Tues: Discussion / quiz

Supp Ex 34, 35, 36, 37, 39

Ch 21 Probs 27, 32

Weds Review

Friday Exam I Covers Ch 20, 21

See website for previous exams

2012 Class Ex I

2013 Class Ex II v1, v2

Equipotentials

Recall that an electric potential consists of one voltage value at each location in space. One way of representing this is via equipotentials, which are effectively contour lines of potential

An equipotential is a line along which the value of electric potential takes the same value.

Demo: PhET Fields + Charges

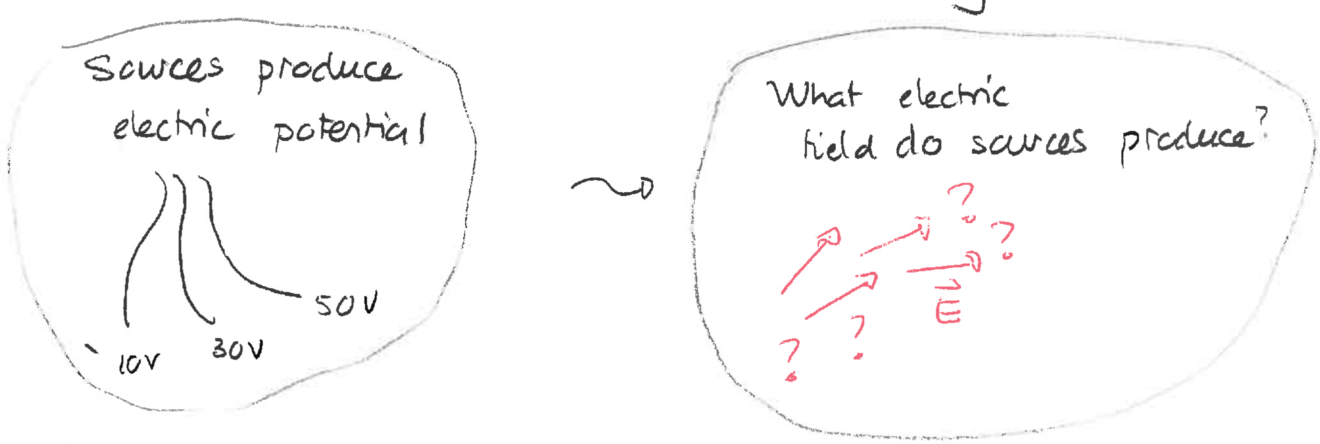
1) place charges
2) show color V
3) show various equipotentials
   ↳ check values box

Electric field and electric potential

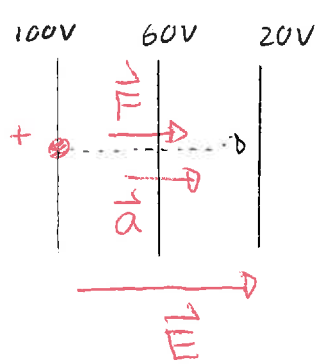
Electric potential is used to describe the potential energy of a probe in the vicinity of sources. It is then used to describe some aspects of how a probe might move.

On the other hand electric field is used to describe the forces acting on a probe. This can also be used to describe the motion of a probe.

The two descriptions must eventually describe motion in the same ways. This means that electric potential and electric field must be related. The question is how are they related.

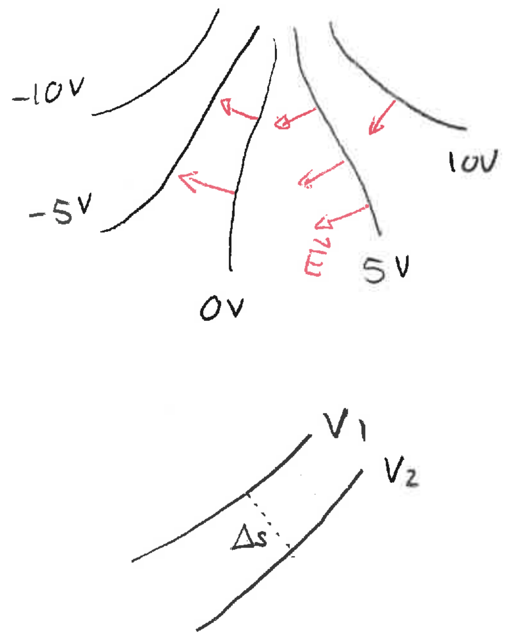


The exact relationship requires calculus. But we can elucidate some ideas by considering a positive probe charge in a potential. We know that when released, the particle will move in direction of decreasing potential. It's speed will increase. Thus acceleration will point as illustrated. This gives the electric force. But $\vec{F} = q\vec{E}$ and $q>0$ gives the indicated electric field direction



Calculus yields similar results for more complicated potentials and it gives the magnitude of the electric field

Equipotentials



Electric field

a) perpendicular to equipotentials in direction of decreasing potential

b) magnitude = rate of change of V with respect to distance

$$E = \left|\frac{\Delta V}{\Delta s}\right|$$

where ΔV is potential difference across Δs

<u>Demo:</u> Show fields with PhET demo.

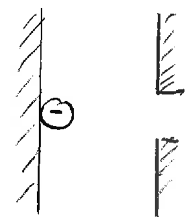
<u>Warm Up)</u> 21.5 E

<u>Quiz 1</u>

Note that this enables us to translate back and forth between fields and potentials.

<u>Quiz 2</u>

Example: A particle gun is used to accelerate electrons. It consists of two metal electrodes spaced 0.0050 m apart. The electron must be accelerated with an acceleration of $3.0\times10^{+17}\ m/s^2$ to the right



initially

a) Determine the electric field needed to do this.

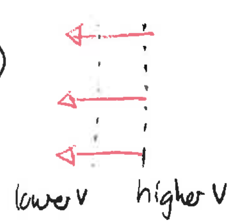
b) Determine the electric potential difference between the plates. Which is at a higher potential?

Answer: a) $\vec{F} = m\vec{a} \Rightarrow \vec{F}$ is right

$$F = ma$$
$$= 9.11\times10^{-31}\,kg \times 3.0\times10^{+17}\,m/s^2$$
$$\boxed{\vec{F} = 2.73\times10^{-13}\,N \quad \text{right}}$$

$\vec{F} = q\vec{E}$ and q is negative $\Rightarrow$ $\vec{E}$ is $\leftarrow$

$$F = |q|E \Rightarrow 2.73\times10^{-13}\,N = 1.6\times10^{-19}\,C\ E$$
$$\Rightarrow E = 1.7\times10^{6}\,N/C$$
$$\Rightarrow \boxed{\vec{E} = 1.7\times10^{6}\,N/C \text{ to } \leftarrow}$$

b) 

so right is higher

$$E = \left|\frac{\Delta V}{\Delta s}\right| \Rightarrow 1.7\times10^{6}\,N/C = \frac{\Delta V}{0.0050\,m}$$

$$\Rightarrow \boxed{\Delta V = 850\,V}$$

Conductors in equilibrium

In a conductor in equilibrium $\vec{E} = 0$.

Then between any points in the conductor

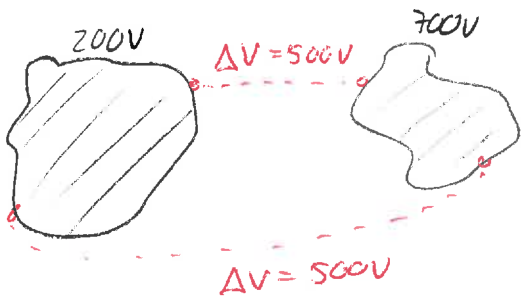
$$E = \frac{\Delta V}{\Delta s} \Rightarrow 0 = \frac{\Delta V}{\Delta s} \Rightarrow \Delta V = 0$$

Thus

Throughout a conductor in equilibrium V has the same value.

Warm Up2

So



Demo: Large capacitor - charge up + measure V on various locations