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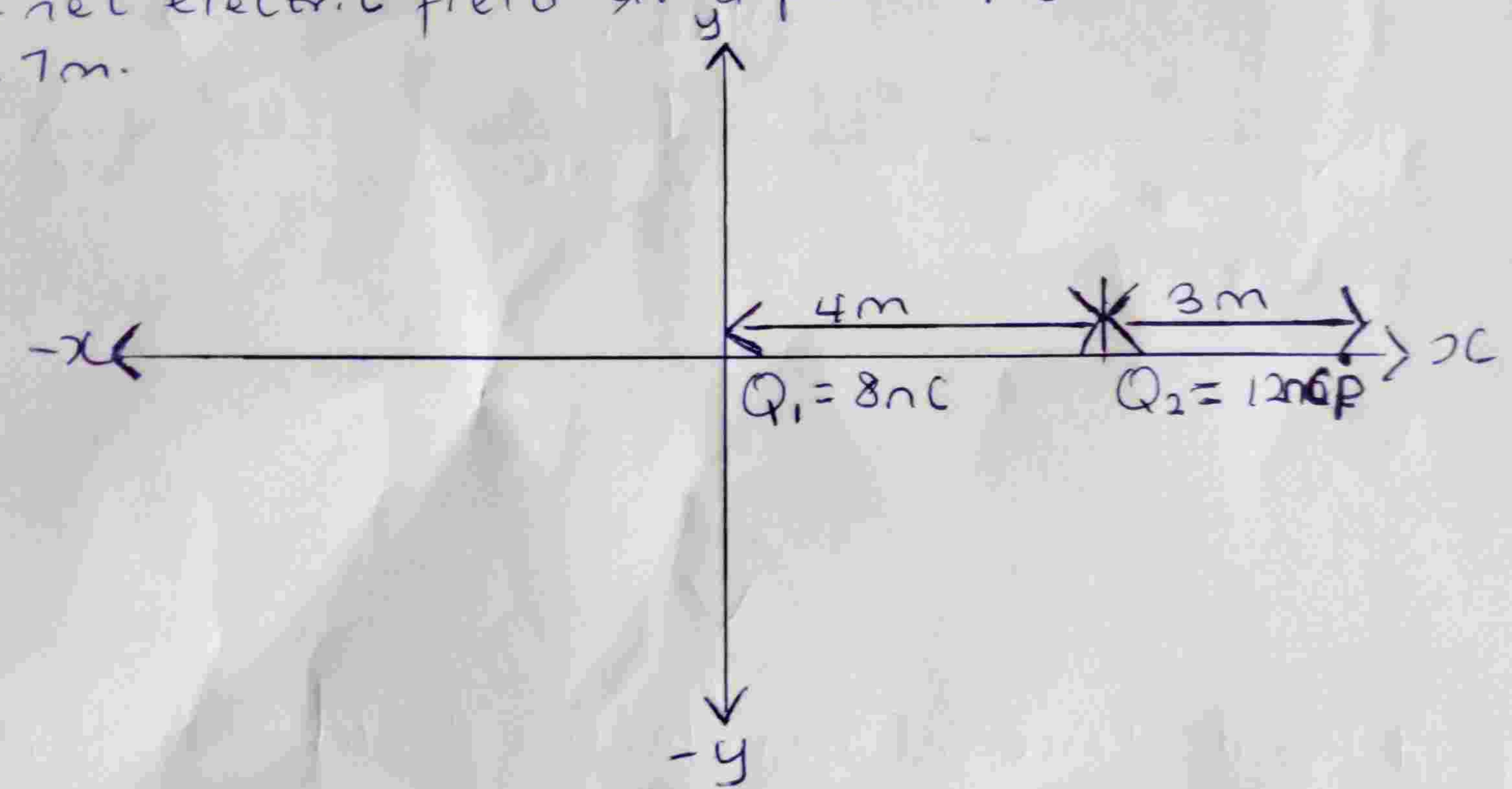
Department: Medicine and Sugery
Course: Physics 102

2(a) Distinguish between the terms; electric field and electric field intesity

An Electric field is a region of space in which an electric charge would experience an electric force while;
Electric field intesity E, can be defined as the force per unit charge.

2(b) A positive charge $Q_1 = 8nC$ is at the origin, and a second positive charge $Q_2 = 12nC$ is on the x-axis at $x = 4m$, find:

i) The net electric field at a point P on the x axis at $x = 7m$.



$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.4694\ N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12\ N/C$$

Vector	Angle	X-Comp	Y-comp
$E_1 = 1.4694N/C$	0	$1.4694\cos\theta = 1.4694$	0
$E_2 = 12N/C$	0	$12\cos 0 = 12$	0
		13.4694	

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$E = \sqrt{\Sigma E_x^2 + E_y^2}$

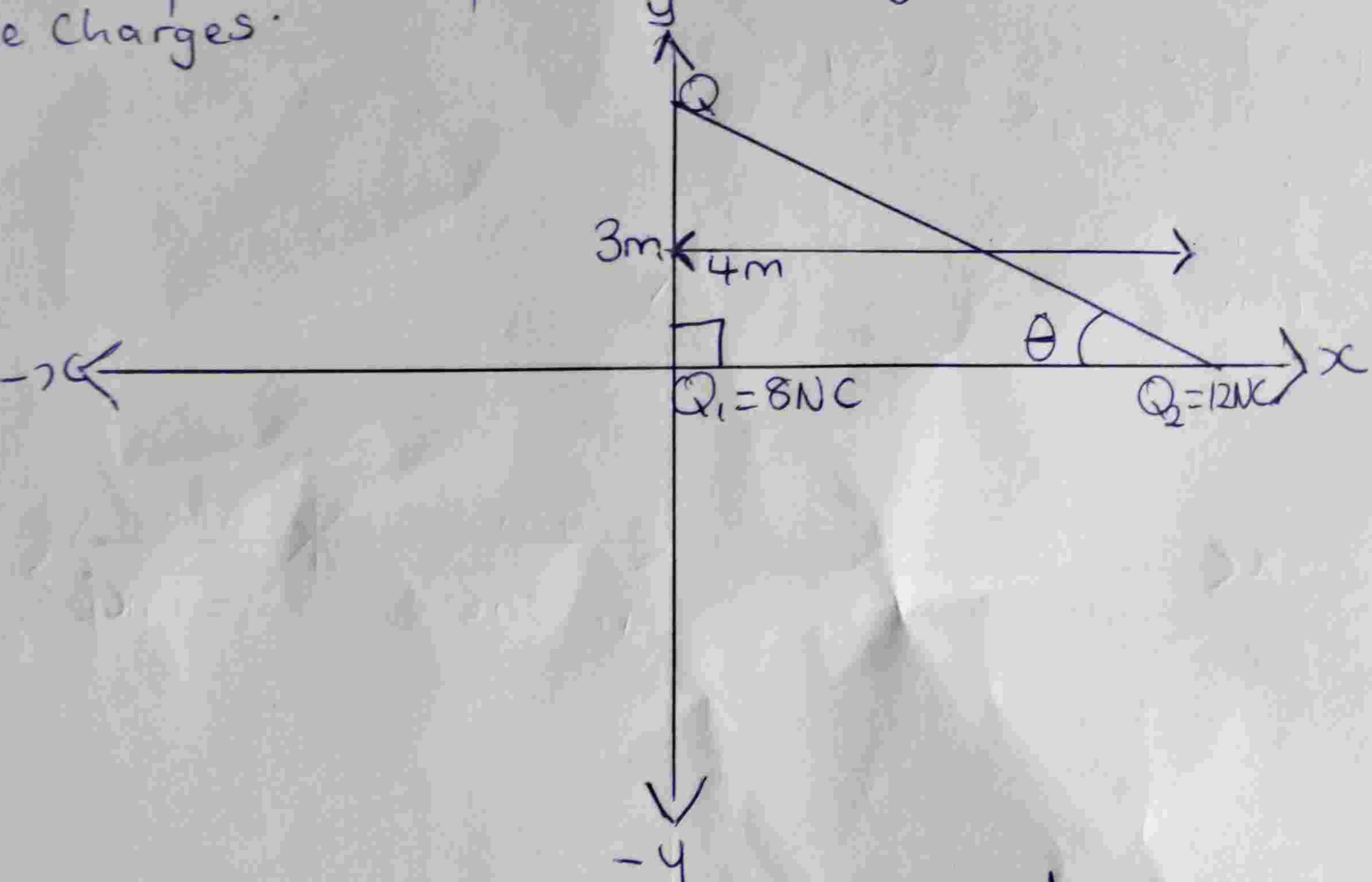
$E = \sqrt{\Sigma E_x^2}$

$E = \sqrt{13.4694^2}$

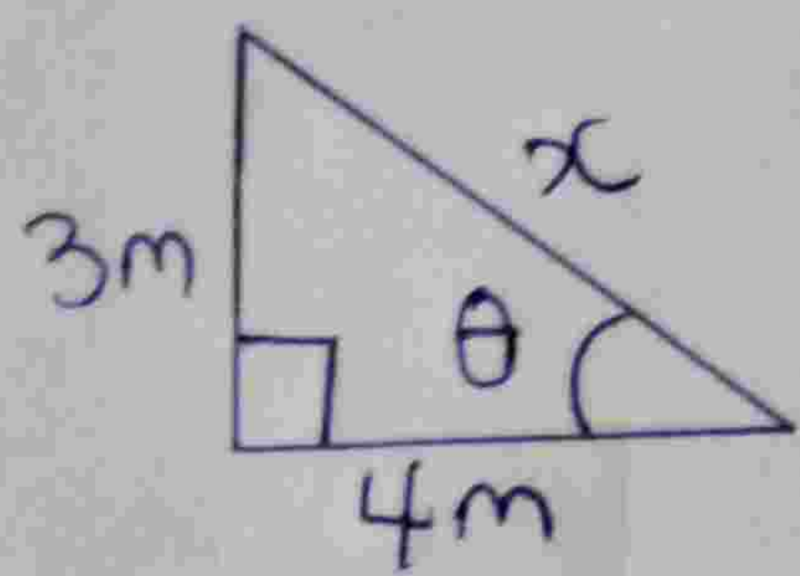
$E = 13.4694$

$\simeq E = 13.5 N/C$

2(ii) The electric field at a point Q on the y axis at y = 3m due to the charges.



To find the distance between electric field at point p and Q_2 using Pythagoras theorem.



$x^2 = 3^2 + 4^2$

$x^2 = 9 + 16$

$\sqrt{x^2} = \sqrt{25}$

$x = 5m.$

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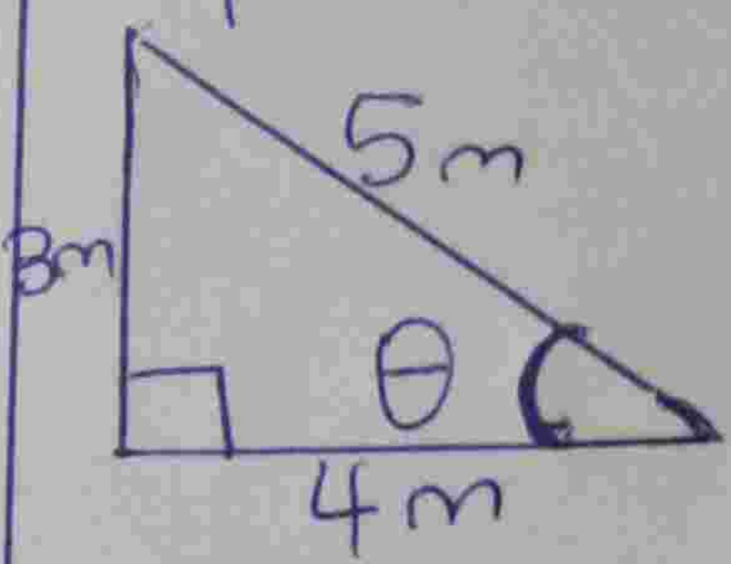
2bii) To find the angle between the horizontal and E_2, do this:



$\sin\theta = \frac{3}{5}$

$\theta = \sin^{-1} 3/5$

$\theta = 36.87°$.

$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$

Vector	Angle	X-component	Y-component
$E_1 = 8N/C$	90°	$8\cos90 = 0$	$8\sin90 = 8$
$E_2 = 4.32N/C$	36.87°	$4.32\cos 36.87 = 3.455995$	$4.32\sin 36.87 = 2.592$
		3.455995	10.592

$E = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$

$E = \sqrt{3.455995^2 + 10.592^2}$

$E = 11.14 N/C$ $\quad$ $E = 11.14 N/C$.

3a) State the formulation of the following identities of charges:

i.) Volume charge density (ii) surface charge density

iii) Linear charge density.

i.) Volume charge density,

$P = \frac{dQ}{dv} \longrightarrow dQ = P\,dv$

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3a

ii.) Surface charge density:

$$\sigma = \frac{dQ}{dA} \longrightarrow dQ = \sigma dA.$$

iii.) Linear charge density:

$$\lambda = \frac{dQ}{dL} \longrightarrow dQ = \lambda dL.$$

b) Explain with appropriate equations, the electric potential difference.

Electric potential difference between two points in an electric field can be defined as the work done per unit charge against forces when a charge is transported from one point to another.

We have different formular for electric potential difference depending on how the case may be;

* we have electric potential in a uniform electric field which is

$$V_B - V_A = \frac{W_{CA} \longrightarrow B2Ag}{q_0}$$

* we also have potential difference as the potential energy for V at charge

$$V_B - V_A = \frac{\Delta U}{q_0}.$$

* We also have electric potential due to single point charge

$$V_B - V_A = \frac{Q}{4\pi\epsilon_0} \left\{ \frac{1}{r_B} - \frac{1}{r_A} \right\}$$

* We also have electric potential due to several point charges.

$$V_p = \frac{1}{4\pi\epsilon_0} \left\{ \frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} + \frac{Q_4}{r_4} \right\}$$

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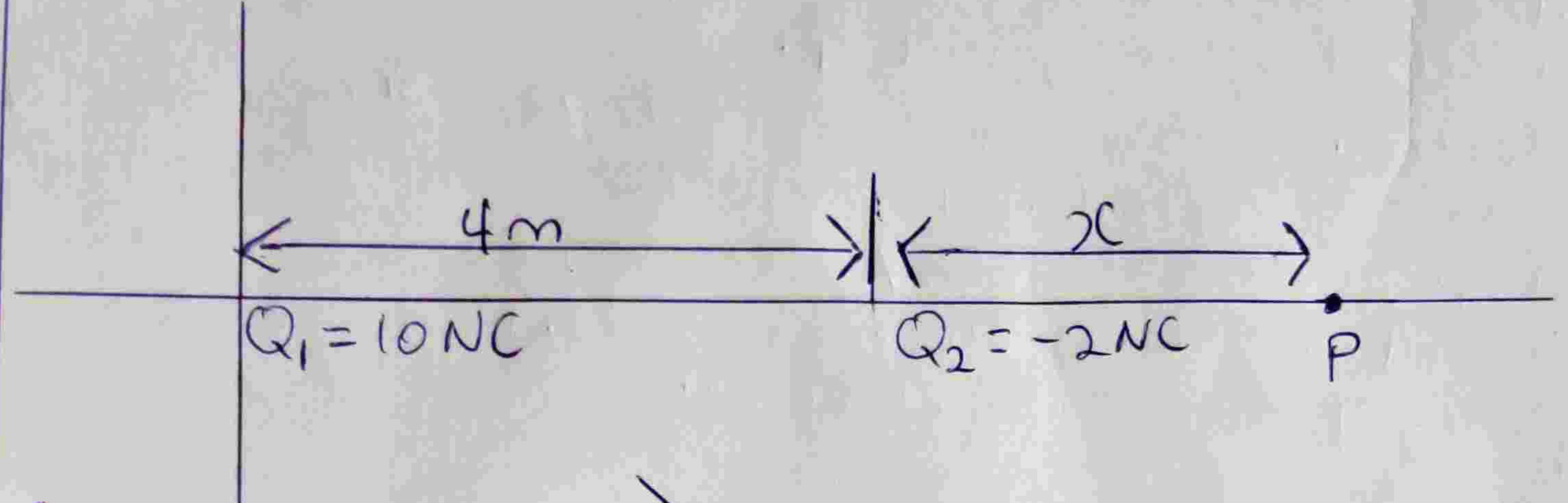
3c) Two point charges $Q_1 = 10\mu C$ and $Q_2 = -2\mu C$ are arranged along the x-axis at $x = 0$ and $x = 4m$ respectively. Find the position along the x-axis where $V = 0$.



$V_p = \frac{1}{4\pi\varepsilon_0}\left\{\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right)$

Let $V_p = 0$

$0 = 9\times10^{9}\left\{\frac{10\times10^{-6}}{4+x} + \frac{(-2\times10^{-6})}{x}\right\}$

$0 = 9\times10^{9}\left[\frac{10\times10^{-6}}{4+x} - \frac{2\times10^{-6}}{x}\right]$

$0 = \frac{90000}{4+x} - \frac{18000}{x}$

multiply through by $(4+x)(x)$

$(4+x)(x)0 = \frac{90000}{\cancel{4+x}}\times\cancel{(4+x)}(x) - \frac{18000}{\cancel{x}}\times(4+x)\cancel{(x)}$

$0 = 90000x - 18000(4+x)$

$0 = 90000x - 72000 - 18000x$

$72000 = 90000x - 18000x$

$72000 = 72000x$

$x = \frac{72000}{72000}$

$x = 1$

$4+x = 4+1 = 5m.$

So the position along the x axis due $V=0$ is 5m.

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4a) What is Magnetic flux?
Magnetic flux is defined as the strength of magnetic field represented by the lines of forces. It is usually represented by the symbol ϕ.

4b) An electron with a rest mass of 9.11×10^{-31} kg moves in a circular orbit of radius 1.4×10^{-7} m in a uniform magnetic field of 3.5×10^{-1} weber/meter square, perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron.

$$\omega = \frac{qB}{mp}$$

$$F_B = qvB\sin\theta \quad \text{where } \theta = 90^\circ$$

$$F_B = qvB$$

$$FB = qvB = \frac{mv^2}{r}$$

$$v = \frac{qBr}{m}$$

$$v = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$v = 8.60593 \text{ m/s}$$

Hence the circular speed

$$\omega = \frac{qB}{mp}$$

$$= \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$= -6.147 \times 10^{10} \text{ rad/sec.}$$

4c) Discuss your answer in (4b)
Since our cyclotron frequency is negative -6.15×10^{10} rad/sec; it means that the charge particle electron circulates in a negative or opposite direction at the angular frequency.

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5a) State the Biot-Savart law.

i.) The vector dB is pependicular both to dî (which points in the direction of the current) and to the unit vector $\hat{v}$ directed from dî towards p.

ii.) The magnitude of $\vec{dB}$ is inversely propotional to r3 where r is the distance from $\vec{dl}$ to P

iii.) The magnitude of dB is propotional to the current I and to the magnitude of the length element $\vec{dl}$

iv.) The magnitude of $\vec{dB}$ is propotional to n θ, where θ is the angle between r and $\vec{dl}$

therefore.

$$\vec{dB} = \frac{N_0}{4\pi} \cdot \frac{I\vec{dl} x \hat{r}^2}{r^2}$$

$$B = \frac{N_0 I x}{4\pi} \int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}} dy \quad --------(***)$$

Using special integrals

$$\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \cdot \frac{4}{(x^2+y^2)^{1/2}}$$

Equation (***) therefore becomes

$$B = \frac{N_0 I x}{4\pi} \left[\frac{4}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$$

$$B = \frac{N_0 I x}{4\pi} \left[\frac{2a}{x^2(x^2+a^2)^{1/2}}\right]$$

$$B = \frac{N_0 I x}{4\pi x} \left(\frac{2a}{(x^2+a^2)^{1/2}}\right).$$

when the length 2a of the conductor is very great in comparison to the distance x from point P, we consider it infinetly long. That is when a is ~~too~~ much greater than x.

$(x^2+a^2)^{1/2} \simeq a$, as $a \rightarrow \infty$

$$\therefore B = \frac{N_0 I}{2\pi x}$$

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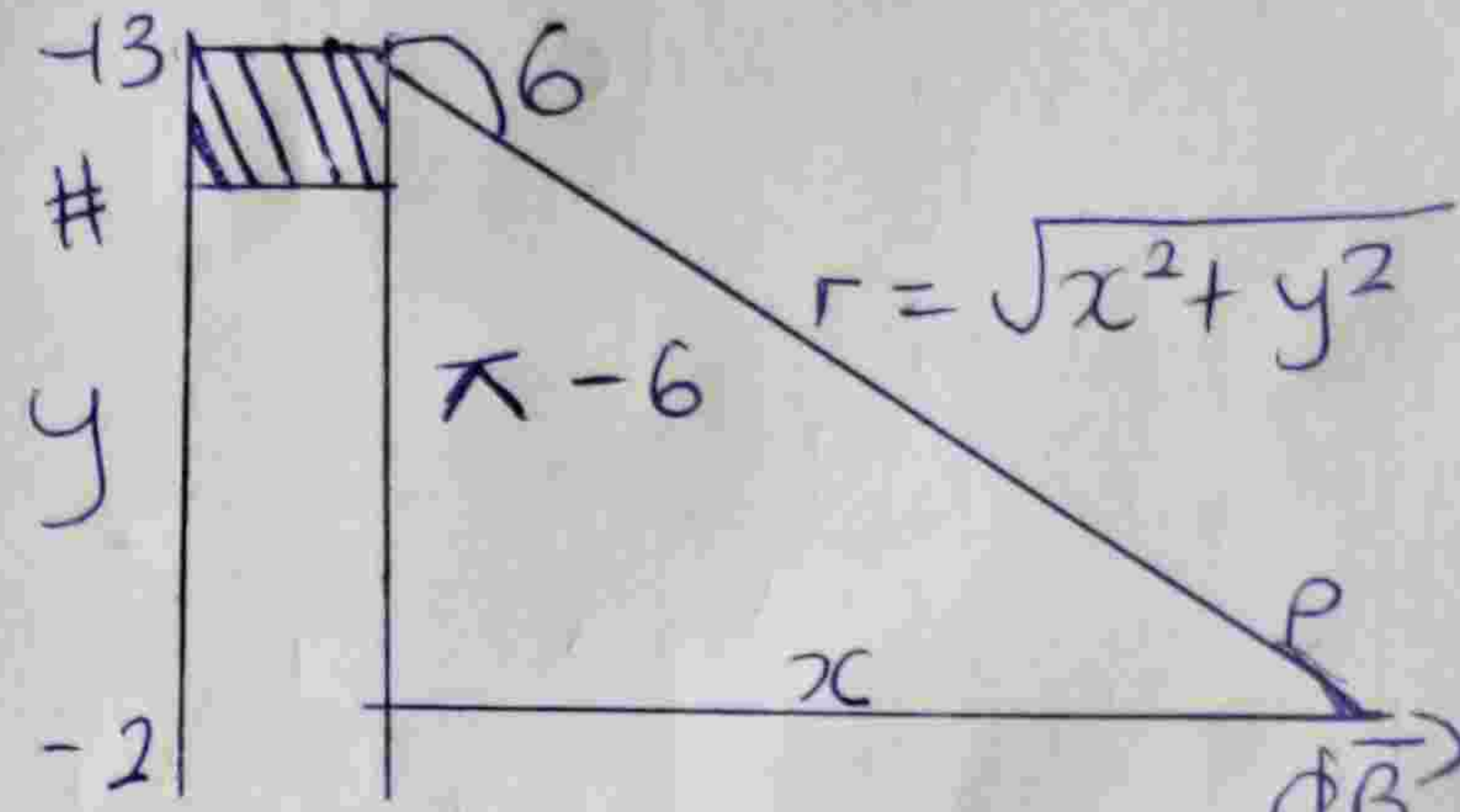
In a physical situation, we have axial symmetry about the y-axis. Thus, at all points in a circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{N_0 I}{2\pi r} \quad ------ (\#).$$

5b) using the Biot-Savart law, show that the magnitude of the magnetic field of a straight-current carrying conductor is given as

$$B = \frac{\mu_0 I}{2\pi r}$$



$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a} \frac{dl\sin\theta}{r^2}$$

$$\sin(\pi-6) = \sin\theta$$

$$\therefore B = \frac{N_0 I}{4\pi}\int_{-a}^{a}\frac{dl\sin(\pi-6)}{r^2}$$

from the diagram, $r^2 = x^2+y^2$ (phythagoras theorem)

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a}\frac{dl\sin(\pi-6)}{x^2+y^2} \quad ------ (*)$$

$$\text{But } \sin(\pi-6) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}} \quad ----- (**)$$

Substitution (**) into (*) we have:

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a} dl\,\frac{x}{(x^2+y^2)(x^2+y^2)^{1/2}}$$

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a} dl\,\frac{x}{(x^2+y^2)^{3/2}}$$

Recall $dl = dy$

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a}\frac{x}{(x^2+y^2)^{3/2}}\,dy$$