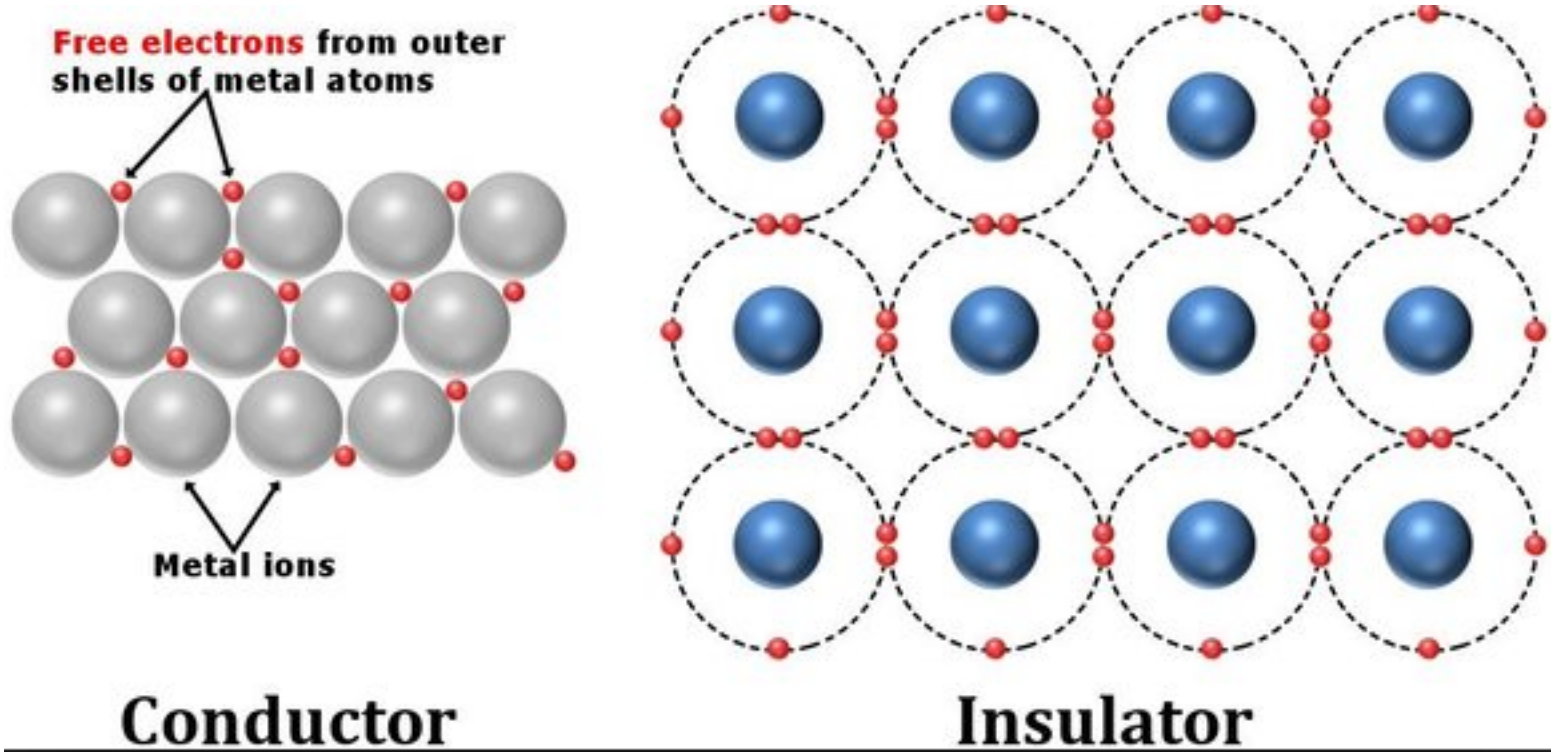
Recitation W5

Jihan Kim

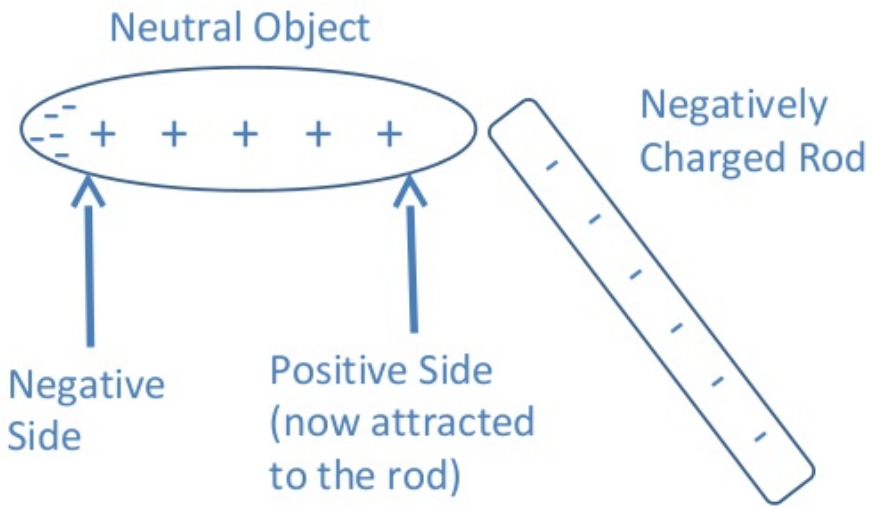
Topic

- Charge in matter
- Coulomb’s law and electric force
- Electric field

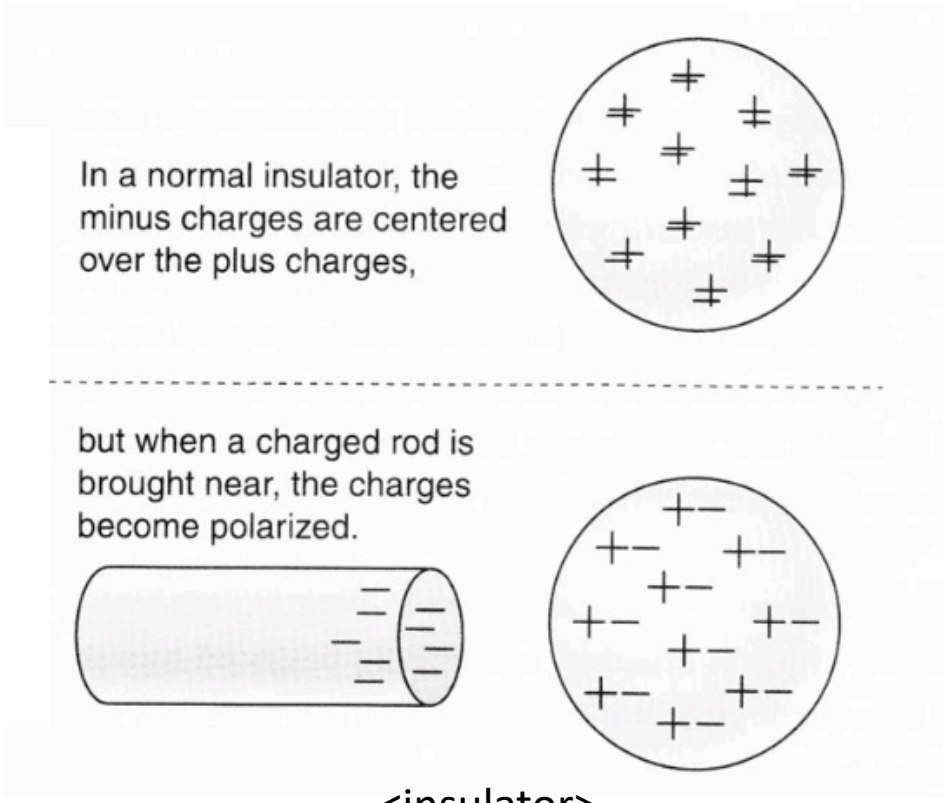
Charges in matter



Induced charge separation

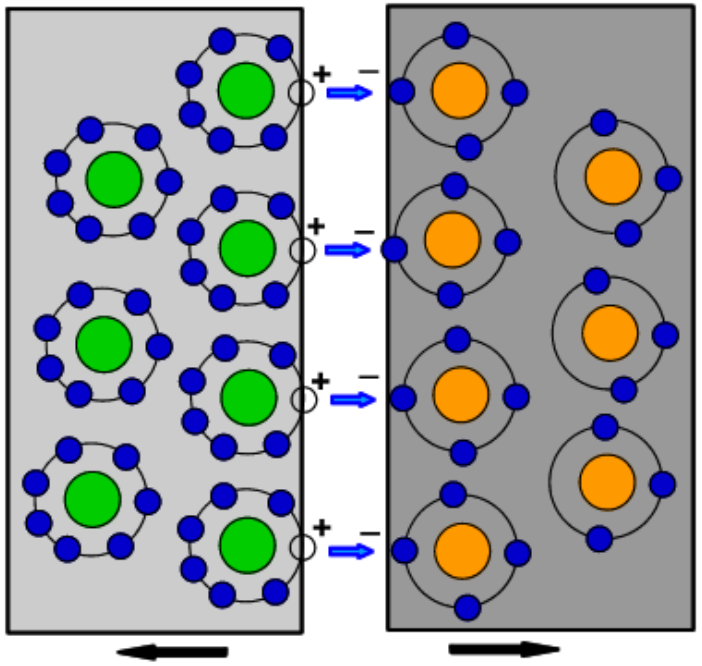


<conductor>



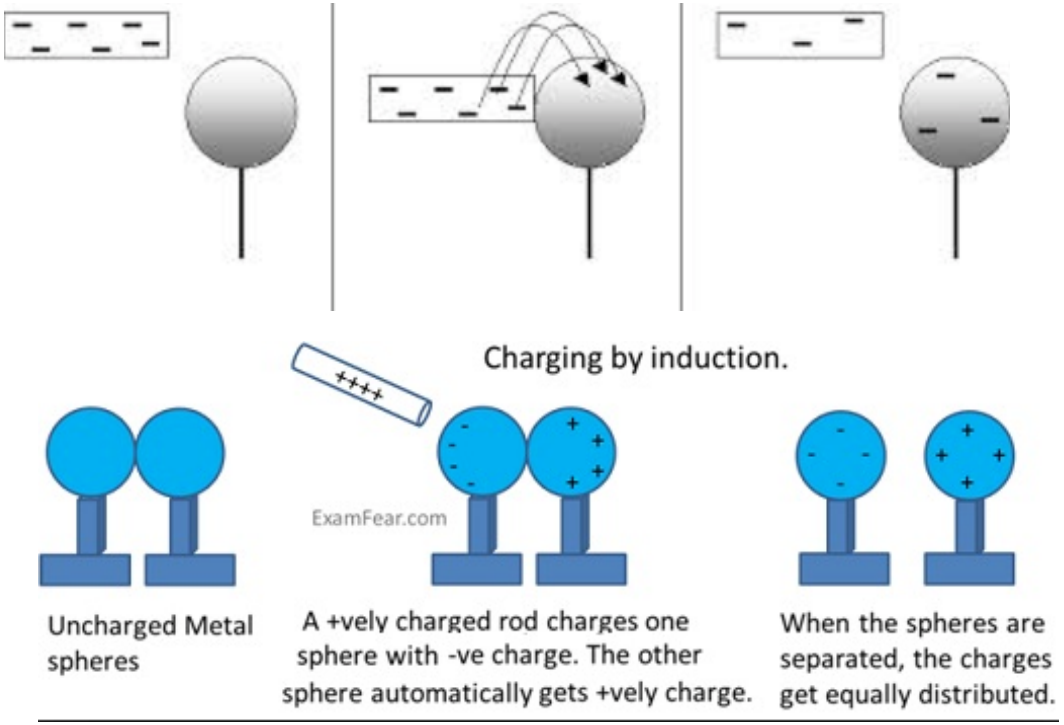
<insulator>

Charging



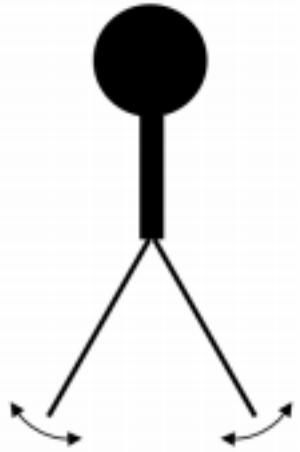
<Insulator>

Charing by conduction



<Conductor>

2. A metal rod with an excess of positive charge touches a previously neutral electroscope and the leaves spread apart. The metal rod is then removed. Which of the following options will cause the leaves to move closer together?

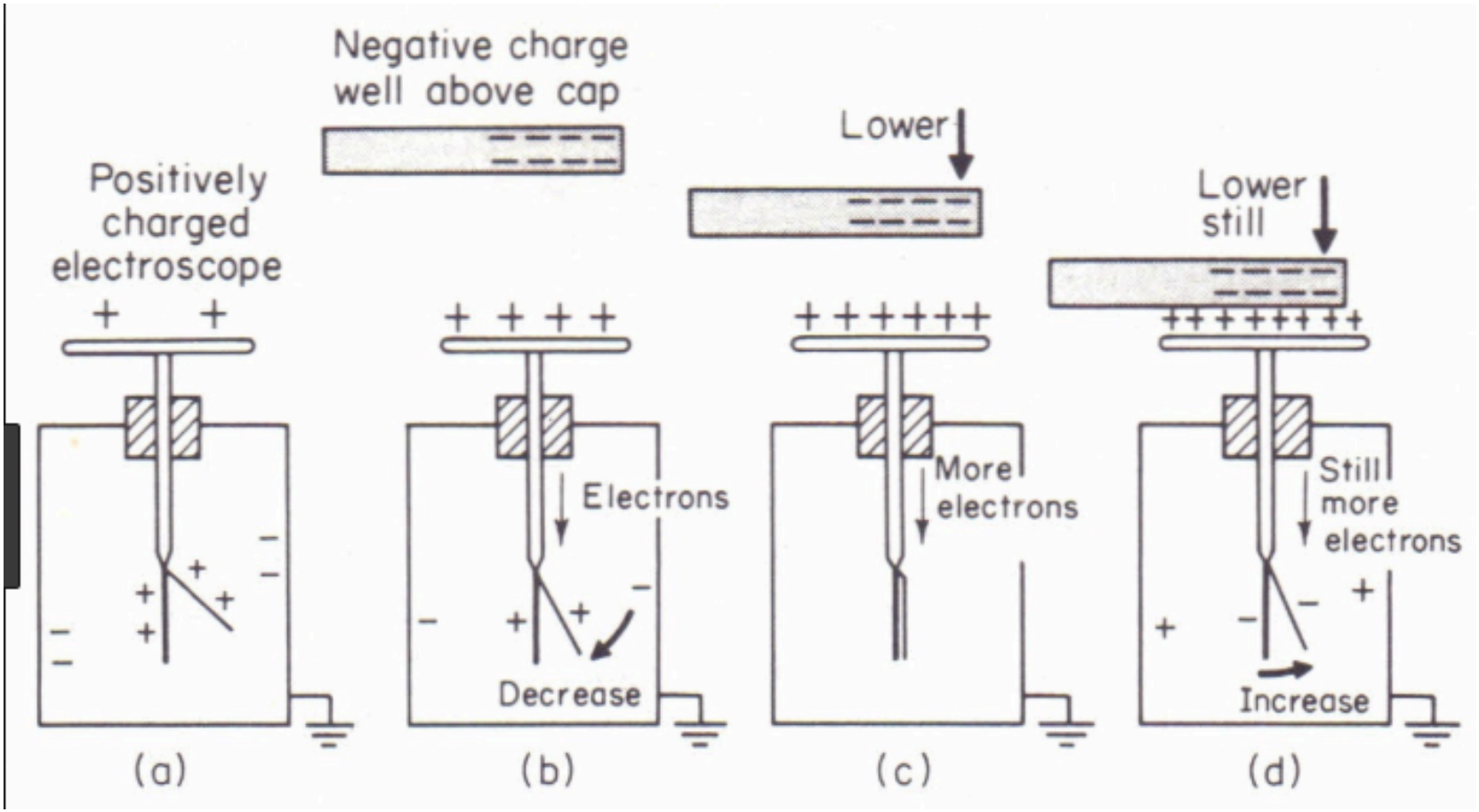


☐ a) Bringing a negatively charged metal rod close to the top of the electroscope

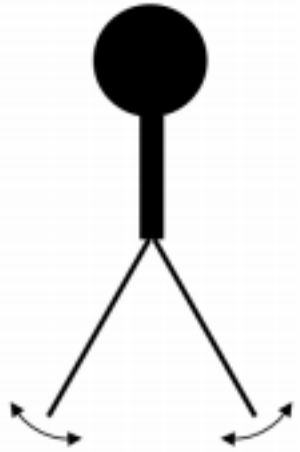
☐ b) Bringing a positively charged metal rod close to the top of the electroscope

☐ c) Bringing a negatively charged insulating rod close to the top of the electroscope

☐ d) Bringing a positively charged insulating rod close to the top of the electroscope


Positively charged electroscope
Negative charge well above cap
Lower
Lower still
Electrons
Decrease
More electrons
Still more electrons
Increase
(a)
(b)
(c)
(d)

2. A metal rod with an excess of positive charge touches a previously neutral electroscope and the leaves spread apart. The metal rod is then removed. Which of the following options will cause the leaves to move closer together?



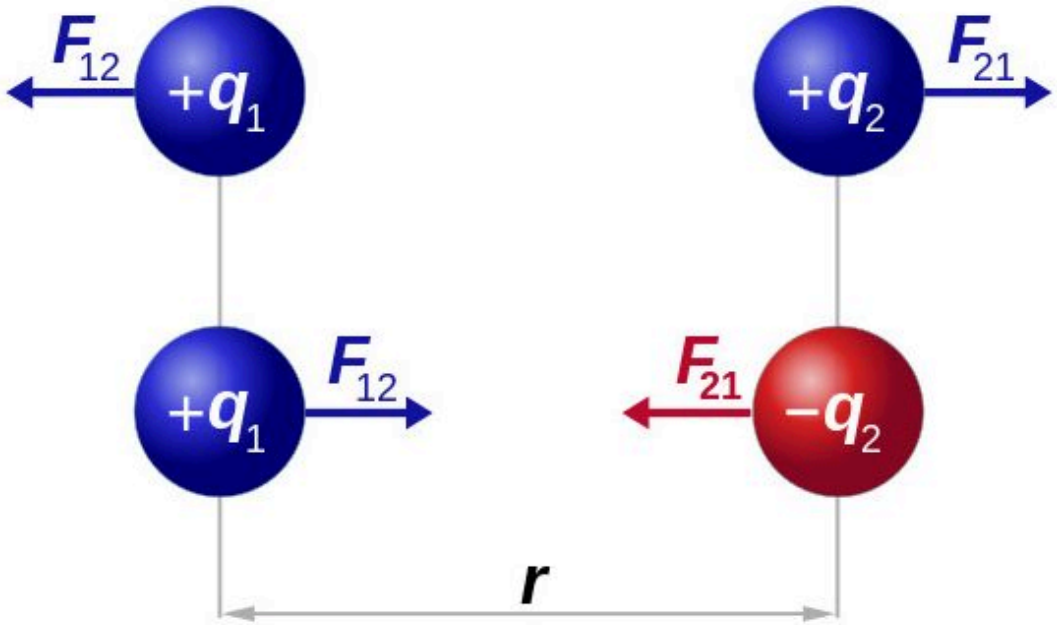
☐ a) Bringing a negatively charged metal rod close to the top of the electroscope

☐ b) Bringing a positively charged metal rod close to the top of the electroscope

☐ c) Bringing a negatively charged insulating rod close to the top of the electroscope

☐ d) Bringing a positively charged insulating rod close to the top of the electroscope

Coulomb's law



$$F_{12} = F_{21} = k\frac{q_1 q_2}{r^2} \qquad (k = 9\times10^9 \frac{Nm^2}{C^2})$$

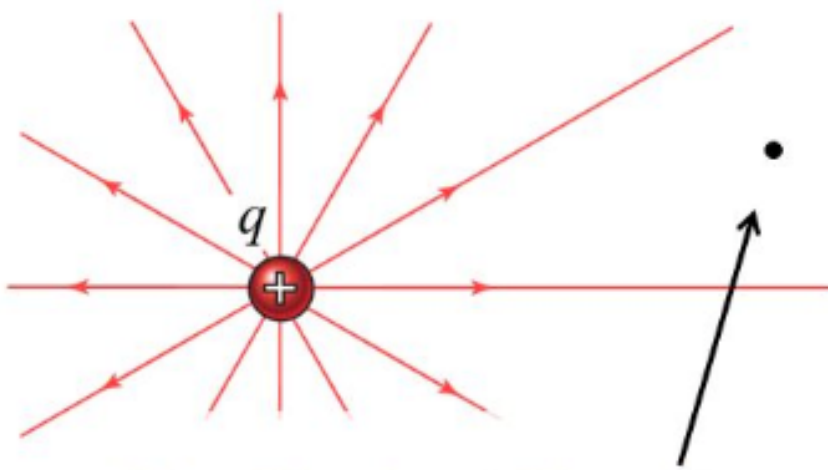
Electric field

Two charges, q and q_2, exert repulsive forces on each other:

$$F_e = \frac{k_e q q_2}{r^2}$$

The electric field created by q at the location of q_2 is:

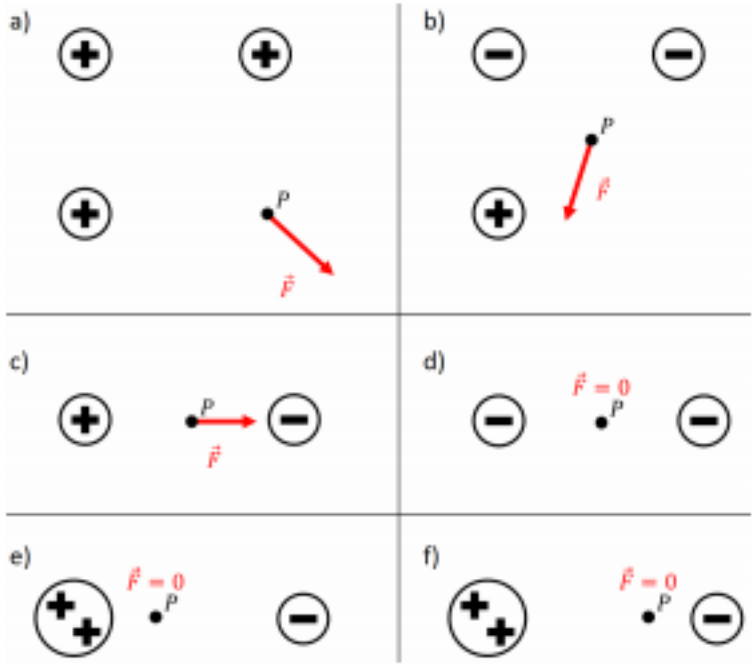
$$E = \frac{F_e}{q_2} = \frac{\frac{k_e q q_2}{r^2}}{q_2} = \frac{k_e q}{r^2}$$



E has this value at this point in space even if q_2 is not there to "feel" it.

4. Which of the following situations correctly depict the force on a negative charge placed at the black dot? (+ and - charges have equal magnitudes, ++ implies twice the charge)

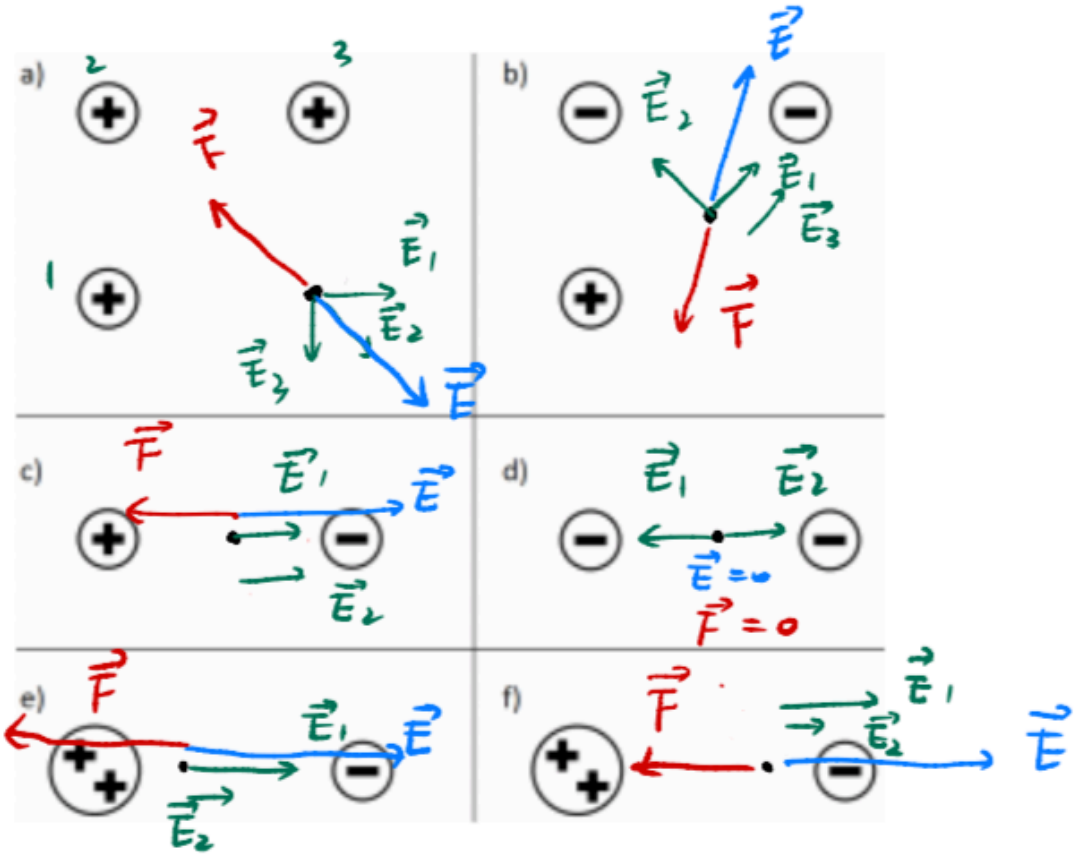
☐ a)
☐ b)
☐ c)
☐ d)
☐ e)
☐ f)



4. Which of the following situations correctly depict the force on a negative charge placed at the black dot? (+ and - charges have equal magnitudes, ++ implies twice the charge)

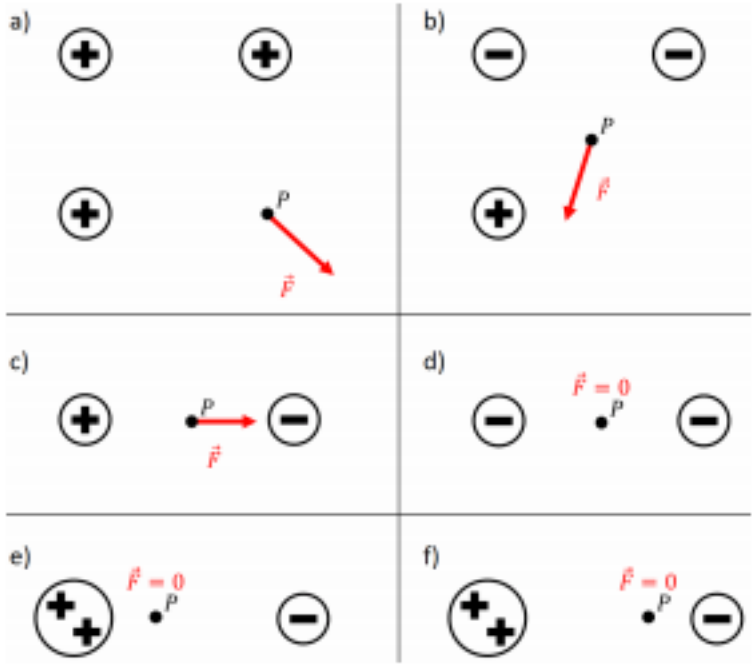
opposite direction to $\vec{E}$

- ☐ a)
- ☐ b)
- ☐ c)
- ☐ d)
- ☐ e)
- ☐ f)



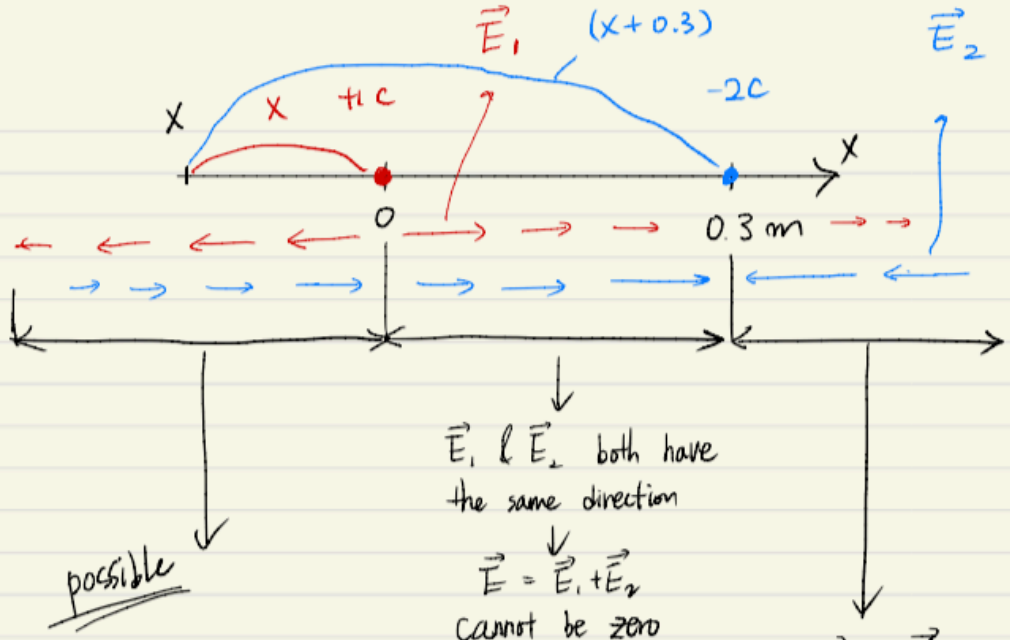
4. Which of the following situations correctly depict the force on a negative charge placed at the black dot? (+ and - charges have equal magnitudes, ++ implies twice the charge)

- ☐ a)
- ☐ b)
- ☐ c)
- ☐ d)
- ☐ e)
- ☐ f)



3. A +1 C charge is placed at the origin. A -2 C charge is placed on the x-axis, 30 cm to the right of the origin. Which of the following statements are true?

☐ a) Other than $x = \pm\infty$, there are no locations on the x axis where the electric field magnitude is zero.
☐ b) Other than $x = \pm\infty$, there is only one location on the x axis where the electric field magnitude is zero.
☐ c) In addition to $x = \pm\infty$, there is more than one location on the x axis where the electric field magnitude is zero.
☐ d) The electric field is zero at a point between the two charges.
☐ e) Other than $x = -\infty$, the electric field is zero at one point to the left of both charges.
☐ f) Other than $x = \infty$, the electric field is zero at one point to the right of both charges.
☐ g) The electric potential energy of the -2 C charge is greater than the electric potential energy of the +1 C charge.



$$\vec{E}_1 = k\frac{|q_1|}{x^2}\langle -1, 0\rangle$$

$$\vec{E}_2 = \frac{k|q_2|}{(x+0.3)^2}\langle 1, 0\rangle$$

$$\vec{E}_1 + \vec{E}_2 = \vec{0}$$

$$\Rightarrow \quad -\frac{k|q_1|}{x^2} + \frac{k|q_2|}{(x+0.3)^2} = 0$$

$$-\frac{kC}{x^2} + \frac{2kC}{(x+0.3)^2} = 0$$

$$\frac{-(x+0.3)^2 + 2x^2}{x^2(x+0.3)^2} = 0$$

$$\Rightarrow \quad x^2 - 0.6x - 0.09 = 0$$

$$x = \frac{0.6 \pm \sqrt{0.36 + 0.36}}{2}$$

$$= \frac{0.6 \pm 0.6\sqrt{2}}{2}$$

$$= 0.3(1 \pm \sqrt{2})$$

We defined X as distance so X must be a positive value.

$$\Rightarrow X = 0.3(1+\sqrt{2})$$

There is only a single point where electric field is zero.

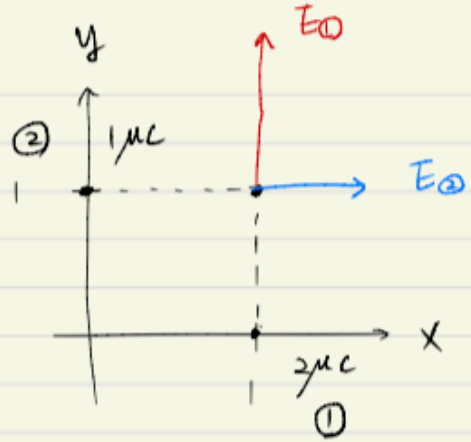
3. A +1 C charge is placed at the origin. A -2 C charge is placed on the x-axis, 30 cm to the right of the origin. Which of the following statements are true?

☐ a) Other than $x = \pm\infty$, there are no locations on the x axis where the electric field magnitude is zero.
☐ b) Other than $x = \pm\infty$, there is only one location on the x axis where the electric field magnitude is zero.
☐ c) In addition to $x = \pm\infty$, there is more than one location on the x axis where the electric field magnitude is zero.
☐ d) The electric field is zero at a point between the two charges.
☐ e) Other than $x = -\infty$, the electric field is zero at one point to the left of both charges.
☐ f) Other than $x = \infty$, the electric field is zero at one point to the right of both charges.
☐ g) The electric potential energy of the -2 C charge is greater than the electric potential energy of the +1 C charge.

1. (6 points) One charge of 2 μC is placed at (x,y) = (1 cm, 0 cm), another charge of 1 μC is placed at (x,y) = (0 cm, 1 cm).

a) What is the electric field at (x,y) = (1 cm, 1 cm)?

b) What is the magnitude of the electric field?



$$\vec{E}_① = \frac{k|q_①|}{|r_1|^2}\langle 0,1\rangle = \frac{(9\times10^9)(2\times10^{-6}\,C)}{(10^{-2})^2}\langle 0,1\rangle$$

$$= 1.8\times10^8\langle 0,1\rangle \ \frac{N}{C}$$

$$\vec{E}_② = \frac{k|q_②|}{|r_2|^2}\langle 1,0\rangle = \frac{(9\times10^9)(1\times10^{-6}\,C)}{(10^{-2})^2}\langle 1,0\rangle$$

$$= 9\times10^7\langle 1,0\rangle \ \frac{N}{C}$$

$$\vec{E} = \vec{E}_① + \vec{E}_②$$

$$= \langle 9\times10^7,\ 1.8\times10^8\rangle \ \frac{N}{C} =$$

$$|\vec{E}| = \sqrt{(9\times10^7)^2 + (1.8\times10^8)^2} = 9\sqrt{5}\times10^7\,\frac{N}{C}$$