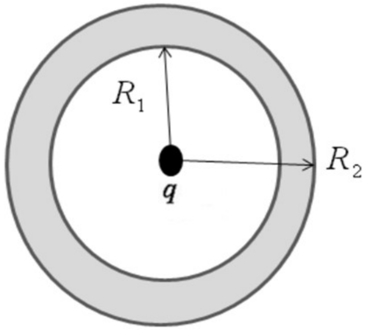
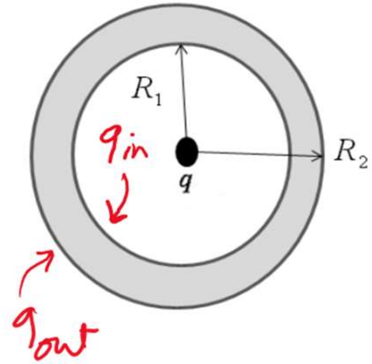
Q1 M2-112-10

A point charge $q = -1.0\times10^{-10}$ C is placed at the center of a spherical conducting shell that has a total charge $Q = 5.0\times10^{-10}$ C, as shown in the figure. The outer surface has radius R2 = 10 cm. The charge density on the external surface is equal to

A) $+3.2$ nC/m^2
B) -3.2 nC/m^2
C) $+4.0$ nC/m^2
D) $+0.80$ nC/m^2
E) -0.80 nC/m^2



Net charge in a cavity totally within a conductor is zero



$\Rightarrow \quad q_{in} + q = 0$

$\Rightarrow \quad q_{in} = -q = +1\times10^{-10}\,C$

From conservation of charge, the total charge of the spherical conductor cannot charge

$\Rightarrow \quad q_{out} + q_{in} = 5\times10^{-10}\,c$

$\Rightarrow \quad q_{out} = 4\times10^{-10}\,C$

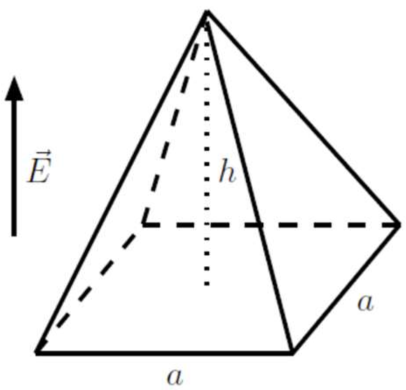
$\Rightarrow$ The charge density on the external surface

$$= \frac{q_{out}}{4\pi r^2} = \frac{4\times10^{-10}}{4\pi(0.1)^2} = 3.2\times10^{-9}\,C/m^2 = 3.2\,nC/m^2$$

Q2 M2-142-6

The figure shows a pyramid with horizontal square base, *a* = 6.00 m on each side, and a height, *h* = 4.00 m. The pyramid is placed in an upward vertical electric field of magnitude *E* = 52.0 N/C. If the pyramid does not include any charge inside, calculate the electric flux, in N.m^2/C, through its four slanted (inclined) surfaces.

A) $+1.87 \times 10^3$
B) -1.87×10^3
C) $+ 0.9 \times 10^3$
D) $- 0.9 \times 10^3$
E) -3.27×10^3



Gauss' Law $\varepsilon_0 \Phi = q_{enc}$

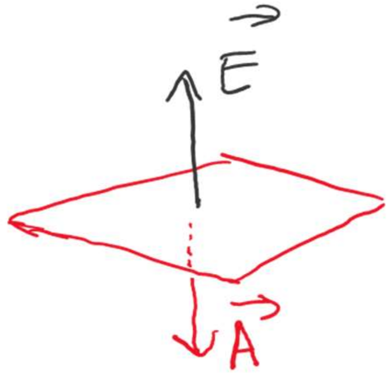
Since $q_{enc} = 0 \Rightarrow \phi = 0$

$$\Phi_{base} + \Phi_{sides} = 0$$

$$\Phi_{base} = \vec{E} \cdot \vec{A} = EA\cos 180 = -Ea^2$$

$$\Rightarrow \phi_{sides} = -\Phi_{base} = Ea^2 = 52(6)^2 \ \frac{Nm^2}{C}$$

$$\Phi_{sides} = +1.87 \times 10^3 \ \frac{Nm^2}{C}$$



Q3 M2-112-8

Consider three infinite non-conducting sheets with uniform charge densities (–σ, +2σ, +3σ), as shown in cross section in the figure. The electric field between plates A and B is given by

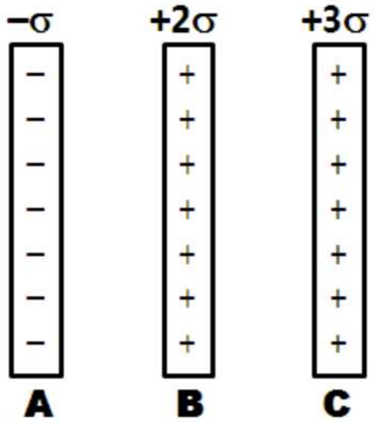
A) $\frac{3\sigma}{\epsilon_0}$ to the left

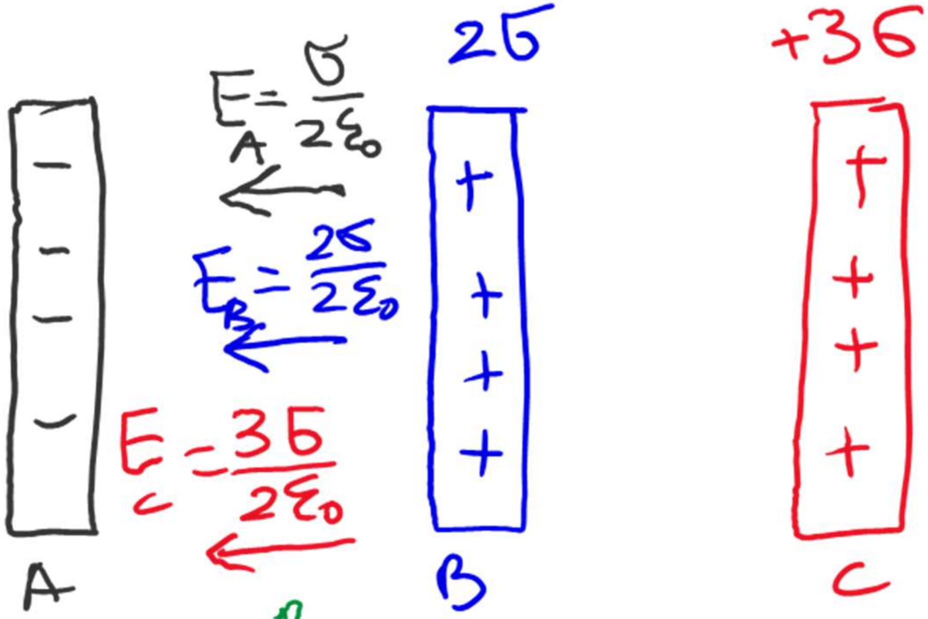
B) $\frac{6\sigma}{\epsilon_0}$ to the left

C) $\frac{3\sigma}{\epsilon_0}$ to the right

D) $\frac{6\sigma}{\epsilon_0}$ to the right

E) $\frac{\sigma}{\epsilon_0}$ to the right



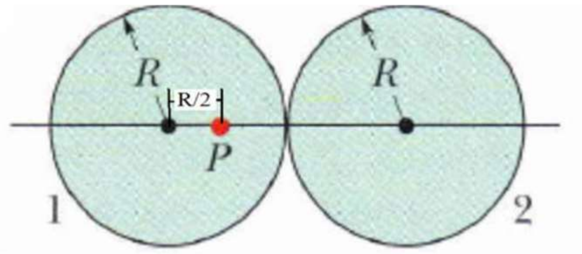


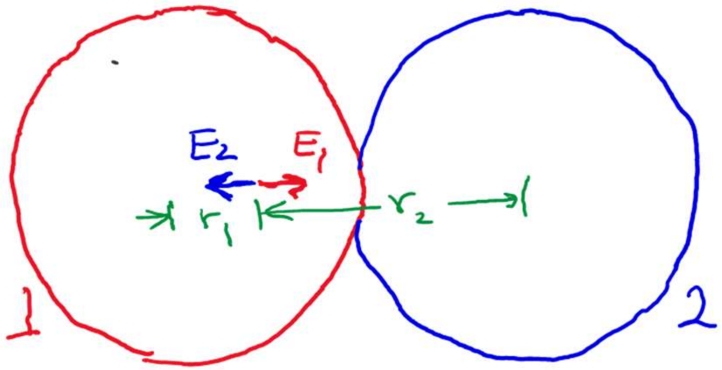
total $= \frac{6\sigma}{2\varepsilon_0} = \frac{3\sigma}{\varepsilon_0}$ to the left.

Q4 M2-132-9

The figure shows the cross sectional area of two identical charged solid spheres, 1 and 2, of radius *R*. The charge is uniformly distributed throughout the volumes of both the spheres. The net electric field is zero at point P, which is located on a line connecting the centers of the spheres, at radial distance R/2 from the center of sphere 1. If the charge on sphere 1 is q_1= 7.8 μC, determine the magnitude of the charge q_2 on sphere 2.

A) 8.8 μC
B) 3.2 μC
C) 9.3 μC
D) 3.5 μC
E) 6.8 μC





$r_2 > R$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{kq_2}{(R+\frac{R}{2})^2}$$

$r_1 < R$

$$E_1 = \frac{kq_1}{R^3} r_1 = \frac{kq_1}{R^3}\left(\frac{R}{2}\right)$$

$$E_2 = E_1 \Rightarrow \frac{kq_2}{(R+\frac{R}{2})^2} = \frac{kq_1}{R^3}\frac{R}{2}$$

$$\Rightarrow \frac{q_2}{(\frac{3}{2})^2} = \frac{q_1}{2} \Rightarrow q_2 = \frac{9}{8} q_1 = 8.8\ \mu C$$

Q5 M2-122-8

A long, straight wire has fixed negative charge with a linear charge density of magnitude 4.5 nC/m. The wire is enclosed by a coaxial, thin walled nonconducting cylindrical shell of radius 20 cm. The shell is to have a positive charge on its outside surface (with a surface charge density σ) that makes the net electric field at points 30 cm from the center of the shell equal to zero. Calculate σ.

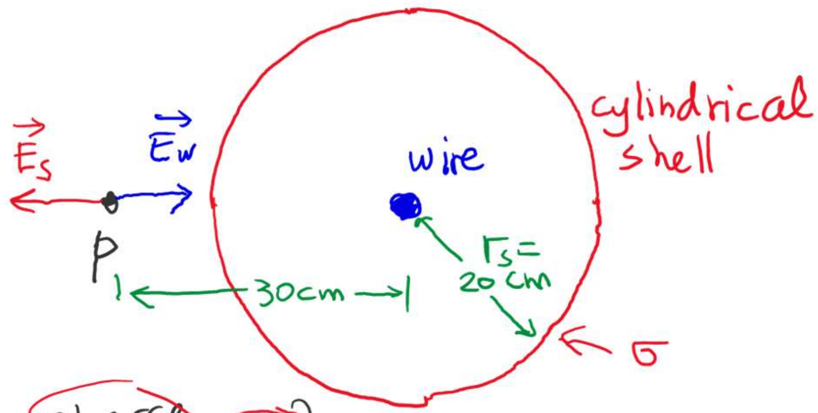
A) 3.6×10^{-9} C/m^2
B) 3.0×10^{-10} C/m^2
C) 1.5×10^{-10} C/m^2
D) 4.5×10^{-7} C/m^2
E) 7.8×10^{-5} C/m^2

Since the point P is outside the cylindrical shell, we can treat the shell as another wire located at the same position of the real wire.

$$E_s = E_w$$

$$\Rightarrow \frac{\lambda_s}{2\pi\varepsilon_0 r} = \frac{\lambda_w}{2\pi\varepsilon_0 r}$$

$$\Rightarrow \lambda_s = \lambda_w$$



$$\lambda_s = \frac{\text{charge}}{\text{length}}$$

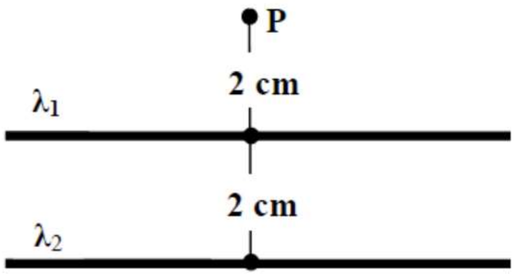
$$\sigma = \frac{\text{charge}}{\text{area}} = \frac{\text{charge}}{2\pi r_s l} = \frac{\lambda_s}{2\pi r_s}$$

$$\sigma = \frac{\lambda_w}{2\pi r_s} = \frac{4.5}{2\pi(0.2)} \frac{nC}{m^2} = 3.6 \times 10^{-9} \frac{C}{m^2}$$

Q6 M2-132-7

Consider two infinitely long thin wires carrying uniform linear charge densities λ_1 and λ_2. The wires are arranged as shown in the figure and λ_2 = +5.50 nC/m. If the net electric field at P is zero, determine the magnitude of λ_1.

A) 2.75 nC/m
B) 1.50 nC/m
C) 1.75 nC/m
D) 2.00 nC/m
E) 0.50 nC/m



$$E_1 = \frac{|\lambda_1|}{2\pi\varepsilon_0 r_1}$$

$$E_2 = \frac{|\lambda_2|}{2\pi\varepsilon_0 r_2}$$

$$E_1 = E_2 \Rightarrow \frac{|\lambda_1|}{r_1} = \frac{|\lambda_2|}{r_2}$$

$$\Rightarrow |\lambda_1| = \frac{r_1}{r_2}|\lambda_2| = \frac{0.02}{0.04}\, 5.5\,\frac{nC}{m} = 2.75\,\frac{nC}{m}$$