Kinetic Energy

Kinetic energy E_K is the name given to the energy that a body possesses because of its motion. You can think of E_K as being the work needed to give a body a certain velocity when it started from rest.

$u = 0$

$$\Delta W = Fs$$

from Newton's second law: $F = ma$

$$\Delta W = mas$$

If $u = 0$, $v^2 = \cancel{u^2}^{\,0} + 2as$

$$s = \frac{v^2}{2a}$$

$$\Delta W = m\cancel{a}\left(\frac{v^2}{2\cancel{a}}\right)$$

$$\Delta W = \frac{1}{2}mv^2$$

The work needed to give a body a velocity v when starting from rest.

Kinetic Energy → $E_K = \frac{1}{2}mv^2$

Example:

Determine the kinetic energy of:

$kg \cdot m^2 s^{-2} = N \cdot m = J$

- a billiard ball of mass 0.20 kg moving at $3.0 ms^{-1}$

$0.90 J$

- an electron of mass $9.1 \times 10^{-31} kg$ moving at $2.0 \times 10^7 ms^{-1}$

$1.8 \times 10^{-16} J$

Example

How much work is done in changing the speed of a vehicle of mass $5.0 \times 10^3 kg$ from $20 ms^{-1}$ to $30 ms^{-1}$?

$$\Delta W = \Delta E_k$$

$$\Delta W = E_{k_2} - E_{k_1}$$

$$\Delta W = \frac{1}{2} m v^2 - \frac{1}{2} m u^2$$

$(\Delta v)^2 \neq v^2 - u^2$

$(v-u)^2 \neq v^2 - u^2$

BE CAREFUL!

(DO NOT USE Δv!)

$$\Delta W = \frac{1}{2} m (v^2 - u^2)$$

$$\Delta W = \frac{1}{2}(5.0 \times 10^3 kg)\left((30 ms^{-1})^2 - (20 ms^{-1})^2\right)$$

$$\Delta W = \frac{1}{2}(5.0 \times 10^3 kg)(500 m^2 s^{-2})$$

$$\Delta W = 1.3 \times 10^6 J$$

$kg\, m^2 s^{-2} = J$

How are momentum and kinetic energy related?

(magnitude)
Momentum: $p = mv$

Kinetic energy: $E_K = \frac{1}{2}mv^2$

$$E_K = \frac{mv^2}{2}\left(\frac{m}{m}\right)$$

$$E_K = \frac{m^2v^2}{2m}$$

$$E_K = \frac{(mv)^2}{2m}$$

Not in your data booklet.

In your data booklet → $E_K = \frac{p^2}{2m}$ or $p = \sqrt{2mE_K}$

Example

$p = 1.0\ kg \cdot ms^{-1}$

A trolley of mass 0.50kg moving at 2.0 ms^{-1} east collides with and sticks to a second identical trolley which is initially at rest.

Calculate the kinetic energy of the two trolleys after the collision.

Recall the Law of Conservation of Momentum:

$$p_{total\,(before)} = p_{total\,(after)}$$

∴ The momentum of the two trolleys after the collision is $1.0\ kg \cdot ms^{-1}$

$$E_K = \frac{p^2}{2m}$$

$$E_K = \frac{(1.0 kg\,ms^{-1})^2}{2(0.50kg + 0.50kg)}$$

$$E_K = 0.50\,J$$

Gravitational Potential Energy

Gravitational potential energy E_p is the name given to the energy of a body because of its position in a gravitational field or, if we are concerned with the Earth, because of its location with respect to the Earth.

The problem => the zero is totally arbitrary

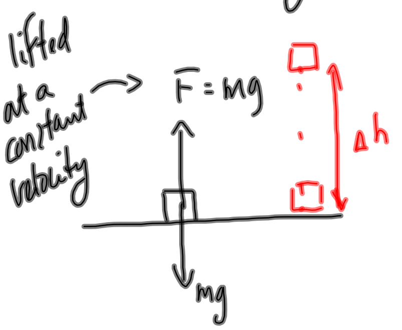
To get around this problem, we deal with the change in gravitational potential energy. We do not need to establish a zero.

Change in gravitational potential energy

Change in gravitational potential energy ΔE_p is the change in energy that a body has due to a change in its position in the direction of a gravitational force. Work must be done in order to change a body's gravitational potential energy.

$$\Delta W = \Delta E_p$$

Consider lifting a mass m a height Δh



$$\Delta W = Fs$$

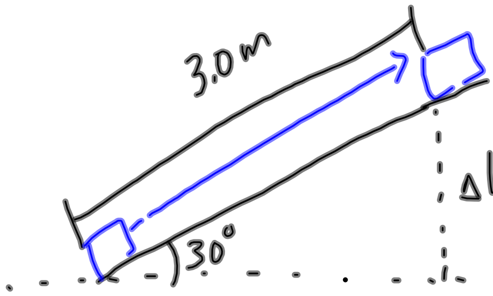
$$\Delta W = mg\Delta h$$

$$\therefore \boxed{\Delta E_p = mg\Delta h}$$

In your data booklet

Example

Calculate the increase in the gravitational potential energy of a body of mass 2.0kg which is moved a distance of 3.0m at an angle of 30° upwards from the horizontal.

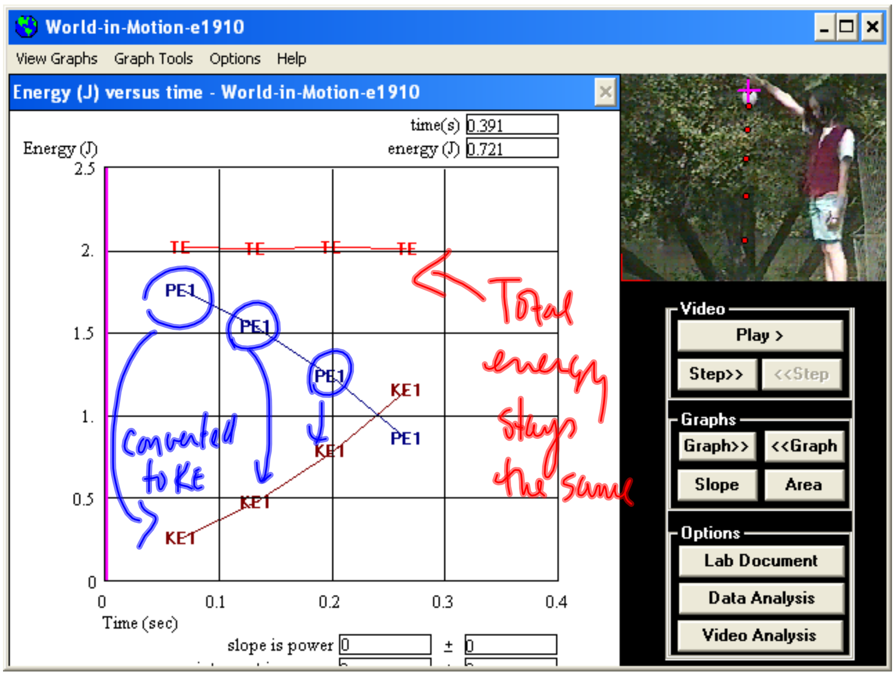


$\Delta h = (3.0\,m)(\sin 30^\circ) = 1.5\,m$

$$\Delta E_p = mg\Delta h$$

$$\Delta E_p = (2.0\,kg)(9.81\,ms^{-2})(1.5\,m)$$

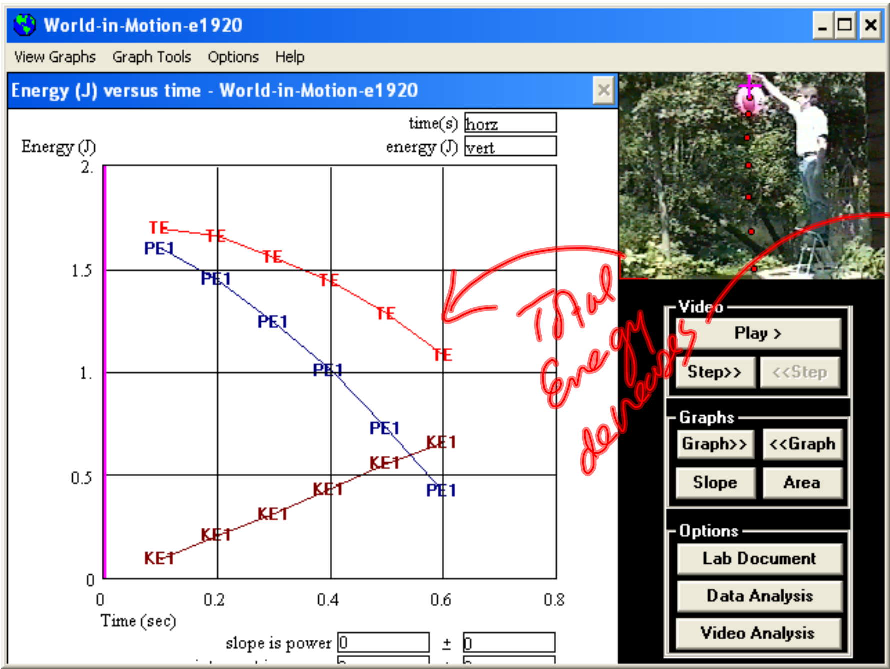
$$\Delta E_p = 29\,J$$



Falling Object

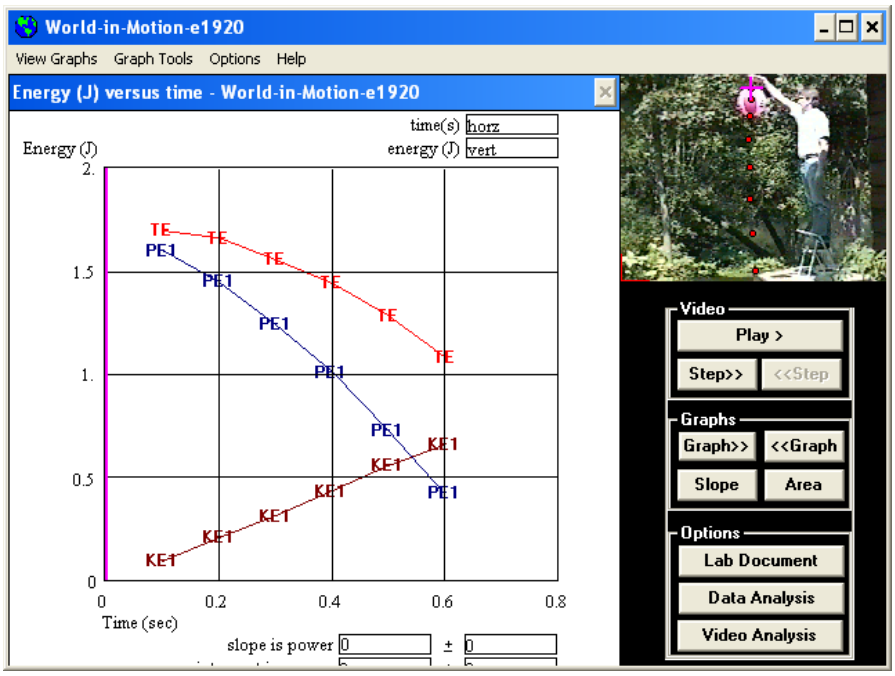
The total energy stays the same in an isolated system.

(no air resistance or friction)



goes into Internal

(negative work is being done by air resistance)


World-in-Motion-e1920
View Graphs Graph Tools Options Help
Energy (J) versus time - World-in-Motion-e1920
time(s) horz
energy (J) vert
Energy (J)
Time (sec)
TE
PE1
KE1
0 0.2 0.4 0.6 0.8
0 0.5 1. 1.5 2.
slope is power 0 ± 0
Video
Play >
Step>>
<<Step
Graphs
Graph>>
<<Graph
Slope
Area
Options
Lab Document
Data Analysis
Video Analysis