

Capacitors, energy storage and dielectrics

AP Physics C (Mechanics and E&M, calculus-based) · Lab

Name: _____ Date: _____ Class: _____

How does the separation of two plates change their capacitance, and what does that tell you about the paper between them? You will build a capacitor from foil and printer paper, add sheets one at a time, and use a multimeter to measure C , then analyse the straight-line graph.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:E&M Unit 10

Aim

Test how the capacitance of a foil-and-paper capacitor depends on plate separation, and use the data to estimate the dielectric constant of paper.

Equipment

- Two sheets of aluminium foil, each 20 cm × 10 cm, on thin card
- Printer paper, 20 cm × 10 cm sheets, up to five
- A multimeter with a capacitance range
- A heavy book or wooden board
- Ruler and micrometer or calipers (to measure a stack of 20 sheets)

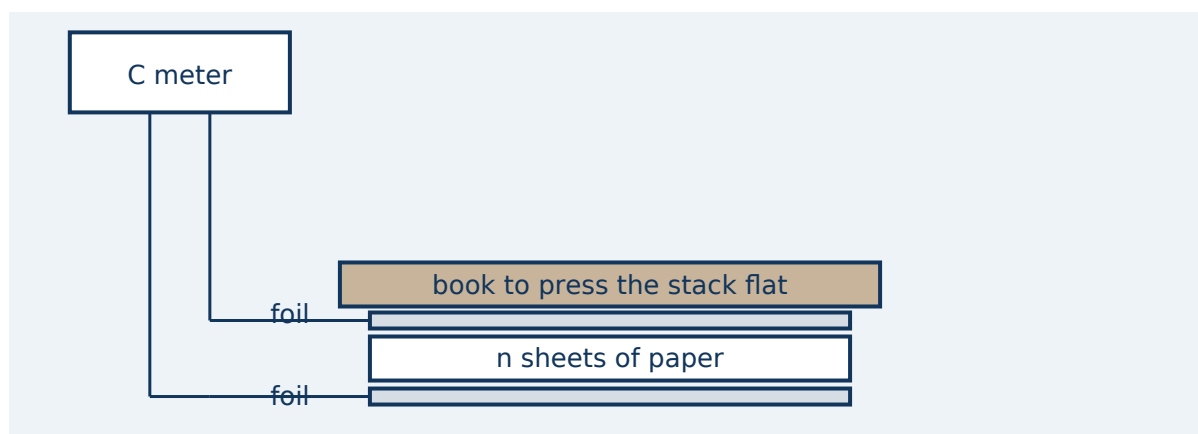
Safety

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No external voltage is used, only the meter. Foil edges can cut: handle the sheets by the card backing and trim any sharp corners.

Method

1. Measure the thickness of 20 sheets of paper and divide by 20 to find t , the thickness of one sheet.
2. Place one foil sheet flat, cover it with one sheet of paper and then the second foil sheet, leaving a tab of each foil outside the paper.
3. Press the stack flat with the book and connect the meter to the two tabs.
4. Read C once the display is steady, then repeat with 2, 3, 4 and 5 sheets of paper.
5. Zero the meter with open leads before each reading to remove stray capacitance.



Set-up: foil plates separated by n sheets of paper, pressed flat and measured with a capacitance meter.

Results

Sample measurements with $t = 0.10$ mm per sheet and plate area $A = 0.0200$ m²:

n (sheets)	1	2	3	4	5
C (nF)	4.6	2.4	1.6	1.2	0.95
$1/C$ (nF ⁻¹)	0.217	0.417	0.625	0.833	1.053

Analysis questions

Question 1 Linearise the data

Explain why plotting $1/C$ against n should give a straight line, then plot it.

Question 2 Gradient

Calculate the gradient of the $1/C$ against n graph in F⁻¹ per sheet.

Question 3 Dielectric constant

Use the gradient, t and A to estimate the dielectric constant of the paper.

Question 4 Air comparison

Calculate the capacitance expected for one sheet if the gap were air, and compare it with the measured value.

Question 5 Intercept

State what the graph's intercept should be and what a non-zero intercept would indicate.

Question 6 Uncertainty

The thickness of one sheet is 0.10 ± 0.01 mm and the gradient is known to 3 %. Estimate the uncertainty in κ .

Question 7 Reducing error

Propose two changes that would make the value of κ more reliable, and say why each helps.