SEP 6 2010

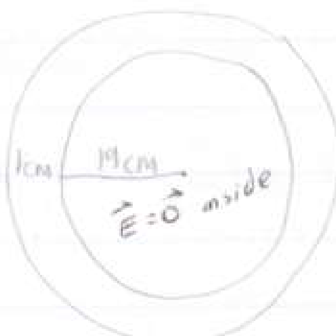
A solid sphere of radius 20cm has a net charge 6×10^{-4} C. The sphere is a conductor

Which has greater net charge?

A) The outermost 1cm-thick shell

B) the inner, 19 cm radius sphere

Flux for 19cm sphere is 0

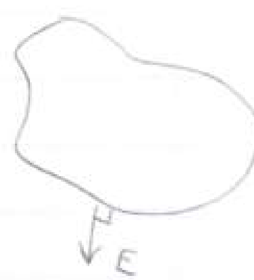


★ All the charge on a conductor is at the surface

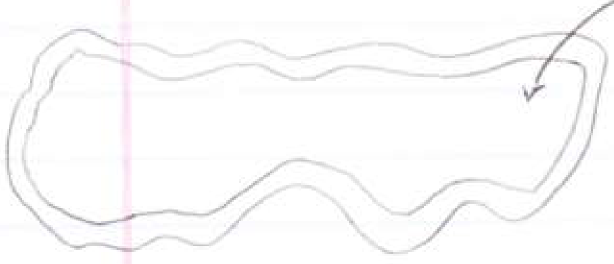
$$\frac{Q_{enclose}}{\varepsilon_0} = \Phi_E = \oint \vec{E} \cdot d\vec{A} = 0$$

Last time: $\boxed{\vec{E} = \vec{0}}$ inside

$\vec{E} \perp$ surface at the surface



Now apply Gauss' law



inside $\vec{E} = \vec{0}$.

so the electric flux is 0,

so $0 = \frac{Q_{enclose}}{\varepsilon_0}$ so $Q_{enclose} = 0$

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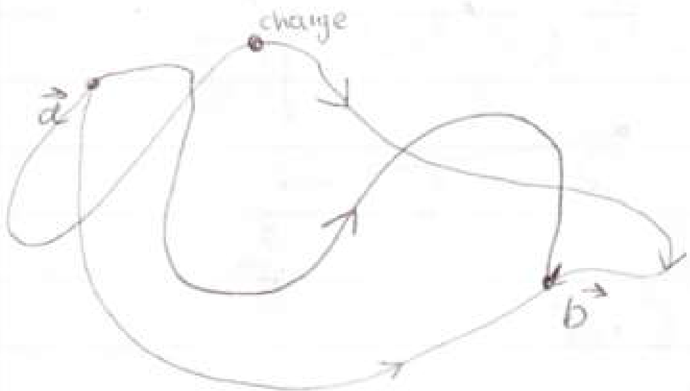
$\vec{F} = \frac{k Q_1 Q_2}{r^2}$ { THIS FORCE IS CONSERVATIVE MEANING WORK IS PATH-INDEPENDENT



FRICTION = NONCONSER FORCE

$$W = \int_{path} \vec{F} \cdot \vec{dl}$$ only depends on $\vec{a}$ & $\vec{b}$

* FOR CONSERVATIVE FORCES ONLY

$$\Delta U = -W$$

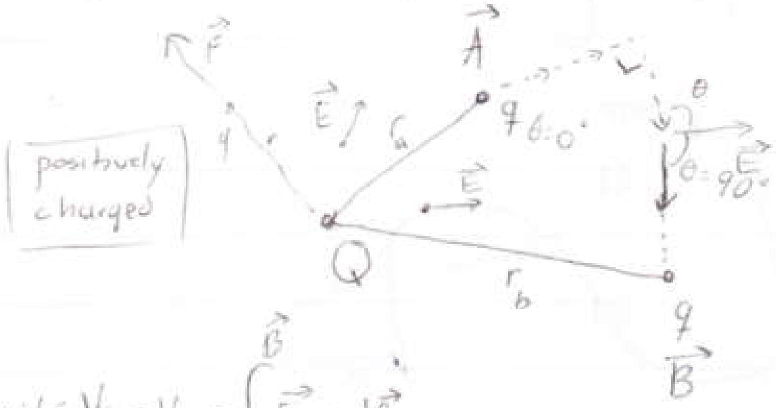
$$U_b - U_a = -\int_a^b F \cdot \vec{dl}$$

(voltage) $$V_b - V_a = -\frac{1}{q}\int_a^b \vec{F} \cdot \vec{dl} = -\int_a^b \vec{E}\, \vec{dl}$$ (electric field)

$F = \frac{k Q_1 Q_2}{r^2} \hat{r}$

Ex

Voltage due to a point charge Q



$$\Delta V = V_b - V_a = -\int_{\vec{A}}^{\vec{B}} \vec{E} \cdot d\vec{l}$$

$$\Downarrow \quad -\int_{\vec{A}}^{\vec{B}} |\vec{E}||d\vec{l}| \cos\theta$$

$$-\int_{r_a}^{r_b} \frac{k|Q|}{r^2} dr \cos\theta$$

$$F = qE = \frac{k|q Q|}{r^2} \Rightarrow E = \frac{k|Q|}{r^2}$$

$$-\int_{r_a}^{r_b} \frac{kQ}{r^2} = \begin{cases} -\int_{r_a}^{r_b} \frac{k|Q|}{r^2} dr \, (+1) & \text{if } Q > 0 \\ -\int_{r_a}^{r_b} \frac{k|Q|}{r^2} dr \, (-1) & \text{if } Q < 0 \end{cases}$$

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$$V_b - V_a = -\int_{r_a}^{r_b} kQ r^{-2}\, dr = -kQ\left(\frac{r^{-2+1}}{(-2+1)}\right)\Bigg|_{r_a}^{r_b}$$

$$= kQ r^{-1}\Big|_{r_a}^{r_b} = kQ r_b^{-1} - kQ r_a^{-1} = \frac{kQ}{r_b} - \frac{kQ}{r_a}$$

A COMMON CONVENTION IS TO DECLARE

$V = 0$ "at infinity"

V at $r = r_a$ is $V_a - V_b = \int_{\infty}^{r_a} \frac{kQ}{r^2}\, dr = \frac{kQ}{r}\Big|_{\infty}^{r_a}$

$$= \frac{kQ}{r_a} - \text{"}\frac{kQ}{\infty}\text{"}$$

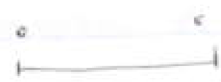
$$= \boxed{\frac{kQ}{r_a}}$$

EX

How much energy does it take to bring two electrons from approx ∞ far away to $3.0 \times 10^{-}$ m apart?

$$Q = -e$$

$$q = -e$$



$r = 3.0$ mm

$\cancel{\Delta U} =$

$$\Delta U = q\Delta V = q(V_r - V_\infty) = q \cdot \frac{kQ}{r} = (-e) \cdot \frac{k(-e)}{r} = \frac{ke^2}{r}$$

$$7.6 \times 10^{-20} \text{ J}$$

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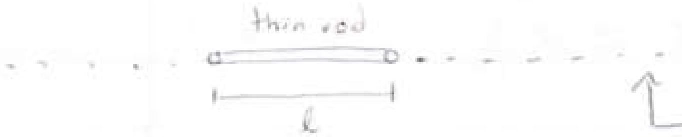
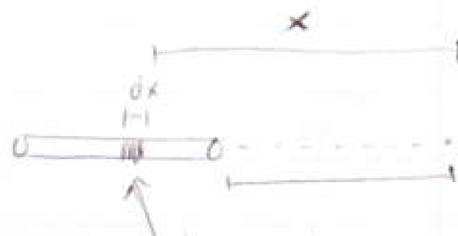
$$V = \frac{kQ_1}{r_1} + \frac{kQ_2}{r_2}$$



Here $V = ?$

uniform distribution of charge with net charge Q.

$$\lambda = \frac{\text{charge}}{\text{length}} = \frac{Q}{\ell}$$



charge $dQ = \lambda d\ell = \frac{Q}{\ell} dx$

$$dV = \frac{k\,dQ}{x}$$

$$V = \int_{x=r}^{x=\ell+r} \frac{k\,dQ}{x} = \int_{r}^{\ell+r} \frac{kQ}{\ell x}\,dx$$

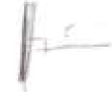
$$\frac{kQ}{\ell}\int_{r}^{\ell+r} \frac{dx}{x} = \frac{kQ}{\ell}\ln|x|$$

$$= \frac{kQ}{\ell}\left[\ln(\ell+r) - \ln(r)\right]$$

$$= \boxed{\frac{kQ}{\ell}\ln\left(\frac{\ell+r}{r}\right)}$$

infinite plane $E = \frac{\sigma}{2\varepsilon_0}$ $V = \frac{-\sigma r}{2\varepsilon_0}$

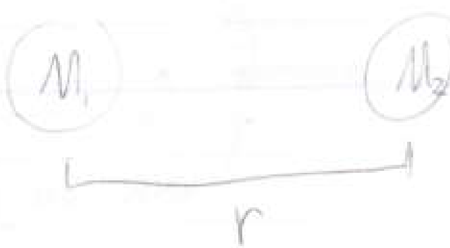
infinite thin rod $E = \frac{2k\lambda}{r}$ $V = -2k\lambda \ln r$



point charge $\vec{E} = \frac{kQ}{r^2}$ $V = \frac{kQ}{r}$

dipole $E \approx \propto \frac{1}{r^3}$ $V \approx \propto \frac{1}{r^2}$

" $\propto$ " means " is proportional to "



$V = -\frac{G m_1 m_2}{r}$

$F_G = \frac{-G m_1 m_2 \hat{r}}{r^2}$

$V = \frac{kQ}{r}$

$\frac{dV}{dr} = \frac{-kQ}{r^2}$

$|\vec{E}| = \left|-\frac{dV}{dr}\right| = \left|\frac{kQ}{r^2}\right|$

radial component of $\vec{E}$

(3,4,5) q radial direction (outward)

(0,0,0) Q

x-component

$E_x = ?$