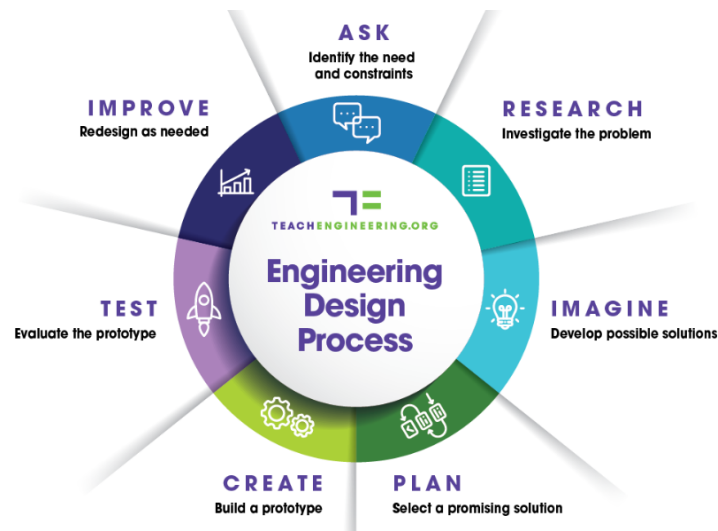


Name:

Date:

Class:

Create a Capacitor Engineering Design Packet **Answer Key**



Ask: Define the Problem

Instructions: Write complete answers to the following questions.

1. In your own words, describe the task you are trying to accomplish. (*What are you being asked to design, and why?*)

Answers will vary. Potential answer: We are being asked to design and build a capacitor that can store as much electrical charge as possible. The goal is to experiment with different materials and designs to see how changes affect the capacitance.

2. What are the variables or parameters that you can change in your design? (*Think about materials, measurements, spacing, etc.*)

Potential answers:

- Plate area: the size of the metal plates or foil
- Plate separation distance: how far apart the two plates are
- Dielectric material: the type of material or electrolyte between the plates
- Shape of electrodes: rectangular, cylindrical, or foil-wrapped block
- Orientation or stacking of plates (if applicable)

3. How do you predict changing these parameters will affect the capacitance? Why do you think so? (*Use evidence from your prior learning or observations.*)

Potential answers:

- Increasing plate area should increase capacitance because larger plates can hold more charge.
- Decreasing the distance between plates should increase capacitance because charges are closer together and attract more strongly.

Name:

Date:

Class:

- Changing the dielectric material can increase or decrease capacitance depending on its ability to store charge (its permittivity).
- Changing the shape of electrodes may slightly affect capacitance because it changes the effective surface area and how charges distribute.

Research: Learn about the Problem

Instructions: Complete the table using your own words.

| Term | Definition (In Your Own Words) |
|---------------------------|--|
| capacitor | A device that stores electrical charge and energy between two conductive plates separated by an insulating material. |
| electric charge | A property of matter that causes it to experience a force in an electric field; measured in coulombs. |
| electron | A negatively charged particle that moves through a conductor to create electric current. |
| voltage (V) | The electric potential difference between two points; it pushes charges through a circuit. |
| current | The flow of electric charge through a conductor; measured in amperes (A). |
| capacitance (C) | A measure of how much charge a capacitor can store for a given voltage; measured in farads (F). |
| farad (F) | The unit of capacitance; 1 farad means a capacitor stores 1 coulomb of charge per 1 volt of potential difference. |
| electrode | A conductor that allows electric current to enter or leave a device, such as the plates of a capacitor. |
| plate area | The surface area of the capacitor's conductive plates; larger areas can store more charge. |
| plate separation distance | The distance between the two plates of a capacitor; smaller distances increase capacitance. |
| dielectric | An insulating material placed between capacitor plates to increase capacitance and prevent direct conduction. |
| electrolyte | A liquid or gel that conducts electricity; can be used as a dielectric in some capacitors. |
| electric field | The region around a charged object where other charges experience a force; exists between capacitor plates. |
| discharge | The process of releasing stored charge from a capacitor. |

Name:

Date:

Class:

| Term | Definition (In Your Own Words) |
|------------|---|
| LCR meter | A device that measures L (inductance), C (capacitance), and R (resistance) of a component. |
| multimeter | A device that can measure voltage, current, resistance, and sometimes capacitance in a circuit. |

Name:

Date:

Class:

Research: Construct a Capacitor

Instructions: Gather the appropriate materials and then follow the directions below to construct a capacitor.

Materials:

- 2 cups
- 1 ruler
- 1 tape (masking or clear)
- 1 scissors
- aluminum foil (30 cm × 30 cm)
- 2 metals from the class supply area
- 2 electrolyte solutions from class supply area
- (optional) 1 small wooden block
- (optional) 1 small rock

Part 1: Constructing the Capacitor

1. Wrap aluminum foil around one cup so that it completely covers the outside in a single layer.
 - a. Use scissors to trim the foil to fit neatly.
 - b. Remove the foil, lay it flat, and measure its length and width.
 - c. Record your measurements in your data table.
2. Re-wrap the foil around the cup. Secure it with tape if needed.
3. Fill the cup 75-90% with one of the electrolyte solutions.
4. Record which electrolyte you used in your data table.
5. Prepare your second metal electrode:
 - a. If using foil, wrap it around a wooden block. Cut it to size, then measure and record its length and width.
 - b. If using a cylinder, measure and record its diameter and height.
 - c. If using a rectangular strip, measure and record its length and width.
6. Once measured, place the metal electrode in the center of the cup, making sure it does not touch the aluminum foil.

Part 2: Measuring Capacitance

7. Measure the distance between the outer foil and the center metal electrode. Record this value.
8. Use the LCR meter to measure the capacitance of your capacitor. Record your measurement.

Part 3: Reflecting and Revising

9. Choose one parameter to change (area, distance, or electrolyte material).
 - a. Make a prediction about how this change will affect capacitance.
 - b. Record your prediction in your data table.
 - c. Change only one variable at a time.
10. Perform at least two trials for each parameter you choose to change.

Name:

Date:

Class:

Imagine: Develop Potential Solutions

Instructions: Based on your experimental data, propose design solutions that could maximize capacitance. You may use available materials, modify them, or create new design components.

Sketch **FOUR** different design solutions below. Make sure to label parts and materials.

| | |
|---------------------------|--|
| <p>Answers will vary.</p> | |
| | |

Name:

Date:

Class:

Plan: Select a Solution

Instructions: Have each team member share their brainstormed design ideas. As a team, select ONE solution that you believe will store the greatest amount of electrical charge (i.e., maximize capacitance).

In the space below, draw and label your team's final design. Be sure to include:

- Clearly labeled parts and materials.
- Predicted measurements (before building).
- Final measured values (after building).

Answers will vary.

Name:

Date:

Class:

Create: Build the Prototype

Instructions: Use your final design plan to construct your optimized capacitor. Update the plan above with the prototype's final measured values.

Test: Measure Capacitance and Collect Data

Instructions: Test the capacitance of your prototype using the same procedure as before.

1. Set up your capacitor for testing
 - a. Connect the two leads of your LCR meter (or multimeter with capacitance function) to the capacitor plates.
 - b. Make sure the inner metal electrode does not touch the outer foil.
2. Measure capacitance
 - a. Record the capacitance in the table below.
 - b. Repeat the measurement at least two times to ensure accuracy.

Dielectric Used: _____

| Metal Identity | Length or Diameter | Width or Height | Surface Area | Separation Distance | Capacitance |
|----------------|--------------------|-----------------|--------------|---------------------|-------------|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Analyze: Reflect on performance and compare to predictions

Instructions: Answer the following questions.

1. Does your capacitor perform as expected?

Answers will vary depending on the student design. For example, if the plates were close together with a large area and a high-permittivity dielectric, the capacitor may perform as expected.

Name:

Date:

Class:

2. Did the measured capacitance match your predictions?

Answers will vary. Students may notice that increasing plate area or decreasing separation increased capacitance, matching predictions, or some designs may differ slightly due to measurement errors.

3. Identify any design factors that might improve performance.

Answers will vary. Examples: using a dielectric with higher permittivity, increasing plate area, reducing separation distance, or improving alignment of the electrodes.

Reflect & Redesign: Iterate to improve the design

Instructions: Answer the following questions.

4. What changes could you make to increase capacitance further?

Answers will vary. Examples: use larger plates, decrease the distance between plates, use a different dielectric material, or stack plates in parallel.

5. Draw or describe a modified design and explain why you think it would work better.

Answers will vary. Example answer: I would make the plates twice as wide and use a thin piece of saltwater gel as the dielectric. This would increase surface area and improve the dielectric constant, increasing capacitance.