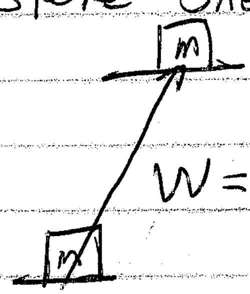
Phys 2426 2017-09-14 Lec 4

Recall definition of work:

- Exert a force, and move object in that direction, you have given the object energy called work.

$$W = \int \vec{F} \cdot d\vec{x} = \vec{F}_{avg} \cdot \Delta\vec{x}$$

- For a conservative force, we can store energy as potential energy.



$$W = F_{push}\Delta y \longrightarrow W = \Delta U$$

Our work of lifting adds to pot. energy.

$$W = F_y \Delta y \longrightarrow \Delta U = mg\Delta y$$
$$= mg\Delta y$$

So we say the potential energy change is

If we stop at the indefinite integral,

$$U_g = \int \vec{F}_{app} \cdot d\vec{x} = -\int \vec{F}_g \cdot d\vec{x}$$

$$U_g = mgy + C$$

(2)

For an Electric Force

$$U_E = -\int \vec{F_E} \cdot \vec{dx} \qquad \vec{F_E} = -\nabla U_E$$

$$F_{Ex} = -\frac{dU_E}{dx}$$

- Force points toward lower potential energy.

With E-Field, we said $\vec{F_E} = q_0 \vec{E}$

$$U_E = -\int q_0 \vec{E} \cdot \vec{dx} = q_0 \left(-\int \vec{E} \cdot \vec{dx} \right)$$

U_E ↑ Elec. Pot. Energy — $\left(-\int \vec{E} \cdot \vec{dx} \right)$ ↑ Elec. Potential

Usually used as: $\Delta U_E = q_0 \, \Delta V$

Because of the def: $E_x = -\frac{dV}{dx}$

- $\vec{E}$ points "downhill" toward lower V.

Protons are ⊕

- Pushed with $\vec{E}$
- Repelled from high V
- Repelled from high U_E

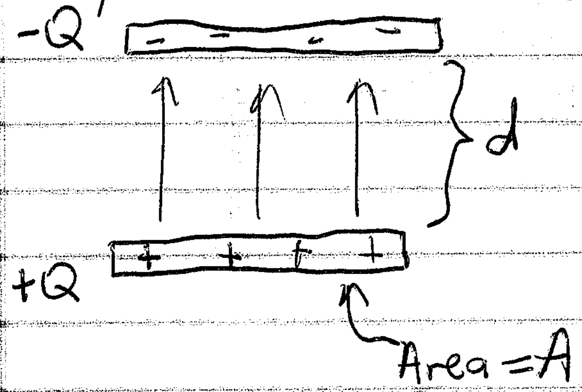
Electrons are ⊖

- Pulled against $\vec{E}$
- Attracted to high-V
- Repelled from high U_E

$$U_E = q_0 V$$

③

Capacitor as Voltage storage.



$$E = 4\pi k \sigma = 4\pi k \, Q/A$$

plate separation

$$\Delta V = -\int E_y \, dy = -E \cdot d$$

Since we know the +Q is at higher V, drop the sign.
Since we know only potential differences matter, drop the Δ.

$$V = Ed = 4\pi k \, Q \frac{d}{A}$$

$$Q = \left(\frac{1}{4\pi k} \frac{A}{d}\right) V$$

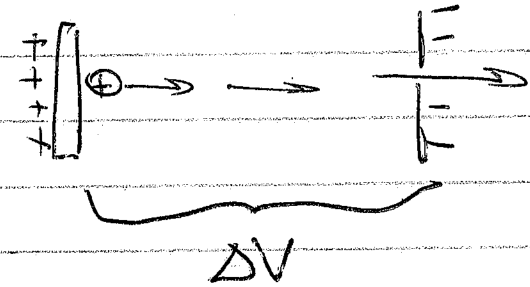
$$Q = C \, V$$

Charge (in C) — Capacitance (in F) — Voltage (in V)

How much energy does the capacitor store?

$$\text{Energy} = \frac{1}{2}(\text{Charge}) \cdot \left(\frac{\text{Energy}}{\text{Charge}}\right) = \frac{1}{2} Q V$$

Particle Accelerator



voltage

Energy given $= q_0 \Delta V$

kinetic energy

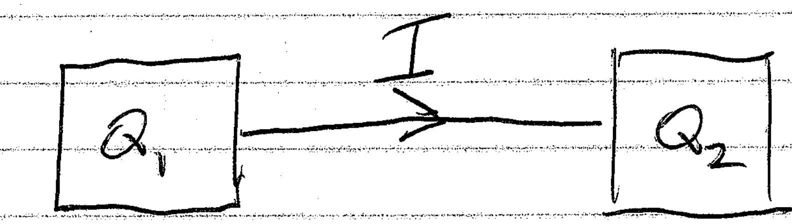
Where does the energy show up? $K = \frac{1}{2} m v^2$

velocity

Electric Current – Flow rate of electricity

$$I = \frac{dQ}{dt}$$ ← Charge that passes by.

↑ Current



$$I = -\frac{dQ_1}{dt} \qquad I = +\frac{dQ_2}{dt}$$

Usually, we don't let Q accumulate. No dead ends.

How do we measure Current?

- Make charges go thru our ammeter.
- Allow current thru meter easily.