Electric

Force & Fields

Coulomb's Law

The electrical force between two charges is proportional to the product of the charge and inversely proportional to the square of the distance between them.

$$F = \frac{k\, q_1\, q_2}{d^2}$$

F = electrostatic force

q_1 and q_2 = charges of two particles

d = distance between objects 1 and 2

k = electrostatic constant ($9 \times 10^9\ Nm^2/C^2$)

Wait a minute...

This looks really familiar!

$$F = \frac{G\, m_1\, m_2}{d^2} \qquad F = \frac{k\, q_1\, q_2}{d^2}$$

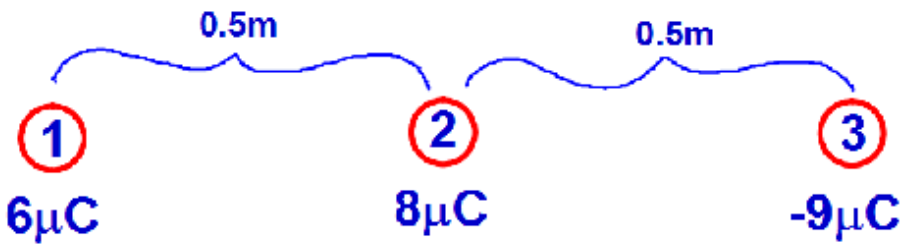
A proton and an electron are separated by a distance of 5.3×10^{-11}m. What is the force between the 2 particles?

$$F = \frac{k q_1 q_2}{d^2}$$

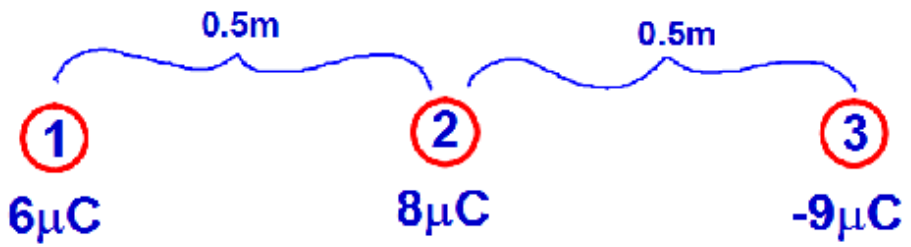
$$= \frac{9 \times 10^9 (1.6 \times 10^{-19})(1.6 \times 10^{-19})}{(5.3 \times 10^{-11})^2}$$

$$= 8.2 \times 10^{-8} \text{ N}$$

(Attractive force)



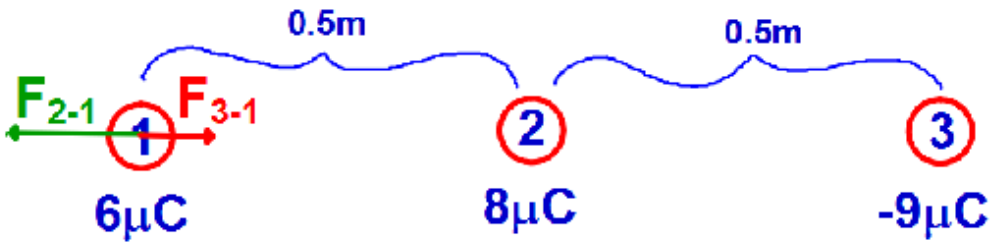
Q. What is the net force on charge 1?



Q. What is the net force on charge 1?

$$F_{2\text{-}1} = \frac{kq_1q_2}{d^2} = \frac{(9\text{x}10^{9})(6\text{x}10^{-6})(8\text{x}10^{-6})}{(0.5)^2} = 1.73\ \text{N}$$

$$F_{3\text{-}1} = \frac{kq_1q_2}{d^2} = \frac{(9\text{x}10^{9})(6\text{x}10^{-6})(9\text{x}10^{-6})}{(1)^2} = 0.49\ \text{N}$$

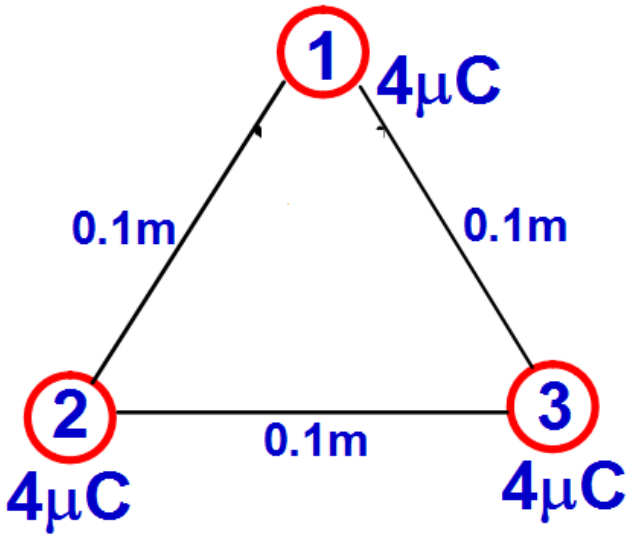


Q. What is the net force on charge 1?

$$F_{2-1} = \frac{kq_1q_2}{d^2} = \frac{(9\times10^{9})(6\times10^{-6})(8\times10^{-6})}{(0.5)^2} = 1.73\ \text{N LEFT}$$

$$F_{3-1} = \frac{kq_1q_2}{d^2} = \frac{(9\times10^{9})(6\times10^{-6})(9\times10^{-6})}{(1)^2} = 0.49\ \text{N RIGHT}$$

$$F_T = F_{2-1} - F_{3-1} = 1.24\ \text{N LEFT}$$



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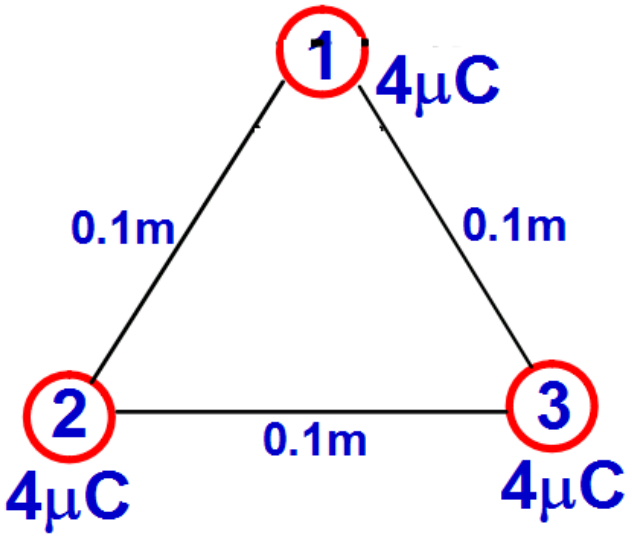

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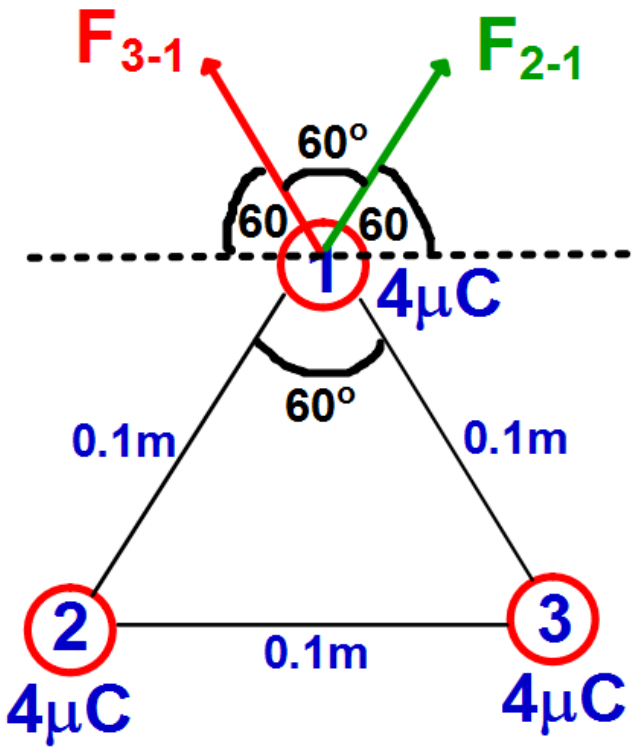
$$F_{2\text{-}1} = F_{3\text{-}1} = \frac{kq_1q_2}{d^2} = \frac{(9\times10^{9})(4\times10^{-6})(4\times10^{-6})}{(0.1)^2}$$

$$= 14.4\ \text{N}$$



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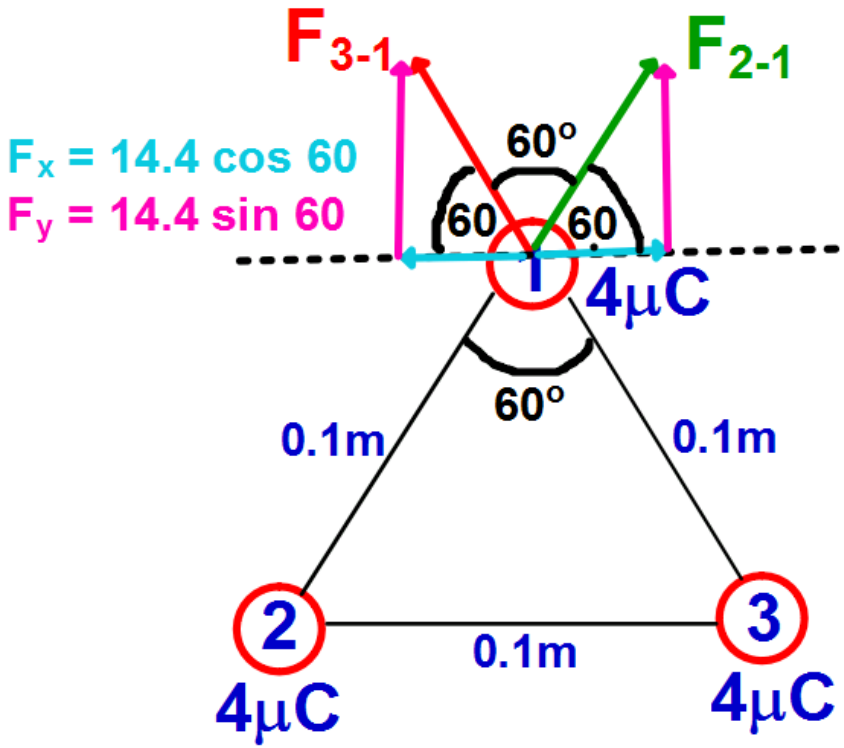

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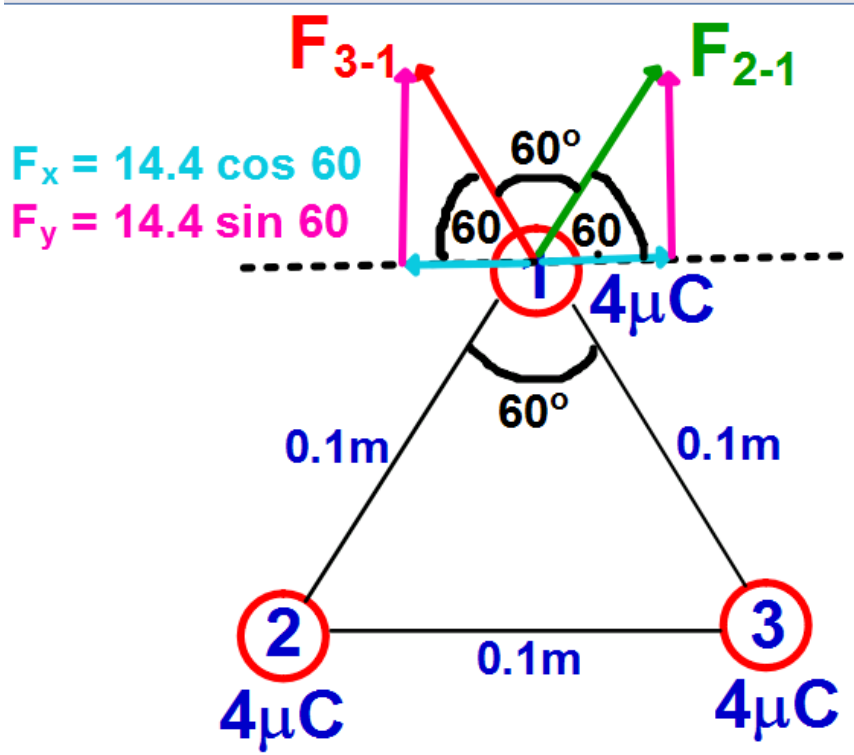

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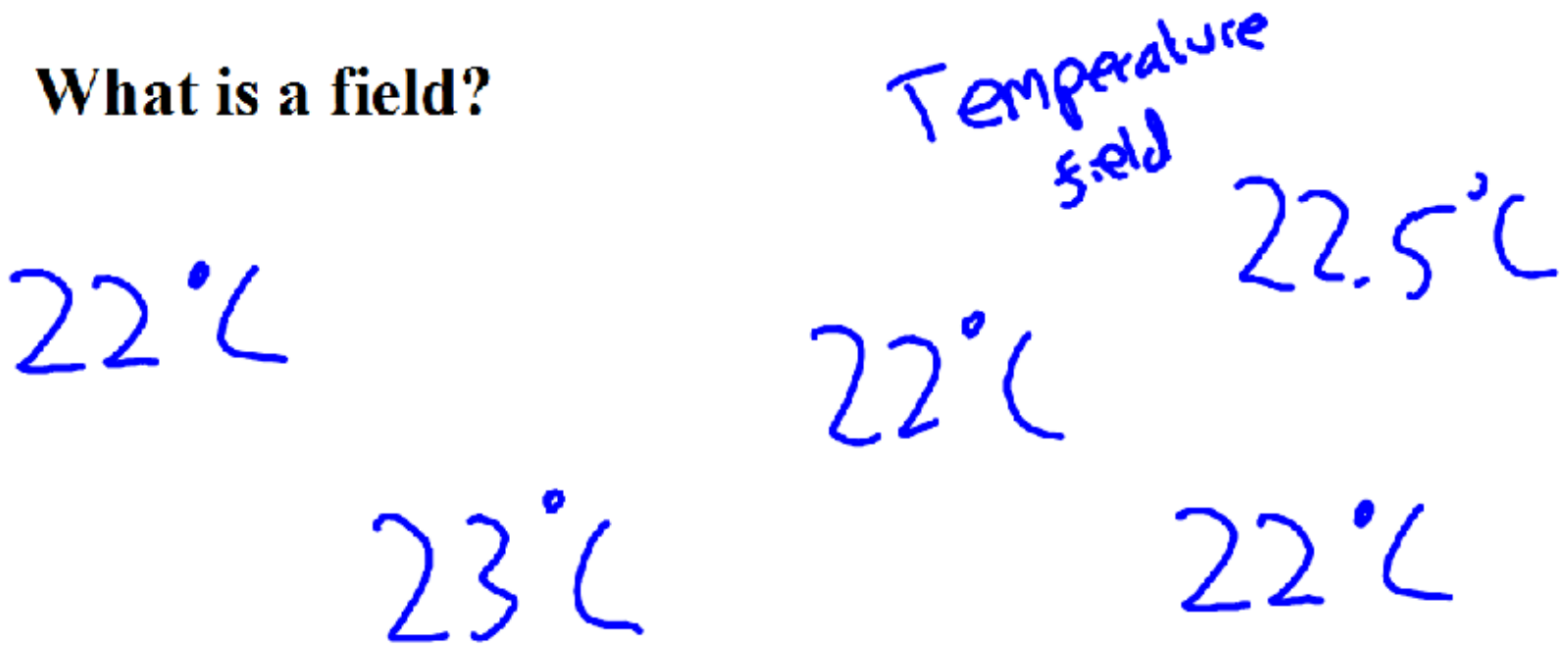
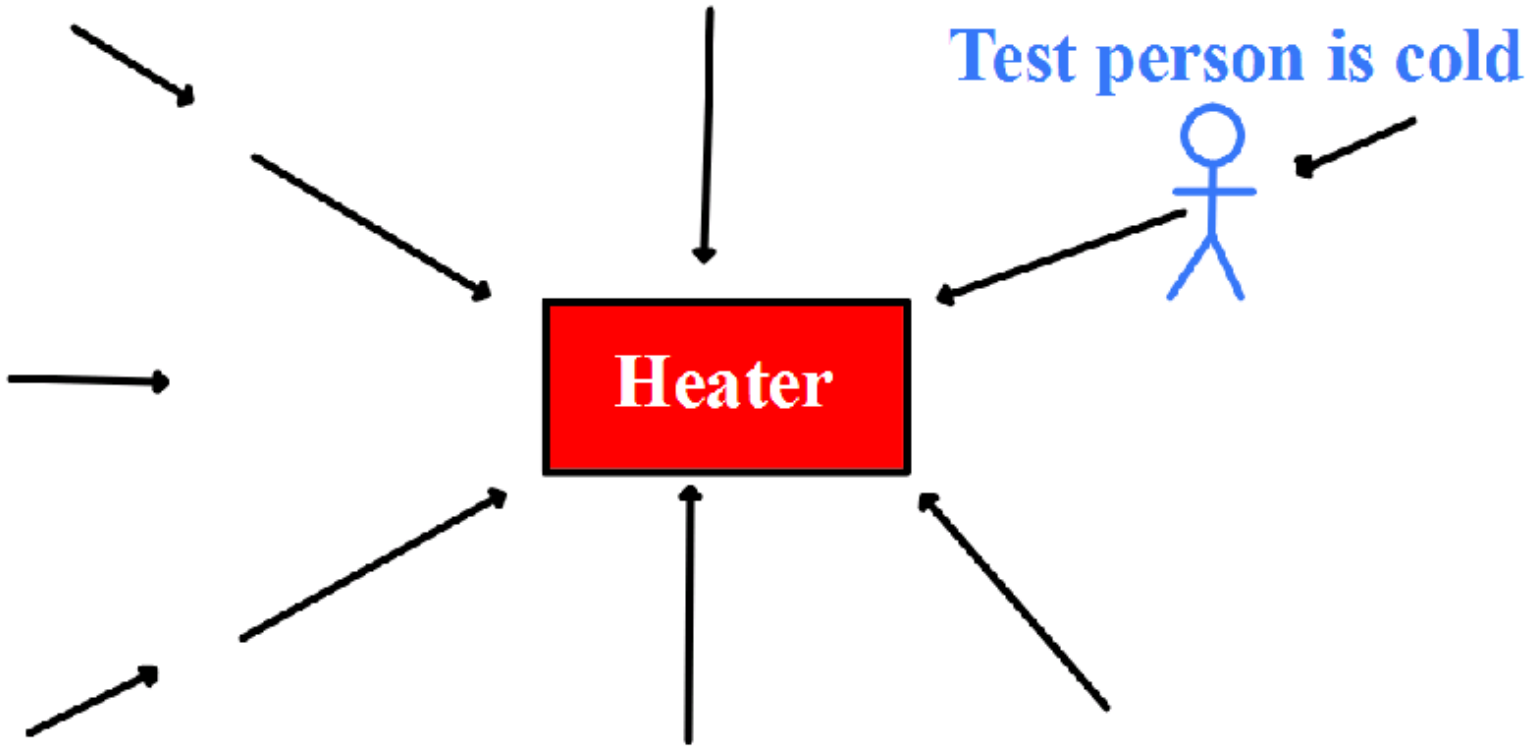
$$= 14.4 \text{ N}$$

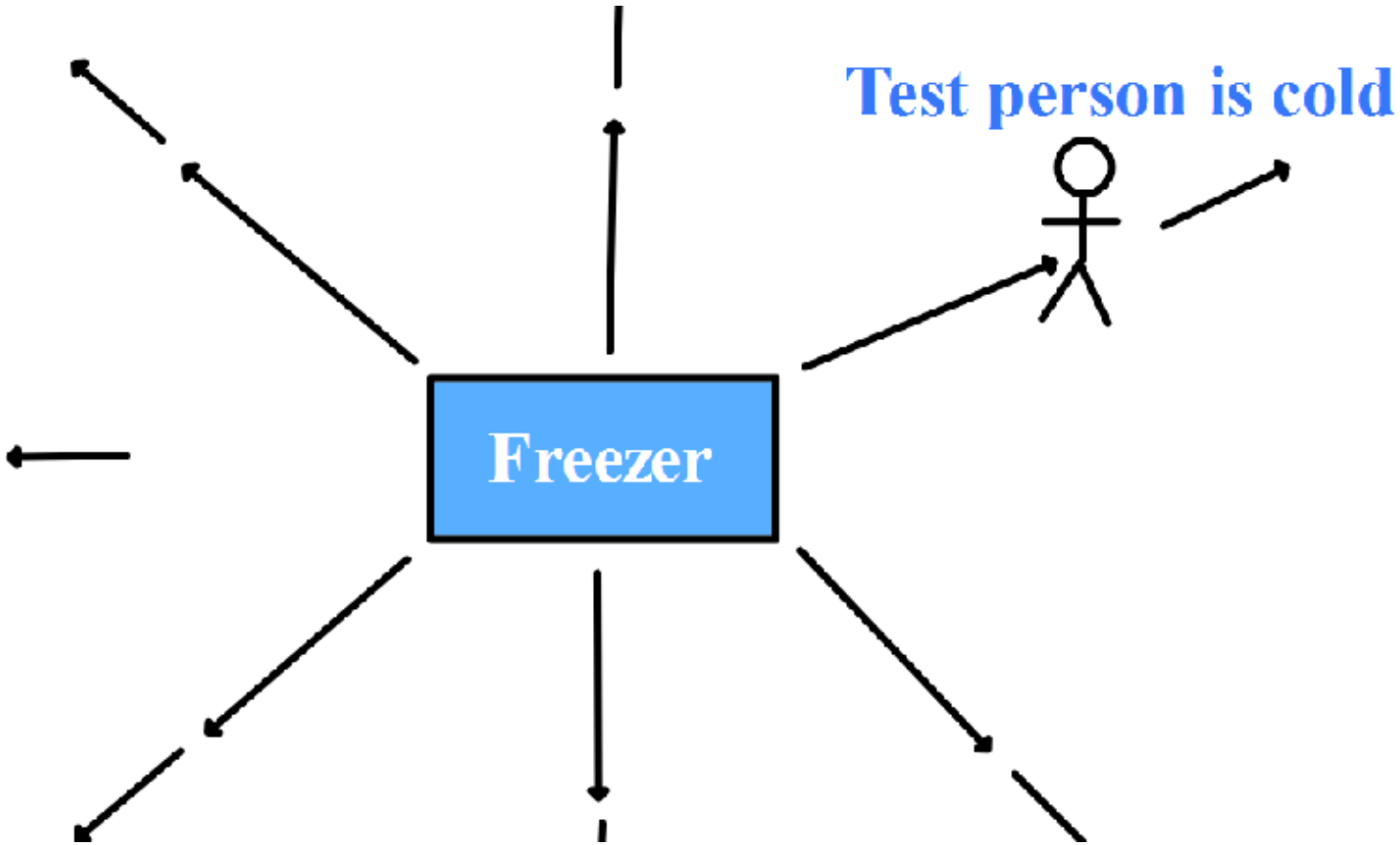
$$F_y = 14.4 \sin 60 = 12.5 \text{ N}$$

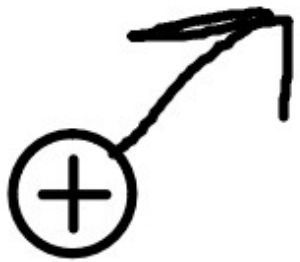
$$F_{TOTAL} = 2 \times 12.5 = 25 \text{ N UP}$$

What is a field?

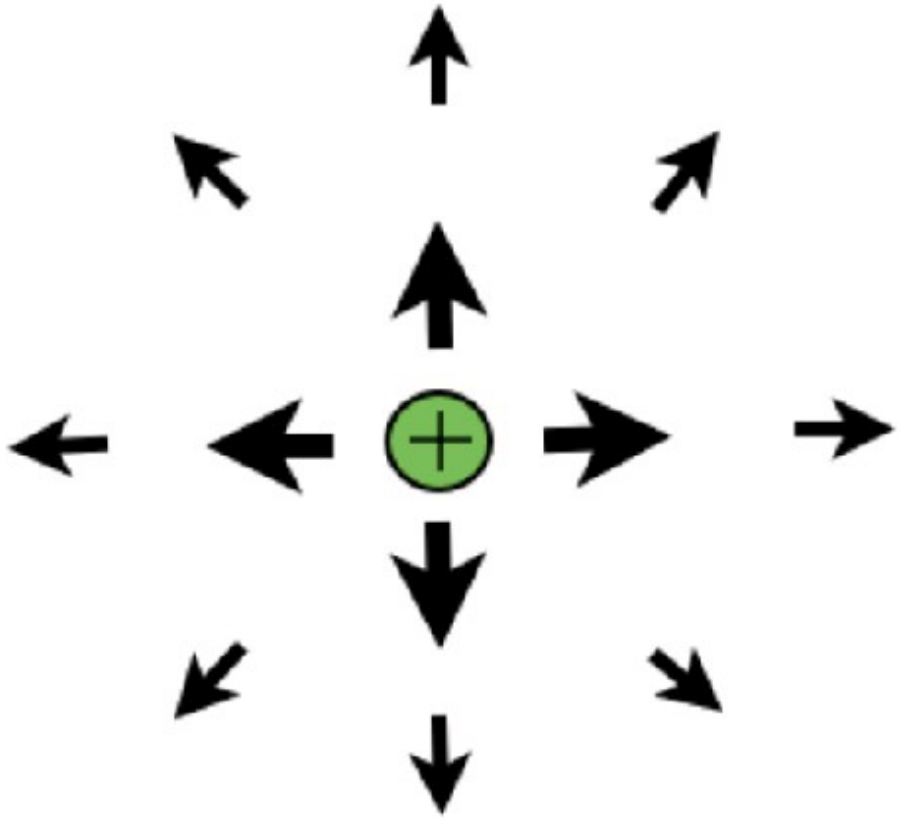


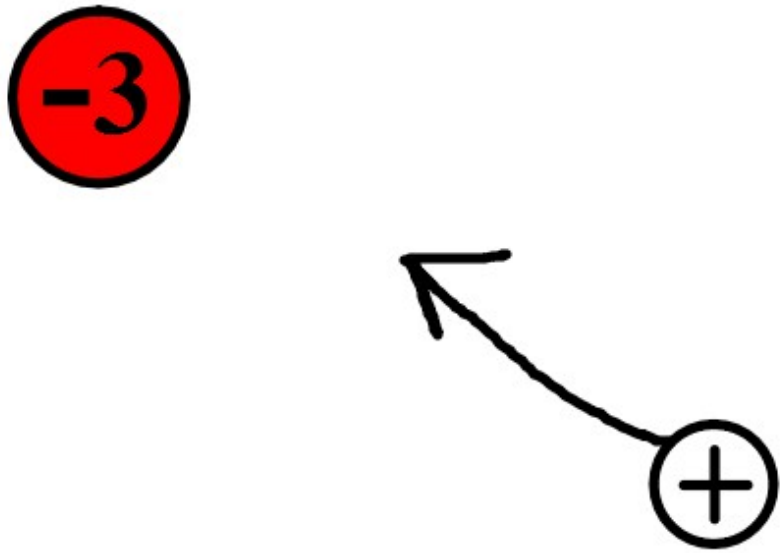

Test person is cold
Heater

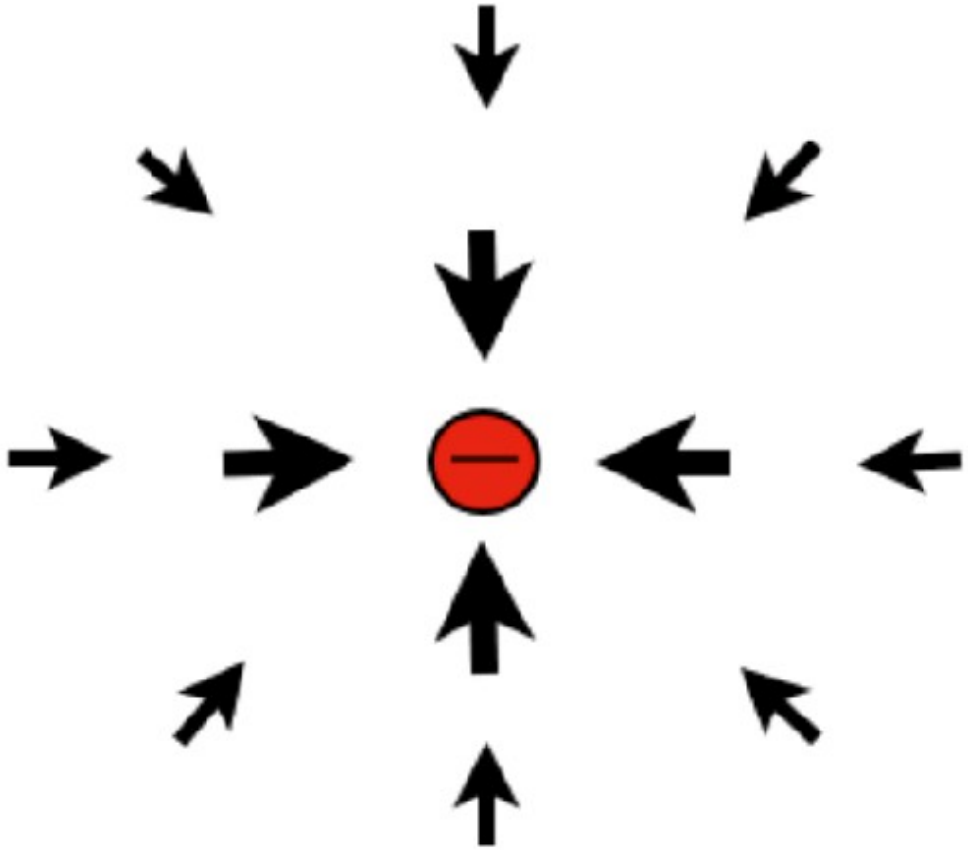

Test person is cold
Freezer

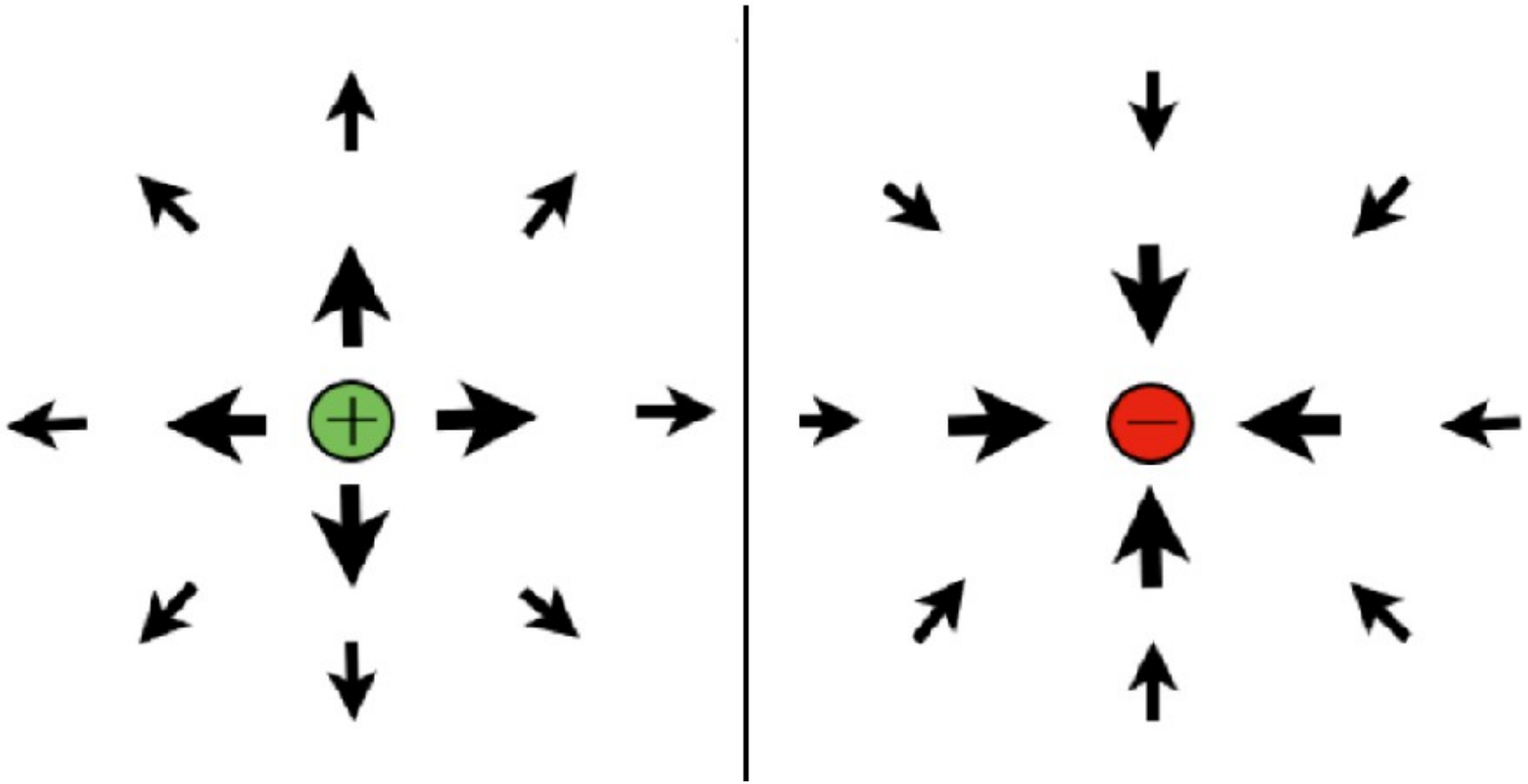


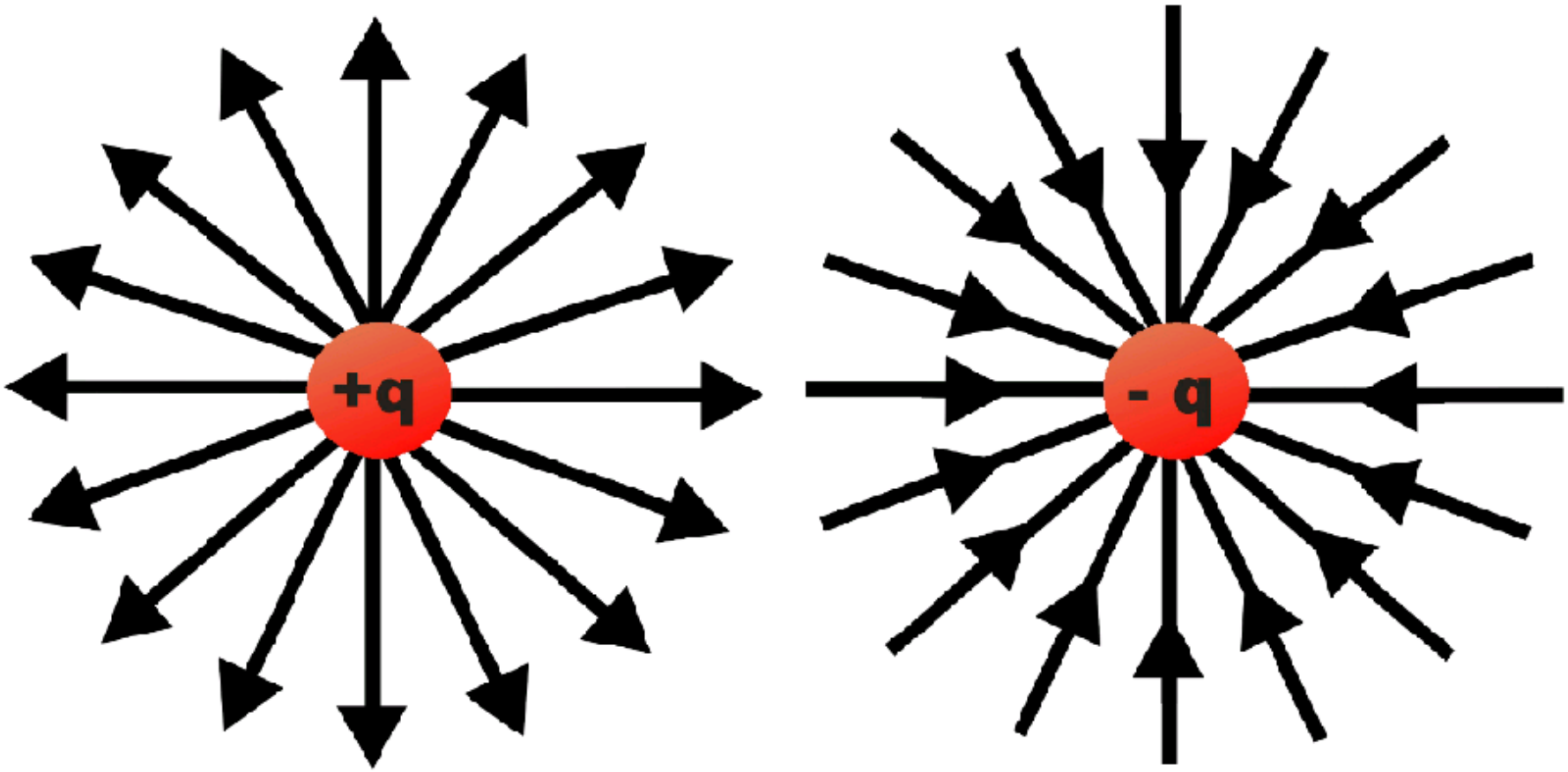

+3

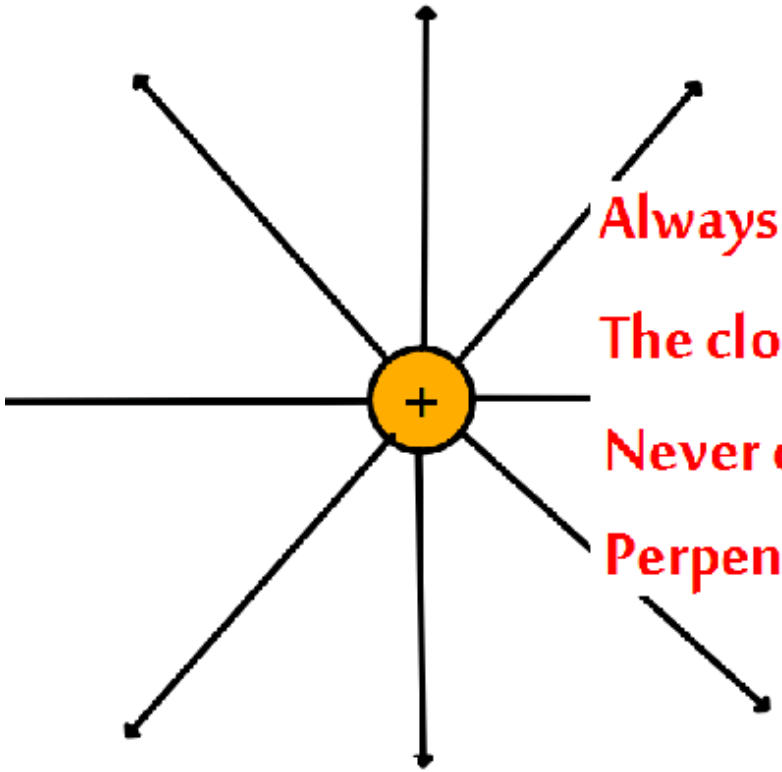



-3






+q
- q



Always come out of positive and into negative

The closer the lines, the stronger the field

Never cross

Perpendicular to surface

So what is an electric field?

- **Nothing deep. It is something we made up because it's useful. It describes the force in the area around a charge or group of charges.**

- **Electric field is the force that a +1 C positive test charge feels.**

Electric field is the force that a +1 C test charge feels. So sub in 1 to the force equation.

$$F = \frac{k\, q_1 q_2}{d^2} \qquad E = \frac{k\, q_1 (1)}{d^2}$$

$$E = \frac{k\, q}{d^2}$$

This is the electric field around a charge q.

Electric Fields

Electric field is the force that a +1 C test charge feels. So in other words, it is the force felt per unit of charge. (The force per Coulomb.)

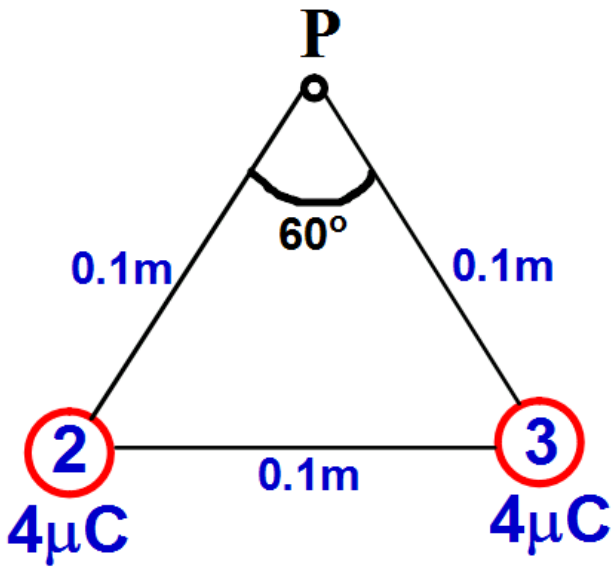
$$E = \frac{F}{q}$$

Electric Fields

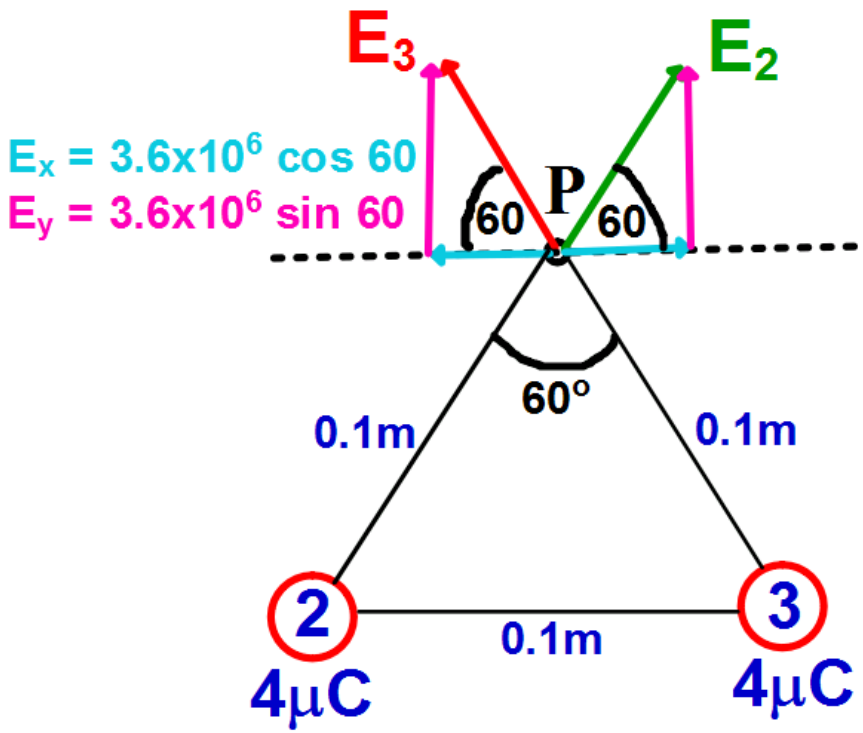
We already have a formula for force.
So we can substitute it in:

$$F = \frac{k\, q_1 q_2}{d^2} \qquad E = \frac{F}{q} \qquad E = \frac{k\, \cancel{q_1} q_2}{d^2 \cancel{q_1}}$$

$$E = \frac{k\, q}{d^2}$$ This is the electric field around a charge q.



Q. What is the overall electric field at point P?



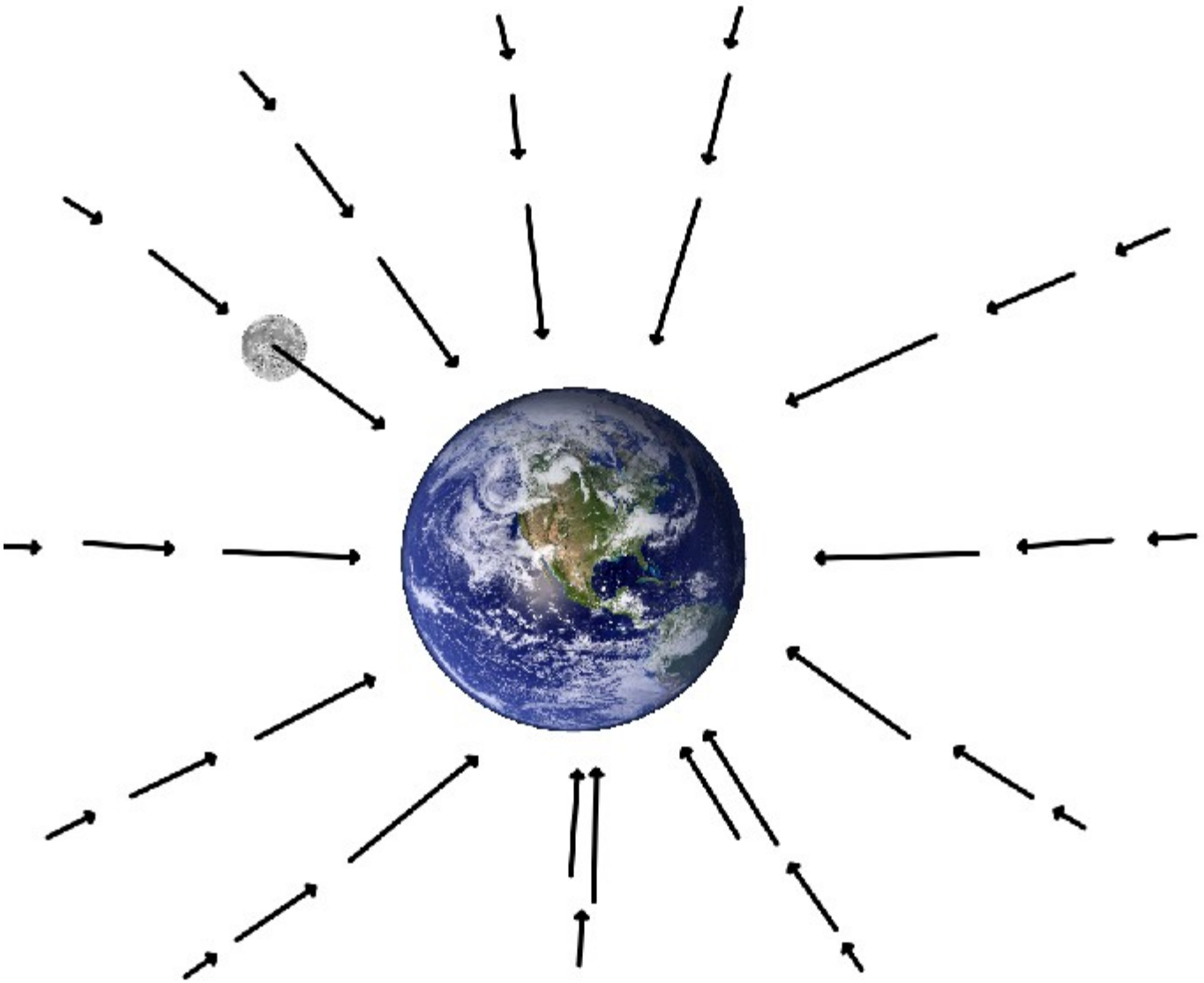
Q. What is the overall electric field at point P?

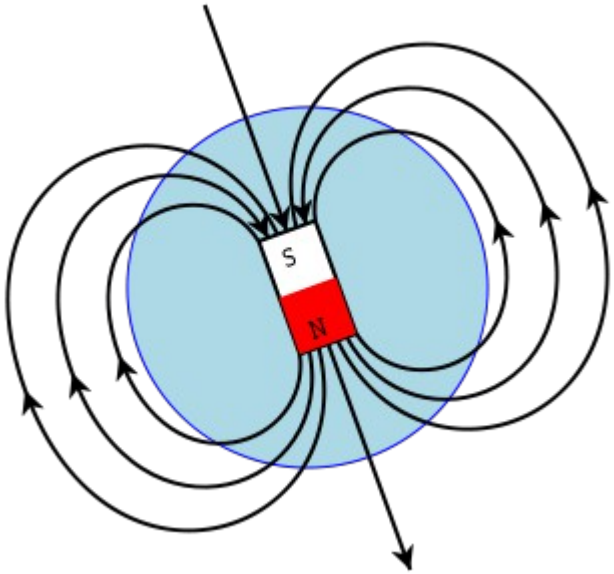
$$E_2 = E_3 = \frac{kq}{d^2} = \frac{(9\times10^9)(4\times10^{-6})}{(0.1)^2}$$

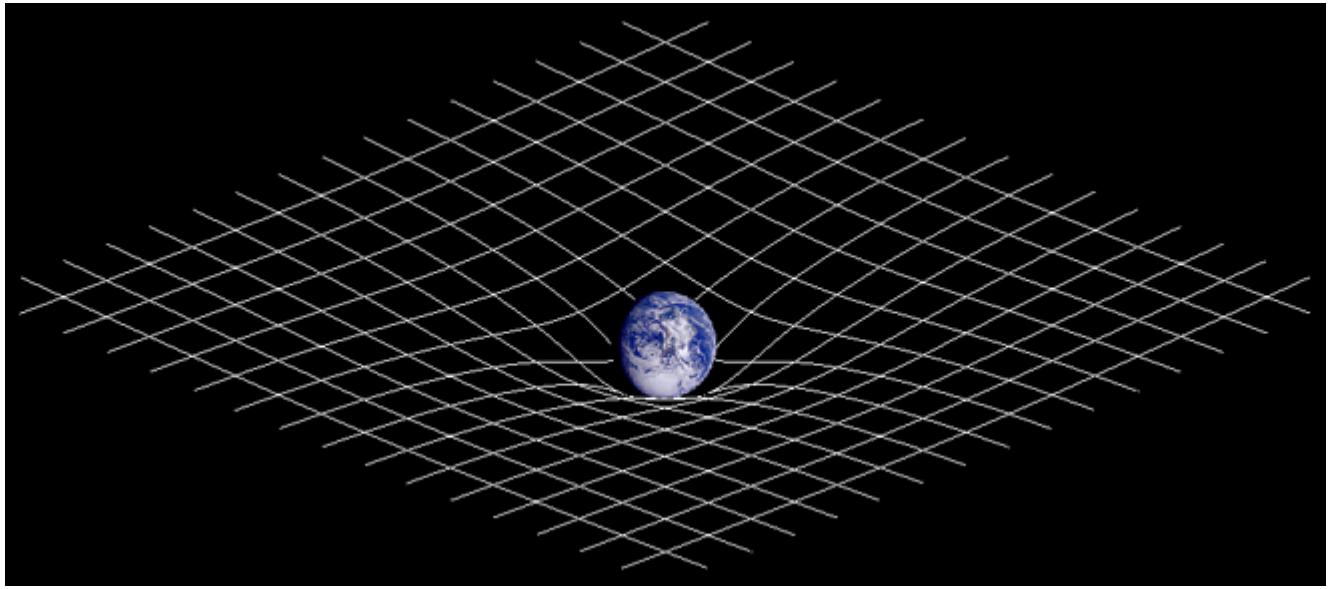
$$= 3.6 \times 10^6 \text{ N/C}$$

$$E_y = 3.6\times10^6 \sin 60 = 3.12\times10^6 \text{ N/C}$$

$$F_{TOTAL} = 2 \times 3.12\times10^6 = 6.24\times10^6 \text{ N/C UP}$$




S
N



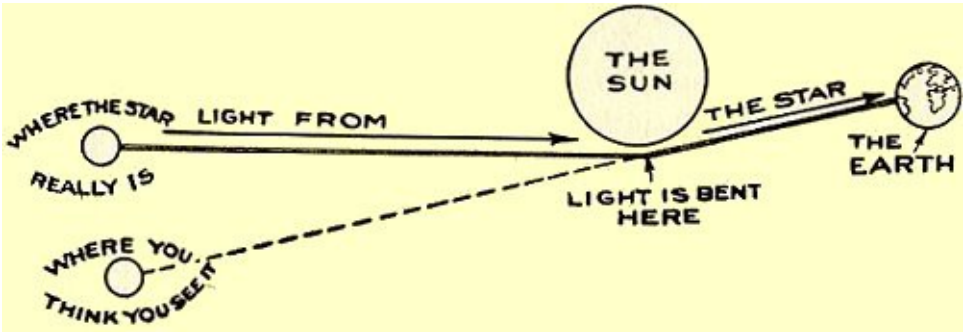


FIG. 72.—You See the Star Where It Is Not.