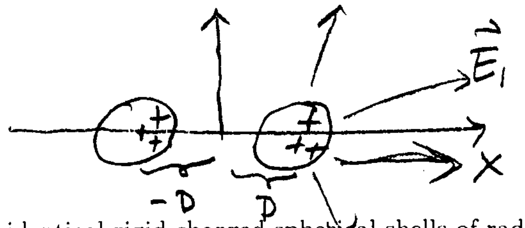


3. Two identical rigid charged spherical shells of radius $R < D$ are at rest and have their centers located at $x = \pm D$ with electric fields given by $\vec{E}_1$ and $\vec{E}_2$. They are released from rest and each sphere moves far away from the other. Describe in detail **two** ways to determine their kinetic energy long after they are released.

$$W_{nc} = \Delta(KE+PE) = (KE+\underset{0}{\cancel{PE}})_f - (\underset{0}{\cancel{KE}}+PE)_i$$

$PE = W_{me}$ in assembling charges.

$$= \underbrace{\text{Energy to assemble each sphere}}_{\text{self energy}} + \underbrace{\text{Energy to bring two spheres near each other}}_{PE_{\text{bring together}}}$$

$$= \frac{1}{2}\epsilon_0\int \vec{E}_1\cdot\vec{E}_1\,d\tau + \frac{1}{2}\epsilon_0\int \vec{E}_1\cdot\vec{E}_1\,d\tau + PE_{\text{bring together}} = \frac{1}{2}\epsilon_0\int(\vec{E}_1+\vec{E}_2)\cdot(\vec{E}_1+\vec{E}_2)\,d\tau$$

$$\boxed{KE = PE_{\text{bring together}} = \frac{1}{2}\epsilon_0\int(\vec{E}_1+\vec{E}_2)\cdot(\vec{E}_1+\vec{E}_2)\,d\tau - \frac{1}{2}\epsilon_0\int\vec{E}_1\cdot\vec{E}_1\,d\tau - \frac{1}{2}\epsilon_0\int\vec{E}_2\cdot\vec{E}_2\,d\tau}$$

METHOD 2 CALCULATE THE FORCE ON A $dq$ in sphere 1 & apply $\vec{F} = \int d\vec{F} = m\vec{a}$

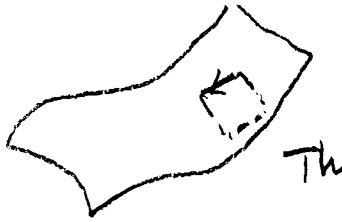
$$d\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{dq\,\vec{E}_2}{r^2}\hat{r}$$

4. What fundamental principle/principles determine why you need only be given $E_\perp$ near a boundary to determine the surface charge density. Explain in detail.

NEED $\vec{\nabla}\times\vec{E} = 0$ & $\vec{\nabla}\cdot\vec{E} = \rho/\epsilon_0$ to define $\vec{E}$

↓ Stokes Th   Divergence Th ↓

$\oint \vec{E}\cdot d\vec{l} = 0$   $\oint \vec{E}\cdot d\vec{a} = \frac{Q_{encl}}{\epsilon_0}$



$E_\parallel^{below} = E_\parallel^{above}$

This doesn't involve $\sigma$

$$\oint \vec{E}\cdot da = E_\perp^{above}A - E_\perp^{below}A = \frac{\sigma A}{\epsilon_0}$$

discontinuity in $E_\perp$ yields $\frac{\sigma}{\epsilon_0}$