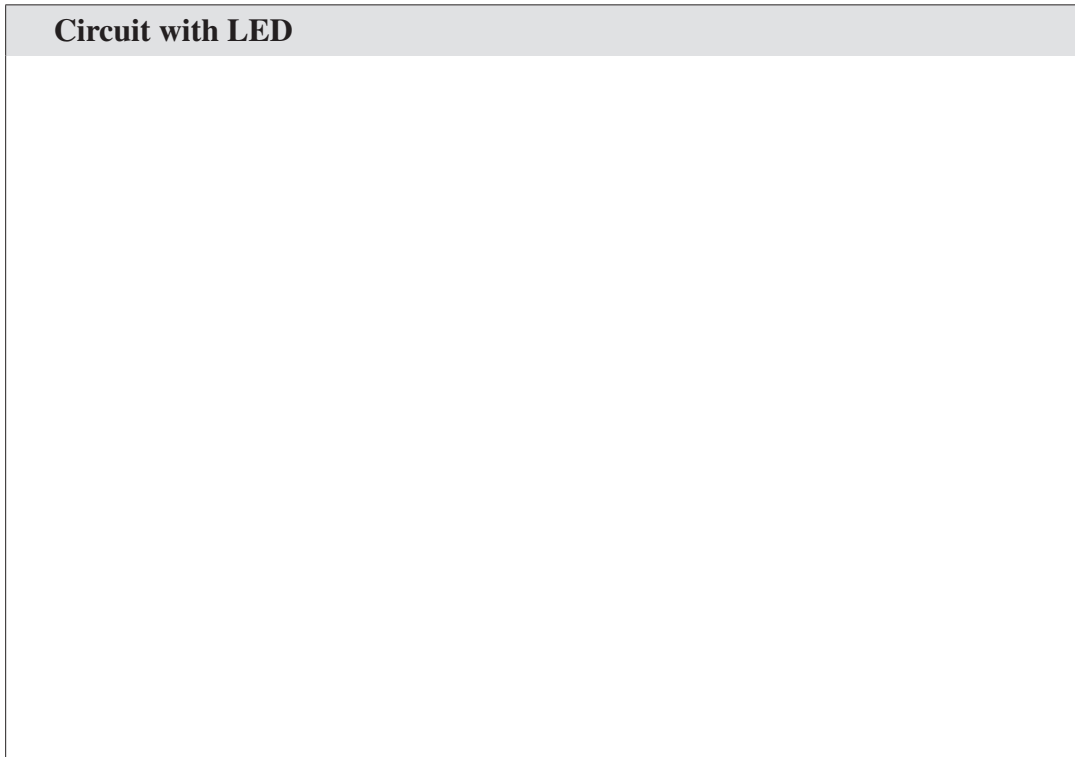
- a. If you insert the black lead into the “common receptacle,” then the red lead will connect to the positive terminal of the power supply.
- b. For measuring voltage, the leads should be placed across the light bulbs (in parallel). Use the “20 V” setting. This means that the voltage being measured should not exceed 20 V. This setup uses approximately 3 V (2 cells in series).
- c. For measuring amperage, the meter should be placed within the circuit (in series).
- d. Use the 200 mA setting for the LED circuit. This current is approximately 0.025 A (25 mA).
- e. Use the 10 A setting for the incandescent bulb circuit. This current is approximately 0.30 A (300 mA).

Note: The settings on the multi-meter indicate the maximum voltage or amperage that should be applied at that particular setting. This is a good demonstration of applying metric conversion principles.

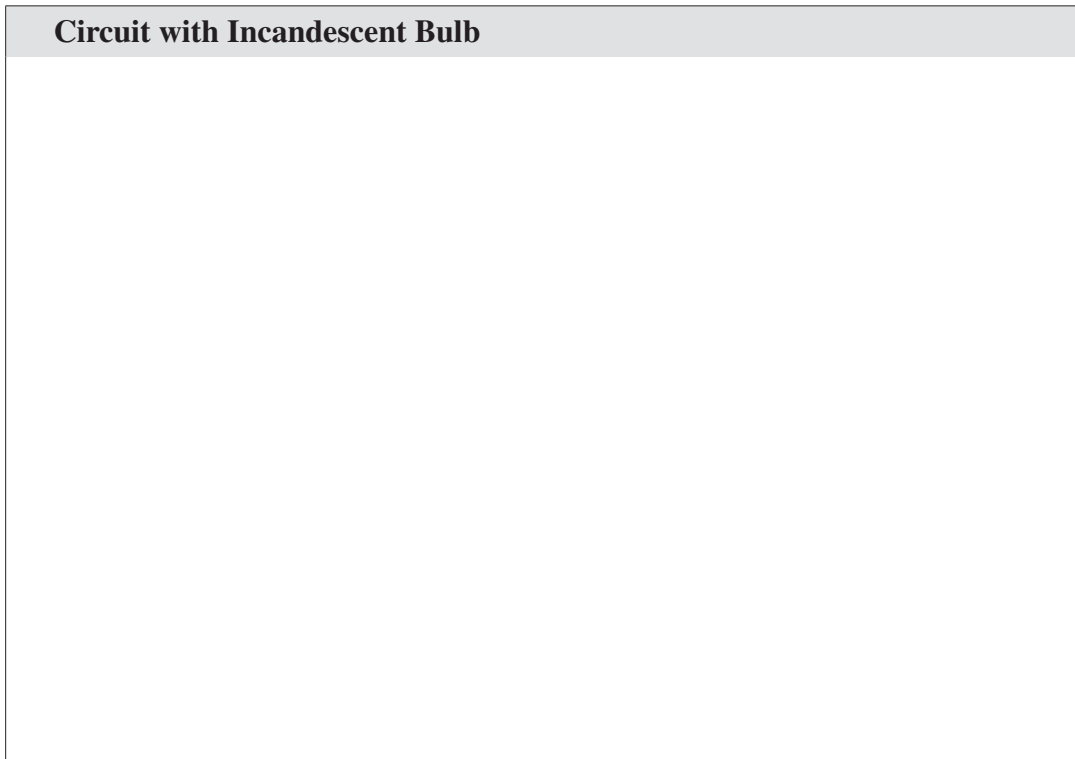
<p>Warning: Do not move the switch on the multi-meter when there is current going through it. Do not turn the power on until the teacher has checked your circuit</p>
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2. Either take digital pictures of your completed circuits and paste them here or draw the appropriate circuit.

Circuit with LED



Circuit with Incandescent Bulb



- After your teacher has checked your circuit, turn the power on. Open the spreadsheet and enter an appropriate formula in cells G2 and G3 to calculate the efficiency of the bulb and LED.

Note that 15 lumens and 35 lumens have been entered for the LED and incandescent bulbs respectively. This is the approximate power output (in terms of light emitted) for these bulbs. If you happen to have the lumen ratings for your bulbs, you can replace these values in the table.



Data Collection

Enter the data from the meters in your circuits into the shaded columns of the spreadsheet. Use this data and the calculations to fill in Table 2.

Table 2

	A	B	C	D	E	F	G
1	Type of Bulb	Voltage (V)	Amperage (A)	Power Input (W) $P=VI$	Lumen Rating of the Bulb (Lumens)	Power Output Rating (W) Conversion Factor 1 Lumen = 0.00147 W	Percent Efficiency (%)
2	LED				15		
3	Incandescent				35		

Interpretations

- How much more efficient is the LED than the incandescent bulb?
.....
.....
- Assume that one LED flashlight and one incandescent flashlight of equal brightness have the same type and number of batteries. How much longer would you expect the batteries in the LED flashlight to last? Explain your answer.
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.....
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Scoring Guide for Doing the Experiment

<i>Score</i>	<i>Scoring Descriptions</i>
4 Standard of Excellence	The circuit is set up correctly and efficiently . Care is taken to use the meters correctly. The description and/or diagrams of the methods and circuitry are correct and clearly depicted . The spreadsheet formulas are almost all correct . The interpretations and limitations reflect a deep understanding of experimental design and concepts related to circuitry and energy efficiency. This is accomplished with minimal assistance.
3	The circuit is set up correctly . Meters are used correctly . The description and/or diagrams of the methods and circuitry are correct . The spreadsheet formulas are mostly correct . The interpretations and limitations reflect an understanding of experimental design and/or concepts related to circuitry and/or energy efficiency. This is accomplished with a little assistance.
2 Acceptable Standard	The circuit is set up correctly but takes some trial and error . It takes some time to use the meters correctly. The description and/or diagrams of the methods and circuitry are mostly correct but may be difficult to decipher . The spreadsheet formulas are mostly correct . The interpretations and limitations reflect an adequate understanding of experimental design and/or concepts related to circuitry and/or energy efficiency. This is accomplished with some assistance.
1	The circuit is set up incorrectly or inefficiently . Care is not taken to use the meters correctly. The description and/or diagrams of the methods and circuitry are unclear . Some of the spreadsheet formulas are correct . The interpretations and limitations reflect a shallow understanding of experimental design and concepts related to circuitry and energy efficiency. A great deal of assistance is required.
0	The performance is not at an appropriate level for a 30-level course.

Scoring Guide for Practical Work Habits and Abilities

<i>Score</i>	<i>Scoring Descriptions</i>
4 Standard of Excellence	Effectively participates in discussions and activities and aids in getting started and keeping focused on the task. Offers practical solutions to problems that arise, actively seeks the input of others, and initiates the sharing of ideas inside and outside of his or her group. Is highly skillful with the use of the computer and the manipulatives used in the experiment. Dependably completes work that is required outside class time and often goes beyond requirements .
3	Contributes to discussions and activities and aids in keeping focused on the task. Offers practical solutions to problems that arise, listens to the input of others, and shares ideas inside and outside of his or her group. Is skillful with the use of the computer and the manipulatives used in the experiment. Dependably completes work that is required outside class time.
2 Acceptable Standard	Participates in discussions and activities and usually focuses on the task. Offers some solutions to problems that arise, usually listens to the input of others, and is willing to share ideas inside and outside of his or her group. Possesses adequate skill in the use of the computer and the manipulatives used in the experiment. Usually completes work that is required outside class time.
1	Does not contribute much to discussions and activities and has difficulty keeping focused on the task. Does not offer practical solutions to problems that arise or fails to listen to the input of others, or share ideas inside and outside of his or her group. Lacks skill or does not participate in the use of the computer and the manipulatives used in the experiment. Often fails to complete work that is required outside class time.
0	The performance is not at an appropriate level for a 30-level course.

Scoring Guide for Research Component

<i>Score</i>	<i>Scoring Descriptions</i>
4 Standard of Excellence	Uses sophisticated research strategies on the Internet (including use of Boolean operators and links) and from other sources with minimal assistance . Sources of information are completely and accurately documented. The report is complete, well organized , and addresses the relevant issues. The information is sifted from a variety of sources that fit together in coordinated fashion and is combined in a sophisticated manner with the student's own ideas.
3	Uses sound research strategies on the Internet (including use of Boolean operators and links) and from other sources with a little assistance . Sources of information are completely documented. The report is complete, well organized , and addresses most of the relevant issues. The information comes from a variety of sources that fit well together, and is combined with the student's own ideas.
2 Acceptable Standard	Uses adequate research strategies on the Internet (including use of links) and from other sources with some assistance . Sources of information are documented . The report is fairly well organized , and addresses the most of the relevant issues . The information comes from a few of sources and relates to the student's own ideas.
1	Uses poor research strategies on the Internet and from other sources and requires a great deal of assistance . Sources of information are not completely documented. The report is incomplete, disorganized , and addresses few of the relevant issues. The information comes from one or two sources and is just a list of related information.
0	The performance is not at an appropriate level for a 30-level course.

Presentation

Imagine that you are given a 15-minute time slot to make a presentation to the mayor and city council. Construct a presentation with the information that you have gathered, and use multimedia tools to convince the council of the following:

The development and use of LED lighting should be a priority for your community.

OR

The development and use of LED lighting is not worthwhile and should **not** be a priority for your community.

Scoring Guide for Presentation Component

<i>Score</i>	<i>Scoring Descriptions</i>
4 Standard of Excellence	The presentation effectively uses multimedia tools to present a point of view in an entertaining and convincing manner. The presentation is imaginative, well-organized, and sophisticated .
3	The presentation effectively uses multimedia tools to present a point of view. The presentation is logical, well-organized, and systematic .
2 Acceptable Standard	The presentation uses multimedia tools to present a point of view in an straight-forward manner. The presentation is logical, organized, and consistent with the facts.
1	The presentation does not effectively use multimedia tools to present a point of view. The presentation is poorly organized, and naive .
0	The performance is not at an appropriate level for a 30-level course.

Appendix: Useful websites

<http://auto.howstuffworks.com/question178.htm>
LED lights-how they work, LED traffic lights

<http://www.theledlight.com/lumens.html>
definitions and conversions to Lumens

<http://gelighting.com/na/home/gela/students/mathconsumer>
information on incandescent lighting

http://www.readersdigest.ca/mag/2004/07/hero_of_the_year.html
A story about a Calgary professor who provides LEDs to developing countries that cannot supply electricity.