Kinetic Energy (energy of motion)

$$KE = \frac{1}{2} m |\vec{v}|^2 = \frac{1}{2} m v^2$$

e.g. 2kg

$\vec{v}_i = 3\hat{x} + 4\hat{y}$ m/s $|\vec{v}_i| = \sqrt{3^2 + 4^2} = 5$

$KE_i = \frac{1}{2}(2\text{kg})(5\text{m/s})^2 = 25\text{J}$

What is KE at top of arc?

A) 0J **B) 9J** C) 16J D) 25J E) 49J

$KE_f = \frac{1}{2}(2\text{kg})(3\text{m/s})^2 = 9\text{J}$

$\Delta KE = KE_f - KE_i = 9 - 25 = -16\text{J}$

Gravity does −16J of work on ball

Work in 1D with constant force F

$\frac{1}{2} m v_f^2 = (v_i^2 + 2a\Delta x) \cdot \frac{1}{2} m$

$\frac{1}{2} m v_f^2 = \frac{1}{2} m v_i^2 + ma\Delta x$

$KE_f = KE_i + F\Delta x$ ← Work

$W = F\Delta x$ in 1D, constant F

$\Delta KE = W$

Work = force × displacement

if object isn't moving ($\Delta x = 0$)

then no work is done on it

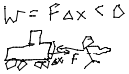
If F & Δx point same direction,

$W = F\Delta x > 0$

W>0

F & Δx are opposite,

$W = F\Delta x < 0$ steal energy



Superman applies force in opposite direction of motion

Note! $v = \frac{\Delta x}{\Delta t}$ so Δx & v point in same direction

e.g. An object mg = 10N falls 2m.

Work done by gravity?

A) 20J B) 0J C) −20J

speeds up

If I lower some object with mg hands at constant speed by 2m

Work done by gravity?

$W = F_g \times \Delta x = (10\text{N}\downarrow) \cdot (2\text{m}\downarrow) = +20\text{J}$

BUT hand exerts a normal force ↑

N=10N ↑

$W_{hand} = -20\text{J}$

total work = $\overset{\text{gravity}}{20\text{J}} - \overset{\text{hand}}{20\text{J}} = 0$

so KE is constant

Springs

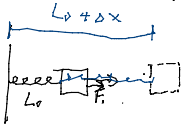
- preferred length L_0
- exert restoring force if you stretch it, to go back to L_0

$$|\vec{F}| = k|L - L_0| \quad \text{Hooke's Law}$$

L: length of spring

$|L - L_0|$: stretch

k: spring constant
stiffness of spring
units of N/m



What work did I have to do to move box a distance Δx?

$W = F\Delta x > 0$

Where did that energy go?
Stored in spring
but can be released again
to do work on something else

Spring force is a conservative force
(Friction is nonconservative)

Energy stored is potential energy PE

How much PE does spring have above?

$$\Delta PE = W = F\Delta x$$
$$= \left(\frac{1}{2}k\Delta x\right)\Delta x$$
$$PE = \frac{1}{2}k(\Delta x)^2 = \frac{1}{2}k(L - L_0)^2$$

A system with PE "wants" to get rid of it

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Gravity is a conservative force

W by gravity is $W = -mg\Delta y$
gravity steals energy
but it will give it back
when object falls (moves down)

$$\Delta PE_g = mg\Delta y$$