a) $Q(r) = \int_V \rho\, d^3r$

$$= \int_0^r \int_0^{2\pi} \int_0^{\pi} \left(\frac{3\rho_0}{R} r' - \rho_0\right) \cdot r'^2 \sin\theta \, d\theta \, d\varphi \, dr'$$

$$= 4\pi \int_0^r \left(\frac{3\rho_0}{R} r'^3 - \rho_0 r'^2\right) dr'$$

$$= 4\pi \left[\frac{3\rho_0}{4R} r'^4 - \frac{\rho_0 r'^3}{3}\right]_0^r$$

$$= 4\pi \left[\frac{3\rho_0 r^4}{4R} - \frac{\rho_0 r^3}{3}\right]$$

b)

Region 1: $r \leq R$

Region 2: $r \geq R$

$Q(r) = \int_{\partial V} \vec{D}\, d\vec{a}$

$$= \int_0^{2\pi} \int_0^{\pi} \vec{D}_r \cdot r^2 \cdot \sin\theta \cdot d\theta \cdot d\varphi$$

$$= \vec{D}_r \cdot r^2 \cdot 4\pi$$

$$\vec{D}_r = \frac{Q(r)}{4\pi r^2}$$

Region 1 :

$$\frac{\cancel{4\pi}\left[\frac{3\rho_0 r'^{\cancel{4}\,2}}{4R} - \frac{\rho_0 r'^{\cancel{3}\,1}}{3}\right]}{\cancel{4\pi r^2}}$$

$$= \frac{3\rho_0 r^2}{4R} - \frac{\rho_0 r}{3}$$

$Q(R) =$

Region 2 : $$4\pi \int_0^R \left(\frac{3\rho_0}{R} r'^3 - \rho_0 r'^2\right) dr'$$

$$= 4\pi \left[\frac{3\rho_0}{4R} r'^4 - \frac{\rho_0 r'^3}{3}\right]_0^R$$

$$= 4\pi \left[\frac{3\rho_0 R^3}{4} - \frac{\rho_0 R^3}{3}\right]$$

$\vec{D}_r$ $$= \frac{4\pi\left[\frac{5\rho_0 R^3}{12}\right]}{4\pi r^2}$$

$$= \frac{5\rho_0 R^3}{12\, r^2}$$

c)

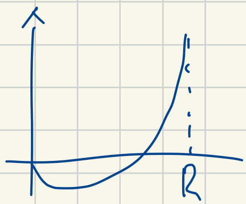
$$\vec{D}_r = \varepsilon \vec{E}$$

$$\vec{E} = \frac{1}{\varepsilon}\vec{D}_r$$

$$\ominus$$

$$= \begin{cases} \dfrac{1}{\varepsilon_0\varepsilon_r}\dfrac{3\rho_0 r^2}{4R} - \dfrac{\rho_0 r}{3} & \text{for } 0 \le r \le R \\ \dfrac{1}{\varepsilon_0}\dfrac{5\rho_0 R^3}{12 r^2} & \text{for } r \ge R \end{cases}$$

$$R^3$$



$$F_g = F_{el}$$

$$m \cdot g = Q_m \vec{E}(h)$$

$$= Q_m \frac{1}{\varepsilon_0}\frac{5\rho_0 R^3}{12h^2}$$

$$W_{mech} = \int_h^b Q_m \frac{1}{\varepsilon_0}\frac{5\rho_0 R^3}{12h'^2}\,dh'$$

need to include

mg

$$= Q_m \frac{1}{\varepsilon_0} \frac{5\rho_0 R^3}{12} \left[-\frac{1}{h'} \right]_h^b$$

$$= Q_m \frac{1}{\varepsilon_0} \frac{5\rho_0 R^3}{12} \left[-\frac{1}{h} + \frac{1}{b} \right]$$

a)

$$j = \frac{I}{A}$$

$$= \frac{I}{\pi(r_2^2 - r_1^2)} \vec{e}_z$$

b) $\int_{\partial A} \vec{H}(\vec{r})\, dr = \int_A \vec{j}(\vec{r})\, d\vec{r} = \underline{I}(A)$

Symm: $\vec{H} = H_\varphi(r)\, \vec{e}_\varphi$

$0 \leq r < r_1$: 1

$r_1 \leq r < r_2$: 2

$r_2 \leq r$: 3

$$\int_{\partial A} H(\vec{r}) = \int_0^{2\pi} H_\varphi(\vec{r}) \cdot \vec{e}_\varphi \cdot \vec{e}_\varphi\, r\, d\varphi = 2\pi r H_\varphi(r)$$

$$H_\varphi(r) = \frac{1}{2\pi r} \int_A \vec{j}\, d\vec{a}$$

① : $0 \leq r < r_1$

$$H_\phi(r) = 0$$

② : $r_1 \leq r < r_2$

a) $\rho = \frac{Q}{V} = \frac{q \cdot L}{R^2 \pi L}$

a) $\vec{H}(\vec{r}) = H_\varphi(\vec{r})\,\vec{e}_\varphi$