Name: Date: Class:

Engineering Notebook

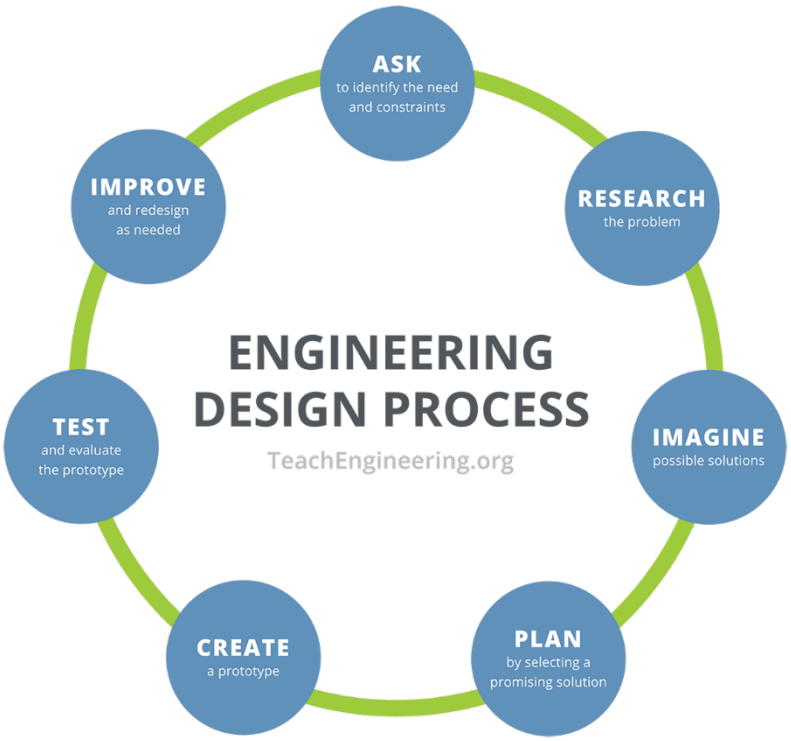
Part 1: Ask, Research, and Imagine

Pre-Assessment Question

Which fruit or vegetable do you think will produce the most voltage? *Mark your response with an X.*

1. raspberries ___
2. spinach ___
3. blueberries ___
4. cherries ___
5. blackberries ___

Engineering Design Process



Ask

What question are we trying to solve?

Name: **Date:** **Class:**

Research
What three things did you learn from the videos?
What do you still wonder after watching the videos?
Imagine
What types of dyes do you think would work the best/have the highest voltage?

Name: **Date:** **Class:**

Part 2: Plan and Create

Plan
Our group will test the dye from _____.   We think our dye will…

Instructions:

1. Gather your fruit or vegetable and other materials.
2. Put on your personal protective equipment (PPE).
3. Prepare your dye by mashing your fruit/vegetable in a zip lock bag or by first using a mortar and pestle and then transferring the liquid to a zip lock bag. (Ask your teacher if you need help deciding which smashing method to use.)
4. Carefully place the conductive glass with the TiO_2 coating into the bag with the crushed fruit or vegetable juice. Allow the glass to sit in the bag for 3-5 minutes.
5. Take the second piece of conductive glass and determine which side is conductive by using the multimeter with its setting placed on resistance (Ω). (Hint: The conductive side gives a non-zero multimeter reading.)
6. Color the conductive side of the glass using a #2 pencil.
7. Use tweezers to take out the conductive glass that was dyed. Only touch the edges of the glass!
8. Use a squirt bottle of water to gently rinse the excess fruit residue off the glass.
9. Place the dyed glass on a paper towel.
10. Gently dab the glass with a paper towel to dry.
11. Assemble the solar cell by sandwiching the graphite side of the conductive glass with the dyed side, making sure that the two pieces are offset/staggered with the edge of the paste to expose as much glass slide as possible and to cover the entire TiO_2 surface.
12. Place a binder clip with the two edges that are flush (e.g., where the two slides meet up on the long side.)

Sketch what your solar cell looks like here. Make sure to label where the following are located: TiO_2 paste, graphite coating, binder clips, and dye.

Name: **Date:** **Class:**

Part 3: Test

Instructions:

1. Put on your PPE.
2. Wait for the teacher to put a small amount of electrolytes on your cell.
3. Place the multimeter probes on opposite ends of the solar cell's conductive glass slides.
4. Place your solar cell under either sunlight or a flashlight.
5. Use the multimeter to test your cell.
   a. Set the multimeter to measure electric potential.
   b. Record your measured voltage in mV in the table below.
   c. Repeat Steps a and b two more times.
6. Calculate the average voltage of your three measurements.
7. Add your group's information to the Class Results Table on the board.
8. Update the Class Results table below with your classmates' results.

Test: Measurements			
Measurement #1: Voltage (mV)	**Measurement #2: Voltage (mV)**	**Measurement #3: Voltage (mV)**	**Average Voltage**

Class Results Table		
Student Group	**Fruit/Vegetable Tested**	**Voltage Results (mV)**

Name: Date: Class:

Evaluate
Instructions: Answer the following questions. 1. What worked in your solar cell? 2. What did not work in your solar cell? 3. What changes could be made to your solar cell to improve the voltage produced? 4. Would a different dye color work better? Why?

Improvement Ideas		
What improvements do I want to see?	**What ideas do I have?**	**Research notes**

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Part 4: Improve

Solar Cell Improvement	
What variable did we change?	**Why?**

Re-Test: Measurements			
Measurement #1: Voltage (mV)	**Measurement #2: Voltage (mV)**	**Measurement #3: Voltage (mV)**	**Average Voltage**

Exit Ticket
Write and explain whether your hypothesis was correct. What changes would you make to further improve your solar cell?