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PHYSICS-I

Chapter # 05

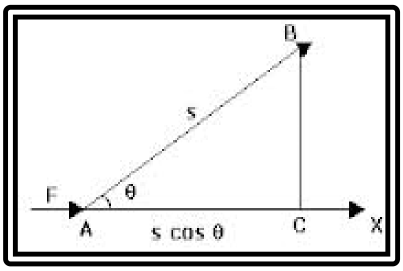
Work, Energy and Power

WORK

FIRST DEFINITION:

Work may be defined as;

"The product of the component of force in the direction of displacement and the magnitude of displacement".



If a force $\vec{F}$ displaces a body through a displacement $\vec{S}$ such that the angle between $\vec{F}$ and $\vec{S}$ is θ then as shown in fig.(i)

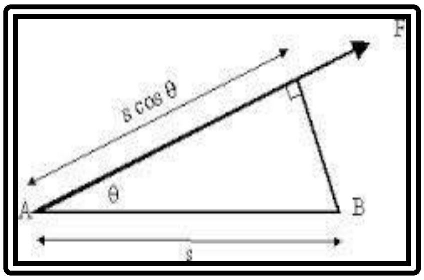
Work = Fcos x S

Work = FScosθ

SECOND DEFINITION:

Work may also be defined as;

"The product of the magnitude of force and the component of displacement in the direction of force"



As shown in fig.(ii)

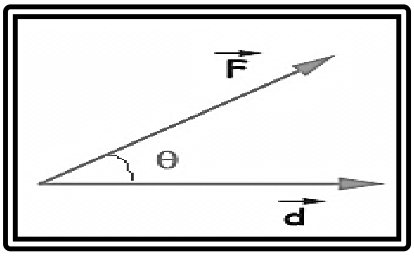
Work= F x Scosθ

Work = FScosθ

THIRD DEFINITION:

Work is defined as;

"The dot product of force and displacement" i.e

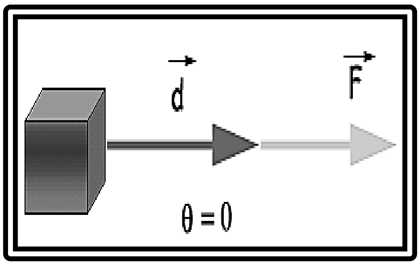


$W = \vec{F}.\vec{S}$ or W = FScosθ

Where θ is the angle between $\vec{F}$ and $\vec{S}$.

DIFFERENT CASES OF WORK DONE BY CONSTANT FORCE:

- **POSITIVE WORK:**



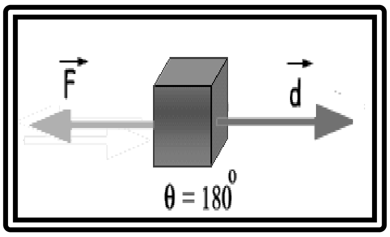
If the force on a body is in the direction of displacement, then θ = 0°. In such a case work is positive. Work is positive also when θ is between 0° and 90°.

W=FS cos θ Cos (0) = 1
W=FS cos (0)
W=FS

Example:

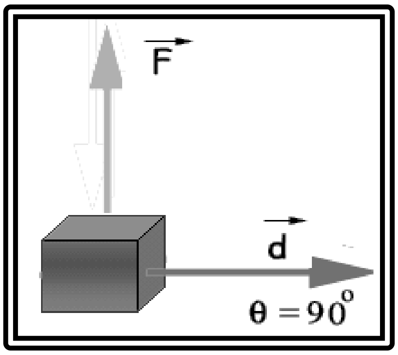
Coolie pushing a load horizontally

- **<u>NEGATIVE WORK:</u>**



If the force on a body is opposite to the direction of displacement, then θ = 180° and cosθ=cos180°= -1. In such a case work is negative. Work is negative also when θ is between 90° and 180°.

- **<u>ZERO WORK:</u>**



If the force on a body is perpendicular to the direction of displacement, then θ = 90° since cos90° = 0 therefore work is also zero.

W=FS cos θ Cos (90) = 0
W=FS cos (90)
W= 0

<u>Example:</u>
1. Work done by a centripetal force is always zero, in this case tangential displacement and centripetal force are manually perpendicular with

<u>UNITS OF WORK:</u>
S.I unit of work is Joule (J)
C.G.S unit of work is Erg.
F.P.S unit of work is Foot-Pound (ft-lb)

<u>OTHER UNITS:</u>
- <u>British Thermal Unit (BTU)</u>

1 BTU = 1055J
- <u>Electronic Volt (ev)</u>

1ev = 1.6×10^{-19}J
- <u>Kilowatt Hour(kwh)</u>

1 kwh = 3.6×10^{6}J

<u>POWER</u>

Power of an agency is defined as

(i) work done per unit area
(ii) rate of doing work

<u>FORMULA:</u>

If work ΔW is done in time Δt then average power is given by

$$P_{av} = \frac{\Delta W}{\Delta t}$$

The instantaneous power is given by

$$P_t = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t}$$

Power-as a dot product

$$P_{av} = \frac{\Delta W}{\Delta t}$$

Since $\Delta W = \vec{F}.\Delta\vec{d}$

Therefore $P = \frac{\vec{F}.\Delta\vec{d}}{\Delta t}$

Or $P = \vec{F} \cdot \frac{\Delta\vec{d}}{\Delta t}$

But $\frac{\Delta\vec{d}}{\Delta t} = v$

Therefore $\boxed{\mathbf{P = F.v}}$

Hence power is the dot product of force and velocity.

UNITS OF POWER:

S.I unit of power is Watt (W).

In British engineering system, unit of power is foot pound per second (ft-lb/sec). If the work is done at a rate of 550ft-lb/sec. then power is said to be one horse-power (hp).

OTHER UNITS OF POWER:

- 1 kilowatt = 1 KW = 1000W
- 1 horse power= 1 hp= 746W
- 1 megawatt = 1 MW = 10^6W
- 1 gigawatt = 1 GW = 10^9W

WORK IN GRAVITATIONAL FIELD

GRAVITATIONAL FIELD IS A CONSERVATIVE FIELD:

A conservative field is that in which

(i) **Total work done along a closed path is zero.**

(ii) **Work done between two points does not depend upon the path followed by the body.**

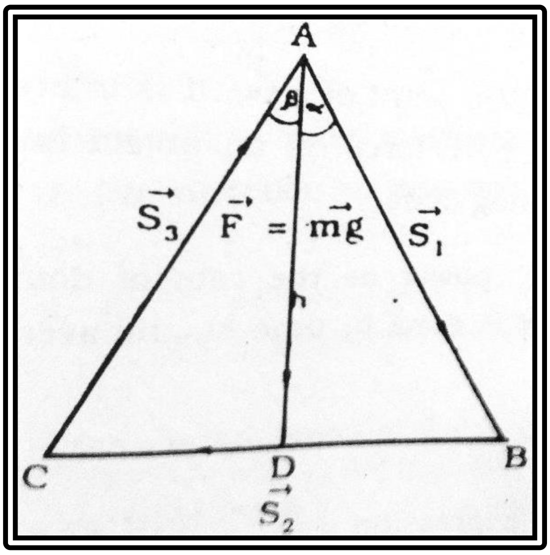
We can show that the gravitational field is a conservative field as follows.

(i) TOTAL WORK ALONG A CLOSED PATH IS ZERO:

Suppose a body is taken along a closed path ABCA is the closed as shown in figure $\vec{S_1}$, $\vec{S_2}$and $\vec{S_3}$ are the three displacements along the close path. Gravitational force along the whole path is $m\vec{g}$ which is directed vertically downward. $\overline{AD}$ is the altitude of length h. it is clear that

$S_1\cos\alpha = S_3\cos\beta = h$

Where α and β are the angles which the altitude $\overline{AD}$ makes with displacements $\vec{S_1}$ and $\vec{S_3}$.



WORK DONE BY GRAVITATIONAL FORCE FROM A TO B

$$W_{A\to B} = \vec{F}.\vec{S_1}$$

$$W_{A\to B} = FS_1\cos\alpha$$

$$W_{A\to B} = mg\,S_1\cos\alpha$$

$$W_{A\to B} = mg\,h \qquad (S_1\cos\alpha = h)$$

WORK DONE FROM B TO C

$$\underset{B\to C}{W} = \vec{F}.\overrightarrow{S_2}$$

$$\underset{B\to C}{W} = FS_2\cos 90°$$

$$\underset{B\to C}{W} = 0$$

WORK DONE FROM C TO A

$$\underset{C\to A}{W} = \vec{F}.\overrightarrow{S_3}$$

$$\underset{C\to A}{W} = FS_3\cos(180°-\beta)$$

$$\underset{C\to A}{W} = FS_3(-\cos\beta)$$

$$\underset{C\to A}{W} = -FS_3\cos\beta \qquad [\cos(180°-\beta)=-\cos\beta]$$

$$\underset{C\to A}{W} = -mgS_3\cos\beta$$

$$\underset{C\to A}{W} = -mgh \qquad (S_3\cos\beta = h)$$

TOTAL WORK

$$\underset{total}{W} = \underset{A\to B}{W} + \underset{B\to C}{W} + \underset{C\to A}{W}$$

$$\underset{total}{W} = mgh + 0 - mgh$$

$$\underset{total}{W} = 0$$

Hence total work along the closed path is zero.

(ii) WORK DOES NOT DEPEND UPON PATH

Movement from C to A and then from A to C will form a closed path. Hence as proved above

$$\underset{C\to A}{W} + \underset{A\to C}{W} = 0$$

$$-mgh + \underset{A\to C}{W} = 0$$

$$\underset{A\to C}{W} = mgh \text{ ---------------------- (i)}$$

now total work done from A to C via point B

$$\underset{A\to B\to C}{W} = \underset{A\to B}{W} + \underset{B\to C}{W}$$

$$\underset{A\to B\to C}{W} = mgh + 0$$

$$\underset{A\to B\to C}{W} = mgh \text{ -------------------- (ii)}$$

Comparing equations (i) and (ii) we get

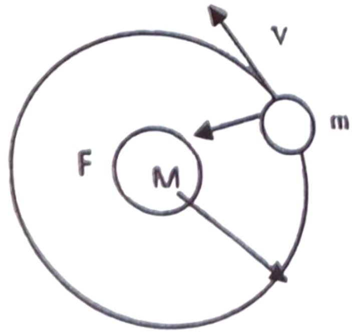
$$W_{A\to C} = W_{A\to B\to C}$$

Hence the work in moving directly from A to C is the same as the work in moving from A to C via point B.
Thus work between points A and C does not depend upon path. It is therefore proved that the gravitational field is a conservative field.

ESCAPE VELOCITY

“Minimum velocity with which the body has to be projected vertically upwards from the surface of the earth or any other planet so that it just crosses the gravitational field of earth or of that planet and never return on its own is called escape velocity.”

CONSIDERATION:



Work is done at the cost of kinetic energy given to the body at the surface of earth. If V_{es} is the escape velocity of the body projected from the surface of earth. Then kinetic energy of the body M and R are the mass and Radius of the earth respectively. The body will escape out of the gravitational field.

DERIVATION:

- $\frac{1}{2} mv_{es}^2 = GMm/R$
- $V_{es} = \sqrt{2GM/R}$
- Since, $g = GM/R^2$
- $V_{es} = \sqrt{2gR^2/R}$

$$\boxed{V_{es} = \sqrt{2gR}}$$

CONCLUSION:

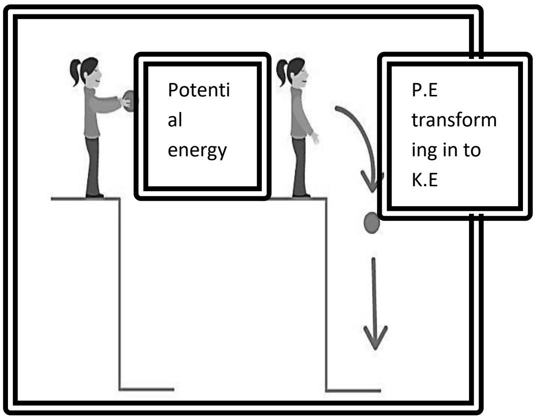
The value of V_{es} comes out to be approximately **11.2 km/s**. The value of escape velocity depends upon mass and radius of the planet of the surface from which the body as to be projected, clearly the values of escape velocity of a body will be different for different planets.

KINETIC ENERGY

DEFINITION:

"The energy possessed by a body due to its motion is called kinetic energy."

DERIVATION OF FORMULA:



Suppose a body of mass 'm' is thrown upward with initial velocity V. due to this velocity, the body has K.E. as the body moves upward it slows down and at a certain height h its velocity become zero. In fact the K.E of the body is used up in doing work against force of gravity. Hence

K.E= work done against force of gravity

Now,

Work done on the body by force of gravity

Work = $\vec{F} \cdot \vec{S}$

Work = $FS\cos\theta$

Where F is the force of gravity which is in downward direction whereas the distance S is being covered in upward direction. Hence $\theta=180°$

Thus

Work = $FS\cos180°$

Work = $mgh\cos180°$ (F=mg and S=h)

Work = $-mgh$ ($\cos180°=-1$)

This is the work done on the body by force of gravity. Hence the work done by the body against force of gravity will be equal to mgh. According to eq. (i) it must be equal to K.E of the body. Thus

K.E = mgh------------------- (i)

Now, from initial to final position of the body,

$V_i = v$

$V_f = 0$

$a= -g$

$S = h$

$2aS = V_f^2 - V_i^2$

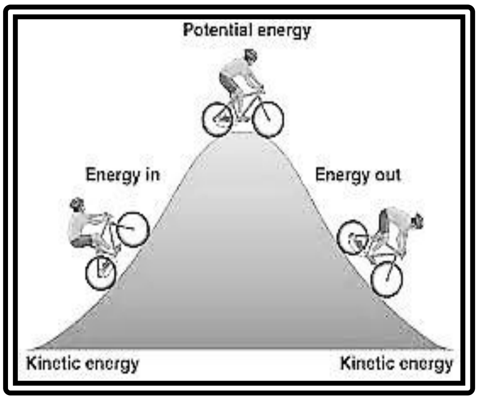
Put this value of h in eq.(ii)

K.E = mg x $\frac{v^2}{2g}$

$$\boxed{\mathbf{K.E = \frac{1}{2}mv^2}}$$

POTENTIAL ENERGY

"When a body is moved against a field of force, work is done on it. The energy stored in the body as a result of this work, is called potential energy."



EXAMPLES:

1. ELECTROSTATIC POTENTIAL ENERGY:

When a charge is moved against electrostatic force, work is done, which is stored in the charge as electrostatic potential energy.

2. ELASTIC POTENTIAL ENERGY:

When a spring is stretched or compressed, work is done against elastic force of the spring and energy is stored in it. This energy is called elastic potential energy.

3. GRAVITATIONAL POTENTIAL ENERGY:

When a body is moved against gravitational force, the work done on it is stored as gravitational potential energy.

DERIVATION OF FORMULA FOR GRAVITATIONAL P.E:

Suppose m is the mass of a body which is lifted to a height h. the force of gravity on the body is its weight mg, which is directed downward. Suppose the lifting force or external force $\vec{F}_{ex}$. Direction of this force is upward. If the body is lifted very slowly such that it gains no appreciable K.E then the work done by lifting force is stored as gravitational P.E hence

P.E = work done by external force against force of gravity

Work = $\overrightarrow{F_{ex}} \cdot \vec{S}$

Work = $F_{ex}S\cos\theta$

Work = $F_{ex}S\cos 0°$

P.E = $F_{ex}S$

As the body is moving upward very slowly, therefore magnitude of external force is equal to the weight of the body. i-e F_{ex} = mg also S=h

Hence

$$\boxed{\mathbf{P.E = mgh}}$$

This is the expression for gravitational P.E.

RELATIVE AND ABSOLUTE GRAVITATIONAL P.E

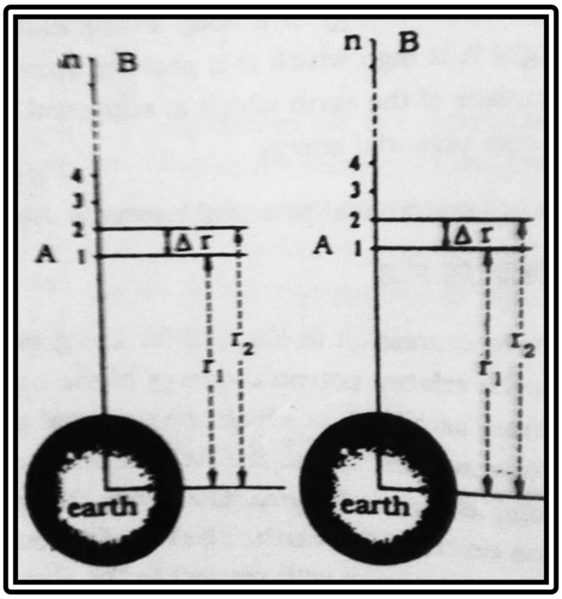
RELATIVE GRAVITATIONAL P.E:

When a body is at a height h from some reference level, it has gravitational potential energy equal to mgh. Infect mgh is the change in potential energy because the body already had some potential energy at the reference level.
When the gravitational P.E of a body is measured with respect to some non-zero P.E level, then the P.E of the body is called relative gravitational potential energy.

ABSOLUTE GRAVITATIONAL POTENTIAL ENERGY:

The gravitational P.E of a body at a point is said to be absolute gravitational P.E when it is measured with respect to a point of zero potential energy. The point of zero P.E is situated at finite distance from the center of the earth. At this point the gravitational field does not exist.

ABSOLUTE GRAVITATIONAL P.E AT THE SURFACE OF THE EARTH:



To calculate the absolute P.E at the surface of the earth, we shall first calculate the absolute P.E at point A which is above the earth's surface.
Suppose a body of mass m is lifted from point S to another point B, very far from A. the gravitational force on the body does not remain constant because the height from point A to B is large. Hence to calculate the work done in lifting the body from A to b, the displacement between these points is divided into small intervals of length Δr. work will be calculated individually for each interval and then all individual works will be added to get total work.

WORK DONE IN THE FIRST INTERVAL:

Gravitational force on mass m at point 1 is,

$$F_1 = G\frac{mM_E}{{r_1}^2}$$

Where G is gravitational constant, M_E is the mass of the earth and r_1 is the distance of point 1 from the center of the earth.

Gravitational force at point 2 is,

$$F_2 = G\frac{mM_E}{{r_2}^2}$$

Where r_2 is the distance of point 2 from the center of the earth.

The average force between points 1 and 2 is,

$$F = \frac{F_1+F_2}{2} = \frac{1}{2}(F_1 + F_2)$$

Substituting the values of F_1 and F_2 we get,

$$F = \frac{1}{2}\left(\frac{GmM_E}{r_1^2} + \frac{GmM_E}{r_2^2}\right)$$

$$F = \frac{GmM_E}{2}\left(\frac{1}{r_1^2} + \frac{1}{r_2^2}\right)$$

$$F = \frac{GmM_E}{2}\left(\frac{r_2^2 + r_1^2}{r_1^2 r_2^2}\right)$$

From the figure,
$r_2 = r_1 + \Delta r$
Put this value in the numerator,

$$F = \frac{GmM_E}{2}\left[\frac{(r_1 + \Delta r)^2 + r_1^2}{r_1^2 r_2^2}\right]$$

$$F = \frac{GmM_E}{2}\left(\frac{r_1^2 + 2r_1\Delta r + \Delta r^2 + r_1^2}{r_1^2 r_2^2}\right)$$

$$F = \frac{GmM_E}{2}\left(\frac{2r_1^2 + 2r_1\Delta r + \Delta r^2}{r_1^2 r_2^2}\right)$$

Since Δr is very small, therefore Δr^2 will be smaller and it may be neglected. Then

$$F = \frac{GmM_E}{2}\left(\frac{2r_1^2 + 2r_1\Delta r}{r_1^2 r_2^2}\right)$$

$$F = \frac{GmM_E}{2} \text{ X } 2\left(\frac{r_1^2 + r_1\Delta r}{r_1^2 r_2^2}\right)$$

$$F = GmM_E\left(\frac{r_1^2 + r_1\Delta r}{r_1^2 r_2^2}\right)$$

From the figure $\Delta r = r_2 - r_1$

Substituting this value in above equation we get,

$$F = GmM_E\left[\frac{r_1^2 + r_1(r_2 - r_1)}{r_1^2 r_2^2}\right]$$

$$F = GmM_E\left(\frac{\cancel{r_1^2} + r_1 r_2 - \cancel{r_1^2}}{r_1^2 r_2^2}\right)$$

$$F = GmM_E\left(\frac{\cancel{r_1}\cancel{r_2}}{r_1^{\cancel{2}} r_2^{\cancel{2}}}\right)$$

$$F = G\frac{mM_E}{r_1 r_2}$$

This value of force is assumed to be constant throughout first interval. Hence for this interval work is given by

$\Delta W_{12} = \vec{F}.\overrightarrow{\Delta r}$

$\Delta W_{12} = F\Delta r\cos\theta$

The force in lifting the body is upward and the displacement $\overrightarrow{\Delta r}$ is also upward, therefore θ=0° thus

$\Delta W_{12} = F\Delta r\cos 0°$

$\Delta W_{12} = F\Delta r$

Substituting the values of F and Δr we have,

$$\Delta W_{12} = G\frac{mM_E}{r_1 r_2}(r_2 - r_1)$$

$$\Delta W_{12} = GmM_E(\frac{r_2 - r_1}{r_1 r_2})$$

$$\Delta W_{12} = GmM_E(\frac{1}{r_1} - \frac{1}{r_2}) \text{ ------------------ (i)}$$

WORK DONE IN OTHER INTERVALS:

From equation (i) work in other intervals can be guessed. Hence

$$\Delta W_{23} = GmM_E(\frac{1}{r_2} - \frac{1}{r_3})$$

$$\Delta W_{34} = GmM_E(\frac{1}{r_3} - \frac{1}{r_4})$$

$$\Delta W_{(n-2)(n-1)} = GmM_E(\frac{1}{r_{n-2}} - \frac{1}{r_{n-1}})$$

$$\Delta W_{(n-2)n} = GmM_E(\frac{1}{r_{n-2}} - \frac{1}{r_n})$$

TOTAL WORK FROM POINT A TO B (from 1 to n)

$W_{1n} = \Delta W_{12} + \Delta W_{23} + \Delta W_{34} + \ldots\ldots\ldots\ldots\ldots + \Delta W_{(n-2)(n-1)} + \Delta W_{(n-1)n}$

$$\Delta W_{1n} = GmM_E(\frac{1}{r_1} - \frac{1}{r_N}) \text{----------------- (iii)}$$

This work is stored in the body as gravitational P.E. since the body already had some P.E at point 1, therefore it is the relative gravitational P.E at point n with respect to point 1. It may be written as,

$$\Delta u = GmM_E(\frac{1}{r_1} - \frac{1}{r_N})$$

The relative gravitational P.E at point 1 with respect to point n will therefore be,

$$\Delta u = -\, GmM_E(\frac{1}{r_1} - \frac{1}{r_N})$$

if the point n is situated at infinity then P.E at point n will become zero and the distance r_n = α. the above equation will then give the absolute gravitational P.E at point 1, which is expressed as

$$u_1 = -GmM_E\left(\frac{1}{r_1} - \frac{1}{\alpha}\right)$$

As $\frac{1}{\alpha} = 0$

Therefore

$$u_1 = -GmM_E\left(\frac{1}{r_1}\right)$$

$$u_1 = -\frac{GmM_E}{r_1}$$

Where r_1 is the distance of point 1 from the center of the earth.

It is clear that the absolute P.E at the surface of the earth will be,

$$\boxed{\mathbf{u} = -\frac{\mathbf{GmM_E}}{\mathbf{R_E}}} \text{ ------------------------ (iii)}$$

Where R_E is the radius of the earth.

<u>ABSOLUTE GRAVITATIONAL P.E AT HEIGHT 'H' ABOVE THE EARTH'S SURFACE:</u>

Suppose h is the height of a point above earth's surface such that $h << R_E$. According to eq.(iii) the absolute P.E at this point is given by,

$$u = -\frac{GmM_E}{(R_E + h)}$$

or

$$u = -\frac{GmM_E}{R_E\left(1 + \frac{h}{R_E}\right)}$$

or

$$u = -\frac{GmM_E}{R_E}\left(1 + \frac{h}{R_E}\right)^{-1}$$

Expanding $\left(1 + \frac{h}{R_E}\right)^{-1}$using binomial theorem, we get

$$u = -\frac{GmM_E}{R_E}\left[1 - \frac{h}{R_E} + \left(\frac{h}{R_E}\right)^2 - \left(\frac{h}{R_E}\right)^3 + -----\right]$$

Since $\frac{h}{R_E}$ is very small number, therefore its higher powers may be neglected.

We get,

$$\boxed{u = -\frac{GmM_E}{R_E}\left(1 - \frac{h}{R_E}\right)}$$

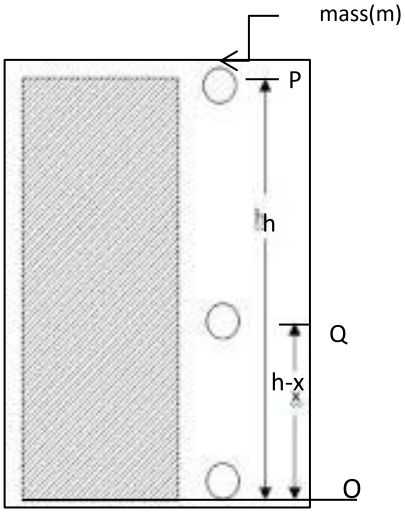
It should be remembered that this relation applies for small attitudes only.

INTERCONVERSION OF P.E AND K.E (FREE FALLING BODIES)

Consider a body of mass m placed at a point P which is at a height h from same level O. if the level O is assumed to be a level of zero P.E then at a point P, the body has P.E equal to mgh.

If the body falls through a distance x, it reaches to a point Q which ai at height (h-x) from the level O. the P.E of the body at point Q is mg(h-x) and

mg(h-x) = mgh – mgx



Hence the body has lost P.E by an amount mgx. If air friction is neglected then this P.E is converted into K.E. if the body reaches to level O then all of its P.E is converted into K.E and we may write,

Loss in P.E = gain in K.E

Now suppose the air friction is also present. When the body falls downward it does work against air friction and thus some of the P.E is used up in dowing work. if 'f' is the air friction then the work done against it is fxh when the body falls from point P to point O. thus from the P.E mgh, energy fxh is lost and the remaining energy is converted into K.E , we may therefore write,

mgh – fxh = gain in K.E

or

mgh = gain in K.E + fxh

or

Loss in P.E = gain in K.E + fh

Loss in p.E = gain in K.E + work done against air friction

This equation is called work-energy equation.

TRANSFORMATION OF ENERGY

The law states that;

"Energy can neither be created nor it can be destroyed, however it can be converted from one form to another".

Einstein showed that both mass and energy are inter convertible. He gave the equation

$$\boxed{\mathbf{E = mc^2}}$$

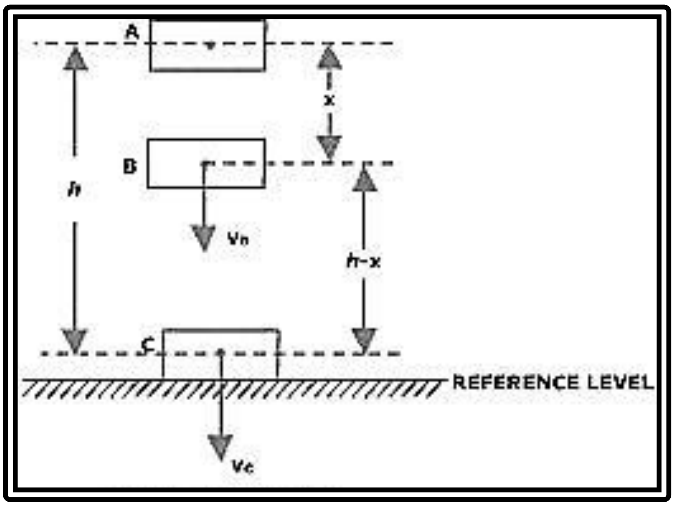
Where E is the energy, m is the mass and C is the speed of light ($3x10^8$m/s)

In fission and fusion reactions large amount of energy is obtained from loss of mass. Sometimes a photon of energy disappears and produces a pair of electron and position. The phenomenon is known as pair production.

From above discussion we conclude that we can create energy by expending something or when we destroy energy we must get something in return.

We can show that total amount of mechanical energy i-e the sum of P.E and K.E remains constant when a body moves under the influence of gravity in the absence of air friction.

Suppose a body of mass m falls from point A to B. the level of point B is assumed to be a level of zero P.E. the sum of K.E and P.E at point A is given by,



$K.E_A + P.E_A = 0 + mgh$

$K.E_A + P.E_A = mgh$---------------- (i)

Similarly for point B,

$K.E_B + P.E_B = \frac{1}{2}mV_B{}^2 + 0$

$K.E_B + P.E_B = \frac{1}{2}mV_B{}^2$-------------- (ii)

Where V_B is the speed of the body at point B.

from A to B we have,

$V_i = 0$

$V_f = V_B$

$a = g$

$S = h$

$Vf2 – Vi2 = 2aS$

$V_B^2 – 0 = 2gh$

$V_B^2 = 2gh$

Substituting this value in eq. (ii) we get,

$K.E_B + P.E_B = \frac{1}{2} m \times 2gh$

$K.E_B + P.E_B = mgh$ ------------------ (iii)

Comparing eq.(i) and (ii), we have

$K.E_A + P.E_A = K.E_B + P.E_B$

When the body falls to a point C through a distance x then sum of K.E and P.E is given by

$K.E_C + P.E_C = \frac{1}{2} mV_C^2 + mg(h - x)$ ------------------- (iv)

Where V_c is the speed at a point C. thus from point A to C we have,

$V_i = 0$ $V_f = V_C$

$a = g$ $S = x$

$V_f^2 - V_i^2 = 2aS$

$V_C^2 - 0 = 2gx$

or $V_C^2 = 2gx$

Put the value of V_C^2 in eq.(iv)

Then

$K.E_C + P.E_C = \frac{1}{2} m \times 2gx + mg(h - x)$

$K.E_C + P.E_C = mgx + mgh - mgx$

$K.E_C + P.E_C = mgh$ ------------------ (v)

compairing equations (i),(iii) and (v) we get

$\mathbf{K.E_A + P.E_A = K.E_B + P.E_B = K.E_C + P.E_C}$

Thus total amount of mechanical energy remains constant.

<u>Kinetic Energy</u>	**<u>Potential Energy</u>**
• Energy stored in the body due to its motion is called kinetic energy • Formula for kinetic energy is $\frac{1}{2}\mathbf{mv^2}$	• Energy stored in the body due to work, is called potential energy • Formula for potential energy is mgh

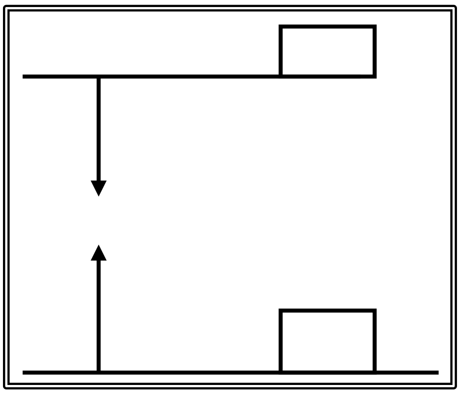
FORMULA SHEET

- **Work = FScosθ**
- $\mathbf{P_{av}} = \frac{\Delta W}{\Delta t}$
- $\mathbf{P = F.v}$
- $\mathbf{K.E = \frac{1}{2}mv^2}$
- $\mathbf{P.E = mgh}$
- $\mathbf{u = -\frac{GmM_E}{R_E}\left(1 - \frac{h}{R_E}\right)}$
- $\mathbf{E = mc^2}$

SCIENTIFIC REASON

Q.1. Does the work done raising a box onto a platform depends upon how fast it is raised up? If not why.

Ans. Work done is given by : Work done = $\vec{F}.\vec{h}$
The work done on the body in raising a box on the platform will appear as increase in P .E.
Work done = Wh = mgh
This equation shows that work done depends upon mass and height and is independent of the velocity of the body. Hence same work will be done if box is raised fast or slow.



Q.2. A light body and a heavy body have equal kinetic energy. Which will have greater momentum?

Ans. Momentum of the body of mass "m" moving with velocity "v" is

$$P = mv$$

And kinetic energy is

$$K.E = K = \frac{1}{2}mV^2$$

$$2K = mV^2$$

$$2Km = m^2v^2$$

$$2Km = (mv)^2 \quad (P = mv)$$

$$2Km = P^2$$

or $$P = \sqrt{2Km}$$

Here k (K.E) is same for both so 'P' is large if 'm' is large. Thus momentum is greater for the heavy body.

Q.3. A light body and a heavy body have the same momentum. Which one has more Kinetic energy?

Ans. As we know that

$$2Km = P^2 \qquad \text{(see above)}$$

$$K = \frac{P^2}{2m}$$

"p" is same for both so 'K' will be large if 'm' is small i.e. light body has more Kinetic energy.

Q.4. What happens to the Kinetic Energy of the bullet when it penetrates into a target?

Ans. When a bullet penetrates into a target, is velocity decreases and becomes zero after covering some distance. So its K.E becomes zero, and is converted into work. By the Work-Energy equation.

Loss in K.E = Work done

Q.5. A block of wood is taken to the bottom of a lake. Does the block posses potential energy? Explain.

Ans. When a wooden block is taken to the bottom of a lake, we have to do work against the up thrust of water by applying an external force on it. This work done is stored in the block as P.E. And when we remove external force, it comes out at the surface and starts floating. This shows that the P.E. is converted into K.E of a wooden block

<u>FIVE YEAR QUESTION</u>

- A pump of how much minimum horse power is needed to lift water through a height of 2.5 m at rate of 50g/min. **(2014)**
- A horse pulls a cart horizontally with a force of 40N at an angle of 25^o above the horizontal and moves along at a speed of 15 m/s. how much work will the horse do in minutes. What is the power output of the horse. Give your answer in horse power. **(2013)**
- Show that gravitational field of earth is a conservation field. **(2014)**
- Derive work energy equation. **(2015)**
- A water pump is needed to lift water through a height of 2.5 m at a rate of 500 gm/minute. Find its minimum power in horse power. **(2011)(2010)**