B2 · Extra practice

Worked solutions | Items 1-2

Extra practice for this lesson. Original questions, not released diploma items. Select one option for multiple choice; other tasks state the required response.

Use $k = 8.99 \times 10^9$ N·m²/C² and $g = 9.81$ m/s² where needed (Alberta Physics 30 data sheets, Constants). For numerical responses, use the stated unit or coefficient and precision. Work in degrees.

B2-D01 · Multiple choice

The force between two charges is F. One charge magnitude becomes four times larger and distance doubles; the other charge is unchanged. What is the new force magnitude?

A. F/4
B. F/2
C. F
D. 4F

1. Coulomb's law depends on the charge product divided by r^2. The numerator grows by 4 and denominator by $2^2 = 4$.

2. The ratio is 4/4 = 1, so the force is F. A ignores the charge change; D ignores the distance change; B fails to square distance.

3. Answer: C.

B2-D02 · Multiple choice

For fixed charges, which graph is ideally a straight line through the origin?

A. Force F against distance r.
B. Force F against $1/r^2$.
C. Force F against r^2.
D. Force F against 1/r.

1. Write $F = k|q_1||q_2|(1/r^2)$. With charges fixed, $k|q_1||q_2|$ is constant. This is y = mx for y = F and $x = 1/r^2$.

2. A, C and D use horizontal variables that do not make F directly proportional to that variable.

3. Answer: B.

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Worked solutions | Items 3-4

B2-D03 · Multiple choice

A charged object A attracts B with 0.300 N. B has twice A’s mass. Which statement about the two forces is correct?

A. B attracts A with 0.300 N in the opposite direction.

B. B attracts A with 0.600 N in the opposite direction.

C. B attracts A with 0.150 N in the opposite direction.

D. Both forces point in the same direction.

1. The two forces have equal magnitudes and opposite directions on different objects. Mass does not change this pair-force equality.

2. B and C incorrectly scale pair forces by mass. D violates their opposite directions. Different masses can produce different accelerations.

3. Answer: A.

B2-D04 · Multiple choice

Which statement correctly compares Coulomb’s and Cavendish’s torsion balances?

A. Both measured only repulsion.

B. Both created charge from nothing.

C. Both made a direct photograph of the charges.

D. Both used a wire’s twist to detect a small force, but studied different forces.

1. Coulomb used torsion to study electric force; Cavendish used torsion to study gravitational attraction. Wire twist makes small forces measurable.

2. Ordinary gravity attracts, so A fails. B violates conservation of charge; C confuses a device that measures force with a field-line drawing.

3. Answer: D.

B2 · Extra practice

Worked solutions | Items 5-6

B2-D05 · Numerical response

Point charges +2.00 µC and +3.00 µC are 0.400 m apart in air. Use $k = 8.99 \times 10^9$ N·m²/C². What is the force magnitude in N? Record three significant figures.

1. Givens: 2.00×10^{-6} C, 3.00×10^{-6} C and r = 0.400 m. Use Coulomb's law for point charges.

2. $F = (8.99 \times 10^9)(2.00 \times 10^{-6})(3.00 \times 10^{-6})/0.400^2 = 0.337125$ N, rounded to 0.337 N. Like signs imply repulsion, though magnitude only was requested.

3. Response: 0.337.

B2-D06 · Numerical response

The force between two charges is initially 0.810 N. Both charge magnitudes are doubled and distance is tripled. What is the new force magnitude in N? Record three significant figures.

1. The charge product changes by $2 \times 2 = 4$. The squared distance changes by $3^2 = 9$.

2. Fnew = $0.810 \times 4/9 = 0.360$ N. Keeping both charge factors is essential.

3. Response: 0.360.

B2 · Extra practice

Worked solutions | Items 7-8

B2-D07 · Numerical response

Point-charge magnitudes are 1.00 μC and 4.00 μC, with force 0.899 N in air. Use k = 8.99 × 10^9 N·m^2/C^2. What is the distance in m? Record three significant figures.

1. Givens identify Coulomb's law. Rearrange $F = k|q_1||q_2|/r^2$ to $r = \sqrt{(k|q_1||q_2|/F)}$.

2. $r = \sqrt{[(8.99 \times 10^9)(1.00 \times 10^{-6})(4.00 \times 10^{-6})/0.899]} = \sqrt{0.0400} = 0.200$ m. Taking the square root recovers a distance.

3. Response: 0.200.

B2-D08 · Numerical response

Sample data for fixed charges give 0.450 N at 0.200 m and 0.1125 N at 0.400 m. On a graph of F against $1/r^2$, what is the slope in N·m^2? Express it as a × 10^{-2} N·m^2 and record a to three significant figures.

1. The horizontal coordinates are 25.0 and 6.25 m^{-2}. Slope = (0.450 - 0.1125)/(25.0 - 6.25) = 0.0180 N·m^2.

2. Since 0.0180 = 1.80 × 10^{-2}, record 1.80. The slope units follow N divided by m^{-2}.

3. Response: 1.80.

B2 · Extra practice

Worked solutions | Items 9-10

B2-D09 · Select all that apply

For two fixed point-charge magnitudes in air, choose every true statement: A. Tripling distance gives F/9. B. Reversing one sign changes the force magnitude. C. Force on A and on B have equal magnitudes. D. The graph of F against r is a straight line.

1. A follows the inverse-square factor $1/3^2$. C is the equal-and-opposite pair-force relation.

2. B is false: reversing one sign changes attraction to repulsion but not $|q_1||q_2|$. D is false: F against $1/r^2$ is linear; F against r is curved.

3. Answer: A and C.

B2-D10 · Matching

Match each change to a force factor. Codes: 1 = 2; 2 = 1/4; 3 = 4; 4 = 1/2. Changes: (a) double one charge at fixed distance; (b) double distance at fixed charges; (c) halve distance at fixed charges. Record a-b-c codes.

1. (a) Force is proportional to either charge magnitude: factor 2, code 1. (b) Distance doubled gives factor $1/2^2 = 1/4$, code 2.

2. (c) Distance halved gives factor $1/(1/2)^2 = 4$, code 3. Thus 123.

3. Answer: 123.

B2 · Extra practice

Worked solutions | Items 11-12

B2-D11 · Ranking

Same charge magnitudes in each case: A has distance r; B has distance 2r; C has distance r/2; D has distance 3r. Rank force magnitudes largest to smallest.

1. Use a common baseline F at r. C gives 4F; A gives F; B gives F/4; D gives F/9.

2. Compare those factors: 4 > 1 > 1/4 > 1/9, so C > A > B > D. The signs do not matter for magnitude.

3. Answer: C > A > B > D.

B2-D12 · Ordering

Order an investigation with measurements: 1 compare several results on a straightened graph; 2 set the charges and keep them fixed; 3 choose and measure centre-to-centre distances; 4 measure force for each distance. What is a sensible four-digit order?

1. Set the controlled source charges first (2). Choose distances and measure them consistently (3). Measure corresponding force values (4).

2. Then compare several results on F against $1/r^2$ (1). Keep the surrounding medium and charge magnitudes fixed to isolate the distance relationship.

3. Answer: 2341.