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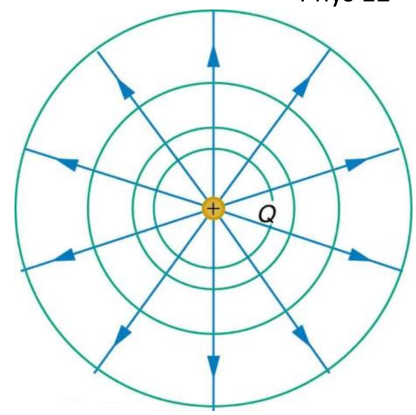
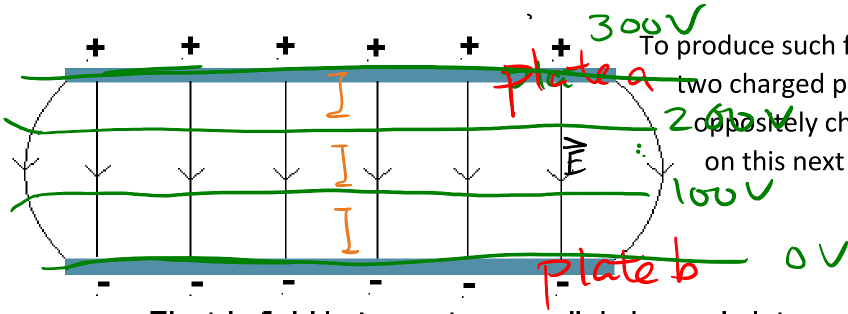
6.06 Uniform Electric Fields



Last lesson, we looked at equipotential lines around charges. Notice that these lines are not equidistant (equally distant) from one another for a charged particle.

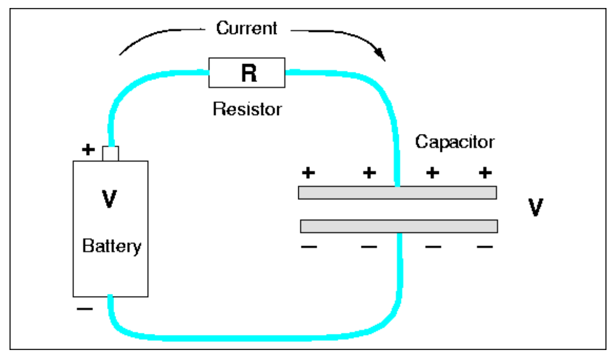
As a result, notice that the relative density of electric field lines also decreases as you move radially away from the charge. Since these electric field changes (magnitude and direction) depending on how far you're from the charge, we call this a **non-uniform field.**

A **uniform field** with constant field strength and direction looks like:



Electric field between two parallel charged plates

To produce such field, we need two charged parallel plates with opposite charges. These 2 oppositely charged parallel plates make up a **capacitor** (more on this next time!).



As the current flows through the circuit, the battery "pumps" the electrons from the positive plate towards the negative plate through the circuit. This causes the 2 plates to be oppositely charged.

Notice that the field lines bend at the ends of the plates.

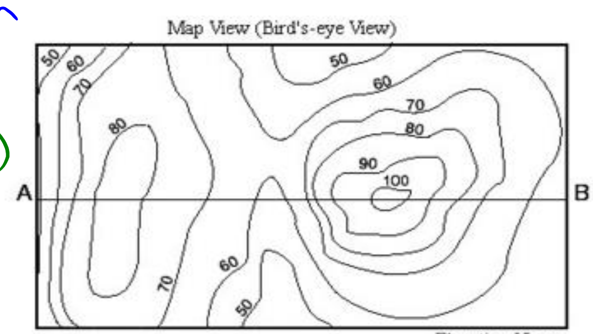
If a proton was placed at the top of the plate how would its potential and kinetic energy change over time? What would it do?

What would the equipotential lines look like between these 2 parallel plates? Let's draw them!

There's a relationship between potential difference and the electric field!

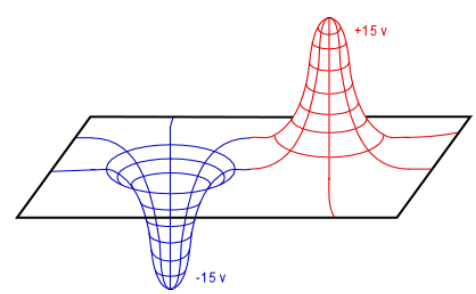
$\vec{E} = \frac{-\Delta V_{a\ to\ b}}{d}$	$V_{a\ to\ b}$ = potential difference between plate a and plate b (V) E = Electric field from _a to b_ (V/m) d = distance between a and b (m)

WHY? Analogy time! Remember these diagrams? ----->



Compare a uniform slope of a hill VS uniform electric field

Uniform slope of hill: 0m, 100m, 200m, 300m, 10m slope = 100m / 10m → 10m up / 1m right
Uniform electric field: 0V, 100V, 200V, 300V, 10m slope = 100V / 10m = 10 V / 1 m ⇒ E field



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★ ONLY FOR PARALLEL PLATES

What about mathematically?

We know that Work = Force x distance: $W = Fd$

Also, $F = Eq$

$\frac{W}{q} = \frac{Eqd}{q} \Rightarrow \frac{W}{q} = Ed$ ★ $V = \frac{W}{q}$

$\Rightarrow V = Ed$

Ex. 1: Calculate the electric field strength between two parallel plates that are 6.00×10^{-2} m apart. The potential of the top plate is 6.0 V and the bottom plate is – 6.0 V. (2.0×10^2 N/C or V/m)

Ex. 2: An electron is accelerated from rest through a potential difference of 3.00×10^4 V. What is the kinetic energy gained by the electron? (4.8×10^{-15} J)

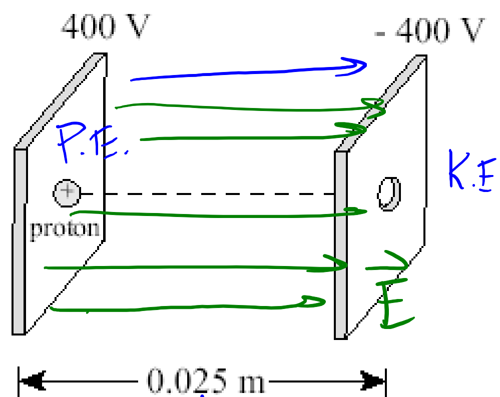
$q \times \text{Electric Potential} = \frac{\text{Potential Energy}}{q} \times q$

$P.E. = qV = 1.60\times10^{-19}\,C\,(3.00\times10^4\,V) = 4.8\times10^{-15}\,J$

$q = 1.60\times10^{-19}\,C$

$E = \frac{F}{q}$ $W = Vq$

Ex. 3: A proton, initially at rest, is released between 2 parallel plates as shown.



a) What is the magnitude and direction of the electric field? (32 000 N/C right)

$\Delta V = -800\,V$

$E = -\frac{\Delta V}{d} = -\frac{-800\,V}{0.025\,m} = 32\,000\,\frac{V}{m}$ right

b) What is the magnitude of the electrostatic force acting on the proton? (5.1×10^{-15} N)

$F = Eq$ $q = 1.60\times10^{-19}\,C$

$= 32000\,\frac{N}{C} \times 1.60\times10^{-19}\,C = 5.1\times10^{-15}\,N$

~~$F = \frac{kq_1q_2}{r^2}$~~

c) What is the velocity of the proton when it exits the – 400. V plate? (390 000 m/s)

Potential Energy: $W = Vq = 800\,V\,(1.60\times10^{-19}\,C)$ $K.E. = \frac{1}{2}mv^2$

$= 1.28\times10^{-16}\,J = K.E. = \frac{1}{2}mv^2$

$1.28\times10^{-16}\,J = \frac{1}{2}(1.67\times10^{-27}\,kg)\,v^2$

$v = 390\,000\,m/s$ right $m_p = 1.67\times10^{-27}\,kg$

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