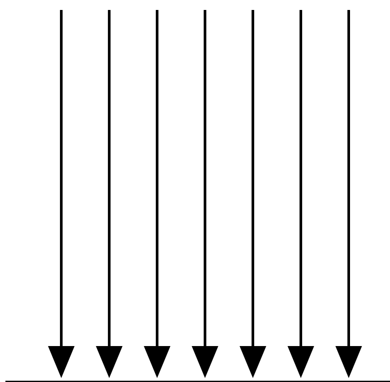
E & M – Unit 2 Review

1. Whether it be gravitational or electrical, an object with "stuff" (mass or charge) experiences a constant force in a uniform field.

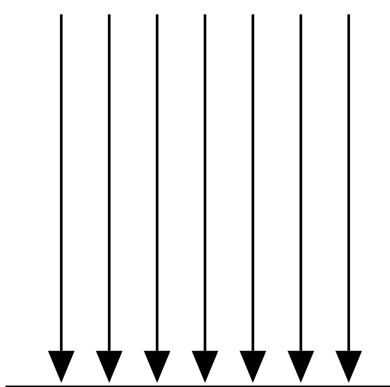
Gravitational



	Force	Energy	Potential
	$F_g = mg$	$E_g = mgh$	$?? = gh$
	$N = kg \cdot \frac{N}{kg}$	$J = kg \cdot \frac{N}{kg} \cdot m$	$\frac{J}{kg} = \frac{N}{kg} \cdot m$

It requires work (transfer of energy) to raise an object with mass against the gravitational field.

Electrical



	Force	Energy	Potential
	$F_e = q\vec{E}$	$E = q\vec{E}d$	$V = \vec{E}d$, or $\Delta V = \vec{E}\Delta x$
	$N = C \cdot \frac{N}{C}$	$J = C \cdot \frac{N}{C} \cdot m$	$\frac{J}{C} = \frac{N}{C} \cdot m$
		or $E = qV$	
		$J = C \cdot \frac{J}{C}$	

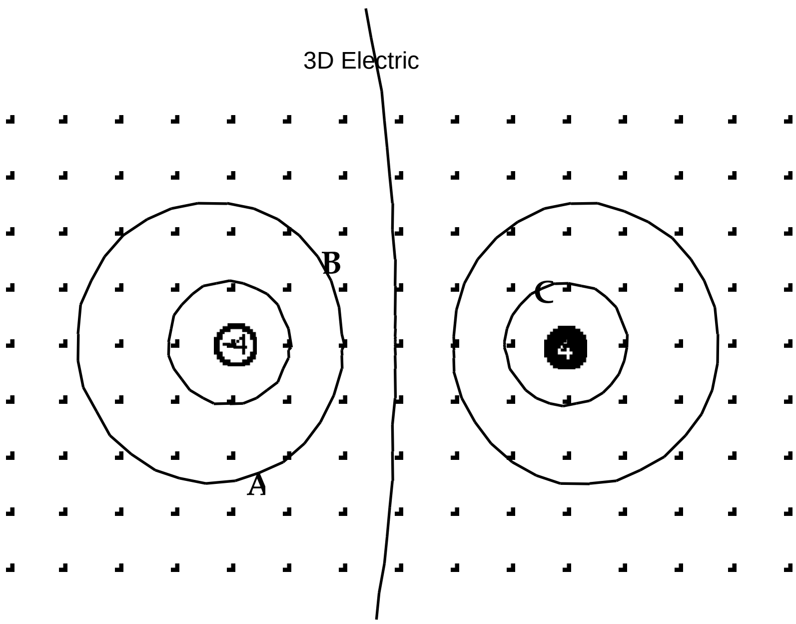
It requires work to move a test charge against the electric field.

2. An object that "falls" in a field will accelerate as potential energy is transferred to kinetic energy.

$$mg\Delta h = \tfrac{1}{2} m\left(v_f^2 - v_0^2\right)$$

$$q\vec{E}d \text{ or } q\Delta V = \tfrac{1}{2} m\left(v_f^2 - v_0^2\right)$$

Electric equipotentials around distributions of charge are like contour lines on a topographic map.

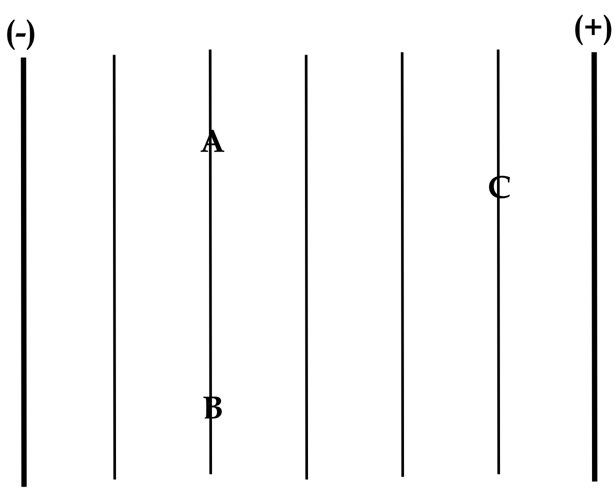


Moving from A to B does not cost any energy because both points are at the same potential.

If the potential difference between the charges is 6.0 V, then moving a proton from B to C would cost you 3.0 eV or 4.8 x 10^{-19} J of energy.

By contrast, an electron would lose that much potential energy as it moved to a position closer to the (+) charge.

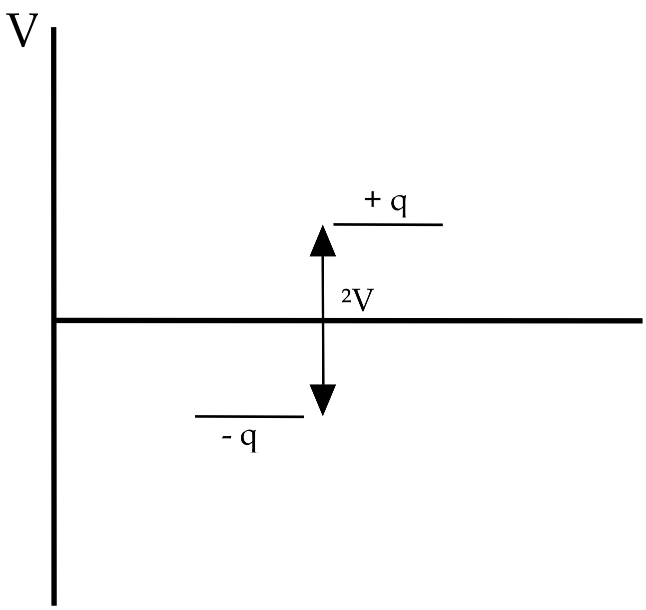
3. Electric equipotentials between charged plates are parallel to the plates; the potential changes uniformly as one moves from one plate to the other.



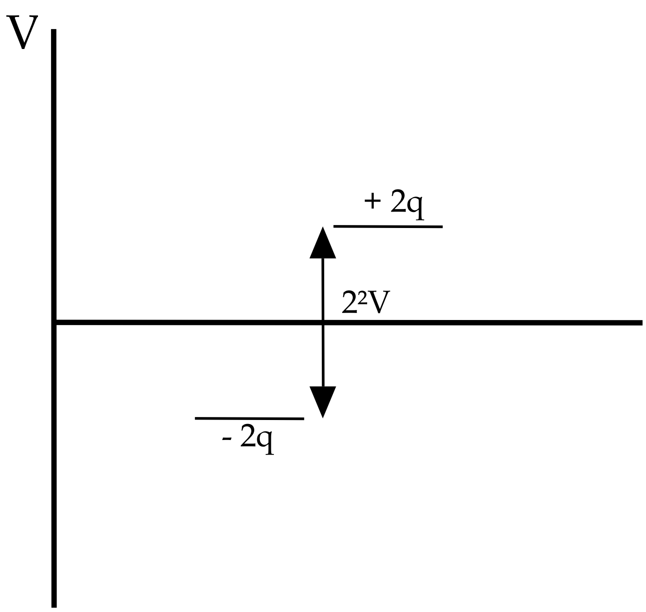
As before, it does not cost you energy to move a charged particle from B to A.

However, if the potential difference between the plates were 12.0 V, then moving a proton from B to C would cost you 6.0 eV or 9.6 x 10^{-19} J.

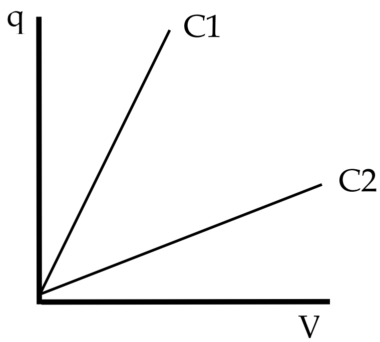
4. Moving charge from one plate of a capacitor to another requires a source of energy (Genecon or battery).



Connecting a battery providing a potential difference of ΔV to the capacitor will cause a quantity of charge, q, to move from one plate to the other. Charge stops moving when the potential difference between the plates matches that of the battery. At that point,the battery can no longer force charge to flow.



If the potential difference applied to the plates were doubled, then twice as much charge would be moved from one plate to the other. The energy stored in the capacitor is 4x as great as before because **both** charge and potential are doubled.



The capacitance, C, is the **slope** of the q *vs* V graph. Capacitor 1 has a greater capacitance than does capacitor 2. The equation of the line is $q = CV$.

5. The energy stored in a capacitor is the *average* of the energy of each charge that is moved from one plate to the other. It is given by $E = \frac{1}{2}qV$ or $E = \frac{1}{2}CV^2$.

   The 1/2 factor takes into account that the potential difference between the capacitor plates decreases as the capacitor is discharged. The average potential difference is 1/2 way between 0 and the maximum value.

6. The capacitance, C, is directly proportional to the area of the plates and is inversely proportional to the distance between them. $C = \frac{q}{V} \propto \frac{A}{d}$.
   It is worthwhile to play "What would happen if…" games with this relationship. For example, doubling the area, while keeping V constant, allows twice as much charge to move between the plates; thus C is doubled. Similarly, doubling d while the capacitor is still connected to the battery (V is constant), reduces the amount of charge on the plates to 1/2 its original value; thus the capacitance is halved.

   What would change if d were doubled after the battery was disconnected (so q remains constant)?