CNS Institute for Physics Teachers

Title:	**Is the Light Bulb Too Good to be True?**
Version:	June 2004
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Appropriate Level:	Grades 9-12
Abstract:	The main objective of this lab is to provide students with the opportunity to design one or more experiments in a real-world situation to test a hypothesis based on the advertising associated with a consumer product, specifically, light bulbs. The science and scientific testing involves spectra, spectroscopy, light intensity, photometry, and color filtering. This lab can be made into an interdisciplinary activity if "insect repellent" light bulbs are included and the students are afforded the opportunity to research the effect of light on insects. This lab is meant to be a high-level inquiry lab, but can be altered to a lower level by the teacher. Several levels of inquiry are provided. The process can be adapted for other content areas.
Special Equipment:	Digital Multi-meters for with electronic photometers (in place of paraffin blocks)
Time Required:	Two to five 40-minute periods plus outside research time depending on the options chosen.
NY Standards Met:	4.1a All energy transfers are governed by the law of conservation of energy. 4.3b Waves carry energy and information without transferring mass. This energy may be carried by pulses or periodic waves. 4.3c The model of a wave incorporates the characteristics of amplitude, wavelength, frequency, period, wave speed, and phase.

Objectives:

Class Time Required:

Teacher Preparation Time Required:

Materials Needed:

- Several different light bulbs with original packaging or copies of the packaging (copy the major panels on all packaging). Examples: clear light bulbs, standard frosted light bulbs (for controls), soft white light bulbs, super soft white light bulbs, specialty light bulbs (that make special claims about the quality of the light), insect repelling light bulbs, fluorescent replacement bulbs, etc. Go to a department store and/or home improvement store and look over the selection of light bulbs.
- Spectrometers (Project Star type) with scales
- Light bulb sockets
- Paraffin blocks and/or light meters
- Aluminum foil (to put between the paraffin blocks, if necessary)
- Rubber bands (to hold the paraffin block and aluminum foil sandwich together)
- Primary color filters (two sets per team)

Assumed Prior Knowledge of Students:

Prior to completing this lab, instruction should have taken place covering basic properties of light, types of spectra, using spectrometers, inverse-square law of light, and light intensity and how to measure it, either with paraffin blocks or light meters. Also, review safety procedures involved in using electrical devices plugged into AC outlets, especially, unplugging the lamp socket before changing a light bulb.

Engage:

Options:

1. Provide a copy of a "Consumer Reports" type article for the students to read. Ask them to react to the article and answer the question "How did the authors of the article find out about the product and check the manufacturer's claims?"
2. Have several products/items that don't live up to their advertised usefulness. Including the packaging for the product. Have a brief discussion about one of the products, the advertising, and the problem with the product. This discussion can take place the day before doing the lab as a teaser as to what will be happening the next day in lab.
3. Have a product other than a light bulb with packaging. Ask the students to read the packaging and record the claims made by the manufacturer. In small groups ask them to come up with ways in which the claims could be verified scientifically. Using white boards might be a good strategy at this point with the students writing the results of their discussion on the white boards. Have the students share their results. Discuss the similarities and differences among each group's findings. This can be done if the plan is to take more than two periods to do the lab.
4. If the plan is to do the lab in two periods, then a brief discussion of advertising claims and how they are tested and the need to test them can take place just prior to starting the lab.

Emphasize the importance of scientific testing in all situations for the protection of the consumer.

Explore:
Tell the students they are now divided into research teams at a "consumer product testing" center. Hand out the version of the assignment sheet suited to the appropriate level of inquiry.

The goal is to investigate the properties of a variety of light bulbs with the advertised properties in mind and determine if there is a scientific basis for the claims made by the manufacturer. The students should be forming a hypothesis as to the results of their investigation. Some experiments will require looking at spectra or checking light intensity, or both, depending on the light bulbs tested. Hypotheses might be that the spectrum of a specialty light bulb should be "bluer" or have "missing colors" when compared to the spectrum of a standard light bulb; that the intensity of a soft white light bulb should be less at a given distance compared to a standard light bulb.

Options:

1. Have the materials laid out and identified as the lab equipment for the investigation.
2. Ask the students to generate a list of what they think they will need to perform their investigation, and then provide the materials.

Based on the claims on the packaging and the student's basic knowledge of light and spectra, the investigation should focus on comparing the spectra of the different light bulbs and how the intensity of light compares for certain bulbs. Students may need to go outside to check solar spectra.

The students should be allowed to explore these options and then apply their ideas and what they've learned in exploring to testing the light bulbs scientifically.

The testing should involve comparing spectra for both bandwidth and intensity, intensity of colors, and intensity of light. The intensity of light comparisons can include numerical data.

It is important for the students to make careful observations of the spectra and to look for details and small differences. The students must be patient in looking for differences in the spectra. If a group is having difficulty and you notice that they are just glancing through the spectrometers, encourage them to take a little more time and study each of the spectra. The quality of the Project Star spectrometers allows for careful observations of the spectra.

Some students initially may not see the difference in brightness between the two paraffin blocks used as a photometer. A demonstration with each group may be necessary if they have not used them prior to the lab.

Explain:
Option 1 (more than two periods):

The final product should be a write-up that, using the results of the investigation, contains conclusions about the properties of the light bulbs and if the properties support the advertising claims.

Students should be encouraged to write a brief journal of the history of their research as part of their write-up. The entries should also include problems, failed attempts, and numerical data.

The most significant part of the write-up will be how the students explain whether or not their scientific experiments support or refute the manufacturer's claims.

Option 2 (up to two periods):

For a two period exploration, the write-up can be a brief summary of what tests were completed and the results of the tests followed-up afterward with the extension described below.

Extend:
The students should write a brief "article" as part of the report suitable for publication in a "Consumer Reports" type of publication. The article should discuss the claims made by the manufacturer and whether, or not, these claims are supported by the scientific evidence.

Evaluate:
Option 1 (more than two periods):

After the students have completed their work, have them return to the white boards in their teams and devise an evaluation rubric. Set a point total prior to their discussions so that it is easier to make comparisons when they are finished.

Briefly discuss the team results and come to a consensus on a rubric and then have each team do a self-evaluation. Collect the results and use the student's results in combination with your own to determine the final assessment of the lab.

Option 2 (up to two periods):

For the two period exploration, the students can summarize their results and conclusions on whiteboards and then, displaying their whiteboard, share their results with the other teams.

<u>Background Information for Teachers:</u>
Light Intensity:
A standard light bulb will come close to obeying the inverse square law of light intensity if the intensity measuring device is not too close to the bulb. At short distances, 10 to 20 centimeters, the intensity may vary as $1/d$ rather than $1/d^2$.

Also, the shape of the bulb determines how the intensity varies with distance. The fluorescent replacement bulbs will come close to the same intensity drop off as a standard light bulb. If a straight fluorescent tube is used, the intensity will drop off as 1/d. So, trying to compare the intensities of a standard light bulb to a fluorescent tube can be problematic.

Spectra:
With the exception of the florescent light bulbs (continuous with bright lines), the students will be looking at continuous spectra and will be looking for missing colors or differences in intensity in particular colors, depending on the advertising and their hypotheses.

If the students are having difficulty determining differences in color, the use of colored filters placed between the spectrometer and the light bulb might be helpful. These will cut down the bandwidth passing into the spectrometer and also the intensity that might make the differences in the spectra show up better.

If the students decide to go outside and look at a solar spectrum, provide them with white reflection cards so that they are looking at reflected sunlight, and emphatically advise them not to look directly at the Sun with the spectrometers.

Resources and References:
Properties of light: any general Physics text can provide the necessary information on light intensity, spectra, and the inverse square law of intensity.

Light bulb information: Some information about a particular brand or type of light bulb can be found by doing an internet search for the company's web site and finding the home lighting page. Information on bug lights can also be found at a company's web site.

Insects and light: An internet search for "bug zappers" can provide information on how bugs react to light from several different points of view.

Additional Information:
Four versions of student sheets are included. Each version represents a different level of inquiry.

Version 1 is the highest level of inquiry and Version 4 is the lowest level.

The different levels are presented here so teachers may compare and contrast and make a decision as to the level of inquiry they want their students to experience.

IS THE LIGHT FANTASTIC?

Student Sheet Version 1

Consumers are continually bombarded with advertisements and hype with regard to new products. Lately some of the new products have been light bulbs. Verify or refute the claims made for the variety of light bulbs provided. Report your results in an appropriate fashion.

IS THE LIGHT FANTASTIC?

Student Sheet Version 2

Consumers are continually bombarded with advertisements and hype with regard to new products. Lately some of the new products have been light bulbs.

Some of the claims include:

- More like sunlight
- Softer light
- Truer light
- Less harsh
- Repels insects
- And others…

Using your knowledge of spectroscopes and spectra, and the equipment provided, investigate the properties of the various light bulbs. Answer the question: Is there a scientific basis for the claims that are made in the advertising?

Summarize your results. Write a report in a form that you might see in a magazine that publishes articles on consumer product awareness, i.e., like a "Consumer Reports."

IS THE LIGHT FANTASTIC?

Student Sheet Version 3

Consumers are continually bombarded with advertisements and hype with regard to new products. Lately some of the new products have been light bulbs.

Some of the claims include:

- More like sunlight
- Softer light
- Truer light
- Less harsh
- Repels insects
- And others…

Considering the advertising associated with one or more light bulbs and using your knowledge of light intensity, spectroscopes, and spectra, and the equipment provided, determine whether or not there is a scientific basis for the claims made.

When ready, use the white boards to summarize the research team's results. Include what was investigated, the experiments performed, results, and conclusions. Make sure that every one on your research team records the information on the whiteboard in their individual notebooks.

In your research team's report,

1. summarize your results.
2. and write a report in a form that you might see in a magazine that publishes articles on consumer product awareness, i.e., like a "Consumer Reports."

IS THE LIGHT FANTASTIC?

Student Sheet Version 4

Consumers are continually bombarded with advertisements and hype with regard to new products. Lately some of the new products have been light bulbs.

Some of the claims include:

- More like sunlight
- Softer light
- Truer light
- Less harsh
- Repels insects
- And others…

Considering the advertising associated with one or more light bulbs and using your knowledge of light intensity, spectroscopes, and spectra, and the equipment provided,

- Devise an experiment to investigate the properties of the various light bulbs.
- Answer the question: Is there a scientific basis for the claims that are made in the advertising?
- When ready, use the white boards to summarize the group's results. Include what was investigated, the experiments performed, results, and conclusions. Make sure that every one on your research team records the information on the whiteboard.

In your research team's report,

1. summarize your results.
2. and write a report in a form that you might see in a magazine that publishes articles on consumer product awareness, i.e., like a "Consumer Reports."