Feb 4

Find your new groups.

Get Whiteboards, racquetball and ruler.

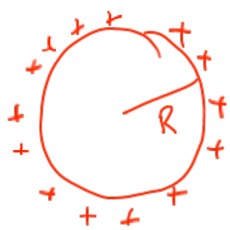
Ponderable: Fields due to two types of spheres

Plot magnitude of $\vec{E}$ vs. r.

$r < R$

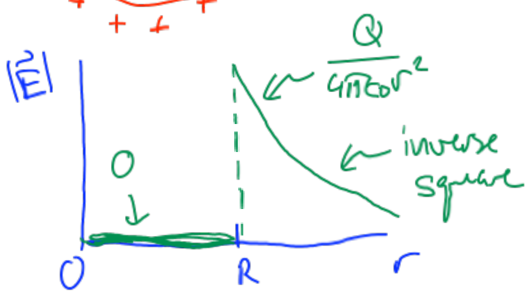
$r > R$

Spherical Shell



Uniformly Charged

$+Q$

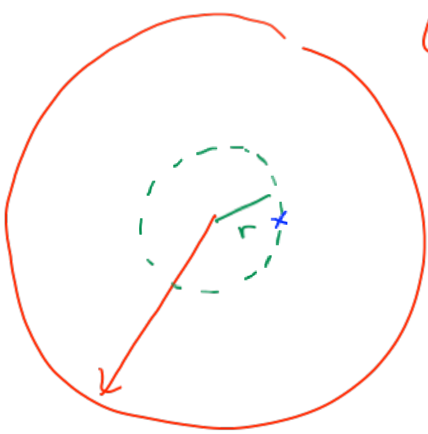


Spherical Ball

Uniformly charged

Throughout interior

$+Q$



Q total charge

$$\rho = \frac{Q}{\text{Vol}} = \frac{Q}{\frac{4}{3}\pi R^3}$$

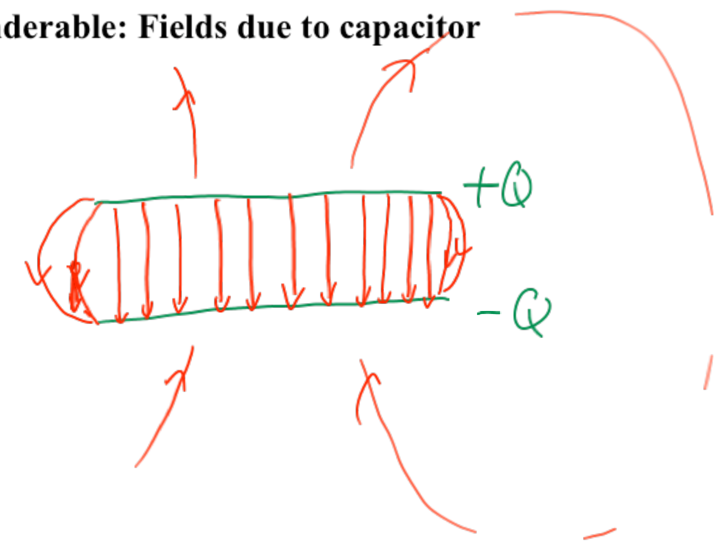
$$q_{inside} = \rho\,\text{volume} = \frac{Q}{\cancel{\frac{4}{3}\pi} R^3}\,\cancel{\frac{4}{3}\pi}\, r^3$$

$$= \frac{Q\,r^3}{R^3}$$

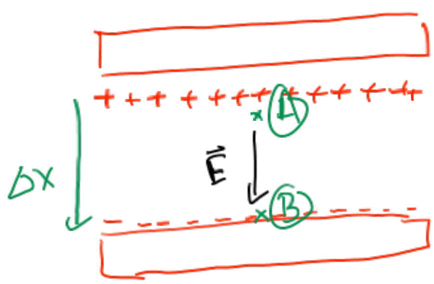
$$E = \frac{1}{4\pi\epsilon_0}\,\frac{q_{inside}}{r^2}$$

$$= \frac{1}{4\pi\epsilon_0}\,\frac{Q\,\cancel{r^3}}{R^3}\,\frac{1}{\cancel{r^2}} = \frac{1}{4\pi\epsilon_0}\,\frac{Q\,r}{R^3}$$

Ponderable: Fields due to capacitor



Ponderable: Electric energy



Particle ^charge q released at position A from rest.

What is the speed when reaches position B a distance Δx away?

$\Delta E = W_{ext}$

System is particle

$W = \vec{F} \cdot \Delta\vec{x} = q\,\vec{E} \cdot \Delta\vec{x} = qE\Delta x$

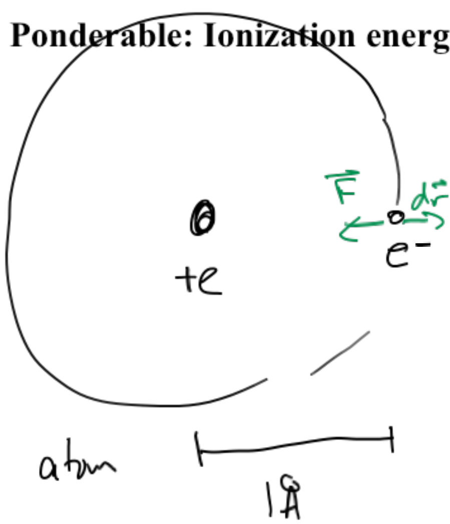
$\Delta E = \Delta K = W$

$K_i = 0$

$K_f = \frac{1}{2} m v_f^2$

$K_f = qE\Delta x \longrightarrow \frac{1}{2} m v_f^2 = qE\Delta x \Rightarrow v_f = \sqrt{\frac{2qE\Delta x}{m}}$

Ponderable: Ionization energy



move e^- far away from atom

How much energy does that take?

$W = ?$

$$\Delta W = \vec{F} \cdot d\vec{r} = F\,dr \cos 180^\circ = -F\,dr$$

$$W = -\int_{1Å}^{\infty} F\,dr = -\int_{1Å}^{\infty} \frac{1}{4\pi\varepsilon_0} \frac{(e)(-e)}{r^2}\,dr$$

$$= \frac{e^2}{4\pi\varepsilon_0} \int_{1Å}^{\infty} \frac{dr}{r^2} = \frac{e^2}{4\pi\varepsilon_0}\left(-\frac{1}{r}\right)\Big|_{1Å}^{\infty} = \frac{e^2}{4\pi\varepsilon_0 (1Å)} = 2.3\times10^{-18}\,J$$

$$= 14.4\,eV$$

Tangible: Potential energy

racquet ball has charge $5\mu C$

bring 2 from ∞ to opposite edges of table

$$\Delta E = W_{ext} = \Delta U$$

Calculate change in potential energy of system.

$$\Delta U = -W_i$$

$$W_{ext} \; \cancel{W_i} = \int_{\infty}^{d} \vec{F}\cdot d\vec{r} = -\int_{\infty}^{d} F\,dr$$

$$= \int_{d}^{\infty} F\,dr$$

$$= \frac{q_1 q_2}{4\pi\epsilon_0}\int_{d}^{\infty}\frac{dr}{r^2} = \boxed{\frac{q_1 q_2}{4\pi\epsilon_0 d} = \Delta U}$$

Discussion: Table of terms

Force $\vec{F}_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$ $\xrightarrow{\vec{F}_{12} = q_1 \vec{E}_2}$ Field $\vec{E}_2 = \frac{1}{4\pi\epsilon_0}\frac{q_2}{r^2}\hat{r}$

$\Big\downarrow\ U = -\int \vec{F}\cdot d\vec{l}$ $\qquad$ $\Big\downarrow\ V = -\int \vec{E}\cdot d\vec{l}$

Energy $U_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$ $\xrightarrow{U_{12} = q_1 V_2}$ electric potential $V_2 = \frac{1}{4\pi\epsilon_0}\frac{q_2}{r}$

$\boxed{\text{not in general } V = E \times r}$

Energy per charge

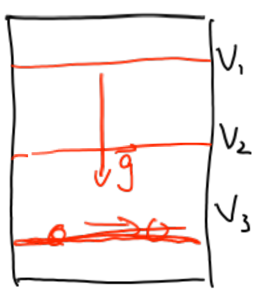
Tangible: Potential (gravitational and electrical)

↑ Gravity Sucks

↑ Opposites Attract

Potential (Energy / charge)

Gravitational Potential



How much work is done by field to move ball from V_1 to V_3?

$W_{field} = \vec{F} \cdot \Delta\vec{r} = -m\Delta V = m(V_1 - V_3)$

What about moving from one place on V_3 to another?

$W_{field} = 0$

Equipotential line, always $\perp$ to field

Moving along equipotential lines takes no work.

Discussion: Sign of change of potential

$$\Delta V = -\int \vec{E}\cdot d\vec{l}$$

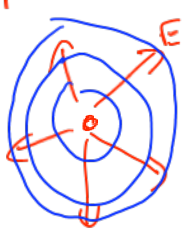
$\vec{E} \parallel d\vec{l}$ $\quad \Delta V < 0$

$\vec{E} \overset{\text{anti}}{\parallel} d\vec{l}$ $\quad \Delta V > 0$

$\vec{E} \perp d\vec{l}$ $\quad \Delta V = 0$

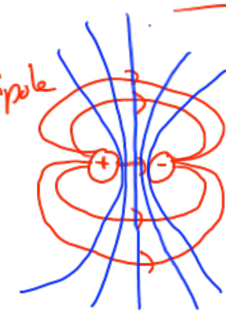
Equipotential lines

point charge?



Sheet?

dipole



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