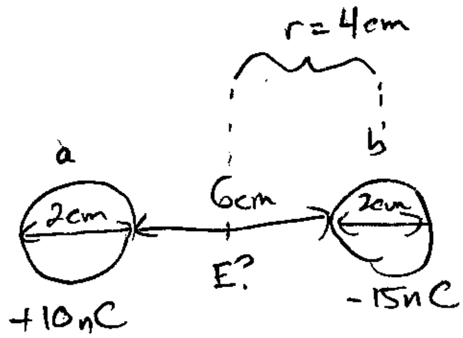
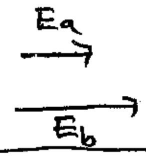
WORSHOP 3.2 Solutions

27.50

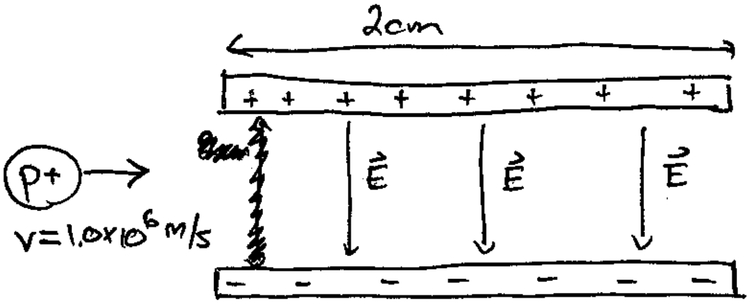




$(r = 4\text{cm})$

$$\vec{E}_{dot} = \frac{K(10\times10^{-9}C + 15\times10^{-9}C)}{(.04m)^2}\,\hat{i} = 1.41\times10^{5}\ N/C\ \hat{i}$$

27.52 Proton has charge $+1.6\times10^{-19}$ C



proton is in E-field for time $\Delta t = \frac{.02m}{1\times10^{6}(m/s)} = 2\times10^{-8}s$

force on proton is given by $\vec{F} = \vec{E}q = m\vec{a}$ (m is proton mass)

$$|\vec{E}| = \frac{\eta}{\varepsilon_0} = 4\pi K\eta = 4\pi K(1.0\times10^{-6}\ C/m^2)$$

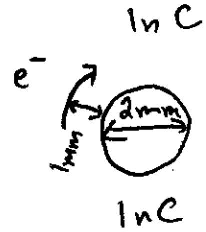
$$|\vec{a}| = \frac{|E|q}{m} = \frac{4\pi K\eta q}{m}$$

$$\Delta y = \frac{1}{2}|\vec{a}|\Delta t^2 = \frac{2\pi K\eta q\,\Delta t^2}{m_{proton}} = \sout{2\pi(9\times10^9\ Nm^2/C^2)}$$

$$= \frac{2\pi(9\times10^{9}\ Nm^2/C^2)(1.0\times10^{-6}C/m^2)(1.6\times10^{-19}C)(2\times10^{-8}s)^2}{(1.67\times10^{-27}kg)}$$

$$\boxed{\Delta y = 2.17\times10^{-3}m = .217\ cm}$$

27.56



$r = 2mm$

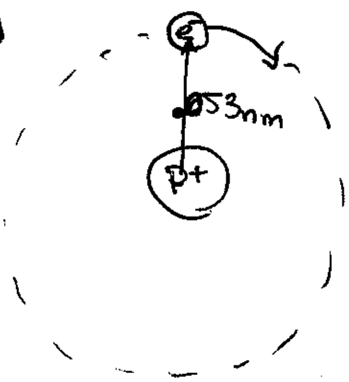
Balance forces:

$$|F_{electric}| = m_{electron}|a| = \frac{m_{e^-} v^2}{r} = \frac{K|q_{sphere}||q_{electron}|}{r^2}$$

$$\Rightarrow V_{e^-} = \left[\frac{K|q_{sphere}||q_{electron}|}{m_{e^-} r}\right]^{1/2} = \sqrt{\frac{(9\times10^9 \, N\, m^2/c^2)(1\times10^{-9}C)(1.6\times10^{-19}C)}{(9.1\times10^{-31}kg)(2\times10^{-3}m)}}$$

$$\boxed{V_{e^-} = 2.8\times10^7 m/s}$$

27.58



$r = .053\times10^{-9}m$

frequency

$$f = \frac{v}{2\pi r}$$

Circumference $2\pi r = v\,\Delta t = \frac{v}{f}$

we have a formula for v from 27.56:

$$v = \sqrt{\frac{K|q_{proton}||q_{e^-}|}{m_{e^-} r}}$$

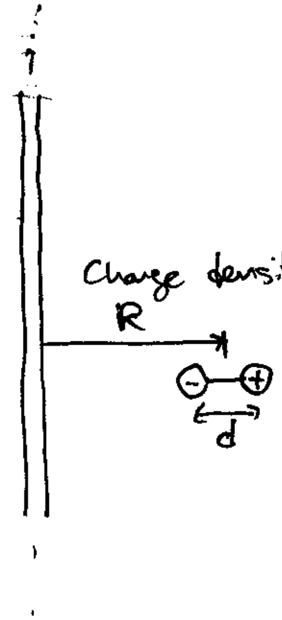
$$\Rightarrow f = \frac{1}{2\pi r}\sqrt{\frac{K|q_p||q_{e^-}|}{m_{e^-} r}}$$

$$= \frac{1}{2\pi(.053\times10^{-9}m)}\sqrt{\frac{(9\times10^9 \, N\, m^2/c^2)(1.6\times10^{-19}c)^2}{(9.1\times10^{-31}kg)(.053\times10^{-9}m)}}$$

$$\boxed{f = 6.56\times10^{15}\,Hz}$$

(s^{-1})

27.61



distance to − charge is $R - d/2$
" + " is $R + d/2$

$$\vec{E} = K\left(\frac{2\lambda}{r}\right)\hat{r}$$

$$\vec{F}_- = \vec{E}_-(-q) = -K\left(\frac{2\lambda q}{R - d/2}\right)\hat{r}$$

$$\vec{F}_+ = \vec{E}_+(+q) = +K\left(\frac{2\lambda q}{R + d/2}\right)\hat{r}$$

$$\vec{F}_{tot} = (-\hat{r})\, K\, 2\lambda q \left[\frac{1}{R - d/2} - \frac{1}{R + d/2}\right]$$

$$= (-\hat{r})\, K\, 2\lambda q \left[\frac{d}{R^2 - (d/2)^2}\right] \underset{R \gg d/2}{\approx} (-\hat{r})\frac{2K\lambda q d}{R^2}$$

and $qd = p$ (dipole moment)

attractive

$$\Rightarrow \boxed{\vec{F}_{tot} = \frac{2K\lambda p}{R^2}(-\hat{r})} \qquad \left(K = \frac{1}{4\pi\varepsilon_0}\right)$$