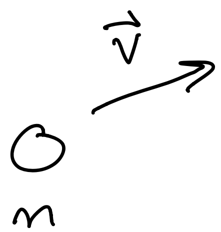
in ch13

$$\vec{E} = \frac{\vec{F}}{q}$$

Want the same thing w/ energy

First a review

Review of Potential Energy



$$K = ?$$

$$K = \frac{1}{2} m v^2$$

Can I change K?

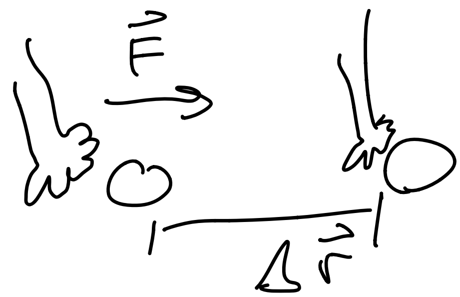
$$\Delta K = K_{Final} - K_{initial} = ?$$

$\Delta K = \text{Work}$

How do I do work?

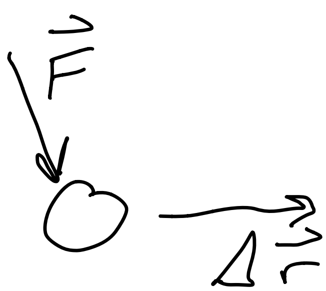
- Apply a force

Work = Force × displacement

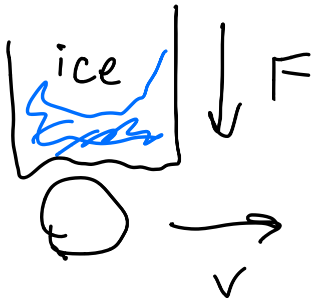


Golf Ball

Force and displacement are both vectors?



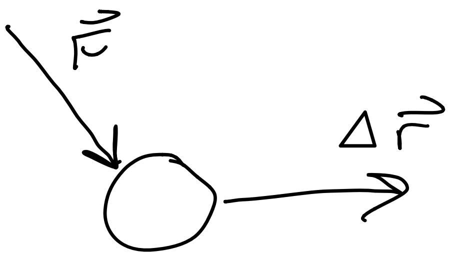
Consider:



I apply a force, the ball moves Δr, but no change in K?

Only Force in the same direction as $\Delta \vec{r}$ does work.

$$\vec{F} = \langle F_x, F_y \rangle$$



$$\Delta \vec{r} = \langle \Delta r_x, 0 \rangle$$

$$W = (F_x)(\Delta r_x)$$

Only F_x does work!

In general

$\vec{F} = \langle F_x, F_y, F_z \rangle$

$\Delta\vec{r} = \langle \Delta r_x, \Delta r_y, \Delta r_z \rangle$

$W = F_x \Delta r_x + F_y \Delta r_y + F_z \Delta r_z$

Example

particle with $q = 2 \times 10^{-11}\ C$

moves from $\langle 0.1, -0.3, 0.4 \rangle m$

to $\langle 0.2, -0.3, -0.2 \rangle m$.

There is an electric field

$\vec{E} = \langle 2000, 0, 4000 \rangle \frac{N}{C}$

$\downarrow$

$$\Delta \vec{r} = \vec{r}_{final} - \vec{r}_{initial}$$

$$= \langle 0.2, -0.3, -0.2 \rangle - \langle 0.1, -0.3, 0.4 \rangle$$

$$\Delta \vec{r} = \langle 0.1, 0, -0.6 \rangle \text{ m}$$

$$\vec{F} = q\vec{E} = 2\times10^{-11} \langle 2000, 0, 4000 \rangle$$

$$\vec{F} = \langle 4\times10^{-8}, 0, 8\times10^{-8} \rangle \text{ N}$$

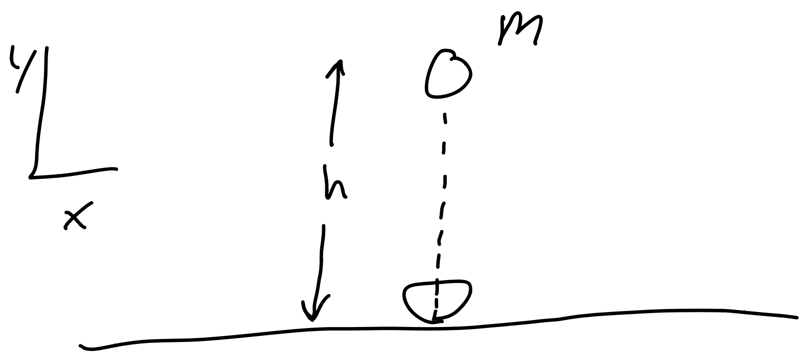
$$W = \vec{F}\cdot\Delta\vec{r} = (4\times10^{-8})(0.1) + (0)(0) + (8\times10^{-8})(-0.6)$$

$$W = -4.4\times10^{-8} \text{ J}$$

$$\Delta K = W = -4.4\times10^{-8}$$

$\downarrow$ gravity

Another example



$W = ?$

$\vec{F} = \langle 0, -mg, 0 \rangle$

$\Delta \vec{r} = \langle 0, -h, 0 \rangle$

$W = (0)(0) + (-mg)(-h) + (0)(0)$

$W = mgh$

K increases

Question:

K of the ball increased

Did the Universe gain energy?

Golf Ball

My hand loses energy

Ball gains energy

$$\Delta E_{sys} = 0$$

Spring Example

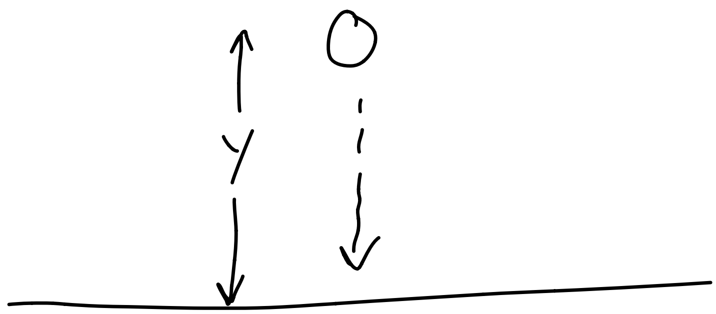
- if I release a spring, the spring gains kinetic energy
- spring does work on the ball
- spring converts stored energy into work which accelerates the ball
- call this potential energy

ball gains energy W

spring loses enegy $-W$

$$\Delta U = -W$$

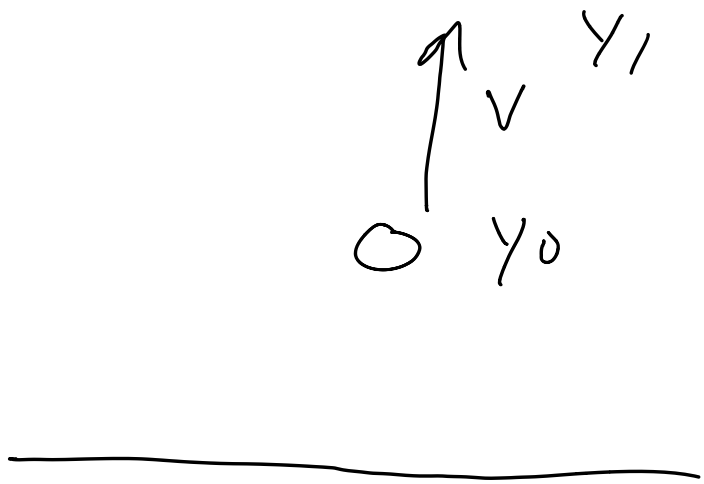
$$\Delta K = W \Rightarrow \Delta K + \Delta U = 0$$



$$U = mgy$$

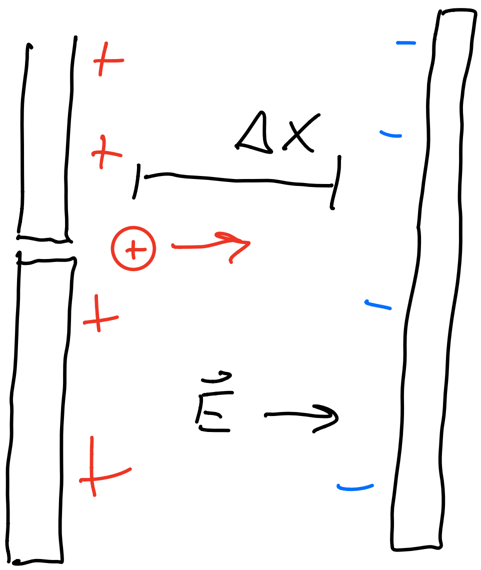
$$\Delta K - mgy = 0$$

$$\Delta K = mgy$$



$y_1 > y_0 \Rightarrow \Delta U > 0$ so $\Delta K < 0$

Example



Will K_{proton} increase or decrease?

$$W = \vec{F} \cdot \vec{\Delta r} > 0$$

K increases

$$\Delta K + \Delta U = 0$$

if $\Delta K > 0$, $\Delta U < 0$

what is ΔU?

$$\Delta U = -W$$

$$W = \vec{F} \cdot \Delta\vec{r}$$

$$= F_x \Delta x + F_y \Delta y + F_z \Delta z$$

$$\Delta y = \Delta z = 0$$

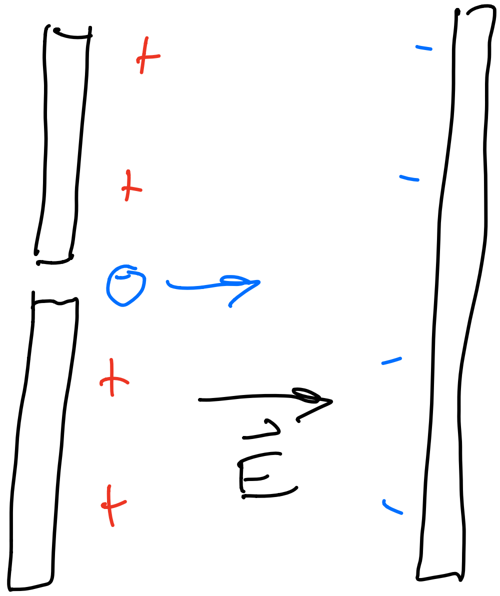
$$W = F_x \Delta x$$

$$F_x = e E_x$$

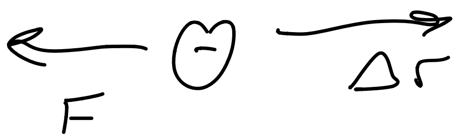
$$W = e E_x \Delta x$$

$$\Delta U = -W = -e E_x \Delta x$$

electron?



K of electron?



$W < 0$

K will decrease

$$\Delta K + \Delta U = 0$$

if $\Delta K < 0$

$\Delta U > 0$

$$\Delta U = -W$$

$$= -F_x \Delta x + 0 + 0$$

$$= -(-e E_x \Delta x)$$

$$\Delta U = e E_x \Delta x$$