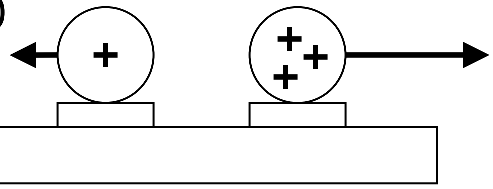
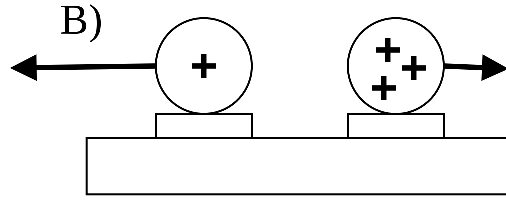
Q21-1. Two uniformly charge spheres are attached to frictionless pucks on an air table. The charge on sphere 2 is three times the charge on sphere 1. Which force diagram correctly shows the magnitude and direction of the electrostatic forces on the two spheres?

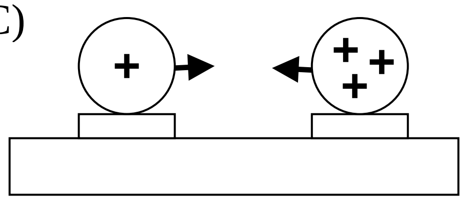
A)



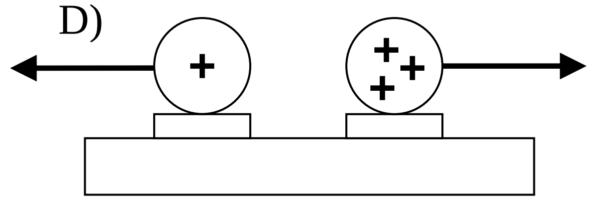
B)



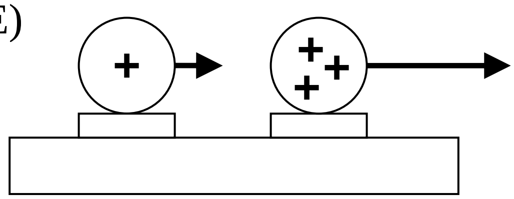
C)



D)



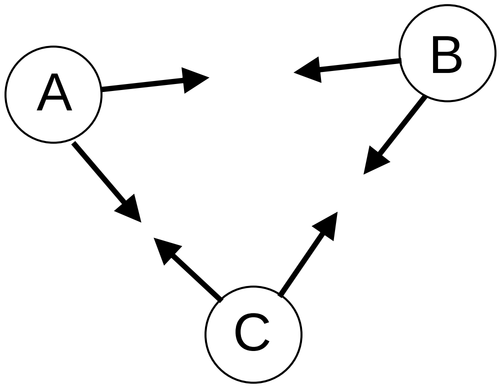
E)



Answer: D (By Newton's 3rd Law and by the form of Coulomb's Law)

Q20-2. A scientist performs an experiment to try to determine the correct model of charge.
Model 1: There are two kinds of charge, called plus and minus. Like charges repel. Unlike charges attract.
Model 2: There are three kinds of charge, called red, green, and blue. Like colors repel. Unlike colors attract.

Here is the experiment: there are three unknown point charges labeled A, B, and C. It is found that charges A and B attract each other, and charge C is attracted to both A and B.



A) This disproves model 1 and is consistent with model 2.
B) This disproves model 2 and is consistent with model 1.
C) This disproves both model 1 and model 2.
D) This is consistent with both model 1 and model 2.

Answer: A This disproves model 1 and is consistent with model 2.

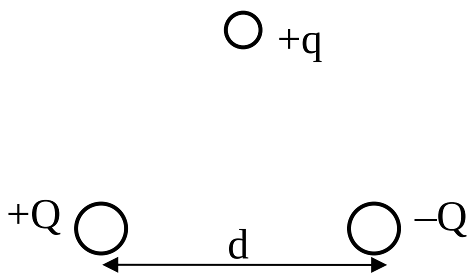
Q21-3. Two protons are near each other. Each feels an electrostatic repulsion of magnitude F_{elec} and a gravitational attraction of magnitude F_{grav}, due to the other charge.

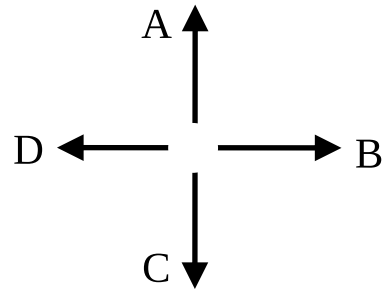
As the charges are moved apart, the ratio $\frac{F_{elec}}{F_{grav}}$ …

A) increases B) decreases C) remains constant

Answer: remains constant

Q21-4. An electric dipole consists of two equal and opposite charges (+Q and –Q) separated by some fixed distance d . A charge +q is brought near the dipole and is positioned so that the distances to the +Q and the –Q charges are identical as shown below:



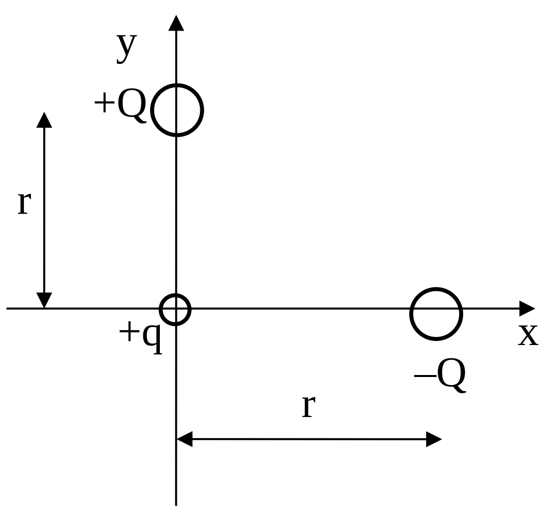


E) Some other direction

What is the direction of the net electrostatic force on the +q charge?

Answer: to the right (Draw the vector diagram, showing the forces on +q)

Q21-5. What is the correct expression for the **y-component** of the force on +q due to the other charges +Q and –Q ?



A) $+k\dfrac{Qq}{r^2}$

B) $-k\dfrac{Qq}{r^2}$

C) $+\sqrt{2}\ k\dfrac{Qq}{r^2}$

D) $-k\ \sqrt{2}\ \dfrac{Qq}{r^2}$

E) None of these!

Answer: $-k\dfrac{Qq}{r^2}$ (Notice that the y-component of the force is negative)

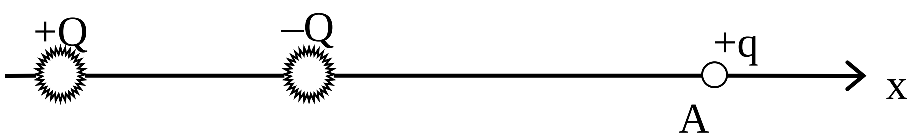
Q21-6. Vector Review: How many of these equation make no sense?

- $\vec{A} = \hat{j}$
- $\vec{B} = 3\hat{i} + \hat{j} - 5\hat{j}$
- $\vec{C} = \dfrac{\vec{A}}{3}$
- $\vec{C} = \vec{A} + \hat{i}$
- $\vec{C} = 4 - \hat{i}$

A) 0 (All make sense) B) 1 C) 2 D) 3 E) 4

Answer: The last one $\vec{C} = 4 - \hat{i}$ makes no sense. You can't add a number and a vector. All the others makes sense.

Q21-7. An electric dipole (+Q and –Q separated by a distance d) is placed along the x-axis as shown. A positive test charge +q is placed at position A to the right of the dipole.



The positive test charge feels a force that is
A) zero. B) to the right. C) to the left.

If the test charge +q is removed, electric field at position A is
A) zero. B) to the right C) to the left
D) There is no electric field at point A, when the test charge is removed.

If a negative test charge –q is used to measure the Electric field at A, the electric field at position A is A) zero. B) to the right C) to the left

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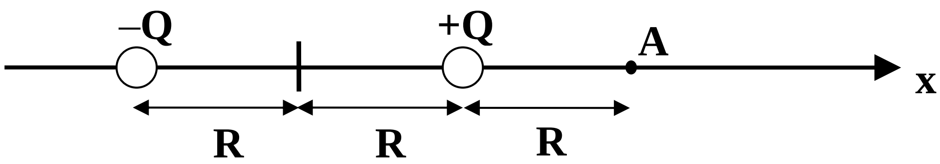
Answers: The force on +q is to the left. The E-field at A points to the left, regardless of whether the test charge is positive (+q) or negative (–q).

Q20-8. The definition of the electric field at a point is given by $\vec{E} = \frac{\vec{F}_{on\,q}}{q}$
Does the direction of the electric field depend on the sign of the test charge q?
A) Yes B) No

Answer: No. The E-field at a point does not depend on the test charge.

Q21-9. Two charges +Q and – Q are located on the x-axis as shown, what is the magnitude of the electric field at point A?



A) $\frac{kQ}{R^2}\cdot\left(1-\frac{1}{9}\right)$

B) $\frac{kQ}{R^2}\cdot\left(1-\frac{1}{4}\right)$

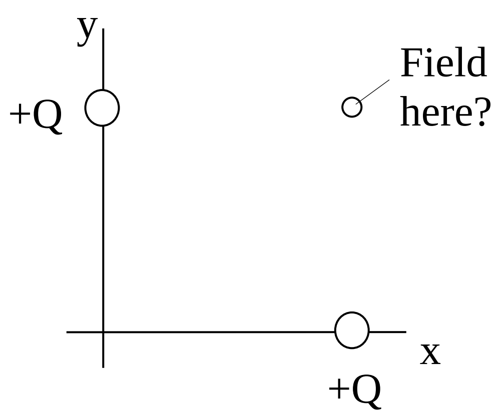
C) Zero

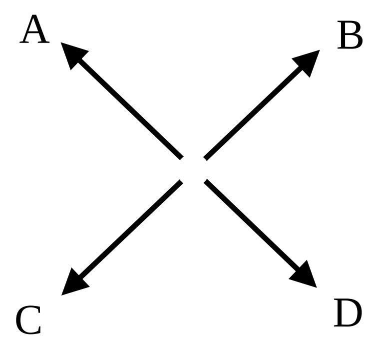
D) $\frac{kQ}{R^2}\cdot\left(\frac{1}{9}-1\right)$

E) None of these.

Answer: $\frac{kQ}{R^2}\cdot\left(1-\frac{1}{9}\right)$

Q21-10. Two positive charges, each of size +Q, are equal distances from the origin as shown. What is the direction of the electric field at the point in empty space which forms a square with the two charges and the origin?





E) No Field there

Answer: B (upper right)   Draw a vector diagram!

Q20-11. I bring a positively charged rod near an uncharged (neutral) metal can. The can is …
A) attracted to the rod B) repelled from the rod C) neither attracted nor repelled.

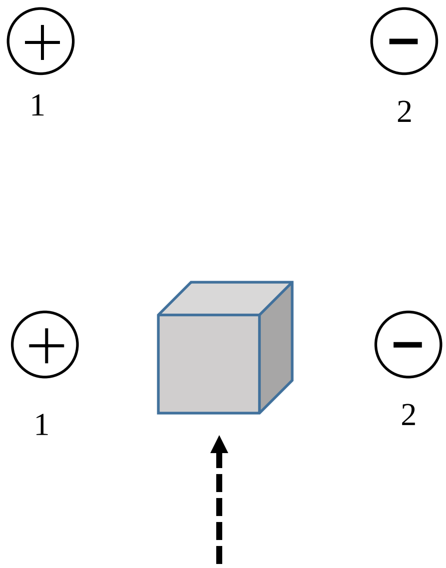
Answer: The can is attracted.

Q20-12. I bring a negatively charged rod near an uncharged (neutral) metal can. The can is …
A) attracted to the rod B) repelled from the rod C) neither attracted nor repelled.

Answer: The can is attracted.

Q20-13. A positive charge (charge 1) and a negative charge (charge 2) are a fixed distance d apart. Then an electrically neutral cube of polarizable material is placed between the two charges. When the cube is placed in between, the net electric force on charge 2 does what?

A) increases B) decreases C) remains unchanged.



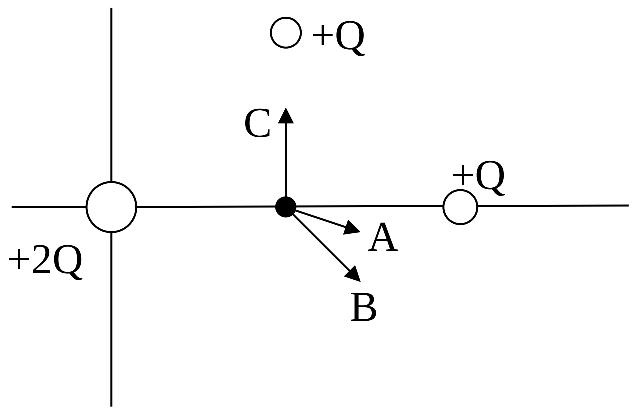
Answer: The net electric force on charge 2 increased, due to the polarization charges on the cube. (Draw the polarization charges!)

Q21-14. Two socks are observed to attract each other. Which, if any, of the first 3 statements **MUST** be true? (emphasis on MUST)

A) The socks both have a non-zero net charge of the same sign.
B) The socks both have a charge, of opposite signs.
C) Only one sock is charged; the other is neutral.
D) None of the preceding statements **must** be true.

Answer: D. The socks might be attracting because they have opposite sign charges. Or it could be that only one of them is charged and the other is neutral, in which case the attraction is due to polarization of the neutral sock.

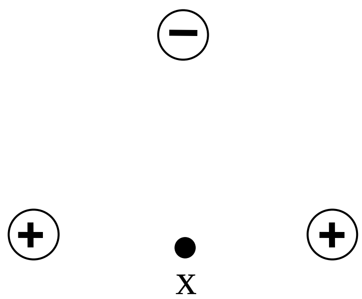
Q21-15. A point in empty space is near 3 charges as shown. The distances from the point to each of the three charges are identical.

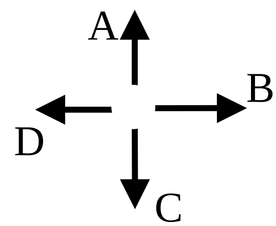


The direction of the electric field at that point is..
A: Some angle less than 45^o below the +x-direction.
B: 45^o below the +x-direction. C: along the +y directions
D: Some other angle. E: The electric field at that point is zero.

Answer: 45^o below the +x-direction. (Draw the E-field diagram showing the E-fields from each of the charges separately, then vector add the fields from each charge to get the total E-field.)

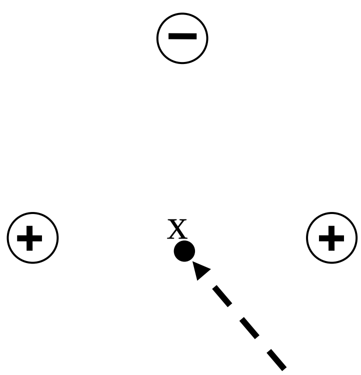
Q21-16. Three charges of equal magnitude are arranged as shown. What is the direction of the electric field at point x?

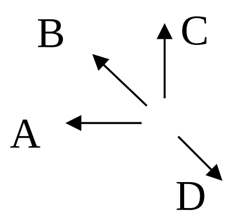




E) None of these.

An electron is fired into the region of the three charges from the lower right as shown. What is the direction of the acceleration of the electron when it is at point x?

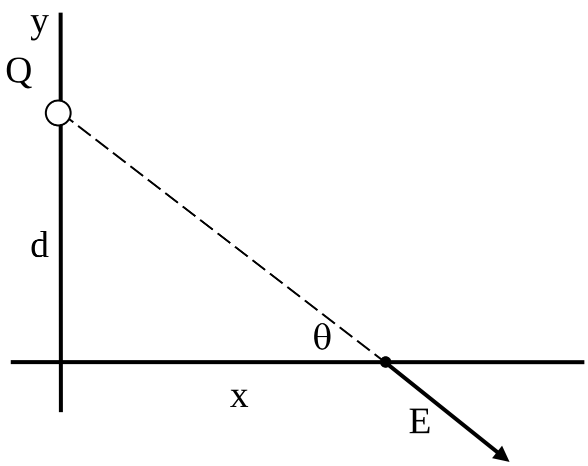




E) None of these.

Answers: The direction of the E-field at point x is straight up (choice A). The direction of the acceleration of an election is the direction of **a** = **F**/m = q**E**/m = –e**E**/m (vector quantities are in bold here). The charge of an electron is q = –e. Because the electron has negative charge, the direction of the force is opposite the direction of the E-field. So the direction of the acceleration is straight down (None of these).

Ch20-17. A positive charge Q is on the y-axis at y = d. What is the magnitude of the E-field at position x, on the x-axis?



A) $\dfrac{kQ}{(d+x)^2}$

B) $\dfrac{kQ}{x^2+d^2}$

C) $\dfrac{kQ}{\left(x^2+d^2\right)^2}$

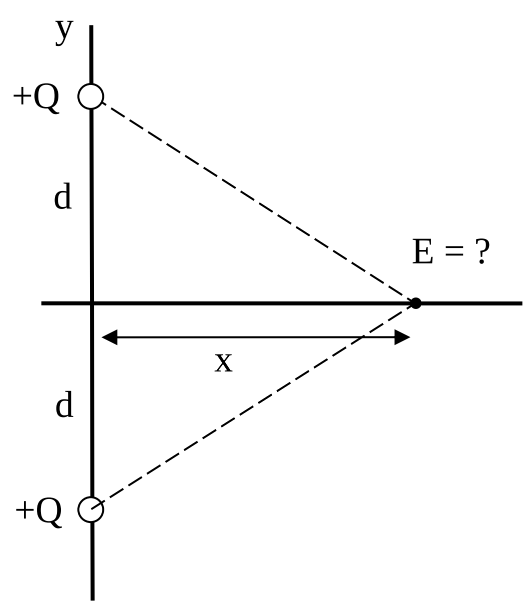
D) $\dfrac{kQ}{\sqrt{x^2+d^2}}$

E) None of these

What is E_x the x-component of E at position x on the x-axis?

A) $E\dfrac{d}{\sqrt{x^2+d^2}}$ B) $E\dfrac{x}{\sqrt{x^2+d^2}}$ C) $E\dfrac{x^2}{\sqrt{x^2+d^2}}$ D) None of these

What is the magnitude of the electric field at point x on the x-axis due to the two +Q charges shown on the y-axis?



A) $\dfrac{2kQx}{\left(x^2+d^2\right)^{3/2}}$

B) $\dfrac{2kQd}{\left(x^2+d^2\right)^{1/2}}$

C) $\dfrac{2kQx}{\left(x^2+d^2\right)^{1/2}}$

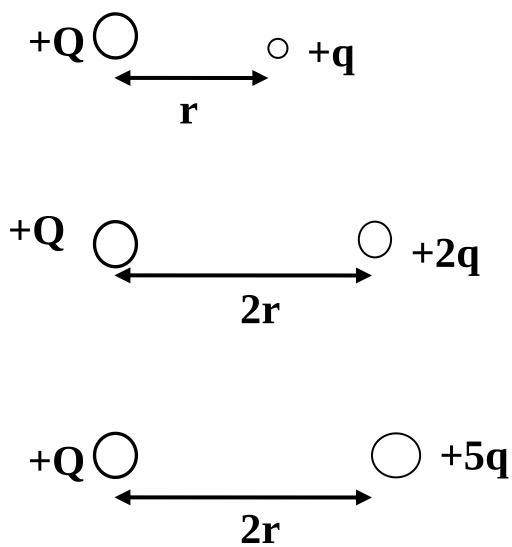
D) None of these

Answers: $E = \frac{kQ}{r^2} = \frac{kQ}{x^2+d^2}$

$$E_x = E\cos\theta = E\frac{x}{r} = E\frac{x}{\sqrt{x^2+d^2}}$$

$$E_{tot} = 2E_1\cos\theta = 2\frac{kQ}{(x^2+d^2)}\frac{x}{\sqrt{x^2+d^2}} = \frac{2kQx}{\left(x^2+d^2\right)^{3/2}}$$

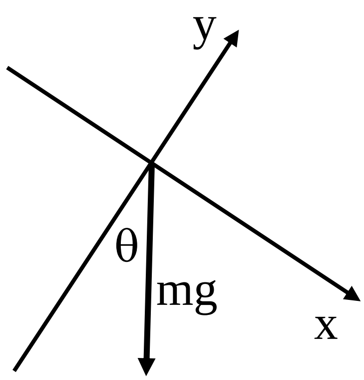
Q21-18. A charge +Q is fixed in space. A second charge +q is brought a distance r away. Then +q charge is removed and another charge +2q is brought a distance 2r away. Then the +2q charge is removed and a charge +5q is brought a distance 2r away.



Which charge feels the largest force?
A) +q
B) +2q
C) +5q
D) Two of the charges feel the same size force.

Answer: +5q

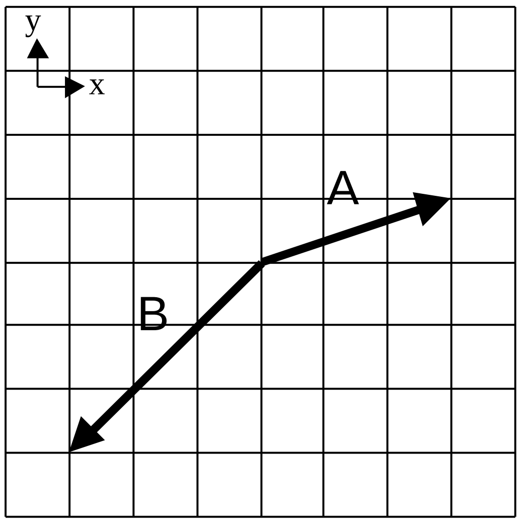
Q21-19. Trig Review: In a tilted xy coordinate system, the weight vector m**g** is straight down. The coordinates are tilted at an angle θ as shown. What is W_y , the y-component of the weight mg?



A) +mg sinθ
B) –mg cosθ
C) –mg sinθ
D) +mg
E) 0

Answer: –mg cosθ (careful with the signs!)

Q21-20. Two vectors $\vec{A}$ and $\vec{B}$ are shown. Consider the vector sum $\vec{C} = \vec{A} + \vec{B}$. What is C_y, the y-component of $\vec{C}$?



A: 3

B: 2

C: –2

D: –4

E: None of these/don't know.

Answer: $C_y = A_y + B_y = +1 - 3 = -2$

