Quiz 1 Answer

1- A point charge of 30 nC is located at the origin while plane y = 3 carries a surface charge density of $p_{s\,=}$ 10 nC/m^{2}. Find **D** at (0, 4 , 3).

$$\mathbf{D} = \mathbf{D_Q} + \mathbf{D}_p = \frac{\mathrm{Q}}{4\pi\, \mathrm{r}^2}\mathbf{a_r} + \frac{p_s}{2}\mathbf{a_n}$$

$$\mathrm{r} = \sqrt{(0-0)^2+(4-0)^2+(3-0)^2} = 5$$

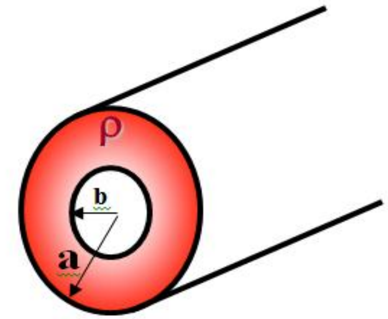
$$\mathbf{D} = [\left(\frac{30 \text{ x } 10^{-9}}{4\pi\,(5)^2}\right) . \frac{[(0,4,3)-(0,0,0)]}{5}] + [\frac{10 \text{ x } 10^{-9}}{2}]\,\mathbf{a_y}$$

$$= \left(\frac{30}{500\,\pi}\right)(10^{-9})\left(0\,\mathbf{a_x}, 4\,\mathbf{a_y}, 3\,\mathbf{a_y}\right) + 5\,(10^{-9})\mathbf{a_y}$$

$$= 0.076\,\mathbf{a_y} + 5.057\,\mathbf{a_z}\ \mathrm{nC/\,m^2}$$

Quiz 1 Answer

2- Find the electric field intensity **E** anywhere inside and outside the hollow charged cylinder as shown in the Figure, with charge density $\rho = \rho_v$.



$$\oint \mathbf{D} \,.\, \mathbf{ds} = \mathbf{Q} = \int \rho \, \mathrm{dv} \quad \rightarrow \quad \oint \mathbf{E} \,.\, \mathbf{ds} = \frac{1}{\varepsilon_0} \int \rho \, \mathrm{dv}$$

<u>At r < b</u>

$$\mathrm{E}_1 \,.\, 2\,\pi\, \mathrm{r}\, l = \frac{1}{\varepsilon_0}(0)$$

$$\rightarrow \qquad \mathrm{E}_1 = 0$$

Quiz 1 Answer

<u>At b < r < a</u>

$$E_2 \,.\, 2\,\pi\, r\, l = \frac{\rho}{\varepsilon_0}\,\pi\,(r^2 - b^2)\,l$$

$\rightarrow$

$$E_2 = \frac{\rho}{\varepsilon_0}\,\frac{(r^2 - b^2)}{2r} \quad \text{v/m}$$

<u>At r > a</u>

$$E_3 \,.\, 2\,\pi\, r\, l = \frac{\rho}{\varepsilon_0}\,\pi\,(a^2 - b^2)\,l$$

$\rightarrow$

$$E_3 = \frac{\rho}{\varepsilon_0}\,\frac{(a^2 - b^2)}{2r} \quad \text{v/m}$$

Quiz 1 Answer

3- Three point charges $Q_1 = 1$ nC, $Q_2 = -2$ nC, and $Q_3 = 3$ nC are positioned one at a time and in that order at (0, 0, 0) , (1, 0, 0) and (0, 0, -1) respectively. Calculate the energy in the system after each charge is positioned.

Quiz 1 Answer

After positioning Q_1 , $W_1 = 0$

After positioning Q_2 , $W_2 = Q_2 \; V_{21} = \dfrac{Q_2 \, Q_1}{4\,\pi\,\varepsilon_0 |(1,0,0)-(0,0,0)|} = \dfrac{(1)(-2)10^{-18}}{4\,\pi\,x\;10^{-9}/\,36\pi}$

$$= (-2)x\,10^{-18}\;x\;9\;\mathrm{x}\;10^{9}$$

$$= \text{-18 nJ}$$

After positioning Q_3 , $W_3 = Q_3\,(V_{31} + V_{32}) + Q_2\,V_{21}$

$$= 3\;x\;9\;\mathrm{x}\,10^{9}\;[\frac{1}{|(0,0,-1)-(0,0,0)|} + \frac{-2}{|(0,0,-1)-(1,0,0)|}]\text{ - 18 nJ}$$

$$= 27\left(1 - \frac{2}{\sqrt{2}}\right) - 18$$

$$= \text{-29.18 nJ}$$