week 9 : ch 20 3.6 n m apr.

Examples 5 electric dipole Eq 20.4 $\vec{E} = \Sigma \vec{E}_i$ 2 protons

6 (+) charged ring $E = \frac{kQx}{(x^2+a^2)^{3/2}}$ x → x 1.2 3.6

7 line charge

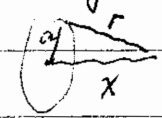
Problems 20-2, 6, 9, 28, 30, 69, Bonus 20-72

20-2 : since gravit'l force is 10^{-40} times weaker than electric force between two protons. Why is Gravit'l force ever impor

A: because electric forces can cancel (+ & - charges) while Gravit'l forces are always attractive

20-6 The direction of $\hat{r}$ does not depend on whether the e charge is positive or negative. Because $\hat{r}$ is a geometrical construct. Yes direction of $\vec{E}$ does depend on sign of charge

20-9 Example 6 : E field due to a ring of charge is not given by kQ/r^2

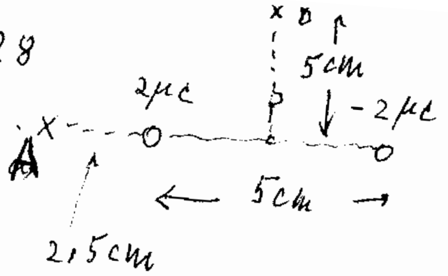


$r = \sqrt{a^2 + x^2}$

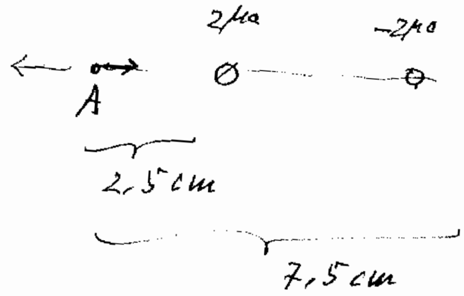
but is given by $\frac{kQ}{(x^2+a^2)^{3/2}} \cdot x$

because there is a cancellation between the $\vec{E}$ vectors coming from different parts of ring.

20-28



a) field at A :



The field from 2μc is to the left $\quad E_2 = k\dfrac{2\mu c}{(0.025)^2}$ to left

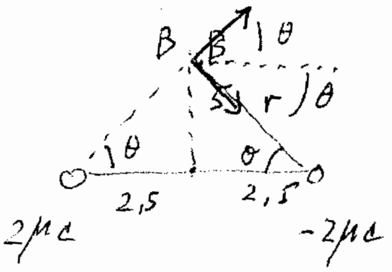
" " " -2μc " " " right $\quad E_{-2} = k\dfrac{(2\mu c)}{(0.075)^2}$ to right

net field $= k \times 2 \times 10^{-6}\,c \left(\dfrac{1}{(0.025)^2} - \dfrac{1}{(0.075)^2} \right)$ to left

$k \to 9\times10^{9}$

$18 \times 10^{3} \quad (\quad 1,422.2 \quad) = \boxed{2.56 \times 10^{7}\ N/c}$ to left.

b) field at B



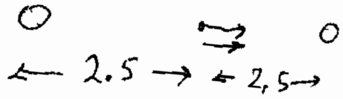
magnitude of each of the fields:

$\dfrac{k \times 2\mu c}{(0.025)^2 + (0.05)^2} = 5.76 \times 10^{6}$

$\cos\theta = \dfrac{2.5}{\sqrt{(2.5)^2 + (5)^2}} = \dfrac{2,5}{5,59} = 0.447$

Total field $= 2 \times 5.76 \times 10^{6} \times 0.447 = \boxed{5.15 \times 10^{6}\ N/c}$ to right.

c)



both fields add

field from each charge = $k \times \frac{2\mu c}{(0.025)^2} = \frac{9\times10^9 \times 2\times10^{-6}}{(0.025)^2} = 2.88\times10^7$

total field $= 2 \times 2.88\times10^7 =$ $\boxed{5.76\times10^7 \ V/c}$ to the right

20-30

long wire, uniform charge density λ (unknown)

$E = \frac{2k\lambda}{r}$

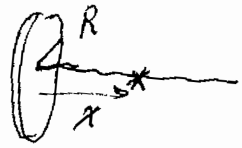
If $r_1 = 0.22m$, $E_1 = 1.9$ k N/c

If $r_2 = 0.38m$ $E_2 = ?$

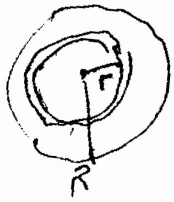
$\frac{E_1}{E_2} = \frac{r_2}{r_1} = \frac{0.38}{0.22} = 1.73$

x $E_2 = E_1/1.73 =$ $\boxed{1.10 \ kN/c}$

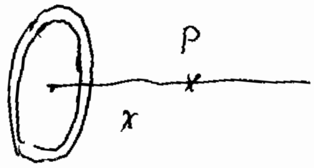
20-69



E field from disk at distance x on axis?



charge on ring, thickness dr is $\sigma \cdot \underbrace{2\pi r \cdot dr}_{\text{area of ring}} = dq$



E field from ring at point P =

$dE = k(dq)\frac{x}{(x^2+r^2)^{3/2}}$

Total Field $= \int dE = \int k(dq)\frac{x}{(x^2+r^2)^{3/2}} = \int_0^R k\,\sigma \cdot 2\pi r\,dr \frac{x}{(x^2+r^2)^{3/2}}$

(dr is the integration variable)

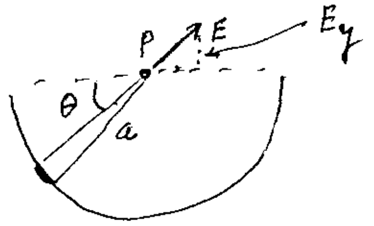
use ~~$t = r^2$; $dt = 2r\,dr$~~ $t = r^2 + x^2 \leftarrow dt = 2r\,dr$

$\rightarrow \int k\sigma\, 2\pi \cdot x \frac{1}{2}\,dt / (t)^{3/2} = k\sigma x 2\pi \cdot \frac{1}{2}\left(\frac{1}{-1/2}\right) t^{-1/2}\Big|_{x^2}^{x^2+R^2}$

$E_{TOTAL} = k\sigma \cdot 2\pi \cdot \left(\frac{x}{\sqrt{x^2}} - \frac{x}{\sqrt{x^2+R^2}}\right) = \boxed{\frac{2kQ}{R^2}\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)}$

$\pi R^2 \sigma = Q$

Bonus 20-72 semi-circular loop



$$dq = \lambda \cdot a \cdot d\theta$$

$$(dE)_y = k \frac{dq}{a^2} \cdot \sin\theta$$

$$E_y = \int (dE)_y = \int k \frac{dq}{a^2} \sin\theta = k \cdot \int_{\theta=0}^{\pi} \frac{\lambda a d\theta}{a^2} \sin\theta$$

$$E_y = \frac{k\lambda}{a} \int_0^{\pi} \sin\theta \, d\theta = \frac{k\lambda}{a}(-\cos\theta)\Big|_0^{\pi} = \frac{k\lambda}{a}(1+1)$$

express λ in terms of total charge Q

$$\pi a \cdot \lambda = Q$$

$$\therefore E_y = \frac{k \cdot Q/\pi a}{a} \times 2 = \boxed{\frac{kQ}{a^2} \times \frac{2}{\pi}}$$