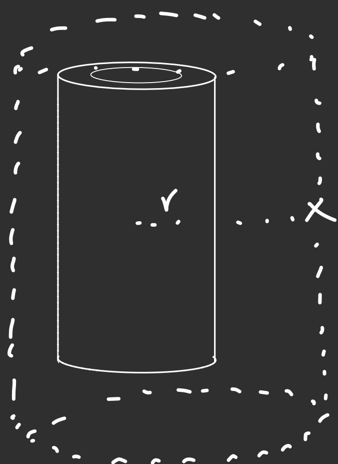
Week 4 HW

(3)

$$\phi = -848 \frac{Nm^2}{C} = \frac{-18.0E\text{-}9\,C + 31.0E\text{-}9\,C + Q_3}{8.85E\text{-}12 \frac{Nm^2}{C^2}}$$

$$\boxed{Q_3 = -20.50E\text{-}9\,C}$$

(4)



$R_1 = 0.037m$

$R_2 = 0.0315\,m$

$\sigma = 3.22E\text{-}3 \frac{C}{m^3}$

$r = 0.0777m$

$$\int E\,dA = \frac{q_{encl}}{\varepsilon_0}$$

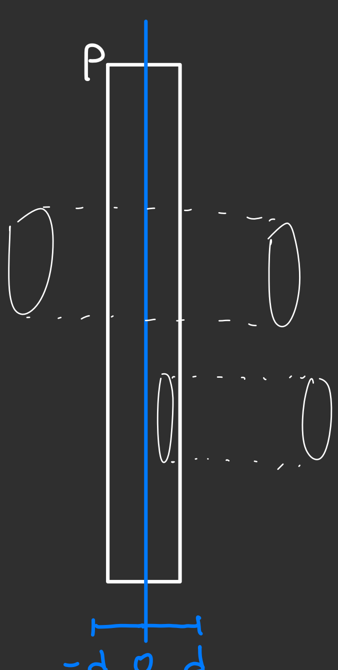
Surface area of gauss cylinder (minus ends)

Volume of charges cylinder ($R_w = R_1 - R_2$)

$$E \cdot 2\pi r h = \frac{\sigma\, \pi R_w^2 h}{\varepsilon_0} \qquad E = \frac{\sigma(R_1^2 - R_2^2)}{2 r \varepsilon_0}$$

$$E = \frac{3.22E\text{-}3\,(0.037^2 - 0.0315^2)}{2\,(0.0777m)(8.85E\text{-}12)} = 882094 \frac{N}{C}$$

(6)



Outside:

$$E \cdot 2s = \frac{P \cdot 2d \cdot s}{\varepsilon_0}$$

I can walk through this one if you guys want

$$z \leq d: E = -\frac{Pd}{\varepsilon_0} \qquad z \leq d: E = \frac{Pd}{\varepsilon_0}$$

Inside:

$$E \cdot 2s = \frac{P \cdot (d+z) \cdot s}{\varepsilon_0} - \frac{P(d-z)s}{\varepsilon_0}$$

$$-d \leq z \leq d: E = \frac{P(z+d)}{2\varepsilon_0} + \frac{P(d-z)}{2\varepsilon_0}$$

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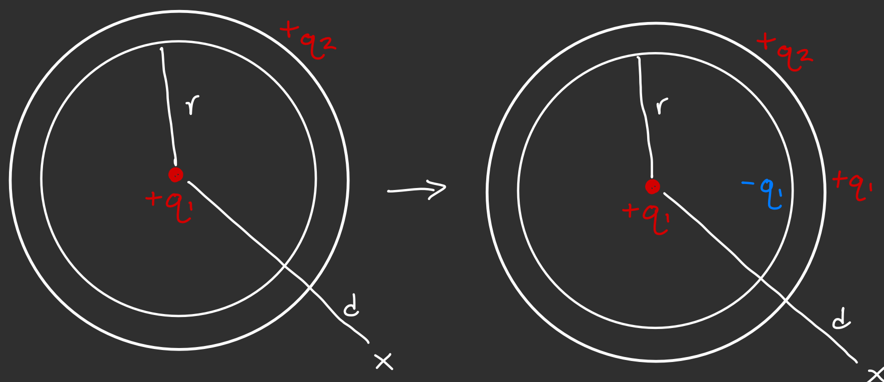

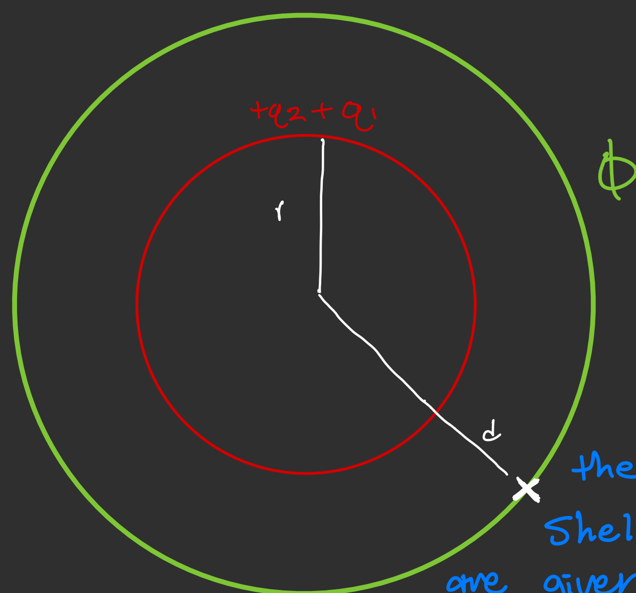

We dont need the SA of the shell because we are given the qenclosed directly

$$\int E\,dA = \frac{q_{encl}}{\varepsilon_0} \qquad E \cdot 4\pi d^2 = \frac{(q_2+q_1)}{\varepsilon_0}$$

$$E = \frac{(q_1+q_2)}{4\pi d^2 \varepsilon_0} = \frac{(3.15E-6 + 8.03E-6)}{4 \cdot \pi \cdot 0.965^2 \cdot 8.85E-12}$$

$$\boxed{E = 481345 \ \frac{N}{C}}$$

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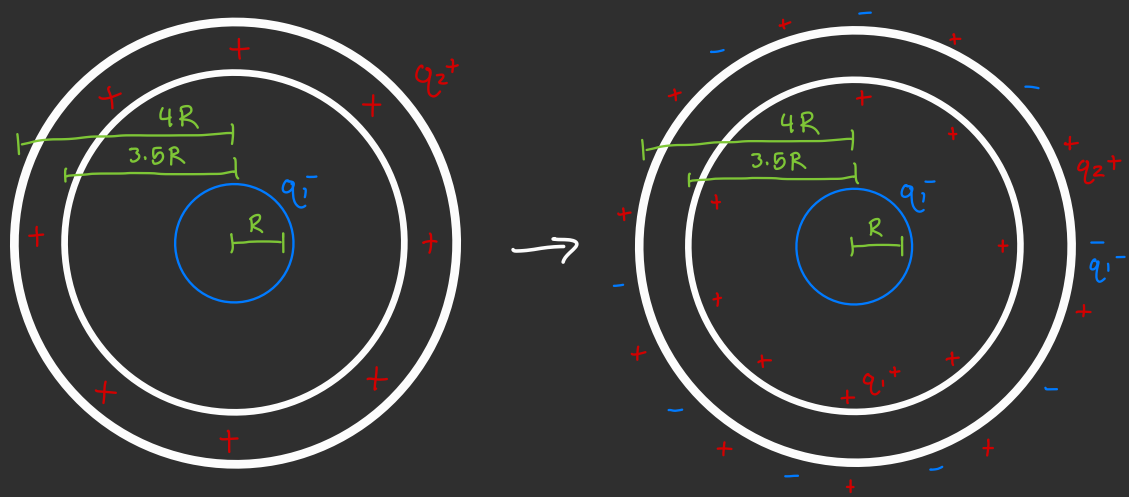
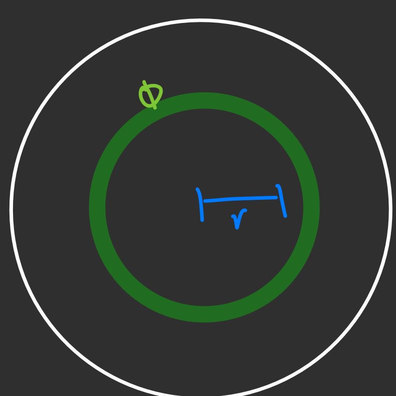


When $r = 0.810R$:

In this case we are inside the inner sphere, therefore we only care about the uniform charge. To find the E field we can consider a gaussian sphere with r on its edge.



$$\int E\,dA = \frac{\sigma \cdot V}{\varepsilon_0}$$

$$E \cdot 4\pi r^2 = \frac{\sigma \cdot \frac{4}{3}\pi r^3}{\varepsilon_0}$$

$$E = \frac{\sigma r^3}{3 r^2 \varepsilon_0} = \frac{-483E\text{-}9 \cdot (0.810R)^3}{3 \cdot (0.810R)^2 \cdot 8.86E\text{-}12}$$

$$E = 2132 \frac{N}{C}$$

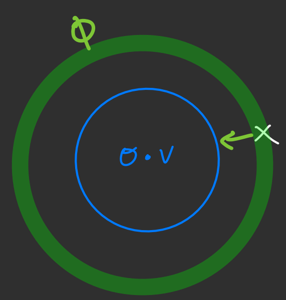
When $r = 3.90R$:

This distance lies inside the conductor. Therefore the E-field is zero

$$E = 0$$

When $r = 1.85R$:

This case lies in between the two objects. We can draw our gaussian sphere with x on its edge and consider the charge on the inner sphere



$$\int E\,da = \frac{\sigma V}{\varepsilon_0}$$

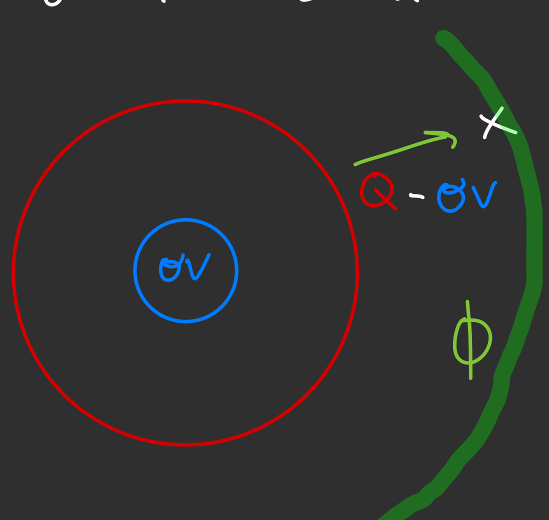
$$E \cdot 4\pi (1.85R)^2 = \frac{\sigma \cdot \frac{4}{3}\pi R^3}{\varepsilon_0}$$

$$E = \frac{\sigma R^3}{3(1.85R)^2 \varepsilon_0} = \frac{-453E-9 \cdot 0.245^3}{3(1.85 \cdot 0.245)^2 \cdot 8.85E\text{-}12}$$

$$E = -1221.4 \tfrac{N}{C}$$

When $r = 4R$:

The final case has the distance outside of the entire system. for this case we have to consider the charge that the inner sphere induces on the outer shell. This will eventually change how large the charge on the surface of the shell is



$$\int E\,dA = \frac{q_{encl}}{\varepsilon_0}$$

$$E \cdot 4\pi (6.10R)^2 = \frac{Q - \sigma \cdot \frac{4}{3}\pi R^3}{\varepsilon_0}$$

$$E = \frac{Q - \sigma \cdot \frac{4}{3}\pi R^3}{4\pi (6.10R)^2 \varepsilon_0}$$

$$E = 156.2 \tfrac{N}{C}$$

(10)

$r = 0.0201$:

Sphere is conductive $E = 0$

$r = 0.0961$:

$$\int E\,dA = \frac{q_{encl}}{\varepsilon_0} \qquad E \cdot 2\pi r \ell = \frac{\lambda \cdot \ell}{\varepsilon_0}$$

$$E = \frac{302E-12}{2 \cdot \pi \cdot 0.0961 \cdot 8.85E-12} = 56.51 \frac{N}{C}$$

$r = 0.113$:

(Pain in the ass)

$$\int E\,dA = \frac{q_{encl}}{\varepsilon_0} \qquad E \cdot 2\pi r \ell = \frac{(\lambda \cdot \ell) + (P \cdot \frac{4}{3}\pi (r - R_2)^3)}{\varepsilon_0}$$

set length to 1 for surface and inner cylinder
(We can do this because they are infinite)

$$E = \frac{\lambda + P \frac{4}{3}\pi (r - R_2)^3}{2\pi r \varepsilon_0}$$

I aint writing all
thoes numbers sorry

$$E = 48.06 \frac{N}{C}$$

$r = 0.137$:

Dont be fooled, we care about both surfaces for this one since the outside is a nonconductor

$$E \cdot 2\pi r (1) = \frac{\lambda + P(\frac{4}{3}\pi (R_3 - R_2)^3)}{\varepsilon_0} \qquad E = 39.64\,N/C$$

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$$Q_{encl} = 10.5 \cdot \frac{4}{3}\pi(0.335)^3 = 1.654$$

$$\text{Inner} = \frac{1.654}{4\pi(0.588)^2} = 0.381$$

$$\text{Outer} = \frac{1.654}{4\pi(0.7)^2} = 0.267$$