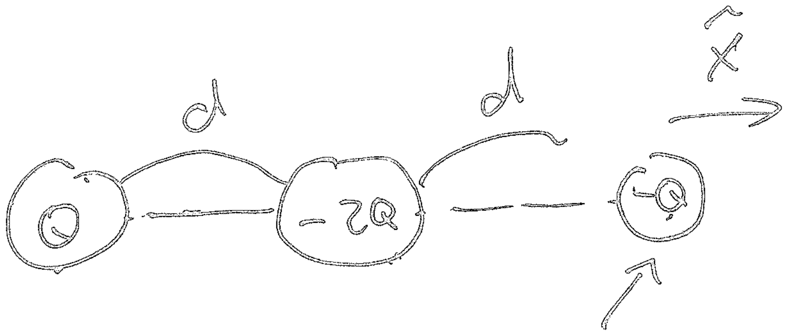
# 1




FIND FORCE ON -Q

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$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}\hat{r}$$

$$\vec{F}_{TOTAL} = \frac{1}{4\pi\varepsilon_0}\frac{-Q^2}{4d^2}\hat{x} + \frac{1}{4\pi\varepsilon_0}\frac{2Q^2}{d^2}\hat{x}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{d^2}\left(2 - \frac{1}{4}\right)\hat{x}$$

$$= \frac{7}{16\pi\varepsilon_0}\frac{Q^2}{d^2}\hat{x}$$

#2 FIND THE TOTAL CHARGE ON A SPHERE WITH RADIUS $a$ IF $\rho(r) = Dr^2$ ($C/m^3$).

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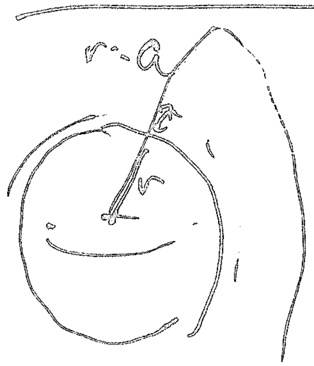


$$dv = 4\pi r^2 dr$$

$$\int dQ = Q$$

$$dQ = dv \cdot \rho$$

$$dQ = \rho\, 4\pi r^2 dr$$

$$Q = \int_0^a \rho\, 4\pi r^2 dr$$

$$= \int_0^a D r^2\, 4\pi r^2 dr$$

$$= 4\pi D \frac{r^5}{5}\Big]_0^a = \frac{4\pi D a^5}{5}$$

#3

FOR THE SAME SPHERE WITH $\rho = Dr^2 \, (C/m^3)$

AND RADIUS $a$ ! FIND ELECTRIC FIELD

EVERY WHERE ( $dV = 4\pi r^2 dr$ )

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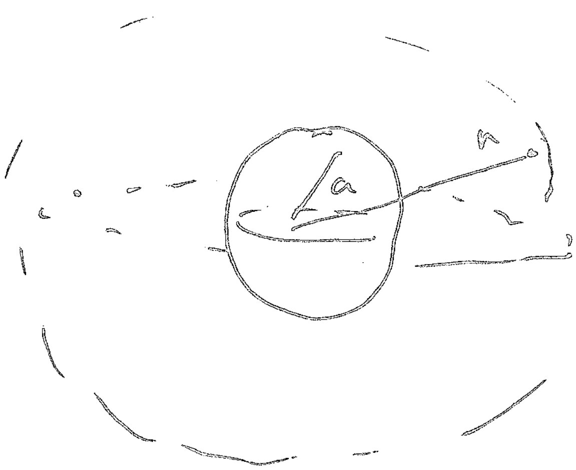



$\underline{r > a}$

$$Q_{ENC} = \frac{4\pi D a^5}{5}$$

$$\Phi = \frac{Q_{ENC}}{\varepsilon_0} = \frac{4\pi D a^5}{5\varepsilon_0}$$

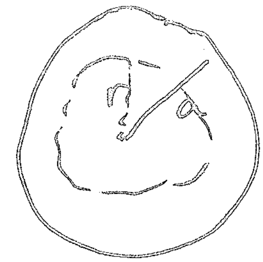
$$\Phi = \underline{E} \cdot \underline{A} = E \cdot 4\pi r^2$$

$$E \cdot 4\pi r^2 = \frac{4\pi D a^5}{5\varepsilon_0}$$

$$E = \frac{D a^5}{5\varepsilon_0 r^2}$$

$$\vec{E} = \frac{D a^5}{5\varepsilon_0 r^2} \hat{r}$$

$r < a$




$$Q_{enc} = \frac{4\pi D r^5}{5}$$

$$\Phi = \frac{Q_{enc}}{\varepsilon_0} = \frac{4\pi D r^5}{5\varepsilon_0}$$

$$\Phi = E \cdot A = E \cdot 4\pi r^2 = \frac{4\pi D r^5}{5\varepsilon_0}$$

$$E = \frac{D r^3}{5\varepsilon_0}$$

$$\vec{E} = \frac{D r^3}{5\varepsilon_0}\hat{r}$$

#4

FOR THE SAME SPHERE CALCULATE VOLTAGE FOR ~~r < a~~ ~~AN~~ r > a AND r < a .

$r > a$ : $\vec{E} = \dfrac{Da^5}{5\varepsilon_0 r^2}\hat{r}$

$r < a$ : $\vec{E} = \dfrac{Dr^3}{5\varepsilon_0}\hat{r}$

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$r > a$

$$E_r = -\frac{\partial V}{\partial r} = \frac{Da^5}{5\varepsilon_0 r^2}$$

$$V = -\int \frac{Da^5}{5\varepsilon_0 r^2}\,dr$$

$$V(r) = \frac{Da^5}{5\varepsilon_0 r} + C$$

$r \to \infty$ $\quad V(\infty) = 0$

$\therefore \; C = 0$

$$V(r) = \frac{Da^5}{5\varepsilon_0 r}$$

$$\left( r \to a \quad V_C \Rightarrow \frac{Da^4}{5\varepsilon_0} \right)$$

$r < a$

$$\bar{E} = \frac{Dr^3}{5\varepsilon_0} = -\frac{\partial V}{\partial r}$$

$$V = -\int \frac{Dr^3}{5\varepsilon_0} dr$$

$$V(r) = -\frac{Dr^4}{20\varepsilon_0} + C$$

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

$V(a)_{inside} = V(a)_{outside}$

$$V(a)_{inside} = -\frac{Da^4}{20\varepsilon_0} + C = \frac{Da^4}{5\varepsilon_0}$$ ($V(a)_{outside}$)

$$C = \frac{Da^4}{5\varepsilon_0} + \frac{Da^4}{20\varepsilon_0}$$

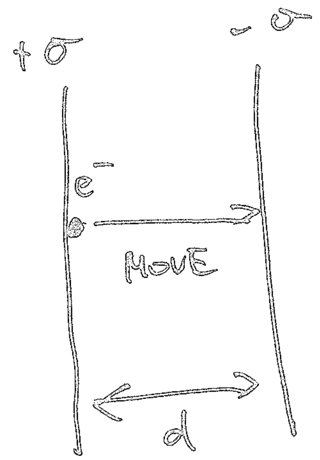
$$C = \frac{Da^4}{4\varepsilon_0}$$

$$\boxed{V(r) = \frac{Da^4}{4\varepsilon_0} - \frac{Dr^4}{20\varepsilon_0}}$$

#5 CALCULATE WORK REQUIRED TO MOVE AN ELECTRON FROM ONE PLATE (INFINITE PLATE) TO THE OTHER

IF

YOU NEED TO MOVE LIKE THIS




$E = \frac{\sigma}{\varepsilon_0}$

$$\text{WORK} = +\frac{e\sigma}{\varepsilon_0}d$$