ALTERATIVE APPROACH FOR 1c–d

$$|E(r)| = \frac{R^3 \rho}{3\varepsilon_0 r^2} \qquad r > R$$

$$|E(r)| = \frac{\rho r}{3\varepsilon_0} \qquad r < R$$

WE TAKE $\vec{E} = -\vec{\nabla} V$

IN SPHERICAL COORDINATES AND

IF THERE ARE NO θ OR ϕ COMPONENTS

$$\frac{\partial V}{\partial r} = -E$$

$r > R$ $\quad V = \int -E\,dr$ INDEFINITE INTEGRAL

$$= -\int \frac{R^3 \rho}{3\varepsilon_0 r^2}\,dr$$

$$V(r) = \frac{R^3 \rho}{3\varepsilon_0 r} + C_1$$

AT $r \to \infty$ ~~V~~ $V = 0$ SO $C_1 = 0$

$$\therefore V(r) = \frac{R^3 \rho}{3\varepsilon_0 r} \qquad \text{FOR } r > R$$

FOR $r < R$

$$V = \int -E\,dr$$

$$= \int -\frac{\rho r}{3\varepsilon_0}\,dr = -\frac{\rho r^2}{6\varepsilon_0} + C_2$$

WHAT IS C_2 ?

SINCE AT $r = R$ E IS FINITE

V MUST BE CONTINUOUS

$$V(R) \text{ FROM OUTSIDE } = \frac{R^3\rho}{3\varepsilon_0 R} = \frac{R^2\rho}{3\varepsilon_0}$$

$$V(R) \text{ FROM INSIDE } = -\frac{\rho R^2}{6\varepsilon_0} + C_2$$

$$C_2 = \frac{\rho R^2}{6\varepsilon_0} + \frac{R^2\rho}{3\varepsilon_0} = \frac{\rho R^2}{2\varepsilon_0}$$

So $\boxed{V(r) = \frac{\rho R^2}{2\varepsilon_0} - \frac{\rho r^2}{6\varepsilon_0} \quad r < R}$