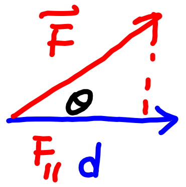
Electric potential :

Review : Work done by a force in moving a mass from initial position to a final position



∥ component of the force in the direction of displacement

$$W_{i\to f} = F_{\parallel} d$$

$$= F\cos\theta\, d$$

$\Delta K = K_f - K_i$ //

change in kinetic energy

for conservative force

$$= -(U_f - U_i)$$

negative change in potential energy

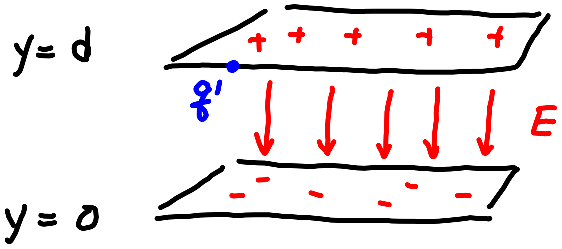
$$K_f - K_i = -(U_f - U_i)$$

$$= -U_f + U_i$$

$$K_f + U_f = K_i + U_i$$

conservation of total mechanical energy

1) Electric potential of a const electric field



uniformly charged plates

$\vec{E}$ constant

what is the work done by the electrical force on a charge q' in moving for $y=d$ to $y=0$?

$q' > 0$

$$W_{y=d\to y=0} = q'Ed = -(U_f - U_i)$$

pot. energy

$$= -U(0) + U(d)$$

$$= U(d) - U(0)$$

$$\Rightarrow U(y) = q'Ey$$

exactly like $U(y) = mgy$

just like $\vec{F} = q'\vec{E}$

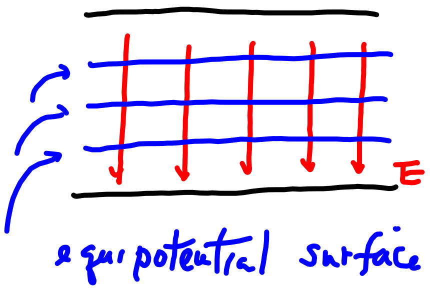
pot. energy $\rightarrow$ $U(y) = q'V(y)$ $\leftarrow$ electric potential

$$\cancel{q'}Ed = \cancel{q'}(V(d) - V(0))$$

$\leftarrow$ electric potential difference

$\uparrow$ voltage difference

The electric potential decreases in the direction of the electric field

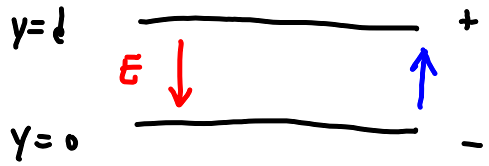


The lines of constant potential are Ey at any y value

Equipotential surface ⊥ to $\vec{E}$

Ex

$d = 4.5\,nm$



$F = (-e)E$

An electron is released at rest from the negative plate
what is its velocty when reaching the upper plate?

$$\underset{\frac{1}{2}m_e v^2}{K_f} - \underset{=0}{K_i} = U_i - U_f \qquad U = q'Ey$$

$$= (-e)\left[V_i - V_f\right]$$

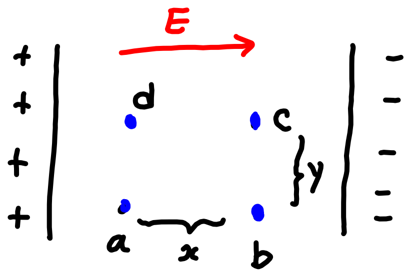
$$= (-e)(-9v)$$

$$\frac{1}{2}m_e v^2 = e\,9v$$

$$v = \sqrt{\frac{2e\,9v}{m_e}} = 1.78 \times 10^{16}\ m/s$$

the pot diff
is $9\,V$
$\shortparallel$
$V_f - V_i$

Constant E field



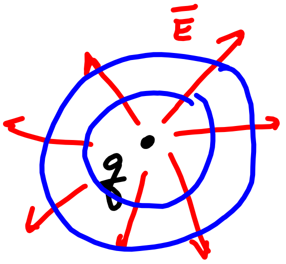
what is the work done by the electric force when q moves from a to b

A	B	C	D
qEy	0	qEx	$qE\sqrt{x^2+y^2}$

which of the following is true

A	B	C	D
$V_b > V_c$	$V_a > V_d$	$V_a > V_c$	$V_b > V_d$

Electric potential of a point charge



← equipotential surface ⊥ to $\vec{E}$

• q'

$$\boxed{V(r) = \frac{kq}{r}} \qquad k = \frac{1}{4\pi\epsilon_0}$$

The potential energy of charge q' in the presence of q's is

$$U(r) = q' V(r)$$

$$\vec{F} = q' \vec{E}$$

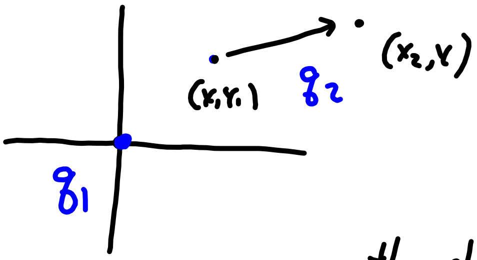
'' due to q

↑ due q

Ex Given q_1 at the origin

and q_2 moves from (x_1, y_1) to (x_2, y_2)

1) what is the change of the electric potential experience by q_2



$$V_1 = \frac{kq_1}{r_1} \qquad r_1 = \sqrt{x_1^2+y_1^2}$$

$$V_2 = \frac{kq_1}{r_2} \qquad r_2 = \sqrt{x_2^2+y_2^2}$$

the change in electric pot is

$$\Delta V = V_2 - V_1 = kq_1\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

2) what is the change in the pot energy of q_2

$$\Delta U = q_2 \Delta V$$

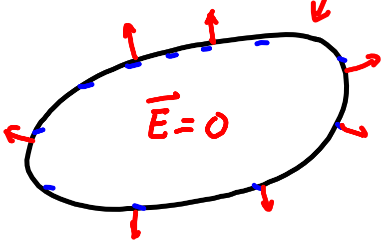
Conductors & Insulators:

metals

are materials in which charge particles (electrons) are free to move

no free moving charge particle

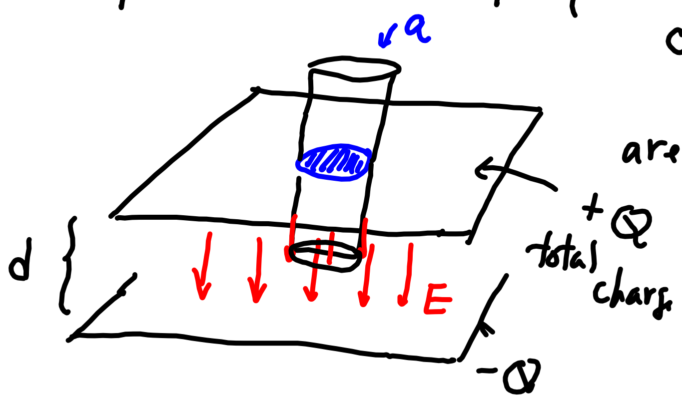
surface is an equipotential surface



metal objects are shinning.

Capacitors : the capacity to hold charge.

Use Gauss' theorem



$\sigma =$ surface charge density $= \frac{Q}{A}$

at the bottom

$$\cancel{a} E = 4\pi k\, q_{enclosed}$$
$$= 4\pi k\, a\, \sigma$$
$$= 4\pi k\, \cancel{a}\, \frac{Q}{A}$$

$$E = 4\pi k \frac{Q}{A}$$
$$= \cancel{4\pi} \frac{1}{\cancel{4\pi}\epsilon_0} \frac{Q}{A}$$

$$\boxed{E = \frac{Q}{\epsilon_0 A}}$$

The potential difference $= V_{Top} - V_{bot} = V = Ed$

$$V = Ed = \frac{Q}{\epsilon_0 A} d =$$

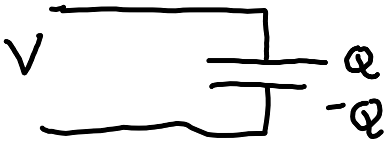
$$\Rightarrow \boxed{Q = \frac{\epsilon_0 A}{d} V} = C V$$

↑ Capacitance

✓ given a pot. diff V → induce separation of Q.

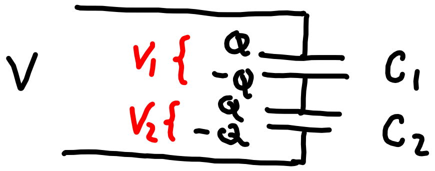
$$C = \frac{\epsilon_0 A}{d}$$

Capacitor → capacity to hold charges



$$Q = CV$$

Capacitors in series ↔ having the same charge

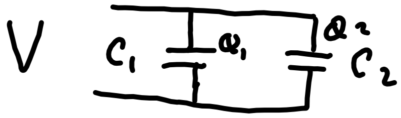


$$V = V_1 + V_2$$

$$\frac{Q}{C} = \frac{Q}{C_1} + \frac{Q}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Capacitors in parallel → same voltage difference .



$$Q = Q_1 + Q_2$$

$$= C_1 V + C_2 V$$

$$CV = (C_1 + C_2)V$$

$$C_{eq} = C_1 + C_2$$