3.2 $\vec{E} = \rho z^2/\varepsilon_0 \, \hat{a}_z$ cube

$\phi = \int \vec{E} \cdot d\vec{S}$ $x = y = z = \pm 2$

$\phi = \int \vec{E} \cdot d\vec{S}_{top} + \int \vec{E} \cdot d\vec{S}_{bottom}$

$Q = \varepsilon_0 \phi$ $\int_{-2}^{2}\int_{-2}^{2} \rho (2)^2/\varepsilon_0 \, dx\,dy$

$= \frac{20}{\varepsilon_0}\int_{-2}^{2}\int_{-2}^{2} dx\,dy$

$= \frac{80}{\varepsilon_0}\int_{-2}^{2} dy$

$= 320/\varepsilon_0$

$\int_{-2}^{2}\int_{-2}^{2} \rho (-2)^2/\varepsilon_0 \, dx\,dy$

$= 320/\varepsilon_0$ $\phi_{top} + \phi_{bottom} = \frac{640}{\varepsilon_0}$

$Q = \varepsilon_0 \cdot \frac{640}{\varepsilon_0} = 640$

3.3 $\rho = 0.08$ m $\rho_s = \rho e^{-20|z|}$ nC/m²

$Q = \int_s \rho_s$

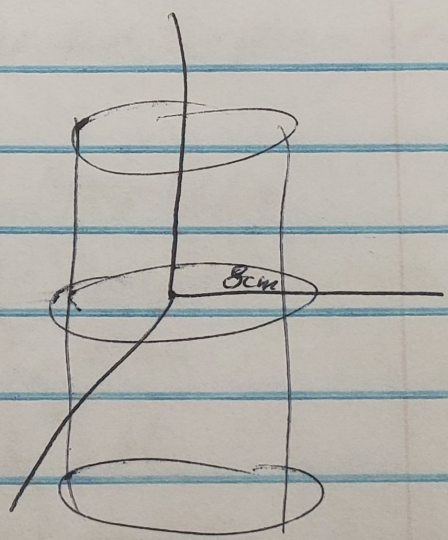
$= \int_{-\infty}^{\infty}\int_0^{2\pi} \rho_s \, r\,d\phi\,dz$

$= 0.08\int_{-\infty}^{\infty}\int_0^{2\pi} \rho e^{-20|z|}\,d\phi\,dz$

$= 0.4\int_{-\infty}^{\infty} e^{-20|z|}\int_0^{2\pi} d\phi$

$= 0.8\pi\int_{-\infty}^{\infty} e^{-20|z|}\,dz$

$= 0.8\pi\,(1/10) \approx 0.25$ nC



$Q = \int_{0.01}^{0.05}\int_{\pi/6}^{\pi/2} \rho_s \, r\,d\phi\,dz$

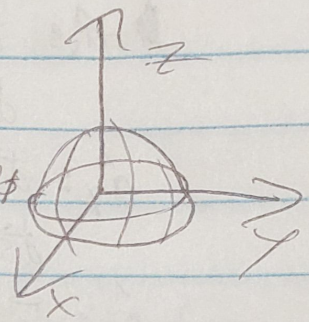
$= 0.08(\pi/3)\int_{0.01}^{0.05} \rho e^{-20|z|}\,d\phi\,dz$

$= 0.4\pi/3\int_{0.01}^{0.05} e^{-20|z|}\,d\phi\,dz$

$= \frac{0.4\pi}{3}(0.0225) = 9.42$ pC

3.7 $\rho_v = 2e^{-1000r}$ nC/m³ $\quad 0 \le r \le 0.001$

$A = 4\pi r^2$



$r = 0.001$ m

$Q = \int_0^{2\pi}\int_0^{\pi}\int_0^{0.001} \rho_v r^2 \sin\theta \, dr\, d\theta\, d\phi$

$= 4\pi(2)\int_0^{0.001} r^2 e^{-1000r}\, dr$

$= 8\pi(1.606E^{-10}) \approx \boxed{4\,nC}$

$D_r = Q/A = 4E^{-9}/4\pi r^2, \quad r = 0.001$

$= \boxed{0.32\,pC}$

3.15 ~~$\rho_v = 0$ for $\rho < 0.001$~~ $\rho_v = 0$ for $\rho < 0.001$ and $\rho > 0.002$

~~$\rho_v = 4\rho$ μC/m³ for $\rho > 0.002$~~ $\rho_v = 4\rho$ μC/m³ for ~~$0.001 < \rho < 0.002$~~

$0 < \rho < \rho_1$

$0 < z < L$ $\quad Q = \int_0^{L}\int_0^{2\pi}\int_{0.001}^{\rho_1} \rho\, d\rho\, d\phi\, dz$

$0.001 \to 0.002 \longrightarrow = \int_0^{L}\int_0^{2\pi}\int_{0.001}^{\rho_1} 4\rho^2\, d\rho\, d\phi\, dz$

$= 8\pi L \int_{0.001}^{\rho_1} \rho^2\, d\rho$

$= \frac{8\pi L}{3}\left[\rho_1^3 - E^{-9}\right]$ μC

$\approx \boxed{\frac{8\pi L \rho_1^3}{3}\,\mu C}$

$D_\rho = \frac{Q}{2\pi\rho_1 L}$

$= \boxed{\frac{4\rho_1^2}{3}}\,\mu C/m^2$

$D_\rho(0.8\,mm) = \boxed{0}$ $\quad 0.0008 < 0.001$

$D_\rho(1.6\,mm) = \boxed{3.4\,\mu C/m^2}$

$D_\rho(2.4\,mm) = \boxed{8.9\,\mu C/m^2}$