CLEAN ENERGY BRIGHT FUTURES
A Program of BEF

Solar Mobile Design Challenge

Lessons 5: Light Source Efficiency-Exploring Irradiance

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DESCRIPTION
This lesson explores the concept of irradiance by having students use a Vernier Pryanometer. Using the "Light Source Efficiency" worksheet to guide their work, students measure irradiance as compared to the Sun's irradiance to see what would be the best light source for powering their solar mobile indoors. This can be done as a demonstration or at a station if you only have one LabQuest2 and Pyranometer.

GRADE LEVEL(S)
6, 7, 8

SUBJECT AREA(S)
Electromagnetic radiation, Irradiance, Pyranometer,

ACTIVITY LENGTH
1-2 class period(s) (~55 minute class period) depending how in-depth you would like your students to explore this topic.

LEARNING GOAL(S)

1. Using a Vernier Pyranometer, students will measure electromagnetic radiation in watts per square meter (W/m^2).
2. Students will compare Sunlight irradiance with various indoor lighting options.
3. Students will make a recommendation as to the optimum indoor lighting for powering solar panels.

CONTENT BACKGROUND

STUDENT BACKGROUND

If students are conducting their own tests they will need to be familiar with the Vernier LabQuest2 and whichever connection option you choose to use, whether it is their GoDirect or Labquest model. Students need instruction on how to use the Pyranometer and what the measurements mean for the various light readings. This may require a discussion of Watts.

EDUCATOR BACKGROUND

Educators should be familiar with

- Vernier LabQuest2 or GoDirect interfaces
- How to use a Vernier Pyranometer and understand what exactly is being measured
- Irradiance: https://en.wikipedia.org/wiki/Solar_irradiance
  Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. The solar irradiance integrated over time is called solar irradiation, insolation, or solar exposure. If an educator would like an

even more in-depth analysis, it is perhaps worth comparing this to lumens as a unit, which only measure particular wavelengths of the spectrum.

- Electromagnetic Spectrum- A good short video on the Sun's energy, PBS NOVA's Electromagnetic Spectrum primer: https://www.pbs.org/video/nova-the-electromagnetic-spectrum/

  Visible light Spectrum: the portion of the electromagnetic spectrum that is visible to the human eye.

MATERIALS NEEDED

HANDOUTS / PAPER MATERIALS

- Student Engineering Notebooks and/or,
- Lesson 5: Light Source Efficiency worksheet

CLASSROOM SUPPLIES

(Materials for a Lab Station if you only have one LabQuest2 and Pyranometer)

- 1-LabQuest2
- LabQuest App
- Vernier Pyranometer
- 2 Volt Solar Panel
- 2 wire leads with clips
- Various lights (fluorescent light, halogen light, incandescent lights, light-emitting, diodes)
- Light stand (s)

ACTIVITY SUPPLIES (PER EVERY 2 STUDENTS)

- If you have more than one Labquest2 and Pyranometer:
- LabQuest2
- Vernier Pyranometer
- 2 Volt Solar Panel
- 2 wire leads with clips
- 1 each of various lights (fluorescent light, halogen light, incandescent bulbs, light-emitting, diodes)
- 1-Light stand
- Access to outdoors for Sun data.

LESSON PROGRESSION

PLANNING AND PREP

Be sure to go over the Vernier Pyranometer settings prior to teaching this lesson. The preset data collection is set for measuring the Sun's irradiance for a longer period of time. Since the indoor lights are constant, a shorter data run of 5 min. is adequate.

LESSON SEQUENCE

PART 1 – LIGHT SOURCE EFFICIENCY INTRODUCTION

1. **(5 min)** Engage students by asking them to predict the irradiance of the Sun (1361 W/m^2 = the average annual solar radiation at the top of the Earth's atmosphere and 1000 W/m^2 =maximum normal surface irradiance at approximately at sea level on a clear day). They will need a bit of

context during the questioning process, so perhaps provide them the irradiance of several types of bright lights. Examples could be a classroom pet's heat lamp, a lighthouse bulb, LED bike lights, etc.

2. **(2 min)** Show the short NASA video on measuring the Sun's irradiance:

   NASA Measures All the Sun's Energy to Earth:
   https://www.youtube.com/watch?v=GKLU8YHSnlc

PART 2 – PYRANOMETER LAB

1. **(10-15 min)** Go over the "**Light Source Efficiency Worksheet**" and discuss why and how to use the Vernier LabQuest2 and Pyranometer.
   Be sure to demonstrate the changes to the LabQuest settings. Demonstrate a two-minute reading using the classroom presentation projector as a light source or another available light source.

   Have students add this reading to their data table.

2. **(20-25 min)** Students conduct the lab at an individual lab station containing a different sources of light (if only one set up is available) or partner stations depending on the amount of available LabQuest2 and Pyranometers. Students record data on their worksheets or directly in their Engineering Notebooks – add their worksheets to Engineering Notebooks at the end of class.
3. **(5-10 min)** Discuss irradiance readings and conclusions. Have students write out their recommendations to the director of the Children's Technology Museum as to what light would be best for the solar display.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENT

- Teachers can assess recorded answers to questions and accuracy of data recording or findings in student Engineering Notebooks or on the "**Lesson 5: Light Source Efficiency Worksheet**."
- Observe how students are using the Pyranometer and discuss findings as students take readings.

SUMMATIVE ASSESSMENT

For a short summative assessment, students will write a short response as to which type of lights they feel should be installed in the Children's Technology Museum. This can be used to assess student understanding of the irradiance lab.

LESSON EXTENSIONS

Have students read or generate questions after looking at the following articles:

- NASA article about the concept of Solar Irradiance:
  https://www.nasa.gov/mission_pages/sdo/science/solar-irradiance.html

- NASA article and short video about TSIS, the Total and Spectral Solar Irradiance Sensor, that is helping research the Earth-Sun connection and improve climate models: https://climate.nasa.gov/news/2659/four-decades-and-counting-new-nasa-instrument-continues-measuring-solar-energy-input-to-earth/