POTENTIAL ENERGY

If a force belongs to the class of CONSERVATIVE Forces then work done against such a force creates POTENTIAL ENERGY; the force can be used to do work in the future due to the situation of the object in question

$$W_{grav} = F_{grav} s_{\parallel} = mg\Delta h$$

as described in lecture yesterday

If I lift one book 1m above the top of the table.

$$W = F_g \cdot s = mgh = 2kg \cdot 9.8 ms^{-2} \cdot 1m$$
$$= 19.6 J$$

$$\Delta PE = mgh = 19.6 J$$

Suppose I drop the book then we could say " Gravity does work on the book

$$W_{grav} = F_g s = mgh = 19.6 J$$

$$\text{net } W = \text{net } F_{\parallel} s = \Delta KE$$

$$\cancel{m}gh \quad \frac{1}{2}\cancel{m}v^2 \Rightarrow v^2 = 2gh$$

$$v = 4.4 ms^{-1}$$

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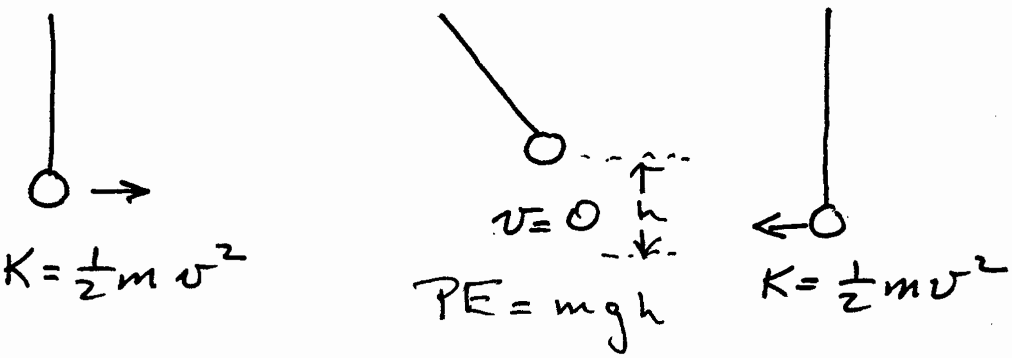
We've alluded to the fact that work + energy can be transformed among various forms. Consider a pendulum



K. E. is there, disappears, then reappears WHERE DID IT GO? Transformed into <u>gravitational</u> <u>potential</u> <u>energy</u>.

To understand this idea called <u>POTENTIAL</u> ENERGY, we need to consider the forces performing the work. Many forces can be classed as <u>CONSERVATIVE</u> <u>FORCES</u>

When Conservative forces do work (or we do work against a conservative force) the work can be recovered. GRAVITY is a conservative force

$KE \rightarrow PE \rightarrow KE$

(work done against grav - stored) (grav does work

n.b. if friction
in the bearings
the energy to
equation
x)

For such forces TOTAL MECHANICAL ENERGY IS CONSERVED :

1) Work (Energy) is ind. of path
2) Work can be recovered
3) $\Delta W = E_{final} - E_{initial}$

For a single conservative force

$$W_{\substack{\text{done by} \\ \text{grav}}} = K_2 - K_1$$

$$W_{\substack{\text{done} \\ \text{against} \\ \text{grav}}} = U_1 - U_2$$

$$\underbrace{U_1 - U_2}_{\substack{\text{Change in} \\ \text{PE}}} = \underbrace{K_2 - K_1}_{\substack{\text{Change in} \\ \text{KE}}}$$

$$E_1 = K_1 + U_1 = K_2 + U_2 = E_2$$

Energy is conserved

This can of course be generalized to include the PE from a variety of CONSERVATIVE FORCES

$$K_1 + U_1^{grav} + U_1^{ELASTIC} + \ldots = K_2 + U_2^{GRAV} + U_2^{ELASTIC} + \ldots$$

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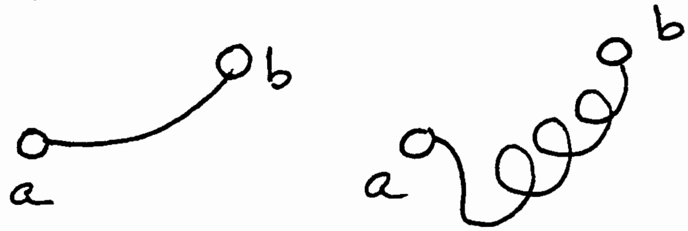
Technically, for conservative forces

$$W = \int_a^b \vec{F} \cdot \vec{ds}$$

is independent of path, depending <u>only</u> on initial + final position (a + b)



No difference in final energy at b

We call the energy due to the fact that the object is at b, the stored energy <u>POTENTIAL</u> <u>ENERGY</u> and then we can define the TOTAL MECHANICAL ENERGY

$$E = K + U$$

Kinetic Energy Potential Energy

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CONSERVATION OF ENERGY

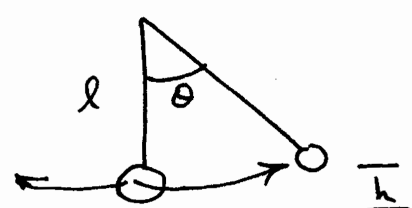
$$KE = \frac{1}{2}mv^2 \qquad PE_{grav} = mgh \ \left(= -\frac{GM}{r}\right)$$
$$PE_{spring} = \frac{1}{2}kx^2$$
$$\vdots$$

We are now prepared to introduce one of the most fundamental concepts in PHYSICS - CONSERVATION OF ENERGY:

LIMITED VERSION : IN AN ISOLATED SYSTEM and IN THE ABSENCE OF NONCONSERVATIVE FORCES (Dissipative)

$$E = KE + PE = \text{const}$$

Energy is neither created nor destroyed merely transformed from one source to another



Center define $h=0$ $\quad PE_{grav} = mgh = 0$
$$KE = \frac{1}{2}mv^2$$

End of swing $\quad KE = 0$
$$PE_{grav} = mgh = mg(\ell - \ell\cos\theta)$$

Suppose $\theta = 60°$ $\cos\theta = 0.5$, $l = 1\,m$, $m = 100g$

AT TOP OF SWING $PE = mgl(1-\cos\theta) = mgl \cdot 0.5$

$$= 0.1\,kg \cdot 9.8\,m\,s^{-2} \cdot 1\,m \cdot 0.5$$

$$= 0.49\,J$$

AT BOTTOM $KE = 0.49\,J = \frac{1}{2} m v^2$

$$v^2 = \frac{2 \cdot 0.49\,J}{0.1\,kg} \Rightarrow v = 3.13\,m\,s^{-1}$$

If we cannot neglect nonconservative forces

$$KE + PE \neq \text{const}$$

because energy goes into dissipation - work against non-conservative forces

$$W_{NC} = \Delta KE + \Delta PE$$

$-\Delta E_{NC}$

n.b. W_{NC} will be negative - doing work <u>against</u> friction or other dissipative force

We can equivalently represent work done by gravity in terms of P.E.

$$\Delta PE + \Delta KE = 0$$

$$-\cancel{m} g \Delta h = \frac{1}{2} \cancel{m} v^2$$

$$\Delta h = -1 m$$

Toss an object up in the air; how high will it go? (Remember the watermelon queen!)

$y = ?$ $\qquad$ $v_0 = 5 m s^{-1}$

$y_0 = h_0 = 15 m$ $\qquad$ $v = 0$

$$\Delta PE + \Delta KE = 0$$

$$\cancel{m} g \Delta h + \frac{1}{2} \cancel{m}\left(\cancelto{0}{v^2} - v_0^2\right) = 0$$

$$v = \sqrt{2g\Delta h}$$

or

$$\Delta h = \frac{v_0^2}{2g} = 1.28 m$$

What is final velocity

$y_0 = h_0 = 16.28 m$ $\qquad$ $v_0 = 0$

$y = 0$ $\qquad$ $v_f = ?$

$$v = \sqrt{2gh}$$

$$= 17.84 m s^{-1}$$