

Charging objects and the force between charges

AP Physics 2 (algebra-based) · Lab answers

The sample readings give a gradient near $3.6 \times 10^{-6} \text{ N}\cdot\text{m}^2$ and a charge of 20 nC. If your own data differ, check that your graph is straight and passes through the origin, and show every conversion into SI units.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 10

Question 1 Convert to force

$F = \Delta m g$. At 3.0 cm: $0.405 \times 10^{-3} \times 9.81 = \mathbf{3.97 \times 10^{-3} \text{ N}}$. At 8.0 cm: $0.058 \times 10^{-3} \times 9.81 = \mathbf{5.7 \times 10^{-4} \text{ N}}$.

Question 2 Calculate $1/r^2$

$r = 0.080, 0.060, 0.050, 0.040, 0.030 \text{ m}$ gives $1/r^2 = 156, 278, 400, 625$ and $\mathbf{1111 \text{ m}^{-2}}$. Corresponding forces are $5.7 \times 10^{-4}, 9.9 \times 10^{-4}, 1.46 \times 10^{-3}, 2.24 \times 10^{-3}$ and $3.97 \times 10^{-3} \text{ N}$.

Question 3 Plot and describe

The points lie close to a straight line through the origin, so **F is proportional to $1/r^2$** , in agreement with Coulomb's law.

Question 4 Gradient

Gradient = $3.97 \times 10^{-3} / 1111 = \mathbf{3.6 \times 10^{-6} \text{ N}\cdot\text{m}^2}$. It equals kq^2 , the constant in $F = kq^2/r^2$.

Question 5 Charge on a sphere

$q^2 = 3.6 \times 10^{-6} / 8.99 \times 10^9 = 4.0 \times 10^{-16} \text{ C}^2$, so $q = \mathbf{2.0 \times 10^{-8} \text{ C}}$ (20 nC).

Question 6 Testing the power law

$n = \ln(3.97 \times 10^{-3} / 5.69 \times 10^{-4}) / \ln(8.0 / 3.0) = 1.944 / 0.981 = \mathbf{1.98}$, which is very close to 2.

Question 7 Sources of error

Charge leaks into humid air, so the force falls over time and the readings are **too low**. The

charged sphere above also induces charge on the balance pan, changing the force.
Improvement: work quickly in dry air and recharge between readings.