PHYSICS 122 WORKSHEET 3 1/29/2018

NAME: Key SECTION:

1. i) Write down the definition of electric flux. $\Phi = \sum_S \vec{E} \cdot \Delta \vec{A}_S = Q_{enc}/\varepsilon_0$

ii) Consider a sphere of radius R. Use the definition above to calculate the net flux passing out of the sphere if it encloses a charge of magnitude Q.

$$\Phi = 4\pi R^2 E = Q_{enc}/\varepsilon_0$$

iii) Write down Gauss' Law. Does your answer from part ii) agree?

$$EA = \frac{Q_{enc}}{\varepsilon_0}$$

Yes

3. Consider a solid conducting sphere of radius R with charge Q distributed uniformly along its surface. Calculate the electric field:

i) inside the sphere,

$r < R$: $E(4\pi r^2) = Q_{enc}/\varepsilon_0 = 0$ since all charge on surface

$E = 0$ inside

ii) on the surface of the sphere,

$$\vec{E} = \vec{E}_N + \cancel{\vec{E}_P}$$

$r = R$ $$= \frac{\sigma}{\varepsilon_0} \hat{n} = \frac{Q}{4\pi R^2 \varepsilon_0} \hat{n}$$

iii) outside the sphere.

$r > R$: $E(4\pi r^2) = Q_{enc}/\varepsilon_0$

$$E = \frac{Q}{4\pi r^2 \varepsilon_0}$$

4. Consider a solid **non**-conducting sphere of radius r_1 with uniform charge density ρ. Enclosing the sphere is a hollow conductive shell of radius $r_2 > r_1$. Using Gauss' Law, calculate:

i) $E(r < r_1)$ i.e electric field inside the solid non-conducting sphere.

$$E \cdot 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0} = \frac{\rho \cdot \frac{4}{3}\pi r^3}{\varepsilon_0}$$

$$E = \frac{\rho r}{3\varepsilon_0}$$

ii) $E(r_1 < r < r_2)$ i.e electric field between the hollow conductive shell and solid non-conducting sphere.

$$E \cdot 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0} = \frac{\rho \cdot \frac{4}{3}\pi r_1^3}{\varepsilon_0}$$

$$E = \frac{\rho r_1^3}{3\varepsilon_0 r^2}$$

iii) $E(r_2)$ i.e electric field *inside* the conductor.

$E = 0$ inside cond. !

iv) $E(r > r_2)$ i.e electric field outside the shell.

$$E \cdot 4\pi r^2 = \frac{Q_{enc}}{\varepsilon_0} = \frac{\rho \cdot \frac{4}{3}\pi r_1^3}{\varepsilon_0}$$

$$E = \frac{\rho r_1^3}{3\varepsilon_0 r^2}$$