PHYSICS 570 – Master's of Science Teaching

"Electricity"
Lecture 9 – Work, Electrical Potential Energy, Electric Potential, and Voltage.

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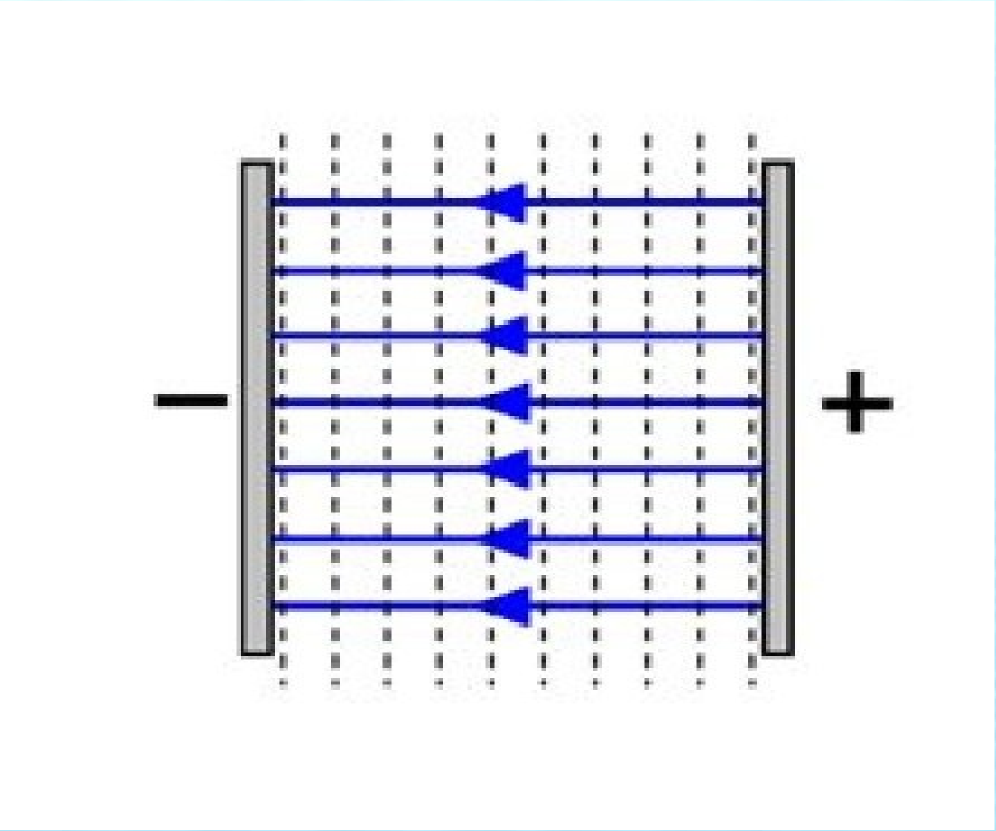
Electrical Potential Energy and Work.

W = Force x distance if the force is constant.

So inside a capacitor, where the electric field is constant, what is the Work on a charge Q?



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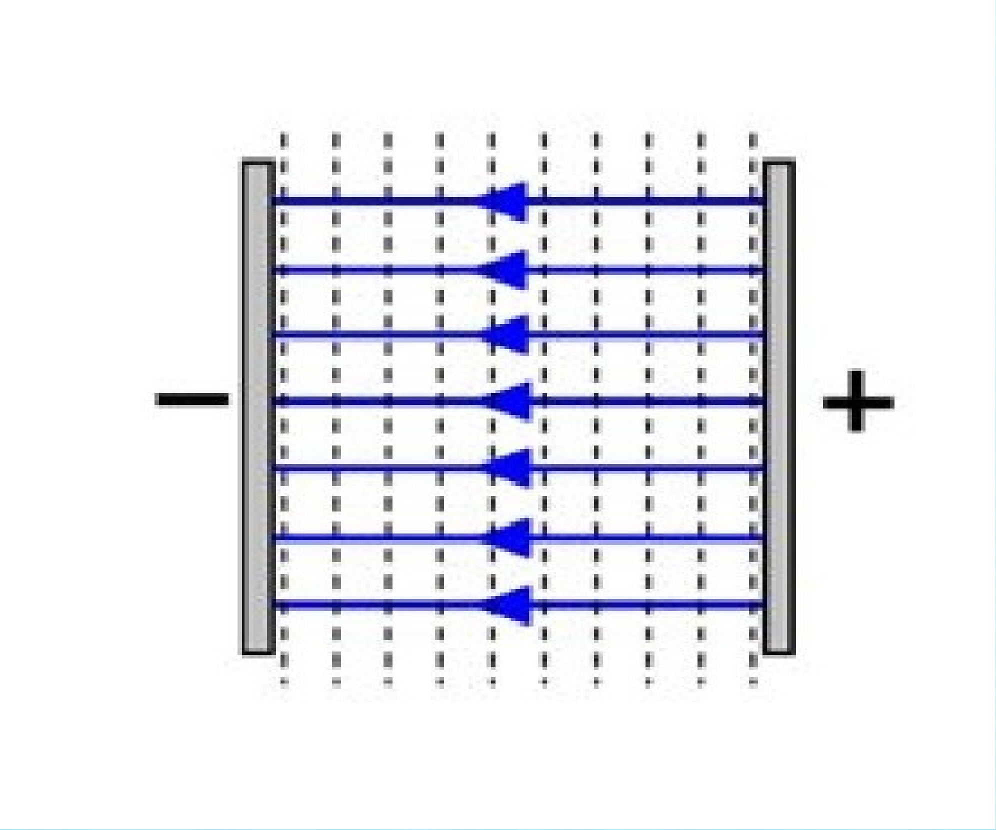


$W = -QEd$

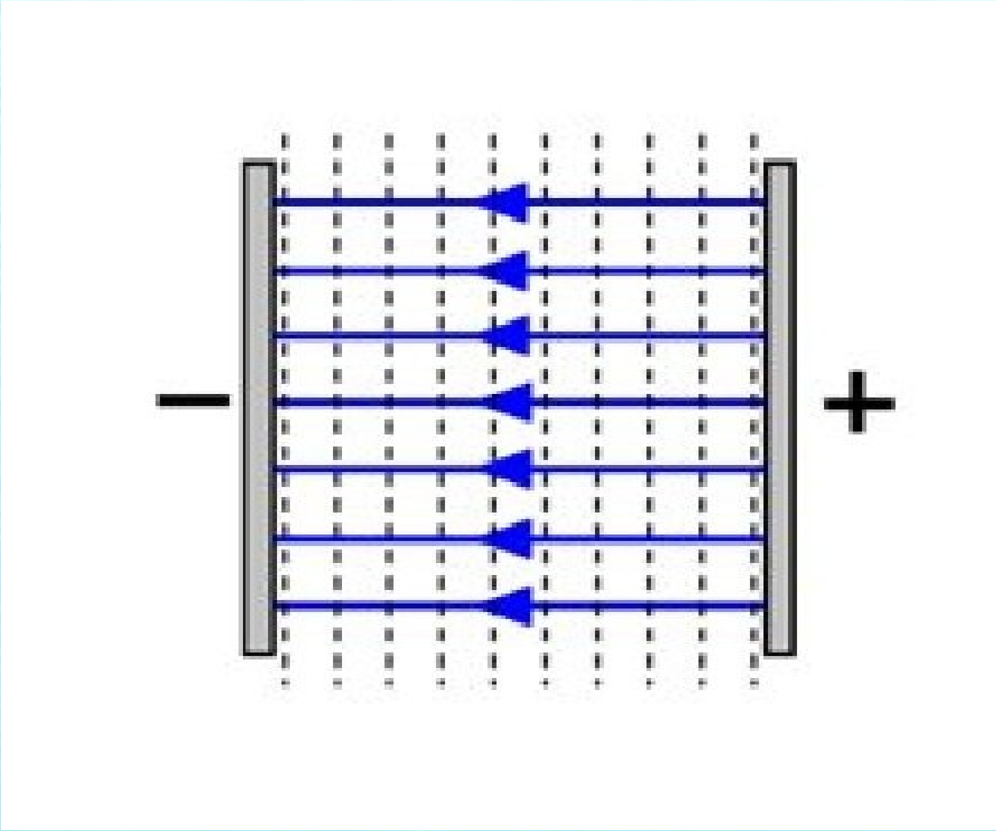
$U = -W = QEd$

Electrical Potential Energy and Work. 4

What if you take a zigzag path through the capacitor?

Work STILL = QEd

(Try going on an Equipotential …
no Work done there)



Electric Potential Energy

Gravitational

$$\text{Total Energy} = m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$$

Electric

$$\text{Total Energy} = q E h_i + \frac{1}{2} m v_i^2 = q E h_f + \frac{1}{2} m v_f^2$$

Homework … Lecture 9, Problem 1
An 0.1 Coulomb sphere is at rest in 1000 N/C electric field.
If it moves 3 meters though the field and its mass is 2 kg,
what is its final speed?

Electric Potential Energy

Electric

$$\text{Total Energy} = qEh_i + \frac{1}{2}mv_i^2 = qEh_f + \frac{1}{2}mv_f^2$$

Formula only works if E is constant, but we can call Eh the Voltage (or potential). Then the formula becomes

$$\text{Total Energy} = q\phi_i + \frac{1}{2}mv_i^2 = q\phi_f + \frac{1}{2}mv_f^2$$

Electric Potential

$$\phi = \frac{U}{q}$$

(Potential is potential energy per unit charge)

So if you put 1 Coulomb through 10 Volts, it acquires 10 J.

In general $\text{Total Energy} = U_i + K_i = U_f + K_f$

Problems

You allow a 2 mCoulomb charged sphere with a mass of 1 kg to pass through 1000 Volts.
What will be its speed afterward?
(Homework 9-2)

What is the kinetic energy of the 1 kg sphere before and after going through 1000 Volts?
(Homework 9-3)

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Problems

What are the potential and kinetic energies of the proton after going through 1000 Volts?

(Homework 9-4)

A proton falls through 1000 Volts. What is it's speed?

(Homework 9-5)

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A proton falls through 1000 Volts.
What is it's speed?
(Homework 9-5)

Hewitt Problem 11-5 *(Homework 9-6)*

An electric field does 12 J of work on a charge of 0.0001 C as it moves from point A to point B. What is the voltage change between point A and point B?

How much work does this same field do on a charge of 0.0002 Coulombs?

Hewitt Problem 11-5 *(Homework 9-6)*

An electric field does 12 J of work on a charge of 0.0001 C as it moves from point A to point B. What is the voltage change between point A and point B?

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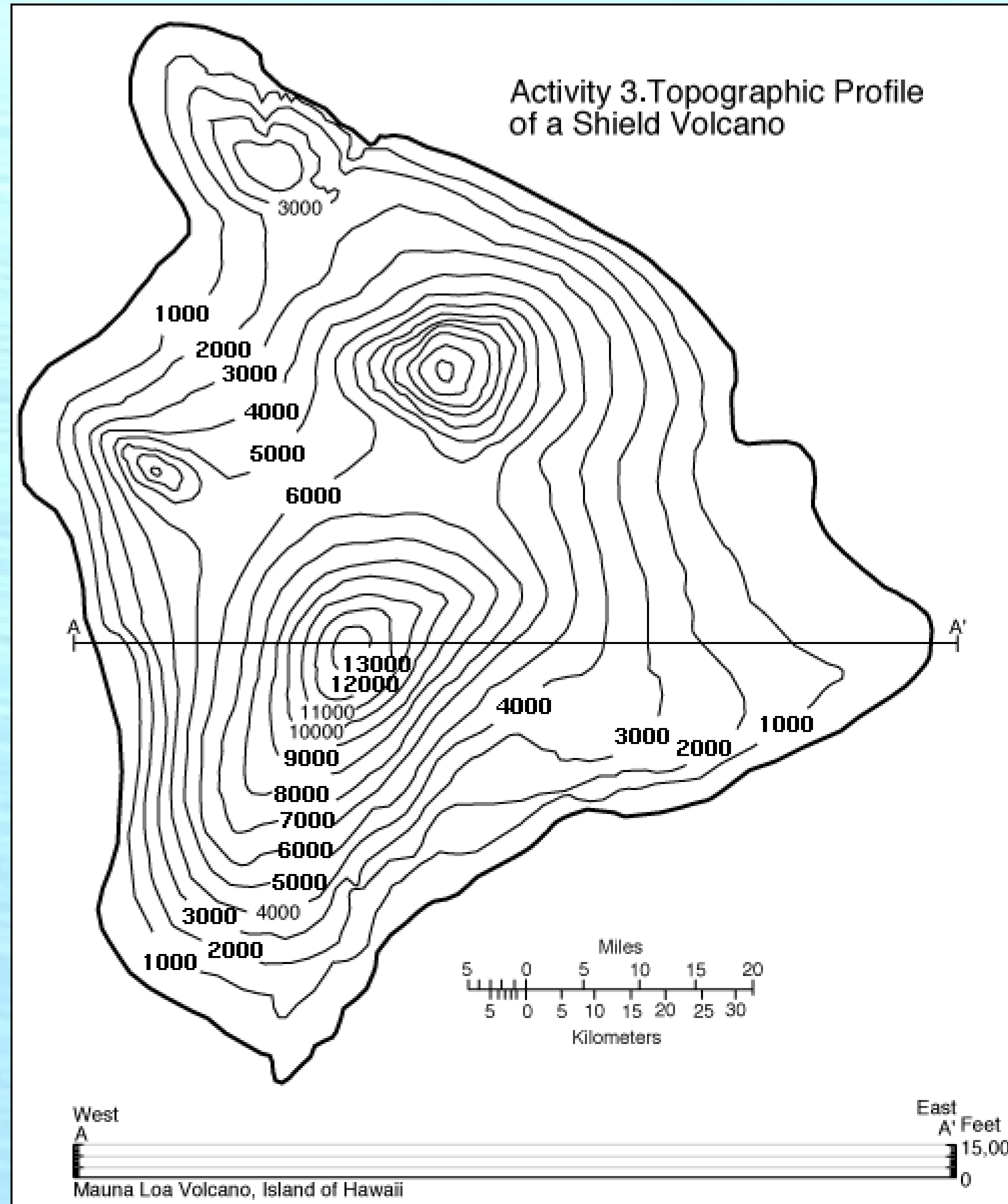
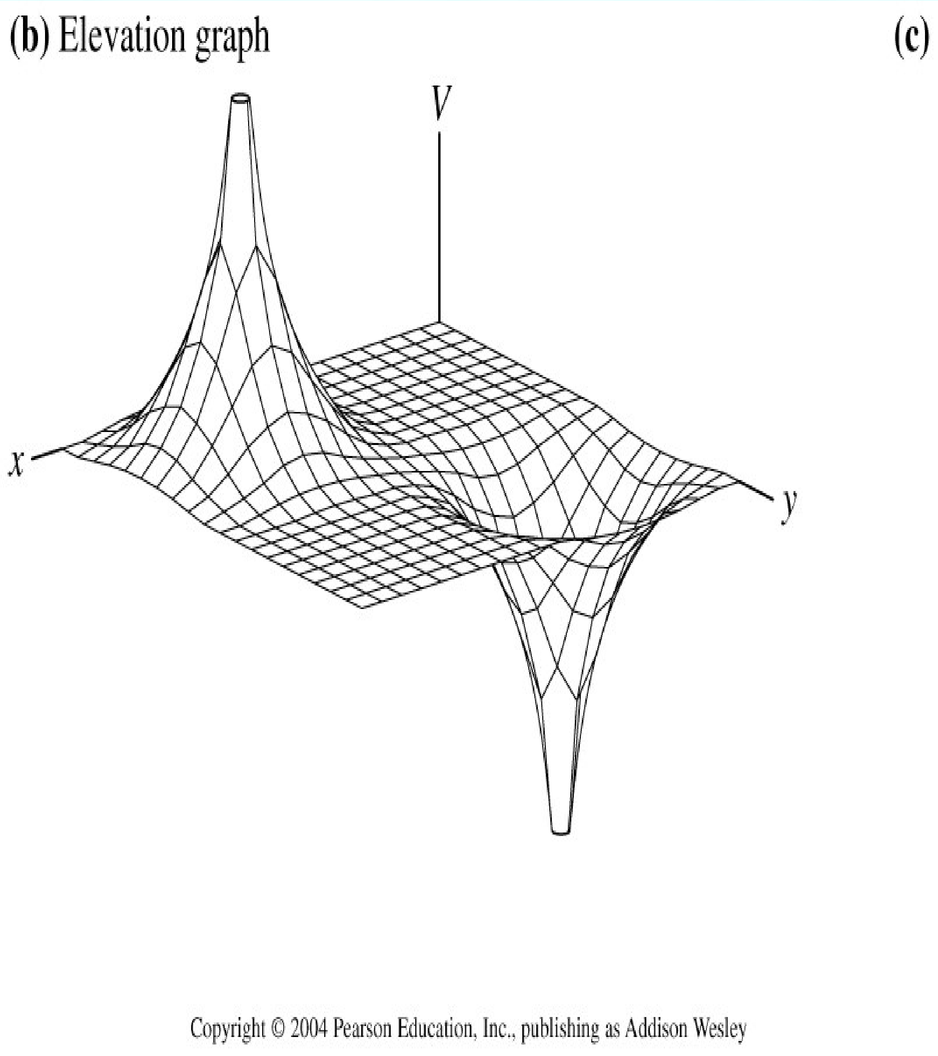
Equipotentials

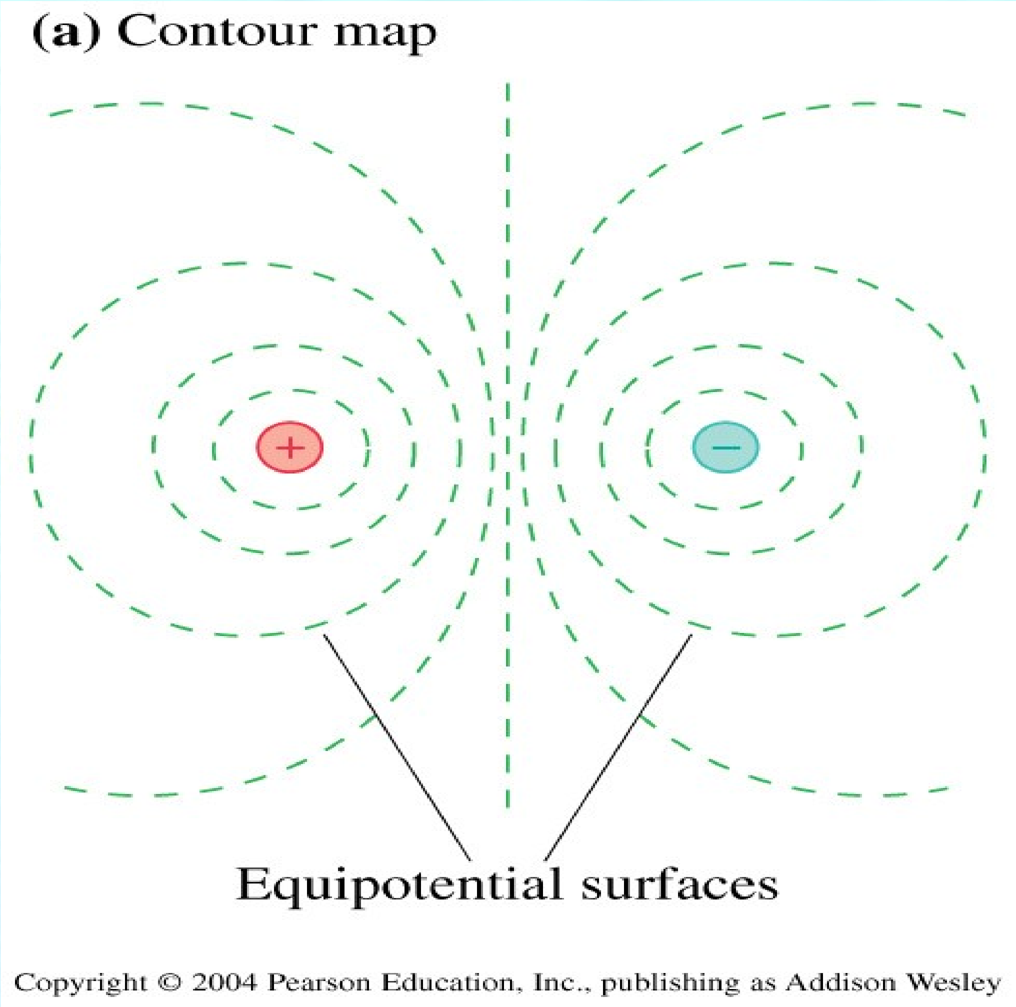
Lines of constant potential

Like contour lines on a map.



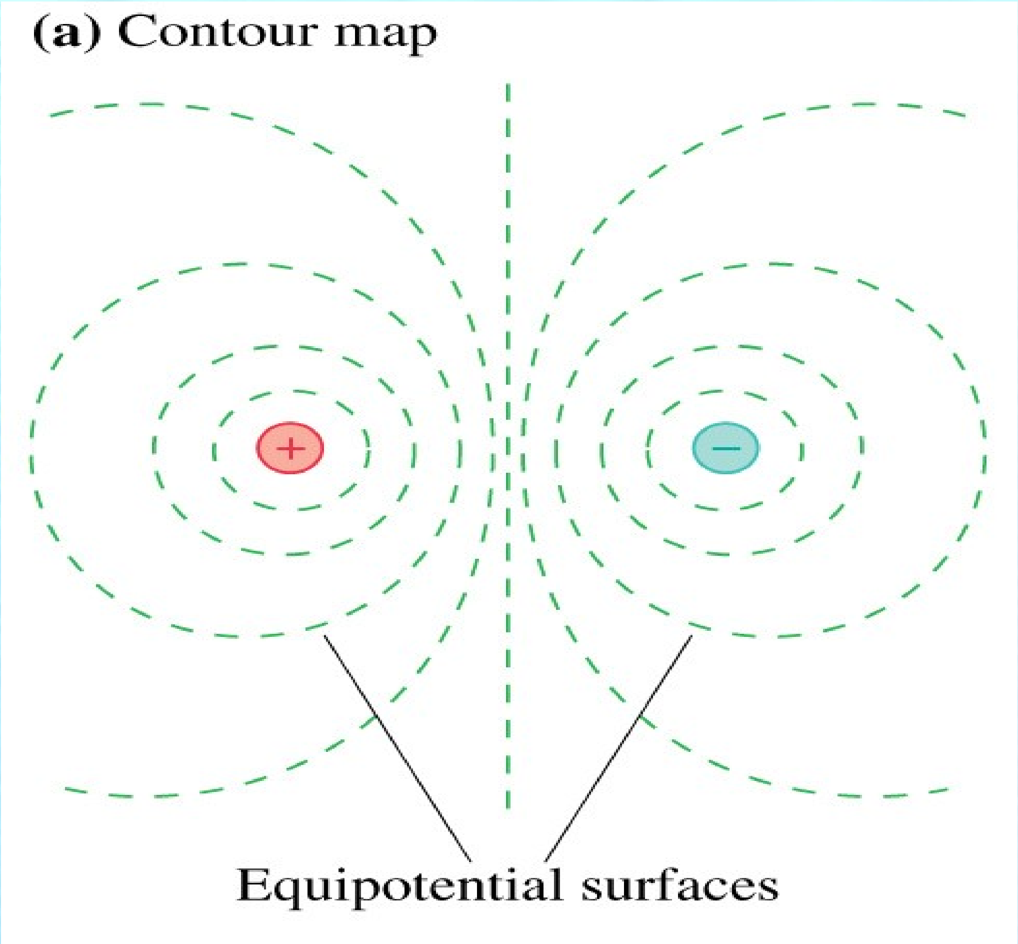
Equipotentials



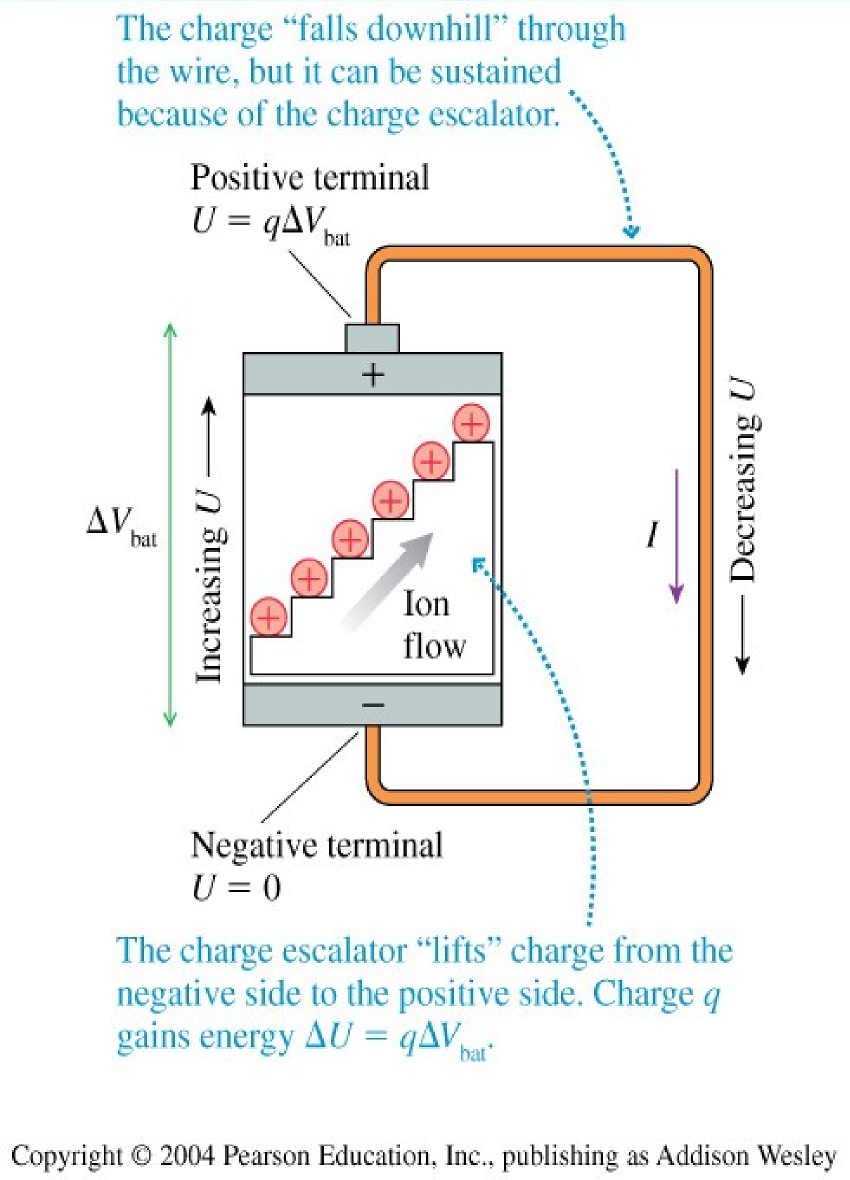


Bottom line

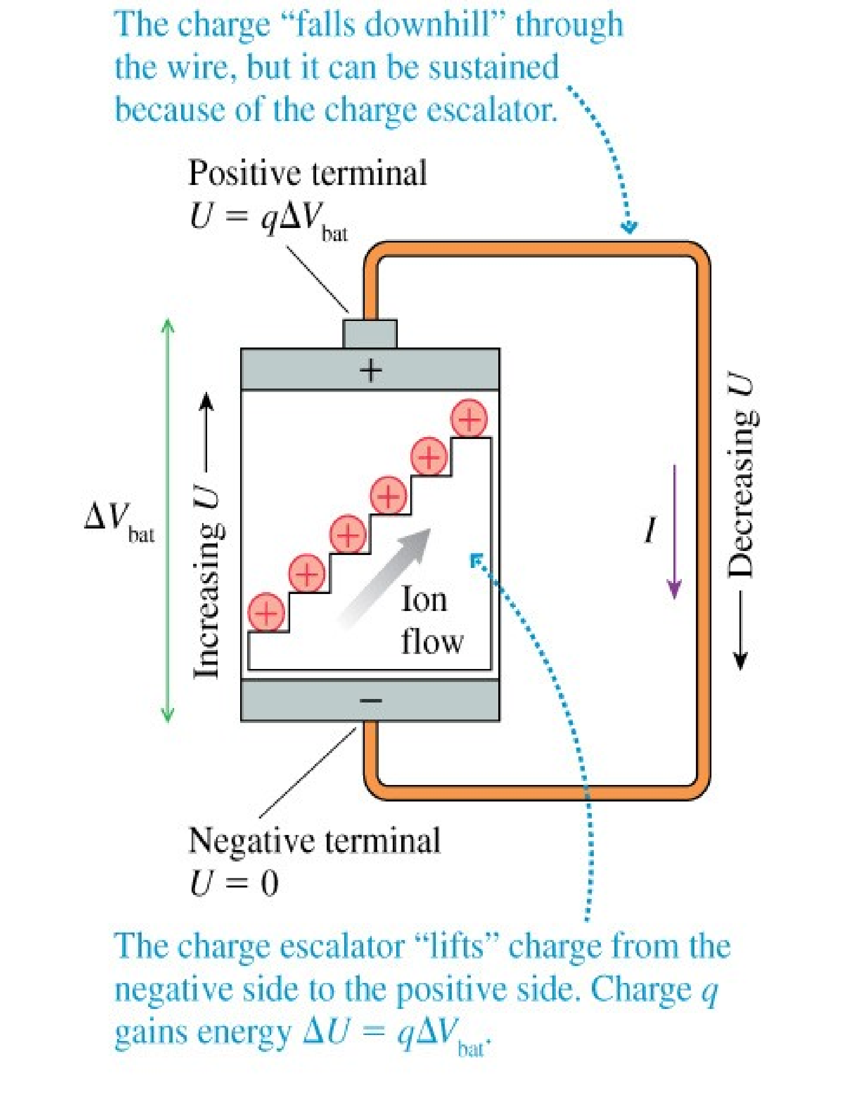
So if you put 1 Coulomb through 10 Volts, it acquires 10 J … regardless of how there got to be 10 Volts there.

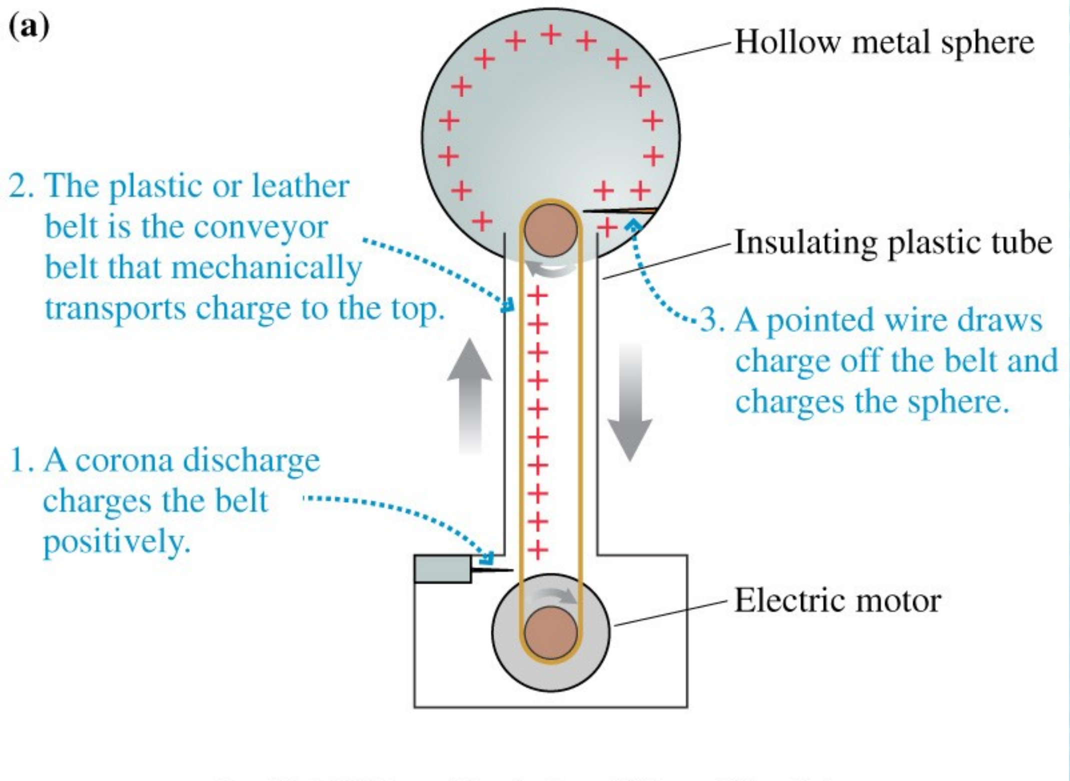


A battery can be a source of potential energy … it's a charge escalator



A battery can be a source of potential energy … it's a charge escalator … like a Van de Graaf.





Batteries

(Homework 9-7)

If a battery says 9-Volts, how much Work does it do on 3 Coulombs that pass through it?

Old televisions had "high voltage supplies" inside … like a large voltage battery. *(Homework 9-8)*

An electron is released from rest at the positive terminal of a 20,000 Volt battery, and the negative terminal is attached to the back of the TV screen. How fast does the electron hit the screen?