

Flux, Gauss's law and continuous charge

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

Model answers use the sample data in the table. Your points should lie close to a straight line through the origin, and the charge on the ball will be of the order of nanocoulombs. State the uncertainty and mention that charge leakage can curve the line.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:E&M Unit 8

Question 1 Check the table

$\tan\theta = x / \sqrt{(L^2 - x^2)} = 0.100 / \sqrt{(0.360 - 0.0100)} = 0.100 / 0.5916 = \mathbf{0.169}$, as in the table.

Question 2 Why $E = V/d$

A Gaussian pillbox around the surface of one plate encloses charge σA and has flux EA only through the face in the gap, so $E = \sigma/\epsilon_0$. The field is the same everywhere between the plates, so $V = E d$ and $\mathbf{E = V/d}$.

Question 3 Equilibrium condition

Forces on the ball: tension T , weight mg and electric force qE . Resolving, $T \cos\theta = mg$ and $T \sin\theta = qE$. Dividing, $\mathbf{\tan\theta = qE / (mg)}$.

Question 4 Charge on the ball

Gradient = $(0.213 - 0.042) / (6.25 \times 10^4 - 1.25 \times 10^4) = 3.4 \times 10^{-6} \text{ C/N}$. Then $q = \text{gradient} \times mg = 3.4 \times 10^{-6} \times 1.2 \times 10^{-4} \times 9.81 = \mathbf{4.0 \times 10^{-9} \text{ C}}$.

Question 5 Surface charge density

$\sigma = \epsilon_0 E = 8.85 \times 10^{-12} \times 6.25 \times 10^4 = \mathbf{5.5 \times 10^{-7} \text{ C/m}^2}$.

Question 6 Uncertainty

Percentage in $x = 2/125 = \mathbf{1.6 \%}$. The gradient depends on the same readings, so the charge is uncertain by about 2 %, plus any error in d and in the ball mass.

Question 7 Improving the experiment

The charge leaks away in humid air and edge effects make the field non-uniform near the plate edges. **Work in dry air, charge the ball just before the run and use larger plates with the ball near the centre.**