

Capacitors, energy storage and dielectrics

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

The answers use the sample data above. Your values will differ because paper thickness, pressure and air gaps vary, but $1/C$ against n should still be close to a straight line through the origin, and κ should come out between about 2 and 4.

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

Question 1 Linearise the data

Since $C = \kappa \epsilon_0 A / (nt)$, $1/C = (t/\kappa \epsilon_0 A) n$, which is proportional to n . The plotted points **fall on a straight line** close to the origin.

Question 2 Gradient

Gradient = $(1.053 - 0.217)/4 = 0.209 \text{ nF}^{-1}$ per sheet = **$2.09 \times 10^8 \text{ F}^{-1}$** per sheet.

Question 3 Dielectric constant

$\kappa = t/(\text{gradient} \times \epsilon_0 A) = (1.0 \times 10^{-4})/[(2.09 \times 10^8)(1.77 \times 10^{-13})] = 1.0 \times 10^{-4}/3.70 \times 10^{-5}$, so **$\kappa \approx 2.7$** .

Question 4 Air comparison

$C(\text{air}) = \epsilon_0 A/t = (1.77 \times 10^{-13})/(1.0 \times 10^{-4}) = 1.77 \text{ nF}$. The measured 4.6 nF is about **2.6 times larger**, consistent with κ near 2.7.

Question 5 Intercept

The line should pass through the origin because $1/C \rightarrow 0$ as $n \rightarrow 0$. A positive intercept in C would show **stray capacitance or air gaps** adding to the reading.

Question 6 Uncertainty

Fractional uncertainty in t is 10 % and in the gradient 3 %, so about 10.5 % in κ , giving **$\kappa = 2.7 \pm 0.3$** .

Question 7 Reducing error

Pressing the stack under a heavier board squeezes out air pockets, and measuring 20 sheets

at once cuts the thickness error. Both make **t** and **C** more trustworthy.