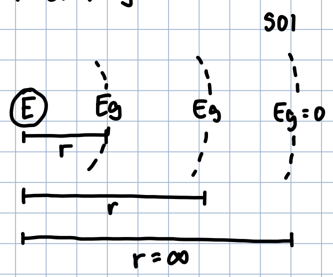
Recall Gravity



$W = \Delta E_g = F_g \Delta r$

Derivative → $\frac{\Delta E_g}{\Delta r} = \frac{GmM}{r^2}$ $\quad GMmr^{-2}$

Integrate → $E_g = -GMmr^{-1}$

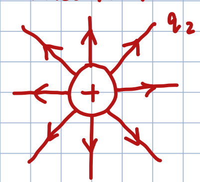
$= \frac{-GMm}{r}$

E is scalar

Electrical Potential Energy

Developed for positive field with positive point charge

Fixed Field



point charge q_1

+

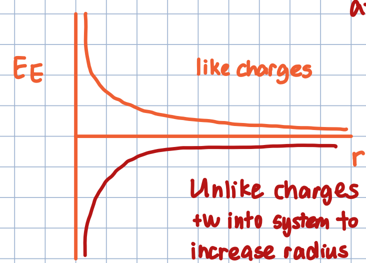
upon release, repulse outwards so $-W$

E_E $\quad E_E$ $\quad E_E = 0$, $r = \infty$

$\Delta E_E = -W = -F_E \Delta r$

$\frac{\Delta E_E}{\Delta r} = -\frac{kq_1q_2}{r^2}$

$E_E = \frac{kq_1q_2}{r}$ ← Electrical Potential Energy at point r



E_E in terms of field strength:

$\Delta E = -F_E \Delta r$

$\Delta E = -q_1\vec{E}\Delta r$ ← Need uniform electric field

Electrical Potential (V)

The value, in volts, of potential energy per unit positive charge for a given point in an electric field

$V = \frac{E}{q}$ ← charge of point charge

$1V = 1\frac{J}{C}$

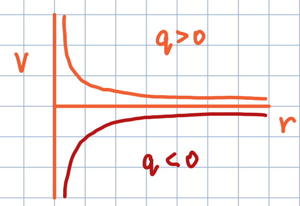
Recall

$E_E = \frac{kq_1q_2}{r}$

$\cancel{q_1} V = \frac{k\cancel{q_1}q_2}{r}$

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

Consider :



*: $V = 0$ when $r = \infty$

*: $V_i = 0 \;\therefore\; \Delta V = V_f$

Electrical Potential Difference (delta V)

The amount of work required per unit charge to move a positive charge from one point to another in the presence of an electric field

$\Delta V = \frac{\Delta E}{q}$ ← charge of point charge q_1

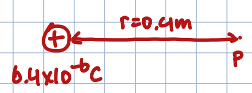
$\Delta E = -q\vec{E}\Delta\vec{r}$

$\cancel{q}\Delta V = -\cancel{q}\vec{E}\Delta\vec{r}$

$\Delta V = -\vec{E}\Delta\vec{r}$

Example 1:

Calculate the electric potential a distance of 0.4m from a spherical point charge of +6.4x10^-6C



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

$$V = \frac{9\times10^{9}(6.4\times10^{-6})}{0.4}$$

$$V = 1.44\times10^{5}\,V$$

Example 2:

How much work must be done to increase the potential difference of a charge of 3x10^-7C by 120V?

ΔV $\therefore \Delta E_E$ +

$q = 3\times10^{-7}C$

$\Delta V = 120V$

$$W = \Delta E = q\Delta V$$

$$= 3\times10^{-7}(120)$$

$$= 3.6\times10^{-5}\,J$$

Example 3:

In a uniform electric field, the potential difference between two points 12 cm apart is 1.5x10^2V.

Calculate the magnitude of the electric field strength

$\Delta r = 0.12m$

$\Delta V = 1.5\times10^{2}$

$$\Delta V = -\vec{\varepsilon}\Delta\vec{r}$$

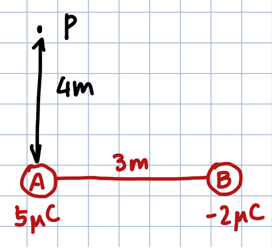
$$|\vec{\varepsilon}| = \frac{\Delta V}{\Delta\vec{r}} = \frac{1.5\times10^{2}}{0.12} = 1.25\times10^{-3}\,\frac{N}{C}$$

Example 4:

A point charge with a charge of 5uC is 3m west of a second point charge with a charge of -2uC

a) Calculate the total electric potential energy of the two charges

b) Determine the electric potential at a point 4m north of the positive charge



a)

$$E_E = \frac{kq_1q_2}{r} = \frac{9\times10^9 \cdot 5\times10^{-6} \cdot -2\times10^{-6}}{3}$$

$$= -0.03\,J$$

b)

$$V_T = V_{AP} + V_{BP}$$

$$= \frac{kq_A}{r_{AP}} + \frac{kq_B}{r_{BP}}$$

$$= \frac{9\times10^9(5\times10^{-6})}{4} + \frac{9\times10^9(-2\times10^{-6})}{5}$$

$$= 11250 + (-3600)$$

$$= 7650V$$