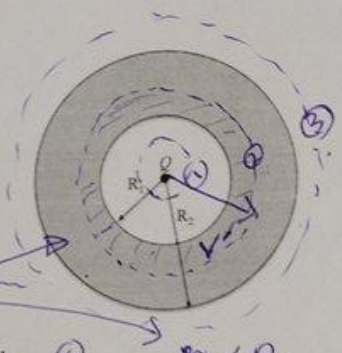
Homework with Discussion/Physics (2) Key **Fall 2017**

A thick ***insulating*** spherical shell of inner radius R_1 and outer radius R_2 has a uniform volume charge density ρ. A positive point charge Q is located at the center of the shell as shown.



1) Determine the electric field for $r < R_1$.

2) Determine the electric field for $R_1 < r < R_2$.

3) Determine the electric field for $r > R_2$.

① G-law $\Rightarrow E(4\pi r^2) = \frac{Q}{\varepsilon_0} \Rightarrow E = k_e \frac{Q}{r^2}$, $r < R_1$ ($q_{in} = Q$)

OR treating as E-field due to a point charge.

② $E = ?$ for $R_1 < r < R_2$, $q_{in} = ? = Q + \rho V'$

$V' = \frac{4}{3}\pi(r^3 - R_1^3)$

$\Rightarrow q_{in} = Q + \frac{4}{3}\pi(r^3 - R_1^3)\rho$

$\Rightarrow \oint E \cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0} \Rightarrow E(4\pi r^2) = \frac{Q}{\varepsilon_0} + \frac{4}{3\varepsilon_0}\pi(r^3 - R_1^3)\rho$

$$\Rightarrow \boxed{E = \frac{Q + \frac{4}{3}\pi(r^3 - R_1^3)\rho}{4\pi\varepsilon_0 r^2}, \quad R_1 < r < R_2}$$

③ $E = ?$ for $r > R_2$, $q_{in} = ? = Q + \rho V$

$V = \frac{4}{3}\pi(R_2^3 - R_1^3)$

$\Rightarrow q_{in} = Q + \frac{4}{3}\pi(R_2^3 - R_1^3)\rho$

$E(4\pi r^2) = \frac{q_{in}}{\varepsilon_0}$

$$\Rightarrow \boxed{E = \frac{Q + \frac{4}{3}\pi(R_2^3 - R_1^3)\rho}{4\pi\varepsilon_0 r^2}, \quad r > R_2}$$