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$$V(\vec{r}_{ip}) = \frac{1}{4\pi\varepsilon_0} \frac{\vec{p} \cdot \hat{r}_{ip}}{r_{ip}^2}$$

$$\vec{p} = \sum_{q_i} q_i \vec{r}_i$$

$$V(\vec{r}_p) = \frac{1}{4\pi\varepsilon_0} \int_{\text{all } q_i} \left[\frac{\vec{P} \cdot \hat{r}_{ip}}{r_{ip}^2} \right] d^3 r_i$$

$$\vec{P} = \frac{\vec{p}}{\text{unit vol}}$$

$$\vec{\nabla}_i \left(\frac{1}{r_{ip}} \right) = \frac{\hat{r}_{ip}}{r_{ip}^2}$$

$$V = \frac{1}{4\pi\varepsilon_0} \int_{q_i} \vec{P} \cdot \vec{\nabla} \left(\frac{1}{r_{ip}} \right) d^3 r_i$$

$$\vec{\nabla}_i \cdot \left(\frac{\vec{P}}{r_{ip}}\right) = \frac{1}{r_{ip}} \vec{\nabla}_i \cdot \vec{P} + \underline{\vec{P} \cdot \vec{\nabla}_i (r_{ip})}$$

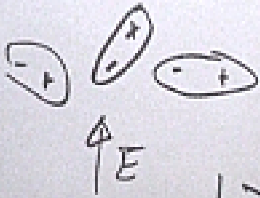
$$V(r_{ip}) = \frac{1}{4\pi\varepsilon_0} \int \frac{1}{r_{ip}} \vec{\nabla} \cdot \vec{P} \, d^3r$$

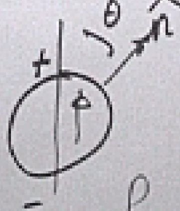
$$- \frac{1}{4\pi\varepsilon_0} \int \vec{\nabla} \left(\frac{\vec{P}}{r_{ip}}\right) \underline{d^3r}$$

$$\sigma_b \equiv \vec{P} \cdot \hat{n}$$

$$\rho_b \equiv - \vec{\nabla} \cdot \vec{P} \leftarrow$$

if $\vec{P}$ const; $\rho_b = 0$





$\vec{P} = P\hat{z}$

$\rho_b = 0$ ($\vec{P}$ unifm)

$\sigma_b = \vec{P}\cdot\hat{n} = P\cos\theta$

in $V(r,\theta) = \sum_{n=0}^{\infty} A_n r^n P_n(\cos\theta)$

out $V(r,\theta) = \sum_{n=0}^{\infty} \frac{B_n}{r^{n+1}} P_n(\cos\theta)$

@ $r=a$, $V_{in} = V_{out}$

$$\sum_{n=0}^{\infty} A_n a^n P_n(\cos\theta) = \sum_{n=0}^{\infty} \frac{B_n}{a^{n+1}} P_n(\cos\theta)$$

$$A_n a^n = \frac{B_n}{a^{n+1}} \Rightarrow B_n = A_n a^{2n+1}$$

$$\frac{\partial V_{out}}{\partial r} - \frac{\partial V_{in}}{\partial r} = -\frac{\sigma}{\varepsilon_0}$$

V, $\vec{\nabla} V$

$$\vec{D} = \underbrace{\varepsilon_0 \vec{E}}_{\boxed{\rho_b ,\ \rho_f}} + \vec{P} \rightarrow Q_f$$

$$\vec{E}_{in} = \frac{c}{3\varepsilon_0}\left[-\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta}\right]$$

$\hat{z}$

$$\vec{E}_{in} = \frac{-c}{3\varepsilon_0}\hat{z}$$

$$\vec{P} = c\,\hat{z} \qquad \vec{P} = 0$$

$$\vec{D} = -\frac{c}{3}\hat{z} + c\,\hat{z} = \frac{2}{3}c\,\hat{z}$$

$$\vec{D} = \varepsilon_0 \vec{E}$$

$\vec{\nabla} \cdot \vec{D} =$

$\rho_b = -3c \quad \sigma_b = cr$

$\vec{E}_{in} \, , \vec{E}_{out}$

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

$\Phi_E = E(4\pi r^2)$

$Q_{enc} = \frac{1}{\varepsilon_0}(-3c)\cancel{4\pi r^2}\,\frac{4}{3}\pi r^3$

$= \frac{-c}{\varepsilon_0} \cdot 4\pi r^3$

$\vec{E}_{in} = \frac{-c}{\varepsilon_0} r \hat{r}$

$\underline{\text{out}}$ $Q_{enc} = (-3c)\cdot\frac{4}{3}\pi a^3$

$+ ca(4\pi a^2)$

$= c4\pi(0)$

$\Rightarrow \vec{E}_{out} = \vec{0}$ $D = \varepsilon E + P$

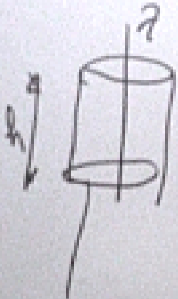
Out: $\vec{P} = \vec{0}$ $\Rightarrow$

$\therefore \vec{D}_{out} = 0$

in: $\vec{E} = -\frac{c}{\varepsilon_0} r\hat{r}$ $\vec{P} = c\vec{r} = cr\hat{r}$

$\vec{D} = -cr\hat{r} + cr\hat{r} = \vec{0}$

$\frac{C\cdot m}{m^3} = \frac{C}{m^2}$ $\oint\!\!\oint \vec{D}\cdot d\vec{A} = Q_{f_{enc}}$



In

$$\oiint \vec{D}\cdot d\vec{A} = Q_{f_{enc}}$$

$$D(2\pi s h) = \lambda h$$

$$\vec{D} = \frac{\lambda}{2\pi s}\hat{s}$$

P?

$\cancel{\epsilon}$ & $\cancel{R}$

out

$$\oiint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$

P4:15
wed

$$\vec{E}_{out} = \frac{\lambda}{2\pi\epsilon_0 s}\hat{s}$$