Physics Daily Lesson Plan
By Jonathan Linley

Concept / Topic To Teach: (What will the student know/be able to do by the end of class?)	**<u>All students:</u>** During this lesson, Students will investigate factors affecting the efficiency of a photovoltaic cell. **<u>TAG/PreAP students:</u>** Students design a lab to find the optimal wavelengths of light for various types of solar cells.
Standards Addressed: (summarize)	(7) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to: (A) examine and describe oscillatory motion and wave propagation in various types of media; (B) investigate and analyze characteristics of waves, including velocity, frequency, amplitude, and wavelength, and calculate using the relationship between wavespeed, frequency, and wavelength; (C) compare characteristics and behaviors of transverse waves, including electromagnetic waves and the electromagnetic spectrum, and characteristics and behaviors of longitudinal waves, including sound waves (8) Science concepts. The student knows simple examples of atomic, nuclear, and quantum phenomena. The student is expected to: (A) describe the photoelectric effect and the dual nature of light; (B) compare and explain the emission spectra produced by various atoms; (C) describe the significance of mass-energy equivalence and apply it in explanations of phenomena such as nuclear stability, fission, and fusion; and (D) give examples of applications of atomic and nuclear phenomena such as radiation therapy, diagnostic imaging, and nuclear power and examples of applications of quantum phenomena such as digital cameras.
Required Materials:	• **INB** • Multiple types of Photovoltaic Cells • Ruler • Protractor • Sun lamp • Multi-meter • Diffraction grating

	• Gloves
Anticipatory Set (Lead-In):	Review prior knowledge about solar energy. Have several demonstrations set up showing photovoltaic cells powering machines (i.e. robot, clock, calculator, yard light, etc.).
Step-By-Step Procedures:	• Pass out **Photovoltaic Lab sheet** (1 per student) • Review **Problem** with students • Read **Information** to students o Give students 1-2 minutes to discuss in groups • Have students complete **Hypothesis** • Go over **Materials** to ensure students understand what each item in the lab is and how to use the materials. **Review lab safety procedures with students.** • Explain the **Experiment** procedures and how to record **Results**. • As each group finishes, have students answer **Conclusion** questions. • Clean up lab station
Closure (Reflect on Anticipatory Set): (wrap up the lesson)	**Lesson Closure** Have students discuss in groups the significance of the P-N junction and its potential current and future effects on modern life.
Assessment Based On Objectives: (how will I know what they have learned today?)	Teacher observation INB entries Lab sheet
Adaptations (For Students With Learning Disabilities):	• Assist the student in finding effective peer note takers from the class. • Provide the student with a copy of your lecture notes or outline. • Allow the student additional time to complete in-class assignments, particularly writing assignments. • Provide feedback and assist the student in planning the workflow of assignments. • Break the larger assignment into smaller components with opportunities for draft feedback. • Provide assistance with proofreading written work. • Shorter reading and writing assignments, or an alternate assignment • Working in a small group, or peer tutoring • Working one-on-one with the teacher • Reducing the difficulty of assignments • Allowing answers to be given orally or dictated • Adapted materials—large print, or highlighted notes

	• Collaboration/consultation among staff, parents, and/or other professionals
Modifications for ELL	• Pre-teach vocabulary • Allow extra time for written responses • Group heterogeneously
Extensions (For Gifted Students): those identified and those not identified	Students will research and report on current Photovoltaic research focusing on one or two approaches to increasing efficiency. Report can be written, oral, poster, digital, etc.
Possible Connections To Other Subjects: (specific)	X MATH X SCIENCE O SOCIAL STUDIES - Historical Timelines/photos X LANGUAGE ARTS – Reading/writing X TECHNOLOGY & DESIGN CYCLE – Research and Report O ELECTIVES O OTHER _________

Photovoltaic Cell Lab

Problem: How do wavelength and cell type effect the efficiency of a photovoltaic cell?

Information: Photovoltaic cells produce electricity by converting light energy into electrical energy. Photons enter the photovoltaic cell and excite electrons in the n-type material. These electrons move away from the n-type material towards the p-type material. The flow of these electrons is electrical current (DC current).

Hypothesis: Different types of photovoltaic cells show peak efficiency at different wavelengths of light.

Secondary Objective: Find the ideal range of wavelengths for a photovoltaic cell.

Experiment:

Materials:

2 or more types of Photovoltaic cells, sun lamp, light filter (can be a piece of cardboard with a 2 mm slit cut to let just a small wavelength range through), diffraction grating, ruler, multi-meter, and protractor.

Experiment Steps: Clean the photovoltaic cell. Connect the multi-meter to the photovoltaic cell. Set sun lamp at six inches directly above the photovoltaic cell and turn on (Safety note: the sun lamp will get extremely hot). Take a reading of the voltage produced by the cell and record your results in table 1.

Place the diffraction grating in front of the solar lamp. Place the solar cell such that the entire spectrum is on the cell. Place the slit just before the red end of the spectrum begins. Take a reading of the voltage and record your results in table 1. Move the slit 2 mm and take and record the voltage again. Repeat this process all the across the spectrum until at least 1 measurement is outside the visible light range.

Repeat this process for each additional cell type.

Graph the results with voltage as the dependent variable (y-axis) and wavelength the independent variable (x-axis) on graph paper or using Excel.

Using the lamp with the slit about 6 inches from the PB cell rotate to a 10° angle to the PV cell. Take a reading of the voltage and record your results in table 2. In increments of 10° increase the angle up to 170° recording your voltage reading at each angle in table 2.

Repeat this process for each additional cell type.

Graph the results with voltage as the dependent variable (y-axis) and angle as the independent variable (x-axis) on graph paper or using Excel.

Results:

Table 1

	PV Cell 1	PV Cell 2	PV Cell 3	PV Cell 4
Full spectrum				
Infrared diffracted				
Diffracted measure 2				
Diffracted measure 3				
Diffracted measure 4				
Diffracted measure 5				
Diffracted measure 6				
Diffracted measure 7				
Diffracted measure 8				
Diffracted measure 9				
Diffracted measure 10				
Diffracted measure 11				
Diffracted measure 12				
Diffracted measure 13				
Diffracted measure 14				
Diffracted measure 15				

Table 2

	PV Cell 1	PV Cell 2	PV Cell 3	PV Cell 4
10°				
20°				
30°				
40°				
50°				
60°				
70°				
80°				
90°				
100°				
110°				
120°				
130°				
140°				
150°				
160°				
170°				

Conclusion:

1. **In each column, where was the greatest voltage recorded besides the full spectrum? Why do you think that the voltage was greatest at each of these points?**

2. **Given your data why do solar cells work better in some parts of the world than others?**