سامبار

Principles of Physics (10th eddition)

phy 132

CH22 : Electric Fields

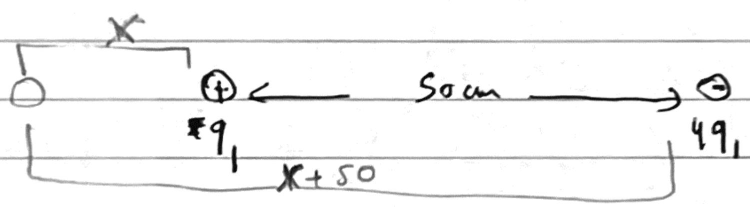
Problems 1, 4, 11, 12, 33, 38, 41, 55

P_1: The charged particles are fixed to an x-axis: Particle 1 of charge $q_1 = 2.1 \times 10^{-8}$ c is at position x = 20 cm and particle 2 of charge $q_2 = -4.00 q_1$ is at position x = 70 cm. (a) At what coordinate on the axis (other than at infinity) is the net electric field produced by the two particles equal to zero? (b) What is the zero-field coordinate if the particle are interchanged.

sol: $q_1 = 2.1 \times 10^{-8} c$ at $x = 20$ cm

$q_2 = -4 q_1$ at $x = 70$ cm

$\Delta x = 70 - 20 = 50$ cm



بما أن الشحنتين مختلفات بالإشارة => نقطة الاتزان بالخارج وأقرب للأصغر

$$\Sigma \vec{E} = 0$$

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

$$\frac{k q_1}{x^2} = \frac{k q_2}{(x+50)^2}$$

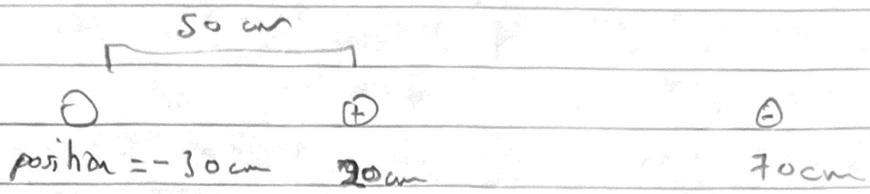
$$\frac{k q_1}{x^2} = \frac{k (4 q_1)}{(x+50)^2}$$

$$\frac{1}{x^2} = \frac{4}{(x+50)^2}$$

سابقاً

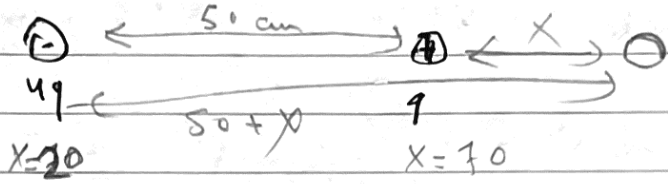
$$\frac{1}{X} = \frac{2}{X+50}$$

$$2X = X + 50 \Rightarrow 2X - X = 50 \Rightarrow X = 50$$



$$X = 20 - 50 = -30\text{ cm}$$

b) If the particle interchanged then



$$\frac{k\,4q_1}{(x+50)^2} = \frac{k\,q_1}{x^2}$$

$$\frac{4}{(x+50)^2} = \frac{1}{x^2}$$

$$\frac{2}{x+50} = \frac{1}{x}$$

$$2x = x + 50$$

$$x = 50$$

x for new q: $70 + 50 = 120\text{ cm} = 1.2\text{ m}$

سام بكار

P4: Density, (a) A charge $-300e$ is uniformly distributed along a circular arc of radius 4.00 cm, which substends an angle of 40°. What is the linear charge density along the arc? (b) A charge $-300e$ is uniformly distributed over one face of a circular disk of radius 2.00 cm. What is the surface charge density over that face? (c) A charge $-300e$ is uniformly distributed over the surface of a sphere of radius 4.00 cm. What is the surface charge density over that surface? (d) A charge $-300e$ is uniformly spread through the volume of a sphere of radius 2.00 cm. What is the volume charge density in that sphere?

Sol :

(a) $Q = -300e = -300 \times 1.6 \times 10^{-19} C = -480 \times 10^{-19}$

$r = 4\ cm = 4 \times 10^{-2} m$

$\theta = 40° = \frac{40 \times \pi}{180} = 0.698$

Linear charge density $\lambda = ??$

$\lambda = \frac{Q}{L}$

$L = r\theta = 4 \times 10^{-2} \times 0.698$

$= 2.792 \times 10^{-2}$

$\Rightarrow \lambda = \frac{-480 \times 10^{-19}}{2.792 \times 10^{-2}} = -1.719 \times 10^{-15}\ C/m$

b) $Q = -300e = -480 \times 10^{-19}$ circuler disk

$r = 2\ cm = 2 \times 10^{-2} m$

surface charge density $\sigma = ??$

$\sigma = \frac{Q}{A} = \frac{Q}{\pi r^2} = \frac{-480 \times 10^{-19}}{3.14 \times (2 \times 10^{-2})^2} = 3.82 \times 10^{-14}\ C/m^2$

سامعنا

(c) $Q = -300e = -480 \times 10^{-19} C$ sphere

$r = 4 cm = 4 \times 10^{-2}$

surface charge density $\sigma = ??$

$$\sigma = \frac{Q}{A} = \frac{Q}{4\pi r^2} = \frac{-480 \times 10^{-19}}{4 \times 3.14 (4 \times 10^{-2})^2} = -2.39 \times 10^{-15} C/m^2$$

(d) $Q = -300e = -480 \times 10^{-19} C$ sphere

$r = 2.00 cm = 2 \times 10^{-2} m$

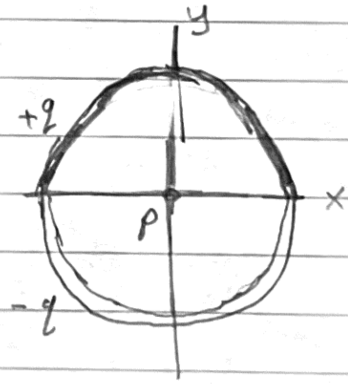
the volume charge density ρ ??

$$\rho = \frac{Q}{V} = \frac{Q}{\frac{4}{3}\pi r^3} = \frac{-480 \times 10^{-19}}{\frac{4}{3} \times 3.14 \times (2 \times 10^{-2})^3}$$

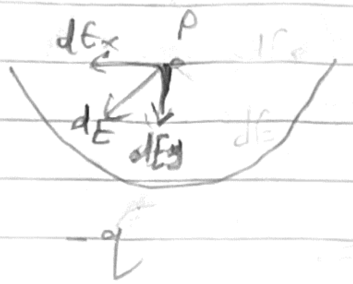
$$= 1.43 \times 10^{-12} C/m^3$$

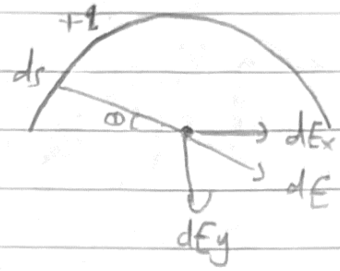
P11: In fig 22-27, two curved plastic rods, one of charge +q and the other of charge -q, form a circle of radius R = 4.25 cm in an xy plane. The x axis passes through both of the connecting points, and the charge is distributed uniformly on both rods. If q = 15 pC. What are the (a) magnitude (b) direction (relative to the positive direction of the x axis) of the electric field $\vec{E}$ produced at P, the center of the circle?

sol:



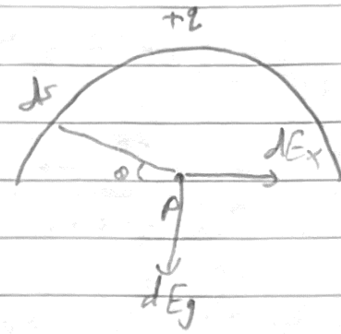
سابقاً





المركبة السينية تلغي بعضها

① E From +q



$dE_x = dE\cos\theta$
$dE_y = dE\sin\theta$

$q = \lambda s$
$q = \lambda R\theta$
$dq = \lambda R\, d\theta$

$$E_y = \int dE_y = -\int \frac{k}{R_2} dq \sin\theta \; \hat{j}$$

$$= -\int \frac{k}{R^2} \lambda R \sin\theta \, d\theta \; \hat{j}$$

$$= -\frac{k\lambda}{R} \int_0^{\pi} \sin\theta \, d\theta$$

$$= \frac{k\lambda}{R} \cos\theta \; \hat{j} \Big|_0^{\pi}$$

$E_y = -\frac{2k\lambda}{R}\hat{j}$ but $\lambda = \frac{q}{s} = \frac{q}{\pi R} = \frac{15\times10^{-12}}{3.14\times4.25\times10^{-2}}$

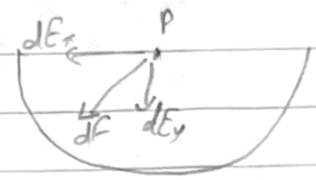
$\Rightarrow \lambda = 1.12\times10^{-10}$ c/m

$$(E_y)^{+} = \frac{-2k\lambda}{R} = -\frac{2\times9\times10^{9}\times1.12\times10^{-10}}{4.25\times10^{-2}\times3.14}$$

$$= -47.63\, N/C \; \hat{j}$$

$\Rightarrow$ direction -90

ساره بكار



E from $-q$

$|E_y^+| = |E_y^-|$

$E_{net} = |E_y^+| + |E_y^-|$

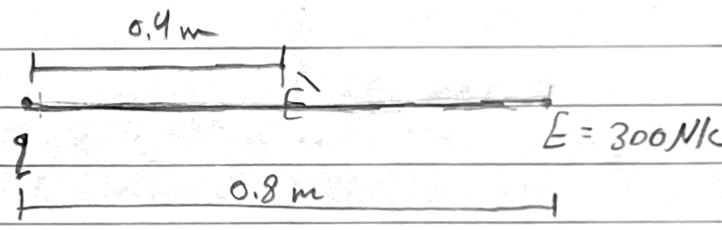
$= 47.43 + 47.43$

$= 94.86$ N/c $(-\hat{j})$

direction $(-\hat{j})$

P12: A charged particle creates an electric field of magnitude 300 N/c at point 0.800 m away. what is the difference in the field magnitude between that point and one at 0.400 m

sol :



$E = \frac{kq}{r^2} \Rightarrow q = \frac{Er^2}{k} = \frac{300 \times (0.8)^2}{9 \times 10^9}$

$\Rightarrow q = 2.13 \times 10^{-8}$ c $= 21.3 \times 10^{-9}$

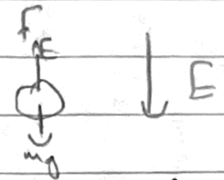
$E' = \frac{kq}{r^2} = \frac{9 \times 10^9 \times 21.3 \times 10^{-9}}{(0.4)^2} = 1198.125$ N/c

$\Delta E = E' - E = 1198.125 - 300 = 898.125$ N/c

سا رونا

P.33: In Milikan's experiment, an oil drop of radius 1.64 μm and density 0.851 g/cm³ is suspended in chamber C (Fig 22-16) when a downward electric field of 3.20×10^5 N/C is applied. (a) Find the charge on the drop in terms of e. (b) If the drop had an additional electron, would it move upward or downward?

$\rho = 0.851\ g/cm^3 = 851\ kg/m^3$



Sol: The drop in equilibrium

$\Sigma F = 0$

The force of gravity = the force of electric field

$mg = -qE$

Where is m: the mass of the drop

q: the charge on the drop

E: the magnitude of the Electric field

⇒ the mass of the drop $m = \frac{4}{3}\pi r^3 \rho$

Where r is radius of the drop,

ρ is the density of the drop

a) ⇒ $mg = -qE$

$$q = -\frac{mg}{E} = -\frac{\frac{4}{3}\pi r^3 \rho g}{E}$$

$$q = \frac{-4(3.14)(1.64 \times 10^{-6})^3 (851)(9.8)}{3 \times 3.2 \times 10^5}$$

$$q = 4.81 \times 10^{-19}\ c$$

$$q = ne \Rightarrow n = \frac{q}{e} = -\frac{4.81 \times 10^{-19}}{1.6 \times 10^{-19}} = -3$$

$$q = -3e$$

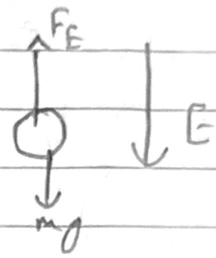
ساره ذكا

b) If the drop had an additional electron then

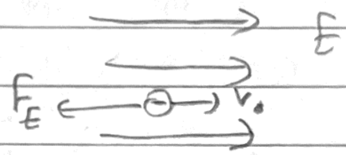
$q = -4e$

$\Rightarrow F_e > mg$

$\Rightarrow$ move upword.



P38: An electron enters a region of uniform electric field with an intial velocity of 30 km/s in the same direction as the electric field, which has magnitude E = 50 N/C (a) what is the speed of the electron 1.5 ns after entering this region? (b) How far does the electron travel during the 1.5 ns interval?



Sol:

a) electrons have a negative charge so moving electron in the same direction of E leads to deceleration.
(The field $\vec{E}$ pointing in the same direction as the velocity leads to deceleration)

$V_0 = 30\,km/s = 30 \times 10^3\,m/s$

$E = 50\,N/C$

$t = 1.5\,ns = 1.5 \times 10^{-9}\,s$

$v = v_0 + at$, where is $a = -\frac{eE}{m}$

من قانون نيوتن الثاني

$ma = -qE$

$ma = -eE$

$a = -\frac{eE}{m}$

سارة مجار

$$v = v_0 - \frac{eE}{m} t$$

$$v = 30\times10^3 - \frac{1.6\times10^{-19}\times 50}{9.11\times10^{-31}} \times (1.5\times10^{-9})$$

$v = 16827.6$ m/s

$= 1.7\times10^4$ m/s

or $a = -\frac{eE}{m} = \frac{-1.6\times10^{-19}\times 50}{9.11\times10^{-31}} = -8.78\times10^{12}$ m/sec

then sub in

$v = v_0 + at$

$= 30\times10^3 - 8.78\times10^{12}\times1.5\times10^{-9}$

$\simeq 1.7\times10^4$ m/s

b) $d = \left(\frac{v+v_0}{2}\right)t$

$$= \frac{((1.7\times10^4) + (30\times10^3))}{2}(1.5\times10^{-9})$$

$= 3.525\times10^{-5}$ m

P41: How much work is required to turn an electric dipole 180° in a uniform electric field of magnitude $E = 46$ N/C if the dipole moment has a magnitude of $p = 3.02\times10^{-25}$ C.m and the initial angle is 23°?

Sol: $W = +\Delta U$

$U = -P.E = -PE\cos\theta$

ساره نجار

$$W = -PE[\cos(180+23) - \cos(23)]$$

$$= -PE[\cos(203) - \cos(23)]$$

$$= -3.02 \times 10^{-25} \times 46 \times [-1.84]$$

$$\boxed{W = 2.56 \times 10^{-23}\ J}$$

or

$$W = -PE[\cos(180+23) - \cos(23)]$$

$$= -PE[\cos 180 \cos 23 - \sin 180 \sin 23 - \cos 23]$$

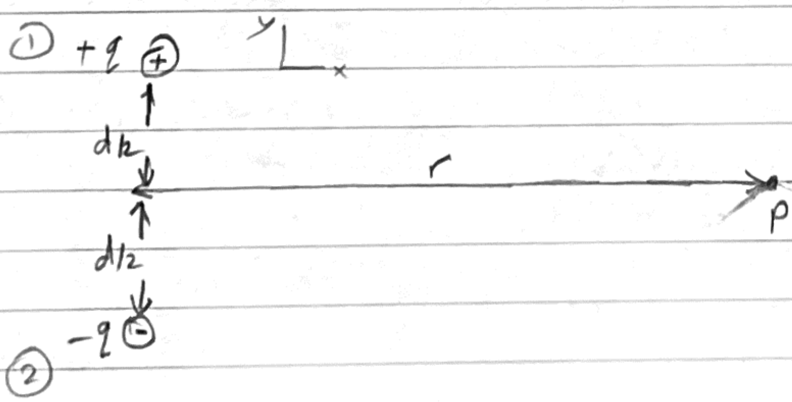
$$= -PE[-\cos 23 - \cos 23]$$

$$= 2PE\cos 23$$

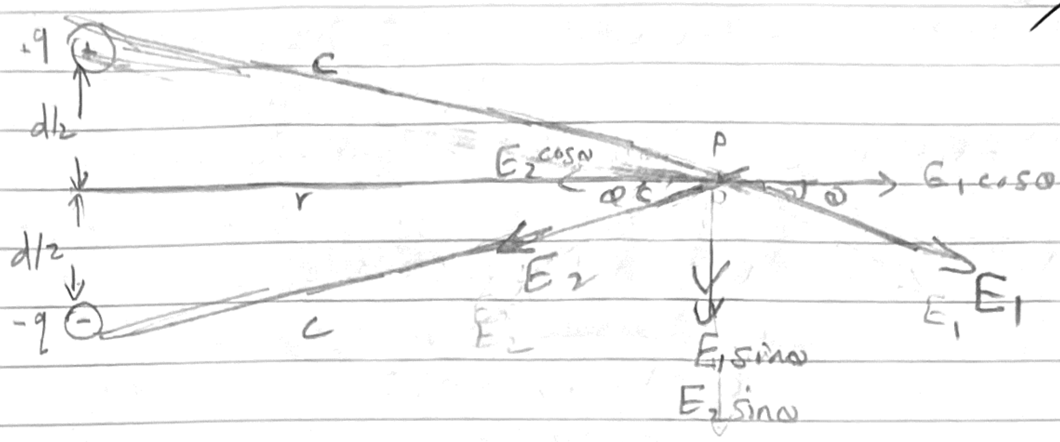
$$= 2(3.02 \times 10^{-25})(46)\cos 23$$

$$= 2.56 \times 10^{-23}\ J$$

P55: Figure 22.47 Shows an electric dipole. What are the (a) magnitude (b) direction (relative to the positive direction of the x axis) of the dipole's electric field at point P, located at distance $r \gg d$?



سارم بكار



المركبات السينية تلغي بعض يبقى المركبات الصادية

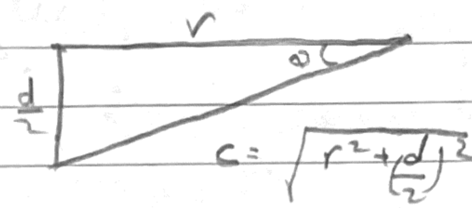
E_x cancelled

$\Sigma E = E_1 y + E_2 y$

$= E_1 \sin\theta + E_2 \sin\theta$

$= \frac{kq}{c^2}\sin\theta + \frac{kq}{r^2}\sin\theta$

$= 2\frac{kq}{c^2}\sin\theta$



$= \frac{2kq}{r^2 + (\frac{d}{2})^2}\sin\theta$

$= \frac{2kq}{r^2 + (\frac{d}{2})^2} \frac{d/2}{\sqrt{r^2 + (\frac{d}{2})^2}}$

$= \frac{kq}{r^2 + (\frac{d}{2})^2} \frac{d}{(r^2 + (\frac{d}{2})^2)^{1/2}}$

$|E| = \frac{kqd}{[r^2 + (\frac{d}{2})^2]^{3/2}} \Rightarrow E = \frac{kqd}{[r^2 + (\frac{d}{2})^2]^{3/2}}$ (-ĵ)

a) $r >> d \Rightarrow E = \frac{kqd}{r^3}$ b) -90