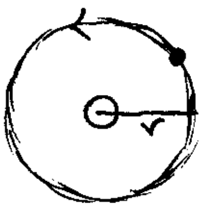
26.43

$f = 1.0 \times 10^6 / s$, $r = 1.0\,cm$



$$E = \frac{1}{4\pi\epsilon_0}\frac{2|\lambda|}{r}$$

$$F = qE = \frac{1}{4\pi\epsilon_0}\frac{2q|\lambda|}{r} = m\frac{v^2}{r}$$

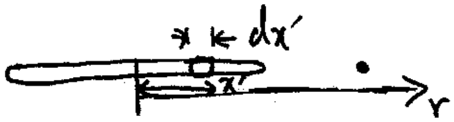
$$\Rightarrow |\lambda| = 4\pi\epsilon_0 \frac{mv^2}{2q} \quad , \ v = r\omega = 2\pi r f \ , \ m = 1.67\times10^{-27}\,kg$$

$$q = 1.6\times10^{-19}\,C$$

$$|\lambda| = 4\pi\epsilon_0 \frac{m(2\pi r f)^2}{2q} = 2.29\times10^{-9}\,C/m$$

$$\therefore \lambda = -2.29\times10^{-9}\,C/m$$

26.44

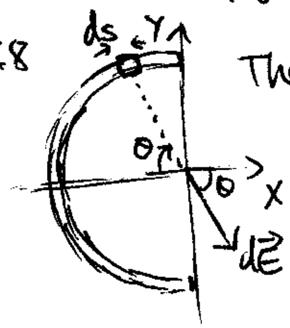


$$dE_x = \frac{1}{4\pi\epsilon_0}\frac{dq}{(r-x')^2} \quad , \quad dq = \frac{Q}{L}dx'$$

$$E_x = \int_{-L/2}^{L/2} dE_x = \int_{-L/2}^{L/2} \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\frac{dx'}{(r-x')^2} = \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\int_{-L/2}^{L/2}\frac{dx'}{(r-x')^2}$$

$$= \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\left[\frac{1}{r-x'}\right]_{-L/2}^{L/2} = \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\left(\frac{1}{r-L/2} - \frac{1}{r+L/2}\right) = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2 - L^2/4}$$

26.48



There will be only E_x because of symmetry.

$$dE_x = dE\cos\theta \ , \ dE = \frac{1}{4\pi\epsilon_0}\frac{dq}{R^2} \ , \ dq = \frac{Q}{L}ds, \ ds = R\,d\theta$$

$$\cancel{dE_x = \frac{1}{4\pi\epsilon_0}\frac{Q}{L}R\,d\theta/R^2 = \frac{1}{4\pi\epsilon_0}\frac{Q}{LR}d\theta}$$

$$dE_x = \frac{1}{4\pi\epsilon_0}\frac{Q}{LR}\cos\theta\,d\theta$$

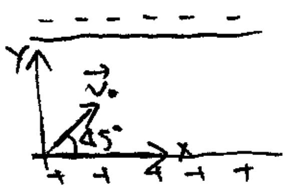
$$E_x = \int_{\theta=-\pi/2}^{\pi/2} dE_x = \int_{\theta=-\pi/2}^{\pi/2}\frac{1}{4\pi\epsilon_0}\frac{Q}{LR}\cos\theta\,d\theta$$

$$= \frac{1}{4\pi\epsilon_0}\frac{Q}{LR}\int_{-\pi/2}^{\pi/2}\cos\theta\,d\theta = \frac{1}{4\pi\epsilon_0}\frac{Q}{LR}\left[\sin\theta\right]_{-\pi/2}^{\pi/2} = \frac{2Q}{4\pi\epsilon_0 LR} \Leftarrow R = L/\pi$$

$$= \frac{1}{4\pi\epsilon_0}\frac{2\pi Q}{L^2}$$

26.53

$\Delta y = 2.0\,\text{cm}$, $E = 1.00\times10^{4}\ \text{N/C}$



$\vec{a} = q\vec{E}/m$

$a_y = \frac{-eE}{m}$, $e = 1.60\times10^{-19}\,\text{C}$, $m = 9.11\times10^{-31}\,\text{kg}$

$= -1.756\times10^{15}\ \text{m/s}^2$

V_y will be zero when the electron is at $y = \Delta y$.

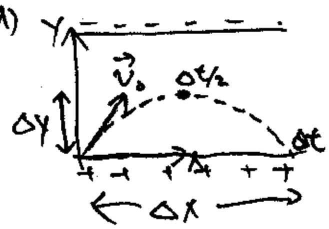
$V_{1y}^2 - V_{0y}^2 = 2a_y\Delta y \Rightarrow 0 - V_{0y}^2 = 2a_y\Delta y$, $V_{0y} = \sqrt{-2a_y\Delta y} = 8.381\times10^{6}\,\text{m/s}$

$V_{0y} = V_0\sin45°$, $V_0 = \frac{V_{0y}}{\sin45°} = 1.19\times10^{7}\,\text{m/s}$

26.54

$V_0 = 5.0\times10^{6}\,\text{m/s}$, $\Delta x = 4.0\,\text{cm}$

(a)



$V_{0x} = V_0\cos45°$

$V_{0y} = V_0\sin45°$

$\Delta x = V_{0x}\Delta t$. $\Delta t = \frac{\Delta x}{V_{0x}} = \frac{\Delta x}{V_0\cos45°}$

$a_y = \frac{0 - V_{0y}}{\Delta t/2} = \frac{-V_0\sin45°\,2V_0\cos45°}{\Delta x} = -\frac{V_0^2}{\Delta x}$

$a_y = \frac{qE}{m}$

$m = 9.1\times10^{-31}\,\text{kg}$
$q = -1.60\times10^{-19}\,\text{C}$

$-\frac{V_0^2}{\Delta x} = \frac{qE}{m}$. $E = -\frac{mV_0^2}{q\Delta x} = 3550\ \text{N/C}$

(b) $V_{1y}^2 - V_{0y}^2 = 2a_y\Delta y \Rightarrow 0 - V_{0y}^2 = -\frac{2V_0^2}{\Delta x}\Delta y$. $\Delta y = \Delta x\frac{V_{0y}^2}{2V_0^2} = \Delta x\frac{V_0^2/2}{2V_0^2}$

$= \Delta x/4 = 1.0\,\text{cm}$

∴ The minimum spacing = 1.0 cm

26.60 $r = 0.050\,\text{nm}$. Find the frequency f

$F = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} = m_e\frac{v^2}{r} = m_e\frac{(r\,2\pi f)^2}{r}$

$f = \sqrt{\frac{1}{4\pi\epsilon_0}\frac{e^2}{4\pi^2 m_e r^3}} = 7.16\times10^{15}\ \text{Hz}$

$e = 1.6\times10^{-19}\,\text{C}$
$m = 9.11\times10^{-31}\,\text{kg}$

27.38

(a) The electric field from the sphere is 0 inside the sphere.

$E(r) = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$ ← from the point charge

(b) 0 : The electric field inside a metal is zero

(c) The total charge inside the sphere of radius $r \geq b$ = 3Q

Using Gauss's law $4\pi r^2 E(r) = \frac{3Q}{\epsilon_0} \Rightarrow E(r) = \frac{1}{4\pi\epsilon_0} \frac{3Q}{r^2}$

(d) If we draw a Gaussian surface including the inner surface of the sphere but excluding the outer surface of the sphere, then the total charge in it is 0 because the flux along the Gaussian surface is zero.

Q (point charge) + Q (inside surface) = 0.

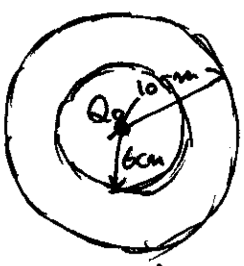
Q (inside ~~sur~~face) = − Q

(e) $Q_{point} + Q_{inner} + Q_{exterior}$ = total charge = 3Q

$\Rightarrow Q - Q + Q_{exterior} = 3Q$

$Q_{ext} = 3Q$

27.42



$r_i = 6cm$. $r_{ex} = 10 cm$

$\sigma_i = -100 nC/m^2$. $\sigma_{ex} = 100 nC/m^2$

The charge Q_i on the inner surface $\Rightarrow Q_{in} = 4\pi r_i^2 \sigma_i$

The charge Q_{ex} on the outer surface $\Rightarrow Q_{ex} = 4\pi r_o^2 \sigma_o$

There should be a charge Q_0 at the center to cause the charge distribution in the sphere. $Q_0 = -Q_i$ to make the electric field in the metal zero.

$\therefore Q_0 = 4.524 nC$. $Q_i = -4.524 nC$. $Q_{ex} = 1.257 \times 10^{-8} C$

(a) $\Phi = \frac{Q}{\varepsilon_0} \Rightarrow 4\pi r^2 E = \frac{Q_0}{\varepsilon_0}$, $E = \frac{1}{4\pi\varepsilon_0}\frac{Q_0}{r^2}\Big|_{r=4cm} = 2.54\times10^4$ N/C

(b) outward because the charge inside the sphere of radius 4cm is positive.

(c) The total charge inside the Gaussian surface of radius 8cm = 0

$\therefore E = 0$

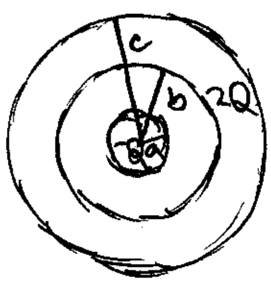
(d) The field is zero.

(e) The Gaussian surface, a sphere of radius 12 cm has a net charge $Q = Q_0 + Q_i + Q_{ex} = 1.257\times10^{-8}$ C in it.

$\Phi = \frac{Q}{\varepsilon_0} \Rightarrow 4\pi(12cm)^2 E = \frac{1.257\times10^{-8}C}{\varepsilon_0}$, $E = 7.86\times10^3$ N/C

(f) Q is positive, so Outward.

27.45



(a) Draw a Gaussian surface of radius r.

$Q_{in} = -Q\frac{r^3}{a^3}$

$\Phi_e = \frac{Q_{in}}{\varepsilon_0} \Rightarrow 4\pi r^2 E(r) = -Q\frac{r^3}{a^3}\frac{1}{\varepsilon_0}$

$E(r) = -\frac{1}{4\pi\varepsilon_0}\frac{Q}{a^3}r$

(b) Draw a Gaussian surface of radius r.

$Q_{in} = -Q$.

$\Phi_e = \frac{Q_{in}}{\varepsilon_0} \Rightarrow 4\pi r^2 E(r) = \frac{-Q}{\varepsilon_0}$, $E(r) = -\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

(c) $E = 0$ inside a metal

(d) $Q_{in} = Q$.

$\Phi_e = \frac{Q_{in}}{\varepsilon_0} \Rightarrow 4\pi r^2 E(r) = \frac{Q}{\varepsilon_0}$. $E(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

27.52

(a) $E(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

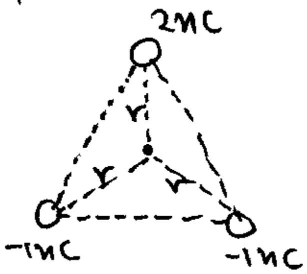
(b) $E(r) = 0$ because there is no charge in the sphere of radius $r < R_{in}$

(c) Draw a Gaussian surface of radius r.

$Q_{in} = Q\frac{r^3 - R_{in}^3}{R_{out}^3 - R_{in}^3}$. $\Phi = \frac{Q_{in}}{\varepsilon_0} \Rightarrow 4\pi r^2 E(r) = \frac{Q}{\varepsilon_0}\frac{r^3 - R_{in}^3}{R_{out}^3 - R_{in}^3}$

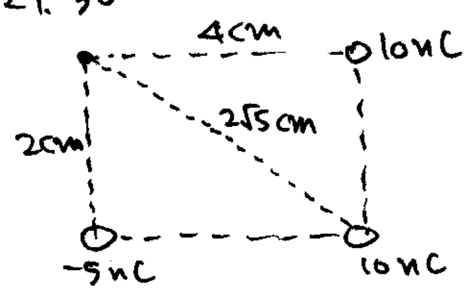
$E(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\frac{r^3 - R_{in}^3}{R_{out}^3 - R_{in}^3}$

29.28



$$V = \frac{1}{4\pi\epsilon_0}\left(\frac{2nC}{r} + \frac{-1nC}{r} + \frac{-1nC}{r}\right) = 0$$

29.30



(a) $V = \frac{1}{4\pi\epsilon_0}\left(\frac{10nC}{4cm} + \frac{10nC}{2\sqrt{5}\,cm} + \frac{-5nC}{2cm}\right)$

$= 2010\ V$

(b) $U = qV = -eV = -(1.6\times10^{-19}C)(2010V) = -3.22\times10^{-16}J$

29.50 $E = \frac{1}{2}mv_i^2 - e\frac{1}{4\pi\epsilon_0}\frac{Q}{R} = 0$ $\quad\left(\begin{matrix} Q = 6.00\,nC, & R = 0.50cm \\ e = 1.6\times10^{-19}C, & m = 9.11\times10^{-31}kg\end{matrix}\right)$

$v_i = \sqrt{\frac{2eQ}{4\pi\epsilon_0 mR}}$

30.35 $E_x(x) = \cancel{(-1000)x\ V/m = -1000x\ V/m}\ (-1000\frac{V}{m^2})x$

$\Delta V = V_f - V_i = -\int_{x_i}^{x_f} E_x(x)\,dx = \int_{x_i}^{x_f} 1000x\,dx\frac{V}{m^2} = 500x^2\Big|_{x_i}^{x_f}\frac{V}{m^2}$

$= 500(x_f^2 - x_i^2)$

30.36 $E_x(x) = (5000\frac{V}{m^2})x$

$V(x) = -\int_0^x E_x(x')\,dx' = -\int_0^x (5000\frac{V}{m^2})x'\,dx'$

$= -2500\frac{V}{m^2}[x'^2]_0^x = (-2500\frac{V}{m^2})x^2$

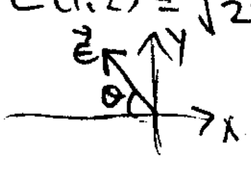
30.45 $V(x,y) = (140x^2 - 250y^2)$ Volts

$\vec{E}(x,y) = (-\frac{\partial V}{\partial x}\hat{x} - \frac{\partial V}{\partial y}\hat{y})$ N/C

$= (-280x\hat{x} + 250y\hat{y})$ N/C

$\vec{E}(1,2) = -280\,N/C\,\hat{x} + 500\,N/C\,\hat{y}$

$E(1,2) = \sqrt{280^2 + 500^2}$ N/C



$\tan\theta = \frac{500}{280}$