Student Worksheets

PARALLEL-PLATE CAPACITOR

Physics Class XII (F Phase)

with Guided Inquiry Model

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PARALLEL-PLATE CAPACITOR

Group Identity

Group

Member

Learning Outcomes

Students are able to apply the concepts and principles of vectors, kinematics and dynamics of motion, fluids, and the phenomena of sound and light waves to solve problems, as well as apply the principles and concepts of heat and thermodynamics, including their various transformations in heat engines. **Students are able to apply the concepts and principles of electricity** (both static and dynamic) and magnetism in various problem-solving scenarios and technological products, and apply the concepts and principles of electromagnetic waves in solving problems. Students are able to understand the principles of logic gates and their application in computer systems and other digital computations. Students are able to analyze the relationships between various physical quantities in the theory of special relativity and quantum phenomena, and demonstrate the application of concepts in nuclear physics and radioactivity in everyday life and technology.

Experiment Objective

1. Determine the factors that affect the capacitance of a parallel-plate capacitor through virtual investigation.
2. Analyze the relationship between plate area (A), plate distance (d), and dielectric material (ε) on capacitance (C).
3. Formulate the mathematical equation of capacitance $C = \varepsilon \cdot A / d$ based on experimental data.

Syntax 1: Orientation

Instructions: Watch the video below!

Video 1. Testing different ways to tap a phone screen
https://youtu.be/nM4WES3vTSA

In the video, three different objects are seen being used to touch the phone screen, but they all produce different results. One object makes the screen move, while the other doesn't respond at all. Yet, all three touch the screen in nearly the same way.
Why does this happen? What allows a finger and stylus to "communicate" with the screen, while a plastic pen cannot?

This phenomenon demonstrates that there is a physical concept underlying how touchscreens work. In this lesson, you will explore the concept of parallel-plate capacitors to investigate how it can be used to explain capacitive touchscreen phenomena.

After observing, answer the following questions:

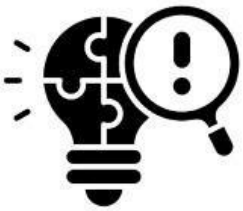
1	What makes a cell phone screen react to finger touch, but not to a plastic pen or glove?
2	What makes a special stylus pen able to click on the screen, even though it looks like a pen?

3	What physics concepts do you think are working behind the scenes of your phone?

Syntax 2: Problem Formulation

Based on the phenomena that have been observed, discuss with your group to formulate questions that will be investigated.

Write at least three problem formulations below!



Syntax 3: Hypothesis Submission

Write down your suspicions before carrying out an investigation!

Hypothesis

1. I suspect the capacitor's ability to store charge is influenced by: _____ because _____

2. I suspect the capacitor's ability to store charge is influenced by: _____ because _____

3. I suspect the capacitor's ability to store charge is influenced by: _____ because _____

Syntax 4: Data Collection

Learning Resources and Materials

1. Physics Touchscreen interactive learning media

SCAN HERE

https://physics-touchscreen-7yx4.vercel.app/

2. Smartphones/Laptops/Other Electronic Devices
3. Student Worksheet (LKM)

Investigation Procedures

1. Prepare a device (either cellphone or laptop) that has internet access
2. Open the Physics Touchscreen learning media, then select the Investigate menu and run the Virtual Capacitor Lab simulation.

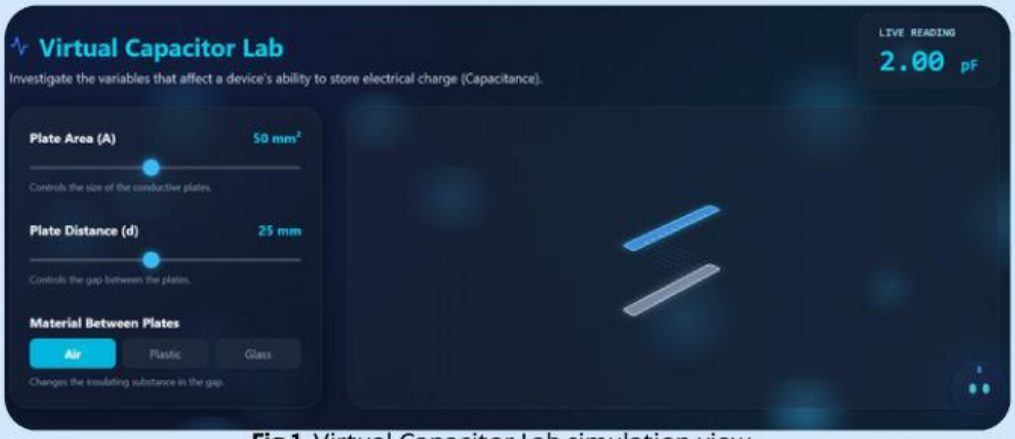


Fig 1. Virtual Capacitor Lab simulation view

3. Observe the variables that can be changed in the simulation, namely the area of the plates (A), the distance between the plates (d), and the type of dielectric material (ε).

4. Conduct an investigation by varying the plate area according to Table 1, while the distance between the plates is set at 25 mm and the dielectric material is air. Observe the change in capacitance (C) and record the results in Table 1.
5. Conduct an investigation by varying the distance between the plates according to Table 2, while the plate area is set at 50 mm2 and the dielectric material is kept constant, namely air. Observe the change in capacitance (C) and record the results in Table 2.
6. Conduct an investigation by varying the dielectric material type (water, plastic, glass), while the plate area is set at 50 mm2 and the distance between the plates is 25 mm. Observe the change in capacitance (C) and record the results in Table 3.
7. Compare all the observed data for use in the analysis stage.

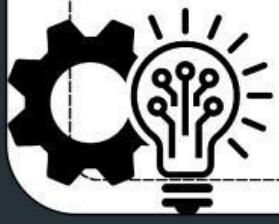
Observation data

Investigation 1

The Effect of Plate Area on Capacitance

Table 1. Observation Data of Plate Area Variation

No	d (mm)	Dielectric material	A (mm^2)	C (pF)	Description
1	25	Air	25		
2			50		
3			75		
4			100		



Investigation 2

The Effect of Inter-Plate Distance (d) on Capacitance

Table 2. Observation Data of Plate Distance Variation

No	Dielectric material	A (mm^2)	d (mm)	C (pF)	Description
1	Air	50	10		
2			20		
3			30		
4			40		

Investigation 3

The Effect of Dielectric Materials on Capacitance

Table 3. Observation Data of Dielectric Material Variation

No	d (m)	A (mm^2)	Dielectric Material	C (pF)	Description
1	25	50	Air		
2			Plastic		
3			Glass		

FYI

Each dielectric material has a different permittivity (ε) value. The permittivity value of a medium is studied in Coulomb's Law and is expressed by the equation::

$$\varepsilon = \varepsilon r \, . \, \varepsilon_0$$

where $\varepsilon_0 = 8{,}85 \times 10^{-12}$ F/m. In this activity, use the permittivity values of each dielectric material in the following table as a reference in conducting the investigation.

Table 4. Permittivity Values of Several Dielectric Materials

Dielectric Material	Nilai Permitivitas (ε) (F/m)
Air	$8{,}85 \times 10^{-12}$
Plastic	$2{,}04 \times 10^{-11}$
Glass	$4{,}43 \times 10^{-11}$

Syntax 5: Hypothesis Testing

Answer the following questions based on the data from the simulations you have collected!

1	Based on Investigation 1, how does the size of the plate relate to the capacitor's ability to store charge?

2	Based on Investigation 2, how does the distance between the plates relate to the capacitor's ability to store charge?

3	Based on Investigation 3, why does the change in material between the two plates affect the capacitor's ability to store charge?

4	Based on these three investigations, what factors influence the capacitor's ability to store an electric charge?

5	In physics, a capacitor's ability to store an electric charge is called capacitance. Based on your investigation, formulate a relationship between capacitance and the factors you've identified.

6 **Based on the results of the experiment, was your hypothesis accepted or rejected? Explain by citing evidence from the data!**

Hypothesis

☐ Accepted ☐ Rejected ☐ Partially Accepted

Explanation

Syntax 6: Conclusion Formation

Write down the conclusions you get based on the results of the experiment!

1. **Write a conclusion regarding the factors that influence the capacitance of a parallel plate capacitor.**

2. **Based on the concepts you have learned, explain again why a smartphone touchscreen can respond to finger touch and a capacitive stylus, but not to a regular plastic pen.**

Use the following terms in your answer: parallel plate capacitor, capacitance, permittivity, dielectric material, electric charge.

ENGINEERING CHALLENGE

Go to the "Engineering Challenge" page. Read and understand the problem!

Problem: It's winter, you're wearing thick gloves and trying to answer an emergency call, but your phone screen is unresponsive!

1. Why does this happen? (Relate to the concept of distance (d) and dielectric materials!)

2. As an engineer, what would you do to keep your gloves usable for clicking on your phone screen?

REFLECTION

Write down the conclusions you get based on the results of the experiment!

1. **What new concept did you learn today?**

2. **Which part helped you most understand how the touch screen works?**

3. **What concepts would you still like to learn more about?**