

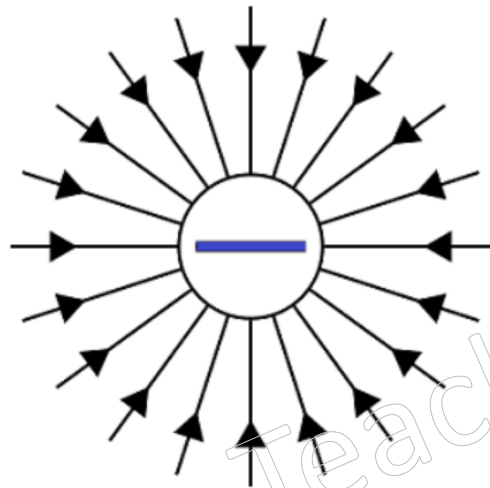
2.3 Electric field due to point charges

2024-09-22

Quick review:

02:00

What does this picture show?

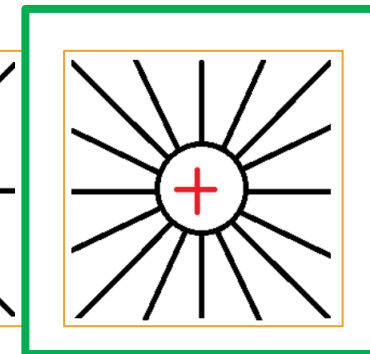
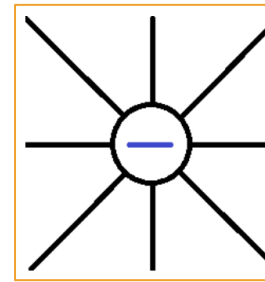
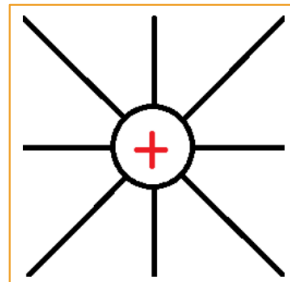


- ☒ Electric field lines around a negative charge
- ☐ Electric field lines around a positive charge
- ☐ Electric field lines around a neutral charge
- ☐ Electric field lines with no charge

2. What units are used to measure the force of an electric field?

- a. Coulombs
- ☒ b. Newtons
- c. Watts
- d. Volts

Which of these electric fields has the strongest force?

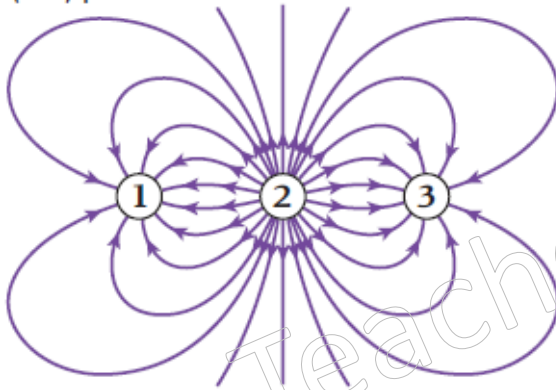


Quick review:

02:00

Concept Check 2.1

Which of the charges in the figure is (are) positive?

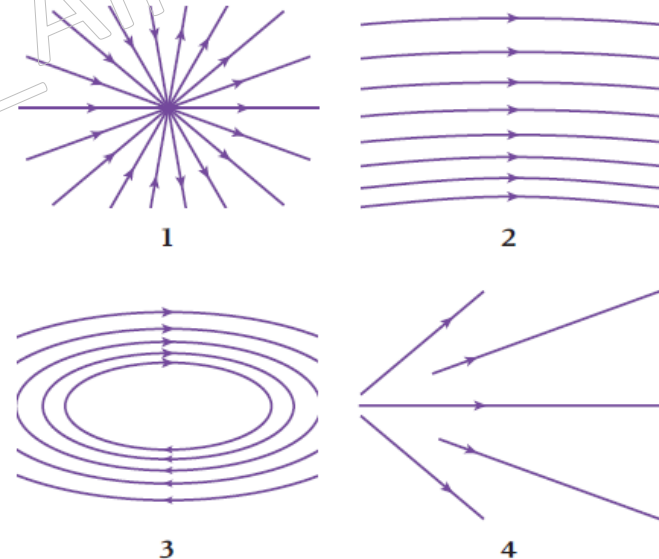


- a) 1
- b) 2**
- c) 3
- d) 1 and 3
- e) All three charges are positive.

Concept Check 2.2

Assuming that there are no charges in the four regions shown in the figure, which of the patterns could represent an electric field?

- a) only 1
- b) only 2**
- c) 2 and 3
- d) 1 and 4
- e) None of the patterns represent an electric field.



Electric field due to point charges

The magnitude of the electric force on a point charge q_0 due to another point charge, q , is given by:

$$F = \frac{1}{4\pi\epsilon_0} \frac{|qq_0|}{r^2}$$

Taking q_0 to be a small test charge, we can express the magnitude of the electric field at the point where q_0 is and due to the point charge q as:

$$E = \left| \frac{F}{q_0} \right| = \frac{1}{4\pi\epsilon_0} \frac{|q|}{r^2}$$

where r is the distance from the test charge to the point charge.

Electric field due to point charges

- The direction of the electric field of a point charge is radial.
- The field points outward for a positive point charge and inward for a negative point charge.
- An electric field is a vector quantity, and thus the components of the field must be added separately.

Teacher Asmaa Alhameed
Telegram: @Asmaa_Alhameed

EXAMPLE 2.1

Three Charges

Figure 2.9 shows three fixed point charges: $q_1 = +1.50 \mu\text{C}$, $q_2 = +2.50 \mu\text{C}$, and $q_3 = -3.50 \mu\text{C}$. Charge q_1 is located at $(0,a)$, q_2 is located at $(0,0)$, and q_3 is located at $(b,0)$, where $a = 8.00 \text{ m}$ and $b = 6.00 \text{ m}$.

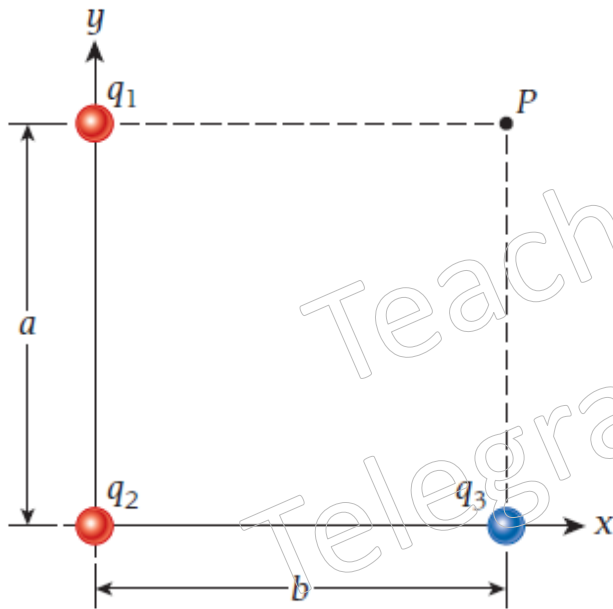


FIGURE 2.9 Locations of three point charges.

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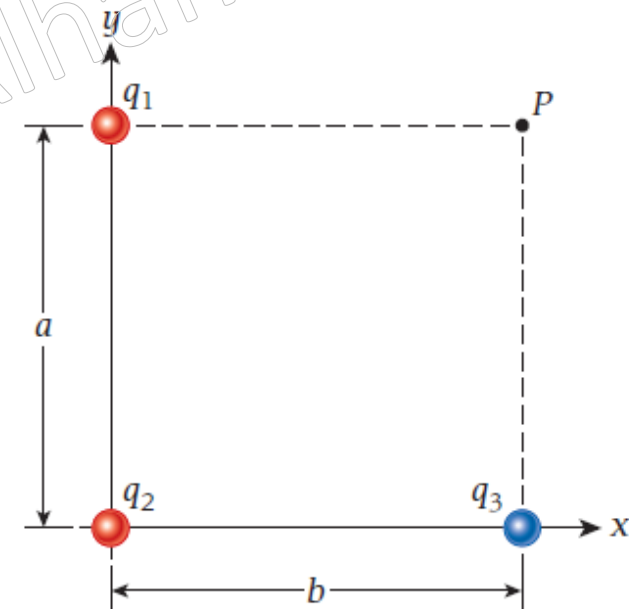


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Teacher Asmaa Alhameed
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The magnitude of the field is

$$E = \sqrt{E_x^2 + E_y^2} = \sqrt{(509 \text{ N/C})^2 + (-312 \text{ N/C})^2} = 597 \text{ N/C}$$

The direction of the field at point P is

$$\varphi = \tan^{-1} \left(\frac{E_y}{E_x} \right) = \tan^{-1} \left(\frac{-312 \text{ N/C}}{509 \text{ N/C}} \right) = -31.5^\circ$$

Practice:

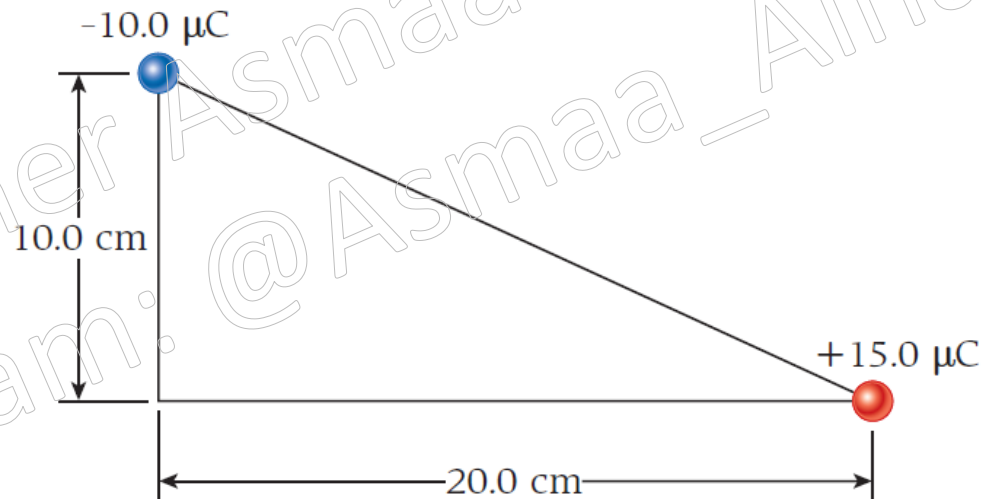
2.25 A point charge, $q = 4.00 \times 10^{-9} \text{ C}$, is placed on the x -axis at the origin. What is the electric field produced at $x = 25.0 \text{ cm}$?

2.26 A $+1.60 \text{ nC}$ point charge is placed at one corner of a square (1.00 m on a side), and a -2.40 nC charge is placed on the corner diagonally opposite. What is the magnitude of the electric field at either of the other two corners?

2.27 A $+48.00 \text{ nC}$ point charge is placed on the x -axis at $x = 4.000 \text{ m}$, and a -24.00-nC point charge is placed on the y -axis at $y = -6.000 \text{ m}$. What is the direction of the electric field at the origin?

Practice:

- **2.28** Two point charges are placed at two of the corners of a triangle as shown in the figure. Find the magnitude and the direction of the electric field at the third corner of the triangle.



- **2.29** A $+5.00 \text{ C}$ charge is located at the origin. A -3.00 C charge is placed at $x = 1.00 \text{ m}$. At what finite distance(s) along the x -axis will the electric field be equal to zero?

Practice:

- **2.30** Three charges are on the y -axis. Two of the charges, each $-q$, are located $y = \pm d$, and the third charge, $+2q$, is located at $y = 0$. Derive an expression for the electric field at a point P on the x -axis.

2.9 Three -9mC point charges are located at $(0,0)$, $(3\text{ m}, 3\text{ m})$, and $(3\text{ m}, -3\text{ m})$. What is the magnitude of the electric field at $(3\text{ m}, 0)$?

a) $0.9 \times 10^7 \text{ N/C}$

b) $1.2 \times 10^7 \text{ N/C}$

c) $1.8 \times 10^7 \text{ N/C}$

d) $2.4 \times 10^7 \text{ N/C}$

e) $3.6 \times 10^7 \text{ N/C}$

f) $5.4 \times 10^7 \text{ N/C}$

g) $10.8 \times 10^7 \text{ N/C}$