Hello: 9851040246
Email: sajitcshakya@gmail.com
Web Address: http://sajitsir.tripod.com

Concept of kinetic energy and potential energy

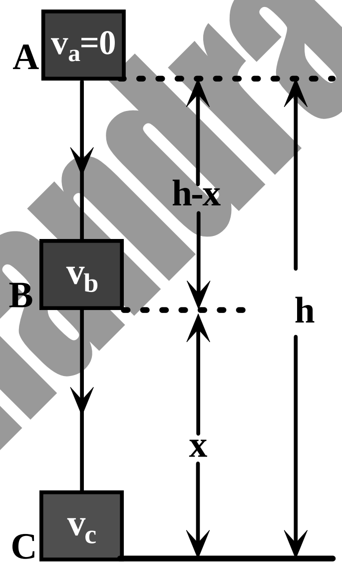
Kinetic energy

It is the energy possessed by the body when it is in motion. Then according to the relation W = F×d, these substances can do work. Such capacity of doing work in such condition is the kinetic energy. In order to know whether the bodies have kinetic energy or not there should be some attempt at stopping them. Then observing the changes in the stopping body kinetic energy can be determined.

Potential energy

It is the energy possesses by the bodies due to which they can do work at some future instance though not at present. This energy is present in substances due to raised position, strained condition, and the centrifugal force. In order to determine whether substances have potential energy or not, they are to be set free. If they perform some work by themselves they have potential energy otherwise not.

Prove that the total mechanical energy (KE + PE) of a freely falling body is conserved



Let a body be allowed to fall freely from a height ‘h’ from rest. Let its mass be ‘m’.

At the starting point A,

Velocity (v_A) $= 0\ ms^{-1}$

Kinetic energy at A i.e. KE_A $= \frac{1}{2}mv_A^{\,2} = \frac{1}{2}m \times 0 = 0$

Height $= AC = h$

Potential energy at A i.e. PE_A $= mgh$

Total energy at A (TE_A) $= KE_A + PE_A$

$= 0 + mgh = mgh$

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After sometime the body reaches point B, when it is 'x' distance above the ground.

At the point B,
Here,
Height = BC = x
Potential energy at B i.e. PE_B = mgx
Considering the motion from A to B, $u = v_A = 0$, $a = g$, $S = AB = h - x$; $v = v_B$

Using relation $v^2 = u^2 + 2aS$ gives

$$v_B^2 = u^2 + 2g(h - x)$$

Now, $KE_B = \frac{1}{2}mv_B^2 = \frac{1}{2}m \times 2g(h - x) = mg(h - x)$

Total energy at B (TE_B) = $KE_B + PE_B$ $= mg(h - x) + mgx = mg(h - x + x) = mgh$

Let *at the end* of the falling motion the body is just about to touch the ground then
Height = 0
So, PE $= mg \times 0 = 0$

Considering the motion from A to C, $u = v_C = 0$, $a = g$, $S = AC = h$

Using the relation, $v^2 = u^2 + 2aS$ gives

$$v_C^2 = u^2 + 2gh$$

Now, $KE_C = \frac{1}{2}mv_C^2 = \frac{1}{2}m \times 2g(h) = mgh$

Total energy at C (TE_C) = $KE_C + PE_C$ = mgh + 0 = mgh

Therefore whenever the body is falling, the total energy of a freely falling body is constant till the end. The loss of one of them is compensated by the gain of the other.

Prove that the total mechanical energy (PE + KE) of a body falling freely on a smooth inclined plane is conserved (constant)

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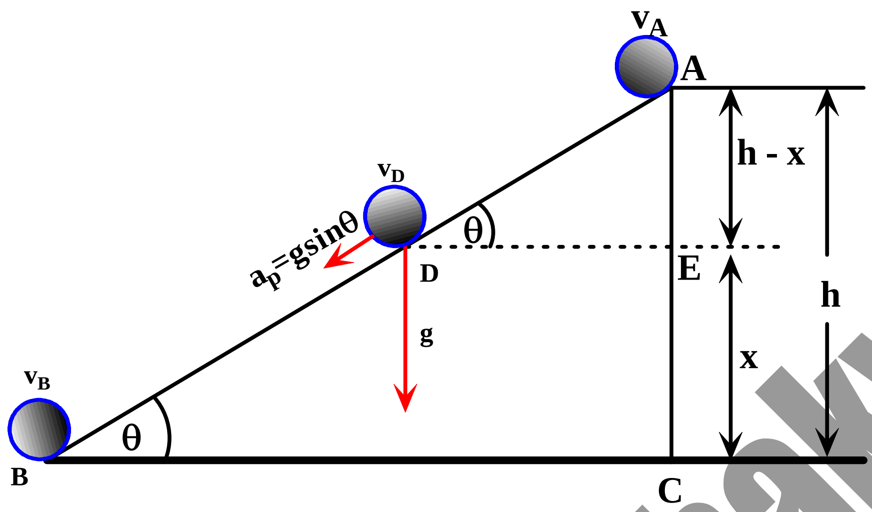

Let a body be allowed to fall along a plane inclined at angle 'θ' with the horizontal. Initially the velocity is zero but increases afterwards because of acceleration 'a_p' along the inclined plane.

At the starting point A

Velocity at A (v_A) $= 0\ ms^{-1}$

Kinetic energy at A i.e. KE_A $= \frac{1}{2}mv_A{}^2 = \frac{1}{2}m \times 0 = 0$

Height $= AC = h$

Potential energy at A i.e. PE_A $= mgh$

Total energy at A (TE_A) = $KE_A + PE_A = 0 + mgh = mgh$

After some time, the body reaches position D, where

Height $= CE = x$

Potential energy at D i.e. PE_D $= mgx$

Considering the motion from A to D, Initial velocity (u) = v_A = 0, $a_p = g\sin\theta$, S = AD, Final Velocity (v_D) = ?

Using relation $v^2 = u^2 + 2aS$ gives

$$v_D{}^2 = 0^2 + 2g\sin\theta \times AD = 2g(AD\sin\theta)$$

In triangle ADE, $\sin\theta = \frac{AE}{AD}$

$$\text{or,}\ AD\sin\theta = AE$$

$$AD\sin\theta = h - x$$

Using the value of $AD\sin\theta$ gives

$$v_D{}^2 = 2g(h - x)$$

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Now, $KE_D = \frac{1}{2}mv_D{}^2 = \frac{1}{2}m \times 2g(h-x) = mg(h-x)$

Total energy at D (TE_D) $= KE_D + PE_D$
$= mg(h-x) + mgx = mg(h-x+x) = mgh$

At point B, it is just about to touch the ground. At that time,
Height $= 0$
Potential energy at B i.e. PE_B $= mg \times 0$

Considering the motion from A to B, Initial velocity (u) = $v_A = 0$, $a_p = g\sin\theta$, S = AB, Final Velocity (v_B) = ?

Using relation $v^2 = u^2 + 2aS$ gives
$$v_B{}^2 = 0^2 + 2g\sin\theta \times AB = 2g(AB\sin\theta)$$

In triangle ABE, $\sin\theta = \frac{AC}{AB}$
or, $AB\sin\theta = AC$
$AB\sin\theta = h$

Using the value of $AB\sin\theta$ gives
$$v_B{}^2 = 2gh$$
Now, $KE_B = \frac{1}{2}mv_D{}^2 = \frac{1}{2}m \times 2gh = mgh$

Total energy at B (TE_B) $= KE_B + PE_B$
$= mgh = 0$

Therefore wherever the body is during the motion, the total energy is always the same, i.e. the total energy always remains constant.