**Grade Level or Subject:** 9-12th grade Biology,Chemistry,Physics,Engineering/Technology

**Total Time Required:** 2- 3 weeks

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# **Lesson Objectives:** Students will be able to:

* Understand the design process through the design of a housing for charging a device.
* Use CAD 3D modeling to 3D print a portable charging station.
* Understand the connection between photosynthesis and photovoltaics (solar power) specifically how it moves electrons.
* Incorporate the facets of biomimicry and the ways that insects use to collect sunlight as the sun changes position by using bio-inspiration.

# **Science Standards and Standards for Technological Literacy:**

***Content specific***

STL (Standards for Technology Literacy)
 **5-G** - Humans can devise technologies to conserve water, soil, and energy through such

 techniques as reusing, reducing, and recycling.
 **9-I** - Established design principles are used to evaluate existing designs, to collect data,

 and to guide the design process.
 **11-Q** - Develop and produce a product or system using a design process.

**Indiana Academic Standard - Science Standards**

**B.2.1** Use a model to illustrate how photosynthesis transforms light energy into stored

 chemical energy.

***Other Standards (Math, Common Core)***

***Introduction to Design Process***

**IDP-1.1** Identify and describe the steps in the design process
 **IDP-3.3** Prepare working drawings including orthographic projections, isometrics, and

 perspective – using appropriate drawing styles and techniques

**IED – 5.9.7** Use the design principles and elements to meet the design criteria and

 constraints to solve a valid problem.

***Integrated Chemistry Physics***

**ICP.8.1** Describe electrical current in terms of the motion of electrons within a device

 and relate the rate of motion of the electrons to the amount of current measured.

**ICP.8.2** Describe the relationship among voltage, current, and resistance for an electrical

 system consisting of a single voltage source and a single device.

***Equipment, Materials and Tools***

|  |  |  |
| --- | --- | --- |
| Tools  | Materials  | Qty/group |
| soldering iron |  | 3-4/class |
| Wire stripper |  | 3-4/class |
| 3D Printer |  |  |
| 3D Modeling Software |  |  |
|  | solder tabbing wire - solder cells together | 1 roll |
|  | NiMh AA battery  | 2/group |
|  | Small Switch  | 1/group |
|  | AA battery holders with red/black wire | 1/group |
|  | USB Charger 0.9V-5V to 5V Power Supply  | 1/group |
|  | 1N914 diode | 1/group |
|  | Solar panel 10Pcs 5V 60MA Epoxy Solar Panel  | 1/group |
|  | Red and Black hook up wire |  |
|  | Double sided foam tape for sticking items to the housing | 1/group |

***Wiring Diagram for the solar charging station***



**Lesson Plan #1**

**Science Inquiry Investigation: Guiding Question –**

How is harvesting solar energy for electricity similar to photosynthesis?

**Time:** 5 periods - 1/week

**Set Induction:** In what way is the process of a plants ability to convert solar energy into stored energy the way a cell phone is charged?

**Lesson objectives:**

 1. Students will understand the process of photosynthesis (specifically, the light reaction).

 2. Students will understand how photovoltaic cells (solar cells) work.

 3. Students will be able to produce a professional looking display board and 5 to 7 minute

 informational video explaining how photosynthesis and photovoltaics are related.

 4. Students will explain how utilizing these processes can be used to produce a solar

 charging station.

 **See Appendix E**

**Procedures / Steps: (Include and/or number the steps or procedures to follow. Note key questions for students to consider / discuss)**

 1. One period of lecture & research increasing knowledge base on the electron flow of

 light reaction in photosynthesis. **See Appendix E**

<https://youtu.be/KfvYQgT2M-k>

 At the end of day one, students should be able to:

- describe the charge of an electron

- describe where electrons are coming from (H2O), where they are going

 (NADP+), and why they are moving (drawn toward NADP+)

- explain what the electrons are used for (powering H+ pumps to generate H+

 concentration gradient)

- differentiate between an electron donor and an electron acceptor

- explain how the light reaction captures and converts solar energy (absorption by

 chlorophyll electrons and conversion to NADPH and ATP)

2. One period of lecture & research increasing knowledge base on electron flow of

photovoltaic cells. **See Appendix E** <https://www.youtube.com/watch?v=xKxrkht7CpY>

 <https://youtu.be/UJ8XW9AgUrw>

At the end of day two, students should be able to:

 - explain how the photoelectric effect produces photoelectrons

 - differentiate between N-type and P-type layers of a solar cell

 - explain why electrons move in the path they do

 3. One period research & brainstorming the light reaction & photovoltaic cells for poster

 & video material.

4. Two periods working on poster display & video

Closure/ Review

1. The process of photovoltaics can be described as biomimicry in action when compared

 with photosynthesis.

2. The flow of electrons in the thylakoid membrane is critical to storing solar energy

 collected from the sun.

3. The flow of electrons in the photovoltaic cell is critical to storing solar energy

 collected from the sun.

**Lesson Plan # 2**

**Science Inquiry Investigation: Guiding Question – How does our solar charger work?**

**Time**: 1 - 2 hours based on prior knowledge.

**Lesson Objectives**: Students will be able to:

1. Understand how photovoltaic cells work.
2. What is voltage, current, resistance and how all three are related (Ohm’s Law).
3. How to design the circuitry for their solar recharger.

**Set Induction**: Plants use photosynthesis to manufacturer their food from sunlight through the transfer of electrons. We copy this process to convert sunlight into electricity using solar cells. How can we use this knowledge to recharge our electronic devices.

**Procedures / Steps**: (Include and/or number the steps or procedures to follow. Note key questions for students to consider / discuss).

1. One hour lecture with activities explaining the various physics principles the students will utilize in the design of their solar recharger.
2. Discuss that a solar cell operation is based on the principle known as the “photoelectric effect.” Basically photons of light are able to knock electrons off of their atoms. These electrons are then funneled along a wire. This is the creation of electric current. Demonstrate this by going to <https://phet.colorado.edu/en/simulation/photoelectric>.
3. Discuss the concepts of: voltage, current, and resistance. See Appendix B. You can use the analogy of water flow for the students on which to scaffold. Independent Contract Plumbers (ICP) handout (Appendix G) can be used to assist in group and full class discussions.

4. Discuss how these three concepts are related through Ohm’s Law. See Appendix C.

5. Sample problems are provided in Appendix D.

6. Discuss the basics of an electrical circuit. Be sure to emphasize the difference between series and parallel circuits. You can use the following virtual lab to assist you. <https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab>.

7. Circuit construction lab located in Appendix E.

**Closure/ Review**

1. Photosynthesis and the photovoltaic cell are similar in that both utilize the photoelectric effect to generate an electrical current.

 2. The 3 main aspects of an electrical current are voltage, current, and resistance.

 3. These 3 main aspects are mathematically related which is described by Ohm’s Law.

 4. Both types of circuits, series and parallel, are used in creating the solar recharger.

**Lesson Plan # 3**

 **Creating a portable charger.**

**Designing a case for Portability:**

**Guiding Question – How can we create a portable housing to protect the components of the solar charger?**

**Time:** 1 week

**Set Induction:**

How do engineers prove their ideas? Can you explain a complex object without its visualization?

**Lesson Objectives:**

1. Create an innovative design using multiple sketches and a decision matrix after observing bio-mimicry and how it applies to solar energy using the design process.
2. Print the designed portable charger model using a 3D printer

**Procedures / Steps:** (Include and/or number the steps or procedures to follow. Note key questions for students to consider / discuss):

1. Brainstorm different ideas to house the components of the portable solar charger.
	1. Purge original thoughts and designs
	2. Give students complements and make designs that will be compatible with the housing
	3. Introduce how different insects use the sun through biomimicry and protect fragile features on their body.
	4. Research prior charging stations
	5. Student will choose their design with the help of a decision matrix (Appendix F).
	6. Create final design sketch
2. Student teams work with computers and parametric modeling software to design the housing components.
3. Student teams note the density of the housing on parametric modeling software to calculate cost of production.
4. Student teams then solder and assemble a 3D printed housing.
5. Student test and evaluate the effectiveness of their chargers.
	1. Students pre-test the power of their solar charger when not in the sun with a multimeter. (Volts)
	2. Place the charger in the best solar oriented position for a set time
	3. Students post-test the power of their solar charger after its been in the sun with a multimeter. (Volts)
	4. Students record the effectiveness of their solar chargers.

**Closure/ Review:**

1. Teacher asks students to share and reflect any unexpected events that occurred during the prototyping process.
2. Steps of the design process
3. CAD 3D modeling - 3D Printing

Assessment

The following are possible sources of formative and summative assessment:

Formative Assessments

1. Lesson 1: Presentation of Photosynthesis
2. Lesson 2: Presentation of how the circuit
3. Lesson 3: Decision Matrix

Summative assessments

1. Pre/post knowledge test
2. Peer review rubric
3. Class Presentation

TRAILS Lesson Resources:

**Activity Extensions:**

How do solar cells work? <https://youtu.be/UJ8XW9AgUrw>

How do solar panels work? <https://youtu.be/xKxrkht7CpY>

**Web Resources:**

Online circuit creator:

TinkerCad Circuits: <https://www.tinkercad.com/#/?type=circuits&collection=designs>

Photoelectric Effect Simulation: <https://phet.colorado.edu/en/simulation/photoelectric>

# Circuit Construction: <https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc>

Online Parametric Modeling Software (online option):

Fusion 360: <https://www.autodesk.com/products/fusion-360/students-teachers-educators>

 TinkerCad Design: <https://www.tinkercad.com/>

Other Resources:

Design Brief

*Scenario:* Current portable solar chargers require continuous reorientation to remain pointed at the sun. Additionally, they are vulnerable to impact and abrasion damage while being carried. Your task is to design a portable solar charger that can absorb sunlight with minimal manual readjustment and a housing that will protect when being transported. Explore natures approaches to absorbing sunlight for sources of design inspiration. Your design must incorporate 3D printing, and a function inspired by nature.

*Your Task:* You and your research team are required to research all about solar cells, recharging electronic devices, and electronic charging stations. With this information you are to design a housing for portable charging components to be used with your electronic device.

*Where do you begin?*: Start with a KWHLAQ report. What do you know about photosynthesis solar energy, how energy works to charge your phone? This will help you begin to consider what information you will need to collect and how you will collect it.