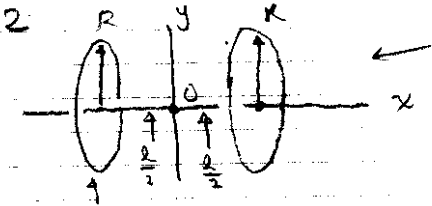
HW SET # 2

21-42



two rings radius R

uniformly distributed charge Q

to get E(x) (on x axis)

From p. 558 to 559

E is directed away from ring (for positive Q) with magnetude

$$E(d) = \frac{1}{4\pi\epsilon_0}\frac{Q\,d}{(d^2+R^2)^{3/2}}$$

where d is distance from center of ring along x axis. (In Ex 21-9 d = x because ring is chosen at x = 0. In Ex 21-9, R = a)

So from superposition

$$E(x) = \underset{\substack{\text{distance to}\\ \text{ring at } \ell/2}}{E(x-\ell/2)} + \underset{\substack{\text{distance to}\\ \text{ring at } -\ell/2}}{E(x+\ell/2)}$$

$$= \frac{Q}{4\pi\epsilon_0}\left[\frac{x-\ell/2}{((x-\frac{\ell}{2})^2+R^2)^{3/2}} + \frac{x+\ell/2}{((x+\frac{\ell}{2})^2+R^2)^{3/2}}\right]$$

21-47

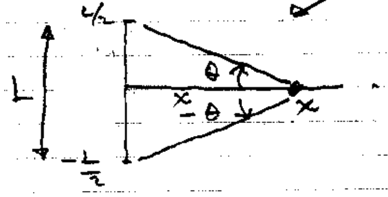


Fig 21-28 with wire length L centered on x axis

Exactly as in Ex 21-10

$$E(x) = \frac{\lambda}{4\pi\epsilon_0}\frac{1}{x}\int_{-\theta_{max}}^{\theta_{max}}\cos\theta\,d\theta$$

where θ_{max} is angle that points to top of the wire and $-\theta_{max}$ the angle that points to bottom.

From figure $\sin\theta_{max} = \frac{L/2}{\sqrt{x^2+L^2/4}}$

Then do the integral:

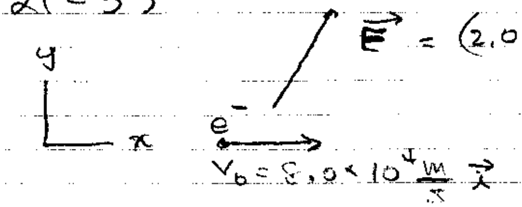
$$E(x) = \frac{\lambda}{4\pi\epsilon_0}\frac{1}{x}\sin\theta\Big|_{-\theta_{max}}^{\theta_{max}}$$

$$= \frac{\lambda}{4\pi\epsilon_0}\frac{1}{x}\left[\sin\theta_{max} - \sin(-\theta_{max})\right]$$

$$= \frac{\lambda}{\cancel{4}_2\pi\epsilon_0}\frac{1}{x}(\cancel{2}\sin\theta_{max})$$

$$= \frac{\lambda}{2\pi\epsilon_0}\cdot\frac{L/2}{\sqrt{L^2/4+x^2}} = \frac{\lambda}{2\pi\epsilon_0}\frac{L}{\sqrt{L^2}}$$

21-55



$\vec{E} = (2{,}0\vec{i} + 8{,}0\vec{j}) \times 10^4 \frac{N}{C}$

$v_0 = 8{,}0 \times 10^4 \frac{m}{s} \vec{x}$

force:

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

$= -e(2.0\vec{i} + 8{,}0\vec{j}) \times 10^4 \frac{N}{C}$

$= -(1.6) \times (2.0\vec{i} + 8{,}0\vec{j}) \times 10^{-15} N$

$= -(3{,}2\vec{i} + 12{,}8\vec{j}) \times 10^{-15} N$

a) $\vec{a} = \frac{\vec{F}}{m} = -\frac{(3{,}2\vec{i} + 12{,}8\vec{j}) \times 10^{-15} N}{9{,}11 \times 10^{-31} kg}$

$= -(3{,}5 \times 10^{15} \frac{m}{s^2})\vec{i} - (1.41 \times 10^{16} \frac{m}{s^2})\vec{j}$

b) $\vec{v}(t) = v_0 + \vec{a}\underset{\uparrow\, 1 \times 10^{-9} s}{t}$ ($\vec{a}$ is constant!)

$= \underset{\uparrow v_x}{(-3{,}43 \times 10^6 \frac{m}{s})}\vec{i} - \underset{\uparrow v_y}{(1.41 \times 10^7 \frac{m}{s})}\vec{j}$

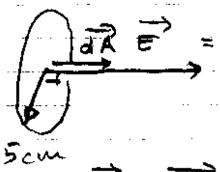
$\tan\theta = \frac{v_y}{v_x} = 4.11 \Rightarrow \theta = -104°$

(v_y and v_x and both negative)

22-1 flux

$\Phi = \int_{circle} \vec{E} \cdot d\vec{A}$

a)



$= 5.8 \times 10^2 N/C$

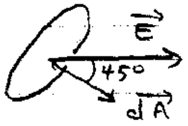
$\vec{E} \cdot d\vec{A} = E\,dA \cos 0° = E\,dA$

$\Phi = \int_{circle} E\,dA = E\int_{circle} dA = E\pi R^2$

$= (5.6 \times 10^2 \frac{N}{C})\pi(.15m)^2$

$= 41 Nm^2/C$

b)

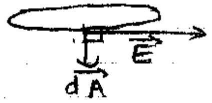


$\Phi = \int_{circle} E\,dA \cos 45°$

$= \frac{E\pi R^2}{\sqrt{2}}$

$= 29 Nm^2/C$

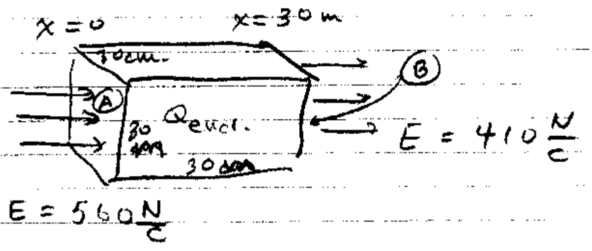
c)



$\Phi = \int_{circle} E\,dA \cos 90°$

$= 0$

22-7



Gauss $\Phi_{Box} = \frac{Q_{encl.}}{\epsilon_0}$

Φ_{Box} gets contributions only from front at $x=0$ and back at $x = 30$ m

$$\Phi = \Phi_A + \Phi_B$$

$$= 560 \frac{N}{C} \times (30m)^2 \cos(\pi)$$

$$+ 410 \frac{N}{C} (30m)^2 \cos 0$$

$$= -560 \times (9 \times 10^2) \frac{Nm^2}{C} + 410 \times (9 \times 10^2) \frac{Nm^2}{C}$$

$$= -1.35 \times 10^5 \frac{Nm^2}{C}$$

$$Q_{encl.} = \epsilon_0 \Phi_{box} = (8.85 \times 10^{-12} \frac{C^2}{Nm^2})(-1.35 \times 10^5 \frac{Nm^2}{C})$$

$$= -11.94 \times 10^{-7} C$$

$$= -1.2 \mu C$$