B1-B4 · Cumulative B

Worked solutions | Items 1-2

Scope: B1-B4 only; not the whole unit or a full diploma examination. Printed matching, ordering, ranking and selection tasks are analogues of digital response tasks.

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.

B1-B4-B-01 · Multiple choice

A positive rod is brought near a neutral metal sphere. Ground is connected, then disconnected while the rod stays nearby. The rod is removed last. What is the sphere's final charge sign?

A. neutral
B. positive
C. negative
D. cannot ever be charged

1. The rod causes electrons to enter from Earth while ground is connected. Disconnecting the ground first keeps the sphere with extra electrons. The final sphere is negative.

2. A neutral answer ignores charge transfer through ground. The same-sign answer reverses the electron movement. A conductor can be charged by this sequence.

3. Answer: C.

B1-B4-B-02 · Multiple choice

A target has calculated electric forces of 0.300 N east and 0.400 N south. What is its net force magnitude?

A. 0.100 N
B. 0.700 N
C. 0.500 N
D. 0.1200 N

1. Givens are two perpendicular force components. The net force is the diagonal, so $F = \sqrt{(0.300^2 + 0.400^2)} = 0.500$ N.

2. Adding the magnitudes (0.700 N) assumes parallel forces; subtracting assumes opposite forces on one line. Multiplication is not a vector-addition rule.

3. Answer: C.

B1-B4 · Cumulative B

Worked solutions | Items 3-4

B1-B4-B-03 · Multiple choice

A field points down at P. What happens to field and force when a negative small test charge is replaced with an equally positive test charge?

A. Both field and force reverse.
B. Field reverses; force does not.
C. Neither reverses.
D. Field stays the same; force reverses.

1. The source arrangement and point are unchanged, so the field stays the same. Replacing q by -q in F = qE reverses the force.

2. The other choices either change the source field without a source change or fail to reverse the negative-charge force.

3. Answer: D.

B1-B4-B-04 · Multiple choice

A pair force has magnitude F. One charge magnitude is multiplied by 2 and distance by 3; the other charge and signs remain fixed. What is the new force magnitude?

A. 2F/3
B. 2F/9
C. 9F/2
D. F/6

1. Use the ratio form of Coulomb's law: $F_{new}/F = 2/3^2 = 0.222222$. The charge factor is first power; distance is squared.

2. Distractors either fail to square distance, invert the ratio, or omit one of the changes. Attraction or repulsion is unchanged.

3. Answer: B.

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Worked solutions | Items 5-6

B1-B4-B-05 · Multiple choice

A positive rod approaches a neutral metal sphere on an insulating stand from the right. Which description is correct?

A. Charge redistributes but total charge remains zero.

B. Total charge must become the same sign as the rod.

C. Positive metal cores flow across the sphere.

D. The sphere cannot feel a net force.

1. No contact or ground connection allows electrons to enter or leave the sphere. Free electrons shift; total charge stays zero.

2. The closer opposite charge can produce net attraction. B assumes net transfer; C moves the wrong particles; D ignores unequal near/far forces.

3. Answer: A.

B1-B4-B-06 · Multiple choice

A sample data set follows an inverse-square force law. Which axes give a straight line?

A. F against r^2

B. F against $1/r$

C. F against $1/r^2$

D. F against r

1. $F = k|q_1||q_2|(1/r^2)$ is $y = mx$ when vertical y is F and horizontal x is $1/r^2$. Axes have units N and m^{-2}.

2. The other horizontal variables do not make force directly proportional to the horizontal coordinate.

3. Answer: C.

B1-B4 · Cumulative B

Worked solutions | Items 7-8

B1-B4-B-07 · Multiple choice

Two equal-magnitude sources lie equally far left and right of P. The left source is positive; the right source is negative. What is the net field at P?

A. Nonzero left.

B. Zero.

C. Nonzero right.

D. Nonzero upward.

1. The positive source’s field points right, away from it. The negative source’s field points right, toward it. The two fields add.

2. Only the field vectors at P can be added. Adding source charges without their positions does not determine the field.

3. Answer: C.

B1-B4-B-08 · Multiple choice

A suspended sphere is at rest with a horizontal electric force right. Which tension direction is possible?

A. Vertical downward.

B. Vertical upward only.

C. Downward and toward the electric force.

D. Upward and opposite the horizontal electric force.

1. Tension acts toward the support along the string. Its upward component balances weight, and its horizontal component opposes the electric force.

2. A and C fail vertical balance; B cannot balance the horizontal force.

3. Answer: D.

B1-B4 · Cumulative B

Worked solutions | Items 9-10

B1-B4-B-09 · Multiple choice

A charge diagram shows field arrows pointing straight out from a point. What source sign and positive-test charge force direction does it represent?

A. Negative source; inward force.
B. Positive source; outward force.
C. Negative source; outward force.
D. Positive source; inward force.

1. Field lines point away from positive sources, and a positive test charge’s force follows E. Thus source positive and force outward.

2. The distractors reverse the direction rule for the source, confuse positive and negative test charges, or do both.

3. Answer: B.

B1-B4-B-10 · Multiple choice

Which statement is guaranteed when unequal conductors on insulating stands touch?

A. Each final charge is zero.
B. The signed total final charge equals the signed initial total.
C. Each object keeps its original charge.
D. All objects must have equal final charges.

1. Charge can transfer among the objects but cannot enter or leave the group. The signed sum therefore stays constant.

2. A wrongly requires the objects to end neutral; C forbids transfer; D assumes a symmetry that may be absent.

3. Answer: B.

B1-B4 · Cumulative B

Worked solutions | Items 11-12

B1-B4-B-11 · Numerical response

Two identical metal spheres on insulating supports start at +10.0 µC and −4.0 µC. They touch then separate far apart, with no charge loss. What is each final charge in µC? Record the positive result to one decimal place.

1. Givens: signed initial charges +10.0 µC and −4.0 µC; identical spheres on insulating stands. Conserve charge: total = +6.0 µC.

2. Equal sharing between identical spheres gives (6.0)/2 = +3.0 µC each. Check the sum equals +6.0 µC.

3. Response: 3.0.

B1-B4-B-12 · Numerical response

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

1. Use Coulomb's law because the two point charges and distance are given. Convert to 3.00×10^{-6} C and 2.00×10^{-6} C.

2. $F = k|q_1||q_2|/r^2 = (8.99 \times 10^9)(3.00 \times 10^{-6})(2.00 \times 10^{-6})/0.400^2 = 0.337125$ N, which rounds to 0.337 N. Signs are unnecessary for magnitude.

3. Response: 0.337.

B1-B4 · Cumulative B

Worked solutions | Items 13-14

B1-B4-B-13 · Numerical response

A charged sphere of mass 4.00×10^{-4} kg hangs at rest with its string 20.0° from vertical. The electric force is horizontal. Use g = 9.81 m/s². What is the electric-force magnitude, expressed as a $\times 10^{-3}$ N? Record a to three significant figures.

1. At rest means a = 0. Balance components: T cos θ = mg and T sin θ = Fe. Dividing eliminates T, so Fe = mg tan θ.

2. $Fe = (4.00 \times 10^{-4})(9.81)\tan 20.0° = 1.42822 \times 10^{-3}$ N. Record 1.43. Charges and distance are not needed.

3. Response: 1.43.

B1-B4-B-14 · Numerical response

A fixed point source has magnitude 2.00 μC. A point is 0.200 m away in air. Use $k = 8.99 \times 10^{9}$ N·m²/C². What is the field strength there, expressed as a $\times 10^{5}$ N/C? Record a to three significant figures.

1. Use $E = k|Q|/r^2$ because a source charge and its distance to a point are known. No test charge is needed.

2. $E = (8.99 \times 10^{9})(2.00 \times 10^{-6})/0.200^2 = 4.495 \times 10^{5}$ N/C, so record 4.50. Source sign would determine toward/away direction, not strength.

3. Response: 4.50.

B1-B4 · Cumulative B

Worked solutions | Items 15-16

B1-B4-B-15 · Numerical response

A negative test charge has charge magnitude 2.00 nC in a field of 3.00×10^{4} N/C north. What is the force magnitude, expressed as a $\times 10^{-5}$ N? Record a to three significant figures.

1. Field and test charge are known, so $|F| = |q|E$. Convert nC: $|q| = 2.00 \times 10^{-9}$ C.

2. $|F| = (2.00 \times 10^{-9})(3.00 \times 10^{4}) = 6.00 \times 10^{-5}$ N. Record 6.00. The full force points south because the test charge is negative.

3. Response: 6.00.

B1-B4-B-16 · Numerical response

At P, two sources have equal magnitude 3.00 µC. The positive source is 0.300 m left of P; the negative source is 0.300 m right of P. Use $k = 8.99 \times 10^{9}$ N·m²/C². What is net field strength, expressed as a $\times 10^{5}$ N/C? Record a to three significant figures.

1. At P, the positive-source field points right and the negative-source field also points right. Add their equal magnitudes.

2. Each $E = (8.99 \times 10^{9})(3.00 \times 10^{-6})/0.300^{2}$. Net $E = 5.99333 \times 10^{5}$ N/C right. Record 5.99. Opposite signs do not cancel these field vectors.

3. Response: 5.99.

B1-B4 · Cumulative B

Worked solutions | Items 17-18

B1-B4-B-17 · Select all that apply

Choose every true statement: A. A negative test charge’s force follows E. B. Field exists without a test charge. C. Ground can supply electrons. D. Net zero force means no individual force.

1. A source produces a field even without a test charge. The force on a positive test charge defines E; the force on a negative one is reversed. Earth can exchange electrons through a conductor. Equal opposite forces can sum to zero.

2. Apply these facts to each statement separately. A statement that denies ground transfer, reverses the negative-test charge rule, or says zero net force means no forces act is false.

3. Answer: B and C.

B1-B4-B-18 · Matching

Methods: 1 = $E = k|Q|/r^2$; 2 = $F = qE$; 3 = balanced forces. Match a-b-c to method codes: (a) find force from E and test charge q; (b) find horizontal electric force from the mass of a sphere at rest and angle; (c) find field from source Q and r.

1. Source charge and distance identify the point-source field equation. Known field and test charge identify $F = qE$. The mass of a sphere at rest and its string angle identify force balance.

2. Choose from the roles of the givens, not from the word “electric.” The requested code follows the printed a-b-c order.

3. Answer: 231.

B1-B4 · Cumulative B

Worked solutions | Items 19-20

B1-B4-B-19 · Ranking

With a fixed point source, points have distances A: 3r, B: r, C: 2r. Rank field strengths largest to smallest; state ties if any.

1. For the same source, $E = k|Q|/r^2$. Smaller distance gives larger field strength. At r/2 the field is 4E(r); at 2r it is E(r)/4; at 3r it is E(r)/9.

2. Rank by inverse-square factors rather than by the raw distances. Each distance here differs, so no strengths tie.

3. Answer: B > C > A; no ties.

B1-B4-B-20 · Ordering

Starting with a neutral conductor, order these actions to retain induction charge without rod contact: 1 connect ground; 2 remove negative rod; 3 disconnect ground; 4 bring negative rod near. Record the four-digit order.

1. Bring the rod near first, then connect ground while holding the rod in place. The rod drives electrons into or out of the sphere through ground.

2. Disconnect ground before removing the rod. This closes the exchange path and retains the transferred total charge. Translate this physical sequence into the printed action numbers.

3. Answer: 4132.