Voltage

The electrostatic potential or voltage is a scalar field whose value is the potential energy per unit charge $V = \frac{U}{q}$

(i.e. the U that a unit charge would have at that point)

Units: 1 volt = $\frac{1 \text{ Joule}}{\text{Coulomb}}$ $\Rightarrow$ 1 Coulomb · volt = Joule

Recall $U_B = U_A - q\int_A^B \vec{E}\cdot d\vec{r}$

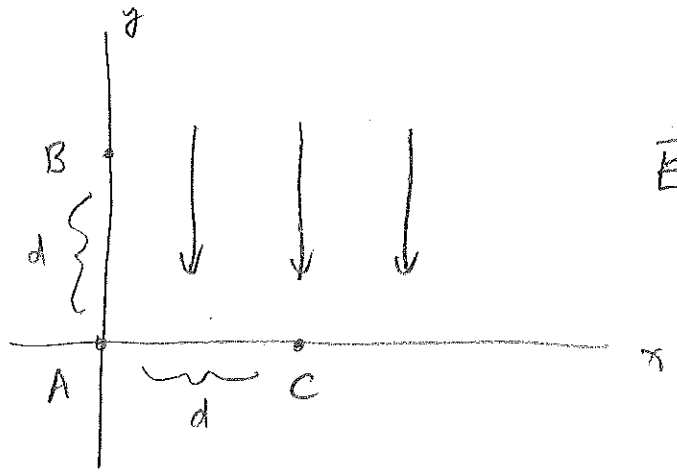
Therefore $V_B = V_A - \int_A^B \vec{E}\cdot d\vec{r}$

As w/ electrostatic potential energy, only differences in voltage are physically meaningful.

$\Rightarrow$ Choose an arbitrary point and set $V = 0$ there.

This point is called "ground"

Consider a uniform electric field



$\vec{E} = (0, -E, 0)$

E = magnitude of y field

What is V_B relative to V_A?

$$V_B - V_A = -\int_A^B \vec{E}\cdot d\vec{r} \overset{\text{choose path along } y\text{-axis}}{=} -\int_0^d E_y\, dy = -\int_0^d (-E)\, dy$$

$$= Ed > 0$$

$\Rightarrow V_B > V_A$

electric field points from higher to lower potential.

What is V_C relative to V_A?

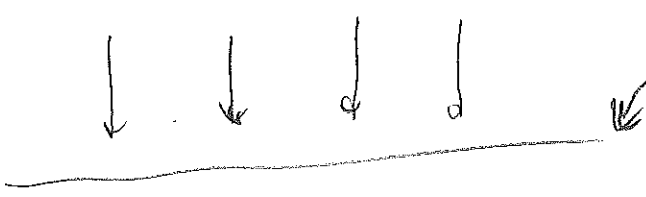
$$V_C - V_A = -\int_A^C \vec{E} \cdot d\vec{r} = -\int_A^C E_x \, dx = -\int 0 \cdot dx = 0$$

(path along x-axis)

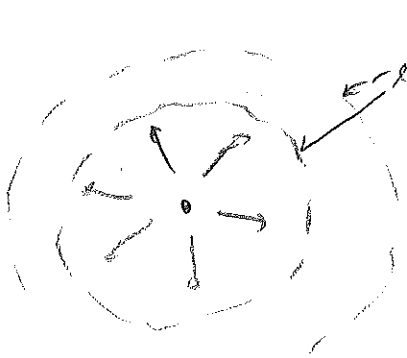
$$V_C = V_A$$

A & C are <u>equipotential points</u>

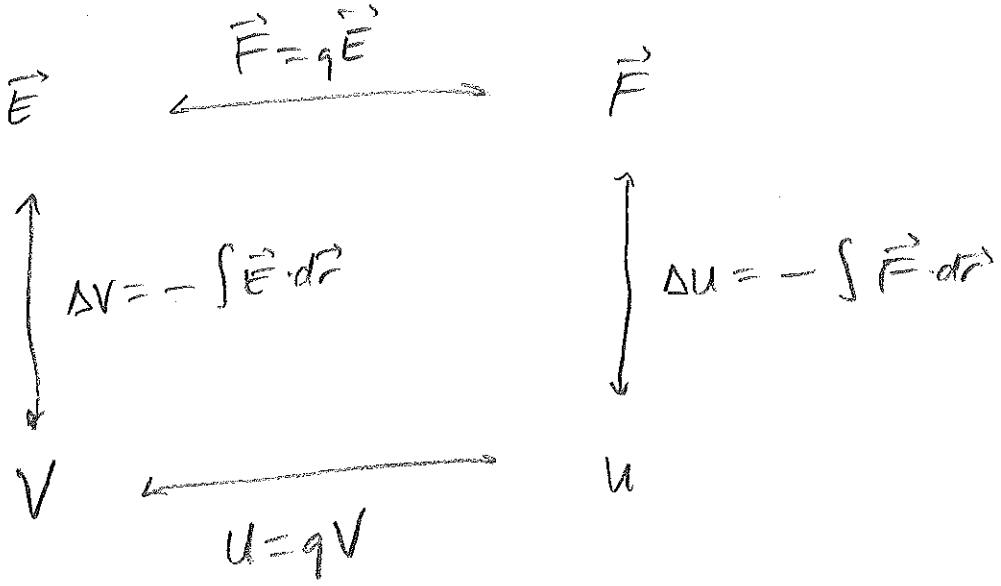
All points with same potential form an <u>equipotential surface</u>

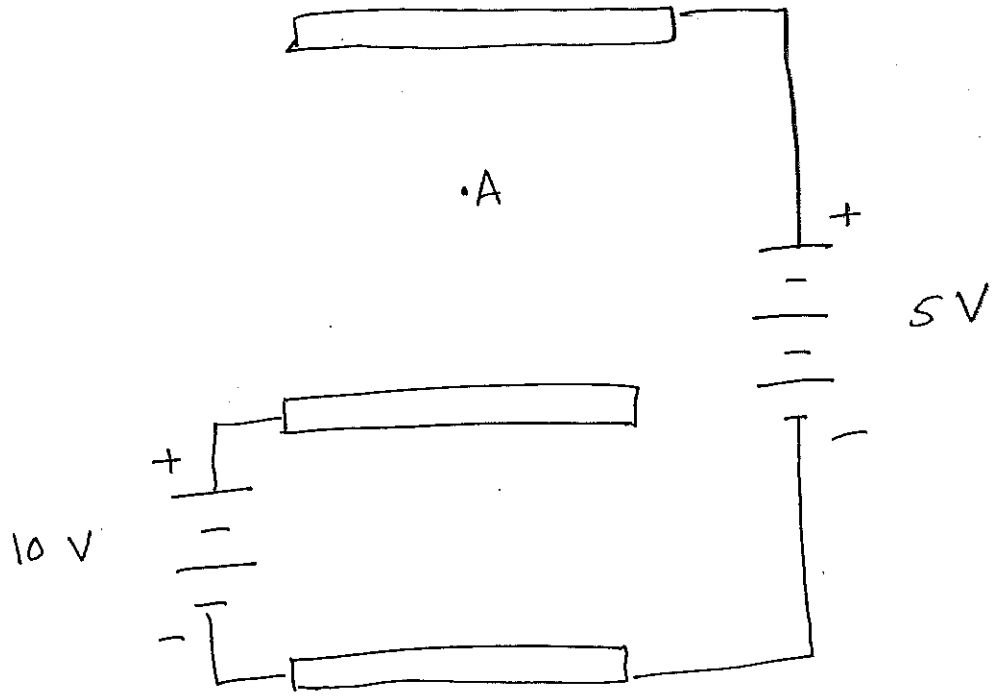


electric field is always perpendicular to an equipotential surface

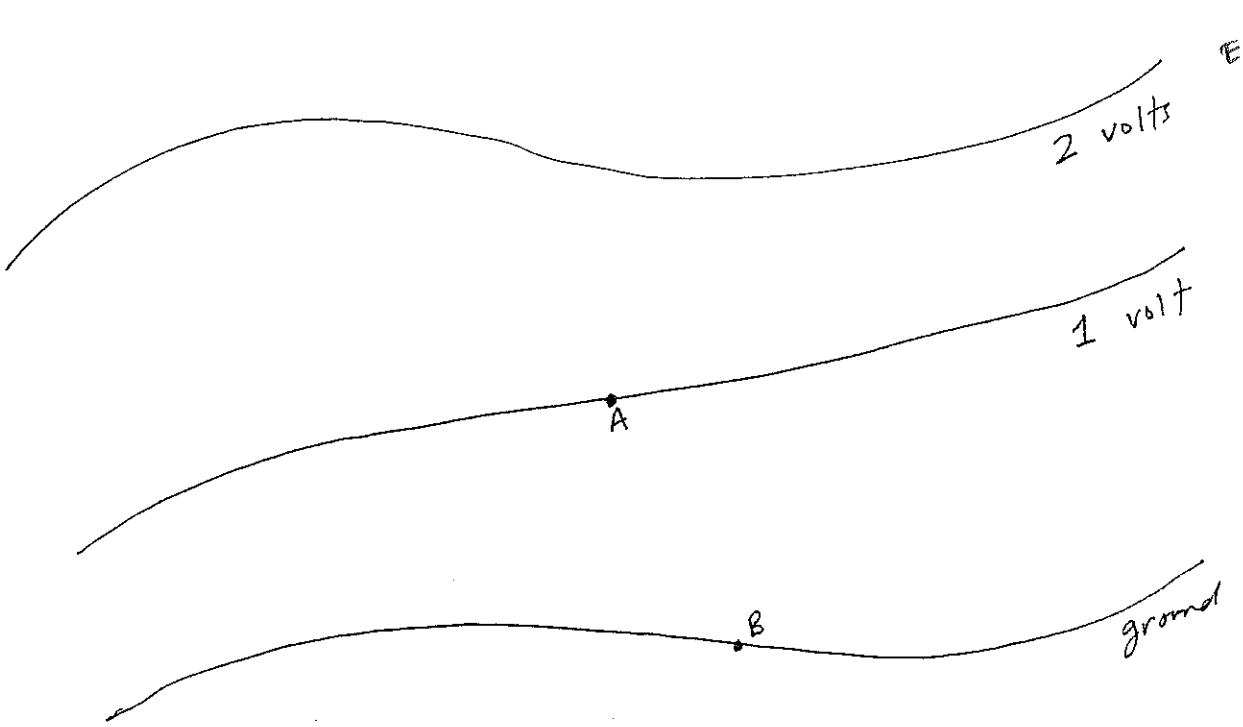


Summary


$\vec{F} = q\vec{E}$
$\vec{E}$
$\vec{F}$
$\Delta V = -\int \vec{E} \cdot d\vec{r}$
$\Delta U = -\int \vec{F} \cdot d\vec{r}$
V
U
$U = qV$



Which way does $\vec{E}$ point at A?



E6

DOES AN ELECTRON HAVE MORE ELECTROSTATIC POTENTIAL ENERGY AT "A" OR "B"?

WHAT IS THE DIFFERENCE IN POTENTIAL ENERGY (IN JOULES) BETWEEN THESE TWO POINTS?

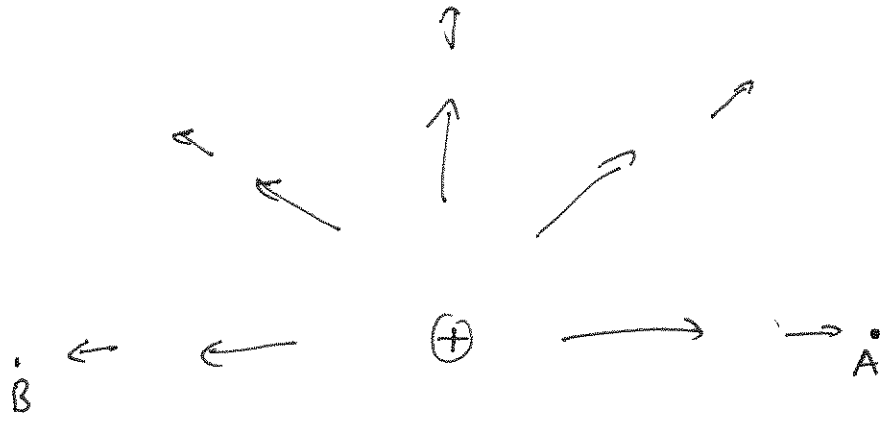
[use this to motivate definition of 1eV] ← need to talk about this...

$1eV = |e|(|V|) = (1.6\times10^{-19}C)V = 1.6\times10^{-19}J$

Ophrus

~~E&M~~

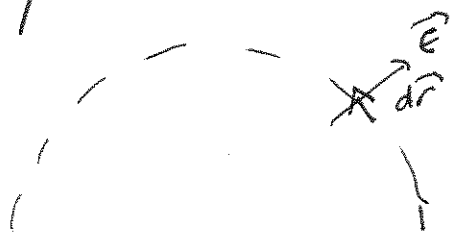
Positive point charge q



What is difference in potential between A and B (equidistant from the charge?)

$$V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{r}$$

Which path? → semi circular



$\vec{E} \cdot d\vec{r} = 0$

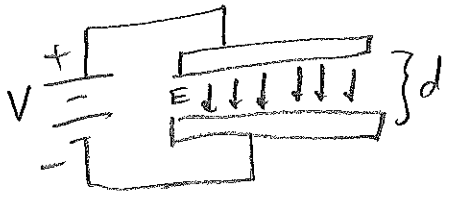
$V_B - V_A = 0$

A & B are equipotential points

~~sphere~~ is an equipotential surface

Parallel plates act as a <u>capacitor</u>, a device for storing charge

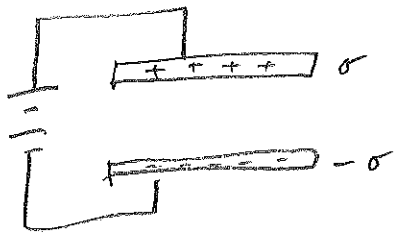
Consider a pair of plates area A separated by distance d connected to a battery voltage V



If the plates are close together, the battery creates an <u>approximately uniform</u> electric field E between the plates

$$V = Ed \quad \Rightarrow \quad E = \frac{V}{d}.$$

It does this by moving charge from one plate to the other



We learned that charged parallel plates create field $E = \frac{\sigma}{\epsilon_0}$

$$\Rightarrow \sigma = \epsilon_0 E = \frac{\epsilon_0 V}{d}$$

The amt of charge on one of the plates $q = \sigma A = \frac{\epsilon_0 A}{d} V$

ie the charge stored is proportional to the voltage.

The constant of proportionality is called the <u>capacitance</u> C.

$$q = CV$$

For parallel plates: $C = \frac{\epsilon_0 A}{d}$