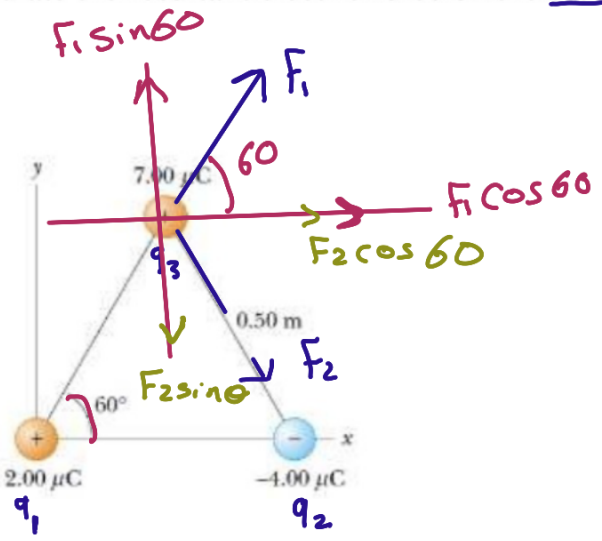
**PHY 220 : EXERCISES-CH:1**

**Q1:** Three point charges are located at the corners of an equilateral triangle as shown in figure below, calculate the resultant electric force on the 7.00μC charge.




$$F_1 = \frac{k\,q_1 q_3}{r^2} = \frac{8.99\times10^{9}\times7\times10^{-6}\times2\times10^{-6}}{(0.5)^2} = 0.503\ N$$

$$F_2 = \frac{k\,q_2 q_3}{r^2} = \frac{8.99\times10^{9}\times4\times10^{-6}\times7\times10^{-6}}{(0.5)^2} = 1.007\ N$$

$$F_1 = F_1\cos60\,i + F_1\sin\theta\,j$$

$$F_1 = 0.503\cos60\,i + 0.503\sin60\,j$$

$$\boxed{F_1 = 0.252\,i + 0.436\,j}$$

$$F_2 = F_2\cos60\,i - F_2\sin60\,j$$
$$= 1.007\cos60\,i - 1.007\sin60\,j$$

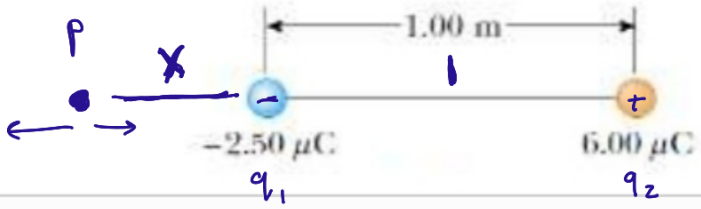
$$\boxed{F_2 = 0.503\,i - 0.872\,j}$$

$$|F| = \sqrt{0.755^2 + 0.436^2}$$
$$= 0.872\ N$$
$$\theta = \tan^{-1}\left(\frac{-0.436}{0.755}\right)$$
$$\theta = -30 + 360$$
$$= 330°$$

$$F = F_1 + F_2 = (0.252 + 0.503)i + (0.436 - 0.872)j$$

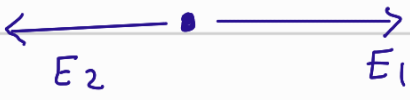
$$\boxed{F = 0.755\,i - 0.436\,j}$$

**Q2:** In Figure below, determine the point at which the electric field is zero.




$E = 0$

$E_1 = E_2$




$$E_1 = E_2$$

$$\frac{k q_1}{x^2} = \frac{k q_2}{(1+x)^2}$$

$$\frac{2.5 \times 10^{-6}}{x^2} = \frac{6 \times 10^{-6}}{(1+x)^2}$$

$$\sqrt{\frac{2.5}{x^2}} = \sqrt{\frac{6}{(1+x)^2}}$$

$$\frac{\sqrt{2.5}}{x} = \frac{\sqrt{6}}{1+x}$$

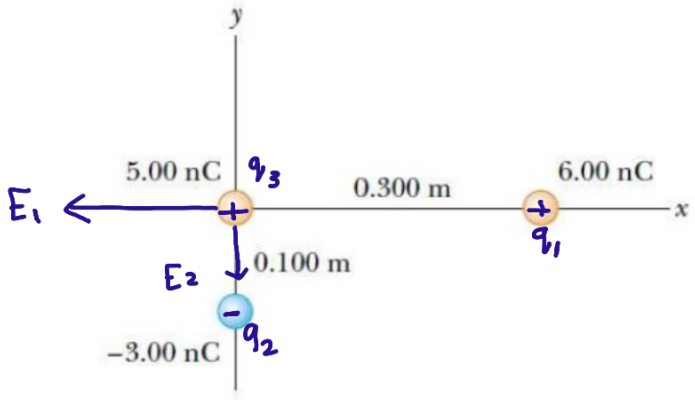
$$\frac{1.581}{x} = \frac{2.449}{1+x} \Rightarrow 2.449x = 1.581 + 1.581x$$

$$2.449x - 1.581x = 1.581$$

$$0.868x = 1.581$$

$$x = \frac{1.581}{0.868} = 1.82\ m$$

**Q3:** Three points charges are arranged as shown in Figure.
(a) Find the vector electric field that the 6.00nC and -3.00-nC charges together create at the origin.
(b) Find the vector force on the 5.00nC charge




a)

$$E_1 = \frac{kq_1}{r^2} = \frac{8.99\times10^9 \times 6\times10^{-9}}{(0.3)^2} = 5.99\times10^2 \text{ N/C}$$

$$-5.99\times10^2\, i$$

$$E_2 = \frac{kq_2}{r^2} = \frac{8.99\times3\times10^{-9}}{(0.1)^2} = 2.7\times10^3 \text{ N/C}$$

$$-2.7\times10^3\, j$$

$$E = E_1 + E_2$$

$$E = -5.99\times10^2 i - 2.7\times10^3 j$$

b) $F = Eq_3$

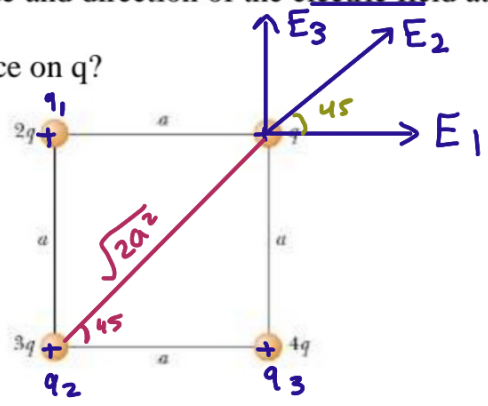
$$F = (-5.99\times10^2 i - 2.7\times10^3 j)(5\times10^{-9})$$

$$F = -3\times10^{-6} i - 13.5\times10^{-6} j \quad N$$

**Q4:** Four point charges are at the corners of a square of side a as shown in Figure below:

(a) Determine the magnitude and direction of the electric field at the location of charge q.

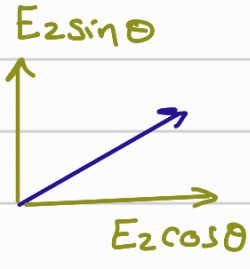
(b) What is the resultant force on q?




$$E_1 = \frac{kq_1}{r^2} = \frac{2kq}{a^2}\, i \quad N/C$$

$$E_3 = \frac{kq_3}{r^2} = \frac{4kq}{a^2}\, j \quad N/C$$

$$E_2 = \frac{kq_2}{r^2} = \frac{3kq}{(\sqrt{2a^2})^2} = \frac{3kq}{2a^2}$$




$$E_2 = \frac{3kq}{2a^2}\cos 45\, i + \frac{3kq}{2a^2}\sin 45\, j$$

$$E_2 = 1.06\,\frac{kq}{a^2}\, i + 1.06\,\frac{kq}{a^2}\, j$$

$$E = E_1 + E_2 + E_3 = \frac{2kq}{a^2}\, i + \frac{4kq}{a^2}\, j + 1.06\,\frac{kq}{a^2} i + 1.06\,\frac{kq}{a^2}\, j$$

$$= (2i + 4j + 1.06i + 1.06j)\,\frac{kq}{a^2}$$

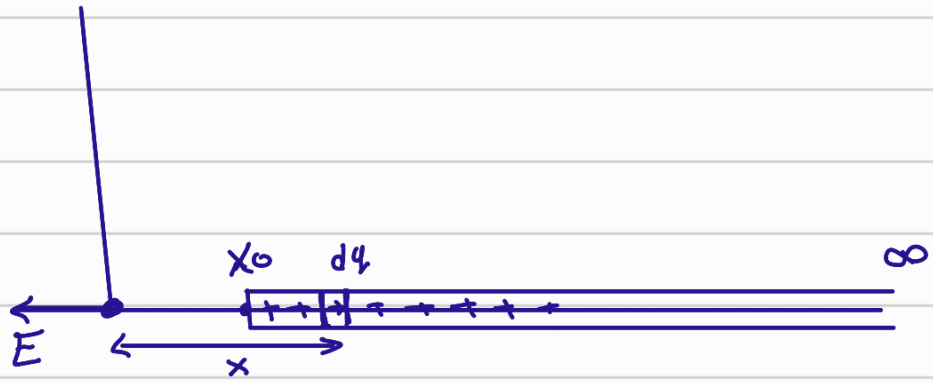
$$E = (3.06i + 5.06j)\,\frac{kq}{a^2} \quad N/C$$

b) $F = qE$

$$F = q\left[3.06i + 5.06j\right]\frac{kq}{a^2}$$

$$F = \left[3.06i + 5.06j\right]\frac{kq^2}{a^2}$$

**Q5:** A continuous line of charge lies along the x axis, extending from $\mathbf{x = x_0}$ to positive infinity. The line carries charge with a uniform linear charge density $\boldsymbol{\lambda}$. What are the magnitude and direction of the electric field at the origin?




$\lambda$

$dq = \lambda dx$

$$E = \int \frac{k\,dq}{x^2} = \int_{x_0}^{\infty} \frac{k\,\lambda\,dx}{x^2}$$

$$E = k\lambda \int_{x_0}^{\infty} x^{-2}\,dx$$

$$E = k\lambda \left[\frac{x^{-1}}{-1}\right]_{x_0}^{\infty}$$

$$E = -k\lambda \left[\frac{1}{x}\right]_{x_0}^{\infty}$$

$$E = -k\lambda \left[\frac{1}{\infty} - \frac{1}{x_0}\right]$$

$$E = \frac{k\lambda}{x_0}$$

$a = 10\,cm = 0.1\,m$

**Q6:** A uniformly charged ring of radius 10.0 cm has a total charge of 75 μC .Find the electric field on the axis of the ring at :
(a) 1.00 cm, (b) 5.00 cm, (c) 30.0 cm, and (d) 100 cm from the center of the ring.

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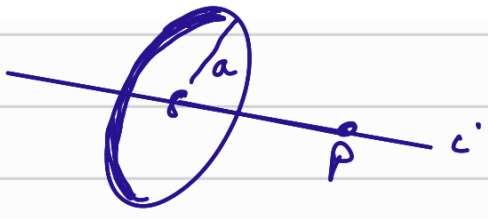
تم اشتقاقه سابقاً




$$E = \frac{k \times Q}{(a^2 + x^2)^{3/2}}$$

a) $x = 1\,cm = 1 \times 10^{-2}\,m$

$$E = \frac{8.99 \times 10^9 \times 1 \times 10^{-2} \times 75 \times 10^{-6}}{(0.1^2 + (1 \times 10^{-2})^2)^{3/2}} = 6.64 \times 10^6\ N/C$$

b) $x = 5\,cm = 5 \times 10^{-2}$

$$E = \frac{8.99 \times 10^9 \times 5 \times 10^{-2} \times 75 \times 10^{-6}}{(0.1^2 + (5 \times 10^{-2})^2)^{3/2}} = 2.41 \times 10^7$$

c) $x = 30\,cm \qquad x = 0.3\,m$

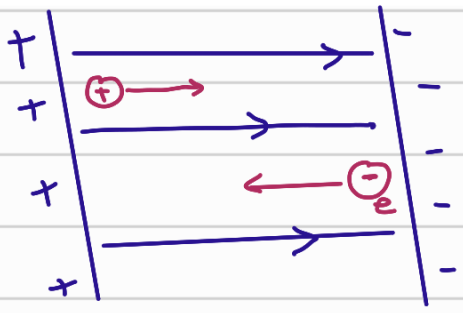
$$E = 6.4 \times 10^6\ N/C$$

d) $x = 100\,cm \qquad x = 1\,m$

$$E = 0.664 \times 10^6\ N/C$$

$m_e = 9.11 \times 10^{-31}$ kg  $m_p = 1.67 \times 10^{-27}$ kg

**Q7:** An electron and a proton are each placed at rest in an electric field of 520N/C. Calculate the speed of each particle 48.0 ns after being released.



$E = 520$ N/C

$t = 48 \times 10^{-9}$ s

$V_o = 0$

$V = V_o + at$  $a = \frac{eE}{m}$

أولاً حسب التسارع للالكترون ثم حسب V

$$a_e = \frac{1.6 \times 10^{-19} \times 520}{9.11 \times 10^{-31}} = 9.13 \times 10^{13} \text{ m/s}$$

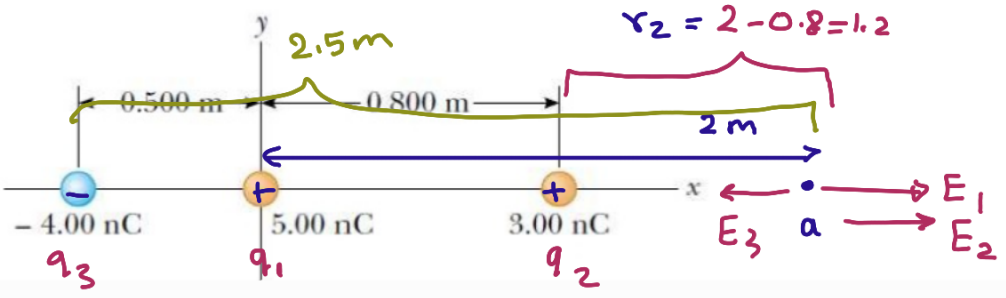
$$V = V_o + at$$
$$0 + 9.13 \times 10^{13} \times 48 \times 10^{-9} = 4.38 \times 10^{6} \text{ m/s}$$

ثانياً حسب تسارع البروتون ثم حسب V

$$V = V_o + a_p t$$
$$= 0 + \left(\frac{1.6 \times 10^{-19} \times 520}{1.67 \times 10^{-27}}\right)(4.8 \times 10^{-9})$$

$$V = 2.39 \times 10^{3} \text{ m/s}$$

**Q8:** Three point charges are aligned along the x axis as shown in Figure. Find the electric field at (a) the position (2.00, 0) and (b) the position (0, 2.00).




a) at position (2,0)

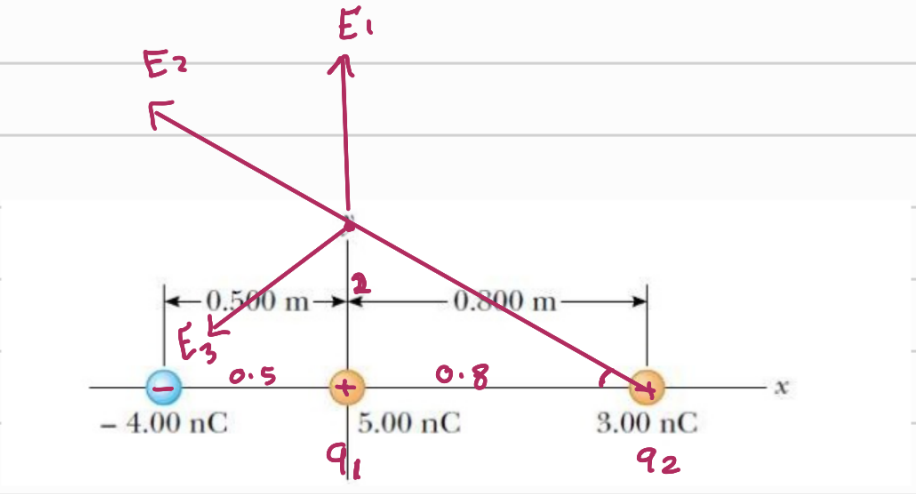

$$E_1 = \frac{kq_1}{r_1^2} = \frac{8.99\times10^{9}\times5\times10^{-9}}{2^2} = 11.25\,i \quad N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{8.99\times10^{9}\times3\times10^{-9}}{(1.2)^2} = 18.75\,i \quad N/C$$

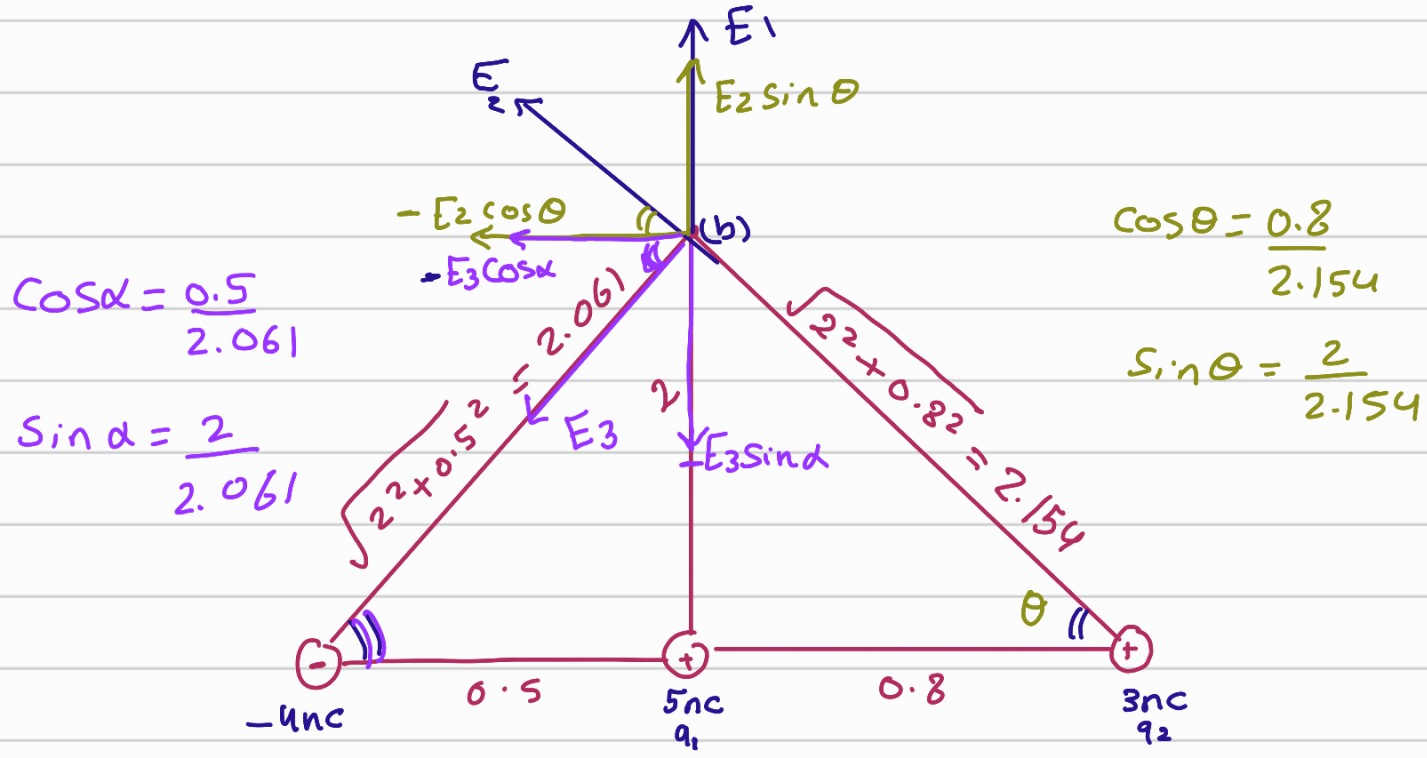
$$E_3 = \frac{kq_3}{r_3^3} = \frac{8.99\times10^{9}\times4\times10^{-9}}{(2.5)^2} = -5.76\,i \quad N/C$$

$$E = E_1 + E_2 + E_3 = (11.25+18.75-5.76)i$$
$$= 24.24\,i$$

b)




at postion at (0,2)




$\cos\alpha = \frac{0.5}{2.061}$

$\sin\alpha = \frac{2}{2.061}$

$\cos\theta = \frac{0.8}{2.154}$

$\sin\theta = \frac{2}{2.154}$

$$E_1 = \frac{kq_1}{r_1^2} = \frac{8.99\times10^{9}\times5\times10^{-9}}{2^2} = 11.25\,j \quad N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{8.99\times10^{9}\times3\times10^{-9}}{(2.154)^2} = 5.819 \quad N/C$$

$$E_2 = -E_2\cos\theta\, i + E_2\sin\theta\, j$$

$$= -5.819\left(\frac{0.8}{2.154}\right)i + 5.819\left(\frac{2}{2.154}\right)j$$

$$E_2 = -2.16\,i + 5.403\,j$$

$$E_3 = \frac{kq_3}{r^2} = \frac{8.99\times10^{9}\times4\times10^{-9}}{(2.061)^2} = 8.47 \quad N/C$$

$$E_3 = -E_3\cos\alpha\, i + -E_3\sin\alpha\, j$$

$$E_3 = -8.47\left(\frac{0.5}{2.061}\right)i - 8.47\left(\frac{2}{2.061}\right)j$$

$$E_3 = -2.054\,i - 8.215\,j$$

$$E = E_1 + E_2 + E_3$$

$$E = 11.25j - 2.16i + 5.403j - 2.054i - 8.215j$$

$$E = -4.215\,i + 8.438\,j$$