Chapter = 04

Work and Energy

What is work? Calculate the Work done on constant force.

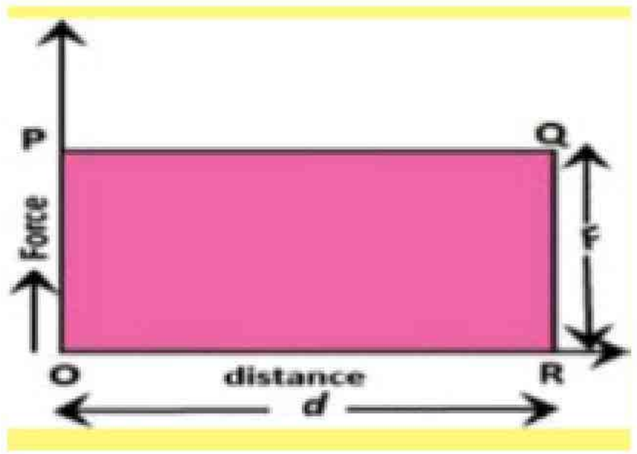
Work: "The dot product of force and displacement is called work". OR The product of the magnitudes of the displacement and the component of the force in the direction of displacement is called work.

Mathematically: $W=\vec{F}.\vec{d}$ = d (FcosΘ) or F (dcosΘ) = Fd cosΘ

Unit: As W=Fd= ($kgms^{-2}$) (s) =Kgm^2s^{-2} which is equal to joule. Its SI unit is Nm=joule. It is scalar quantity.

Definition of joule: When one newton force acts on a body and it cover distance of 1m in the direction of force, than work is said to one joule. 1N*1m=1 J

Dimension: The dimension of work are W=Fd= $[MLT^{-2}]$ [L] = $[ML^2T^{-2}]$



Important points about work: Important points about work are

a) If Θ<90°, work is positive

(As W= Fd cosΘ, as angle CosΘ is positive at less than 90°)

b) If Θ>90°, work is negative

(As W= Fd cosΘ, as angle CosΘ is negative at greater than 90°)

c) If Θ=90°, no work is done

(As W= Fd cosΘ, as angle CosΘ is zero at 90°)

d) If Θ=0°, work is maximum

Constant force: Such a force whose magnitude and direction remains same is called constant force.

Work done by constant force graphical representation: When a constant force acts through a distance d then it can be shown graphically by plotting graph b/w F and d, taking d along x-axis and F along Y axis

Graph for work done by constant force is horizontal straight line parallel to X-axis

Work from graph: Area under the force-displacement curve shows the work done by force graphically.

Area of rectangle=Length*width= Fd=Work

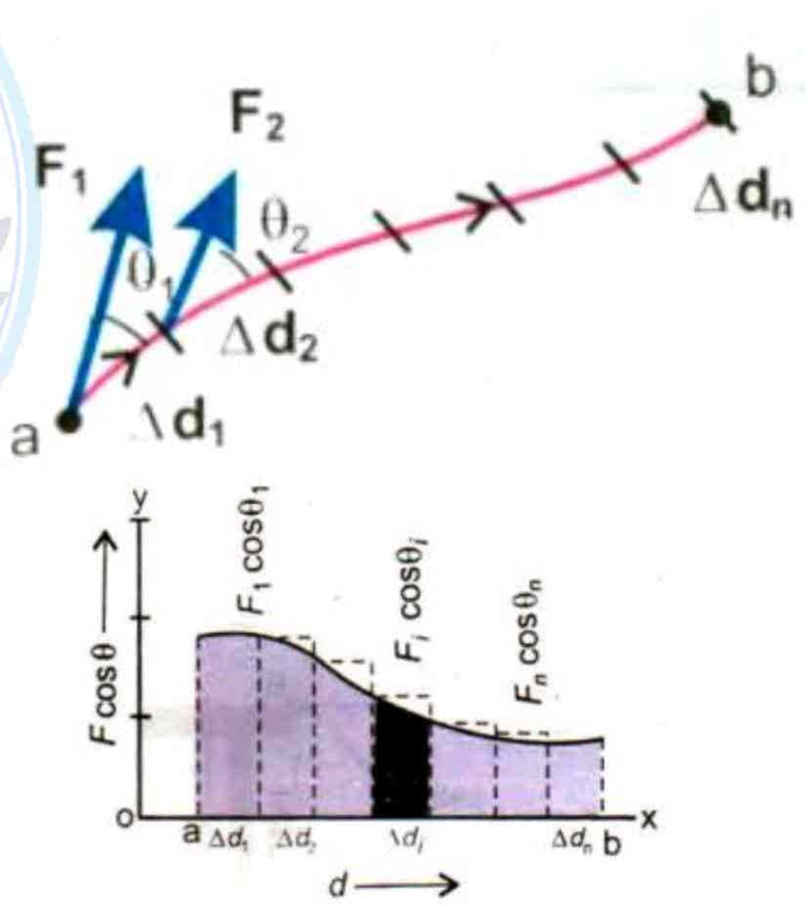
What is variable force? Calculate the work done by variable force.

Variable force: If the magnitude or direction or both of force changes then it is called variable force. For example.

a) Force of gravity on rocket moving away from earth
b) Force exerted by spring.

Work done by variable force: Consider a particle in XY plane moving fr

short interval into displacements $\Delta\vec{d}_1, \Delta\vec{d}_2, \Delta\vec{d}_3, ...\Delta\vec{d}_n$ and forces $\vec{F}_1, \vec{F}_2$



$$\text{Work done by first interval} = \Delta W_1 = \vec{F}_1.\Delta\vec{d}_1 = F_1\Delta d_1\cos\theta_1$$

$$\text{Work done by 2nd interval} = \Delta W_2 = \vec{F}_2.\Delta\vec{d}_2 = F_2\Delta d_2\cos\theta_2$$

$$\text{Work done by 3rd interval} = \Delta W_3 = \vec{F}_3.\Delta\vec{d}_3 = F_3\Delta d_3\cos\theta_3$$

$$\text{Work done by nth interval} = \Delta W_n = \vec{F}_n.\Delta\vec{d}_n = F_n\Delta d_n\cos\theta_n$$

$$\text{Total Work} = \Delta W_1 + \Delta W_2 + \Delta W_3 + ...\Delta W_n$$

$$W = F_1\Delta d_1\cos\theta_1 + F_2\Delta d_2\cos\theta_2 + F_3\Delta d_3\cos\theta_3 + ... + F_n\Delta d_n\cos\theta_n$$

$$W = \sum_i^n F_i\Delta d_i\cos\theta_i$$

This is the work done by variable force.

Graphical Representation: We can calculate the work graphically by plotting graph b/w FcosΘ and d. Area under the graph is divided into n rectangle for each interval. Area of each rectangle show the work done during that interval.

What is gravitational field? Calculate the Work done by gravitational field.

Gravitational field: The space around the Earth in which its gravitational force acts on a body is called gravitational field.

Sign conventions for work done in gravitational field:

a) If displacement is in the direction of gravitational force work is positive
b) If displacement is against the direction of gravitational force, work is negative
c) If displacement is perpendicular to the direction of gravitational force, work is zero

Work done by gravitational field: let us consider a body of mass m being displaced with constant velocity from point A to point B along different path in the presence of gravitational force.

Path-1 Work done along path ADB: This work done is divided into two parts $W_{ADB} = W_{A\to D} + W_{D\to B}$

$W_{A\to D} = \vec{F}.\vec{d} = Fd\cos\theta = mg(d)\cos 90^\circ = 0$, $W_{D\to B} = \vec{F}.\vec{d} = Fd\cos\theta = mg(h)\cos 180^\circ = -mgh$

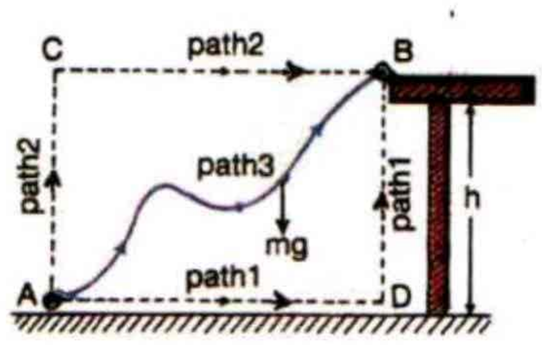
$W_{ADB} = 0 + (-mgh) = -mgh$ ----------(1)

Path-1 Work done along path ACB: This work done is divided into two parts $W_{ACB} = W_{A\to C} + W_{C\to B}$

$W_{A\to C} = \vec{F}.\vec{d} = Fd\cos\theta = mg(h)\cos 180^\circ = -mgh$, $W_{C\to B} = \vec{F}.\vec{d} = Fd\cos\theta = mg(d)\cos 90^\circ = 0$

$W_{ADB} = (-mgh) + 0 = -mgh$ ----------(2)

Path-3 Work done along the curved path AB: Work done along the path AB is divided into small intervals upon which work done is calculated by adding work of each interval



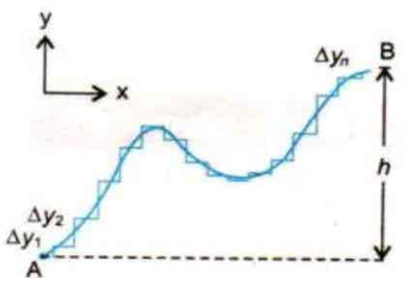
$W_{AB} = mg\Delta y_1 \cos 180^o + mg\Delta y_2 \cos 180^o + mg\Delta y_3 \cos 180^o + ... + mg\Delta y_n \cos 180^o$

$W_{AB} = -mg\Delta y_1 + (-mg\Delta y_2) + (-mg\Delta y_3) + ... + (-mg\Delta y_n)$

$W_{AB} = -mg(\Delta y_1 + \Delta y_2 + \Delta y_3 + ... + \Delta y_n)$ as $h = \Delta y_1 + \Delta y_2 + \Delta y_3 + ... + \Delta y_n$

$W_{AB} = -mg(h) = -mgh$, ---------(3)

Eq(1), (2) and (3) shows that work done along any path give same value so work done is independent of path followed. So work done by gravitational field is independent of path followed.



Work done along closed path:

$W_{ADBCA} = W_{A\to D} + W_{D\to B} + W_{B\to C} + W_{C\to A}$

$W_{ADBCA} = Fd\cos 90^o + Fd\cos 180^o + Fd\cos 90^o + Fd\cos 0^o$

$W_{ADBCA} = 0 + (-mgh) + 0 + (mgh) = 0$, This shows that work done along closed path is zero

Conservative field: The field in which work is independent of path followed" OR the field in which work done along closed path is zero is called conservative field for example, gravitational field, electric field, magnetic field etc.

Non conservative forces: like frictional force, air resistance, tension in string etc.

What is Power? What is average and instantaneous power?

Power: The rate of doing work is called power. Work done per unit time is called power. P=Work/time=W/t
SI unit of power is J/S= watt. It is scalar quantity.

Average power: Total work done divided the total time taken is called average power. $< P >= \frac{\Delta W}{\Delta t}$

Instantaneous power: The value of power at any instant of time in which time approaches to zero instantaneous power. $P_{ins} = Lim\Delta t \to 0 \frac{\Delta W}{\Delta t}$

Watt: The power is said to be one watt if one joule of work is done in one second. 1 J/1sec= 1 watt

Prove that $P = \vec{F}.\vec{v}$

let F is the force acting on moving body with velocity v then power

$$P = \lim \Delta t \to 0 \frac{\Delta W}{\Delta t} = \lim \Delta t \to 0 \frac{\vec{F}.\Delta \vec{d}}{\Delta t}$$

$$P = \vec{F}.(\lim \Delta t \to 0 \frac{\Delta \vec{d}}{\Delta t}) =$$

$P = \vec{F}.\vec{v}$, which show that Scalar product of force and velocity is called power.

Define KWh. Prove that 1kwh=3.6 MJ.

The work done in one hour by a source whose power is 1000 watt is called Killo watt hour. KWh is unit of energy.

$1KWh = 1000W * 3600sec$

$1KWh = 1000 * 3600 \ \ Wsec$

$1KWh = 36 * 10^5 \ J = 3.6 * 10^6 J$

$1KWh = 3.6 \ M \ J$

What is Energy? define the types of energies.

Energy: The ability of body to do work is called energy.
Types of Energy: It has two types a) kinetic energy b) potential energy.

Kinetic energy: Energy possessed by a body due to its motion is called kinetic energy. Formula is $K.E = \frac{1}{2}mv^2$.

Potential energy: Energy possessed by a body due to its position is called P.E. Its formula P.E=mgh.
Gravitational potential energy: The potential energy due to gravitational field at a height h from surface of earth is called gravitational potential energy P.E=mgh
Elastic potential energy: The energy stored in a compressed/ stretched string is called elastic potential energy it is $\frac{1}{2} Kx^2$.

State and explain Work Energy principle.

Statement: work done on a body is equal to change in Kinetic energy, $W=\Delta K.E$
Derivation: let us consider a body mass m moving with initial vi and after some distance d its velocity becomes vf by applying force F then we can calculate the work

$W = Fd$ ----------(1)

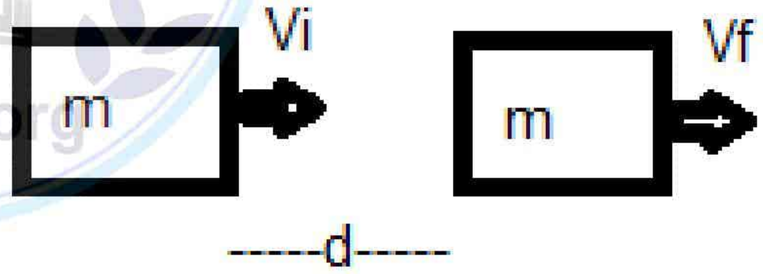
According to the equation of motion

$2ad = v_f^2 - v_i^2$

$d = \frac{v_f^2 - v_i^2}{2a}$ ---------(2)

also $F = ma$ ----------(3)

puttingin equation (1)



$W = ma(\frac{v_f^2 - v_i^2}{2a})$

$W = m(\frac{v_f^2 - v_i^2}{2}) = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = K.E_f - K.E_i = \Delta K.E$

Work = ΔK.E, which is required result

Similarly if a spring is compressed, the work done on it is equals the increase in its elastic potential energy.

What is Absolute Potential Energy? Derive its relation.

Definition: The work done by gravitational force in displacing an object from a position to infinity where the force of gravity becomes zero is called absolute P.E. $U = \dfrac{-GMm}{R}$.

Derivation: As the relation for work done by gravitational force P.E=mgh is true when object is near the surface of Earth and gravitational force remains constant. But if the body is displaced through a large distance, gravitational force does not remain constant, it varies inversely proportional to square of distance. In order to calculate the work done by it the distance b/w 1 to N is divided small steps so that the value of force remains constant for each step. The work done displacing a body from point 1 to point 2 can be calculated as

The distance b/w the center of this step and center of Earth will be $r = \dfrac{r_1 + r_2}{2}$

$r_2 - r_1 = \Delta r$ then $r_2 = \Delta r + r_1$

$$r = \frac{r_1 + \Delta r + r_1}{2} = \frac{2r_1 + \Delta r}{2} = \frac{2r_1}{2} + \frac{\Delta r}{2} = r_1 + \frac{\Delta r}{2}$$

$$r^2 = (r_1 + \frac{\Delta r}{2})^2 = {r_1}^2 + (\frac{\Delta r}{2})^2 + 2(r_1)(\frac{\Delta r}{2}) = {r_1}^2 + r_1(\Delta r)$$

$$r^2 = {r_1}^2 + r_1(r_2 - r_1) = {r_1}^2 + r_1 r_2 - {r_1}^2 = r_1 r_2$$

Force becomes $F = G\dfrac{Mm}{r^2} = G\dfrac{Mm}{r_1 r_2}$

$$W_{1\to 2} = \vec{F}.\Delta\vec{r} = F\Delta r\cos 180^o = -G\frac{Mm}{r_1 r_2}(\Delta r) = -GMm\frac{\Delta r}{r_1 r_2} = -GMm\frac{r_2 - r_1}{r_1 r_2}$$

$$W_{1\to 2} = -GMm(\frac{r_2}{r_1 r_2} - \frac{r_1}{r_1 r_2}) = -GMm(\frac{1}{r_1} - \frac{1}{r_2}) \text{ ----------(1)}$$

Similarly $W_{2\to 3} = -GMm(\dfrac{1}{r_2} - \dfrac{1}{r_3})$ ----------(2)

$W_{3\to 4} = -GMm(\dfrac{1}{r_3} - \dfrac{1}{r_4})$ ----------(3)

$W_{N-1\to N} = -GMm(\dfrac{1}{r_{N-1}} - \dfrac{1}{r_N})$ ----------(N)

Adding all above equations to calculate the total work

$$W_{total} = W_{1\to 2} + W_{2\to 3} + \ldots\ldots\ldots\ldots + W_{N-1\to N}$$

$$W_{total} = -GMm(\frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_2} - \frac{1}{r_3} + \frac{1}{r_3} - \frac{1}{r_4} + \ldots\ldots \frac{1}{r_{N-1}} - \frac{1}{r_N})$$

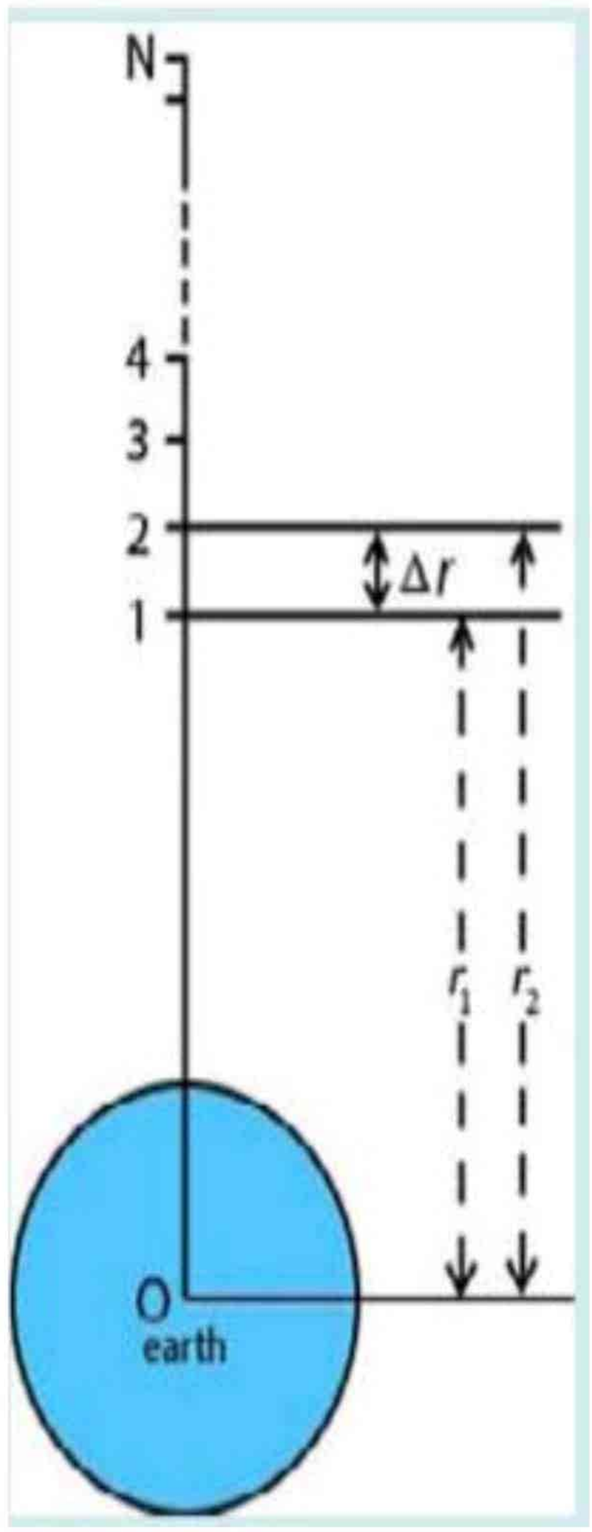
$W_{total} = -GMm(\dfrac{1}{r_1} - \dfrac{1}{r_N})$ $\quad r_N = \infty, then \quad \dfrac{1}{r_N} = \dfrac{1}{\infty} = 0$

$W_{total} = -GMm(\dfrac{1}{r_1} - 0) = -\dfrac{GMm}{r_1}$, this work is stored in form of gravitational P.E

$U = -\dfrac{GMm}{r_1}$, the general expression for distance r from center of earth is $U = -\dfrac{GMm}{r}$

When r increases U also increase and absolute potential on the surface of Earth is r = R

$U = -\dfrac{GMm}{R}$, $-$ive sign shows that Earth's gravitational field for mass is attravitve.



What is Escape velocity? Derive its relation.

Definition: The velocity of a body with which it goes out of Earth's gravitational field is called escape velocity. Its formula $V_{esc} = \sqrt{2gR}$. It depends upon radius and g of planet. Its value for earth 11.2 km/sec.

Derivation:

The initital K.E carries an object to infinite distance from surface of Earth

$$\text{K.E} = \frac{1}{2}mv^2 \text{ ----------(1)}$$

As work done in lifting a body from Earth's surface to infinity is equal to increase in P.E

$$\text{Increase in P.E} = (\text{P.E})_f - (\text{P.E})_i = 0 - (-G\frac{Mm}{\text{R}}) = G\frac{Mm}{\text{R}} \text{ ---------(2)}$$

The body will escape out the gravitational field when both energies are equal

$$\frac{1}{2}mv^2 = G\frac{Mm}{\text{R}} \quad \Rightarrow v^2 = \frac{2GM}{\text{R}}$$

$$v_{esc} = \sqrt{\frac{2GM}{\text{R}}} \text{ ----------(3)}$$

comparing the forces which are acting $\text{mg} = G\frac{Mm}{\text{R}^2}$

$\text{GM} = \text{gR}^2$, putting in equation (3)

$$v_{esc} = \sqrt{\frac{2\text{gR}^2}{\text{R}}} = \sqrt{2\text{gR}}, \text{ This is the formula for escape velocity}$$

for Earth $\text{g} = 9.8\ \text{ms}^{-2}, \text{R} = 6.4*10^6\ \text{m}$

$$\text{V} = \sqrt{2\text{gR}} = \sqrt{2*9.8*6.4*10^6} = 11.2*10^3$$

$$\text{V} = 11.2\ \text{km/s}$$

Explain Interconversion of potential energy and kinetic energy and Conservation of Energy.

Statement: "Energy cannot be created nor destroyed but it can be transformed from one form to other".

Equation: Total energy= P.E+K.E

Consider a body of mass m at rest, at a height h above the surface the Earth. To calculate the P.E and K.E at different position can be calculated as follows

At position A: The body has P.E=mgh and K.E=0, Total Energy= P.E+K.E=mgh+0, total Energy=mgh … (1)

At position B: To calculate the Total Energy at position B when body has fallen through a distance x ignoring friction.

$$\text{P.E} = \text{mg(h - x)} \text{ ------(i)}$$

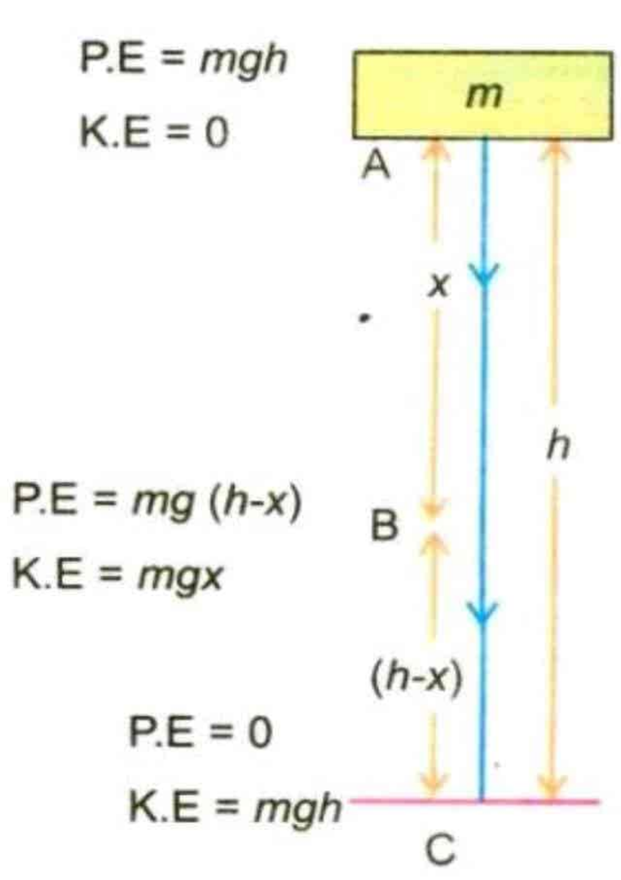
$$\text{K.E} = \frac{1}{2}mv_B^2 \quad \text{to calculate } \text{V}_\text{B} \text{ at point B using equation}$$

$$2\text{aS} = \text{V}_\text{f}^2 - \text{V}_\text{i}^2 \Rightarrow 2\text{gx} = (0)^2 - \text{V}_\text{B}^2 \Rightarrow \text{V}_\text{B}^2 = 2\text{gx} \quad \text{put in equation of K.E}$$

$$\text{K.E} = \frac{1}{2}\text{m}(2\text{gx}) = \text{mgx} \text{ ------(ii)} \quad \text{adding (i) and (ii)}$$

$$\text{E} = \text{P.E} + \text{K.E} = \text{mg(h} - \text{x}) + \text{mgx} = \text{mgh} - \text{mgx} + \text{mgx}$$

$$\text{E} = \text{mgh} \text{ ----------(2)}$$



At point C: Just before strikes the Earth, P.E=0 and K.E= ½ mv_c^2, to find the value of Vc using the equation

$2gh = V_C^{\,2} - (0)^2 \quad \Rightarrow V_C^{\,2} = 2gh$ put in equation of K.E

$$K.E = \frac{1}{2}m(2gh) = mgh \text{ -----(ii)}$$ adding K.E and P.E at point C

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

$$E = mgh \text{ ----------(3)}$$

From equation (1), (2) and (3) it is clear that energy can be changed from one form to other but total remains same. As

$$\textit{Loss} \text{ in P.E} = \text{Gain in K.E} \quad \Rightarrow mg(h_1 - h_2) = \frac{1}{2}m(v_2^{\,2} - v_1^{\,2})$$

In case of frictional force present during downward motion: In this case a part of P.E is used in doing work again friction equal to W=fh the remaining P.E= mgh-fh is converted into K.E

$$mgh - fh = \frac{1}{2}mv^2 \quad \Rightarrow mgh = \frac{1}{2}mv^2 + fh.$$

Loss in P.E= Gain in K.E+ work done against friction

What are Non-conventional Energy sources? Explain.

Definition: The sources which are not commonly used are called non-conventional energy sources.
Names of sources: i) Energy from tides ii) Energy from waves iii) Solar Energy iv) Energy from biomass
Energy obtained from tides: Gravitational force of the moon produces tides in the sea twice a day which can be trapped in a basin by constructing a dam at high tide then water is released in control way to run the turbine and generate electricity
Energy obtained from waves: The tides and winds blow across the surface of ocean water waves produce and energy of these wave can generate electricity.
Salter's duck: The device which converts energy of waves into electricity is called salter duck. It has two parts
Duck float and balance float: The wave energy produce the movement in duck float relative to balance float which generate electricity.
Solar energy: The energy obtained from sun is called solar energy.
Solar constant & its value: Solar energy at normal incidence outside the earth's atmosphere per second per unit area is called solar constant. Its value 1.4 KWm^{-2}.
Solar cell: The device which converts sunlight into electrical energy is called solar cell.
Uses of solar cell: They are used in remote ground based weather stations and in solar calculators.
Energy obtained from biomass: Biomass include organic materials such as crops residue, natural vegetation, trees and animal dung and sewage. There are two methods for conversion of biomass into fuel. (i) Direct combustion (ii) Fermentation.
Geothermal energy: The heat energy extracted from inside the earth in the form of hot water or steam is called geothermal energy.
Digester: Rotting of biomass in a closed tank is called digester.
Aquifer: A layer of rock holding water that allow water to percolate through with pressure is called aquifer.

Renewable	Non renewable	Source of Energy	Original source
Hydroelectric	Coal	Solar, Bio mass	Sun
Wind	Natural gas	Hydroelectric,	Sun
Tides	Uranium	Wind, waves, Fossil fuels	Sun
Biomass	Oil	Tides	Moon
Sunlight	Oil shale	geothermal	Earth

How pollution can be reduced: Pollution can be reduced if (i) people use mass transportation (ii) use geothermal, solar and other renewable energy sources.
How can we save energy: (i) Turning off the light and electrical devices when not in use (ii) Using Energy saver instead bulb (iii) using solar energy (iv) Taking short hot showers.

Chapter = 04

Exercise Short Questions

4.1 A person hold a bag of groceries while standing still, talking to a friend. A car is stationary with its engine running. From the standpoint of work, how are these two situations similar?

Ans. In both cases work is zero, as there is no displacement; W = F d cos θ = F x 0 x cos θ = 0

4.2 Calculate the work done in kilo joules in lifting a mass of 10 kg (at a steady velocity) through a vertical height of 10 m.

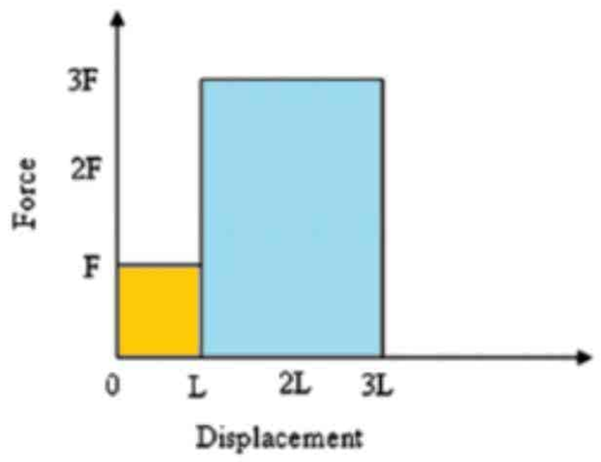
Ans. W = F d cos0o = F d =(mg) d = 10x9.8x10 = 980 J, divide and multiply by 1000 to get result =0.98 KJ

4.3.A force F acts through a distance L. the force is then increased to 3 F, and then acts through a further distance of 2 L. Draw the work diagram to scale.

$$Work = W = (F * L) + (3F * 2L)$$

$$work = FL + 6FL$$

$$work = 7FL$$



4.4 In which case is more work done? When a 50 kg bag of books is lifted through 50 cm, or when a 50 kg crate is pushed through 2 m across the floor with a force of 50 N?

Ans. For books: W = F d cos θ = mgh cos 0o = mgh = 50 x 9.8 x 0.5 = 245 J (more work)

For crate: W = F d cos θ = Fdcos 0o = Fd = 50 x 2 = 100 J More work is done in lifting bag of books.

4.5 An object has 1 J of potential energy. Explain what it means?

An object has one joule of potential energy means that body has capacity to do work of one joule, it means a force of one N is required to raise through a height of 1m. 1J=! N*1m.

4.6 A ball of mass m is held at a height h1 above a table. The tabletop is at a height h2 above the floor. One student says that the ball has potential energy mgh1 but another says that it is mg (h1 + h2). Who is correct?

Both are correct according to their own point of view.

4.7 When a rocket re-enters the atmosphere, its nose cone becomes very hot. Where does this heat energy come from?

Due to work again air friction and with dust particles in air this work converts into heat and nose cone becomes very hot.

4.8 What sort of energy is in the following:

a) Compressed spring= Elastic potential energy

b) Water in a high dam= Gravitational P.E

c) A moving car= Kinetic energy

4.9. A girl drops a cup from a certain height, which breaks into pieces. What energy changes are involved?

When the cup was in the hands of girl it has gravitational P.E when it drop it gain K.E and when it strike the ground this K.E converts into sound energy, heat energy and work in breaking the cup PE → gain in KE → sound energy + heat energy

4.10 A body uses a catapult to throw a stone, which accidentally smashes a greenhouse window. List the possible energy changes

When boy throws the stone elastic P.E is converted into K.E when stone hit the window this K.E converts into sound, heat and work done in breaking the greenhouse window.

Numerical problems

4.1: A man pushes a lawn mower with a 40 N force directed at an angle of 20° downward from the horizontal. Find the work done by the man as he cuts a strip of grass 20 m long.

$$\text{Given Data}: \mathrm{F} = 40\ \mathrm{N}, \theta = 20^\circ, \mathrm{d} = 20\mathrm{m}, \mathrm{W} = ?$$

$$\mathrm{W} = \vec{\mathrm{F}}.\vec{\mathrm{d}} = \mathrm{Fd}\cos\theta = 40 * 20 * \cos 20^\circ = 7.5 * 10^2\ J$$

4.2: A rain drop $\left(m = 3.35 \times 10^{-5}\ kg\right)$ falls vertically at a constant speed under the influence of the forces of gravity and friction. In falling through 100 m, how much work is done by (a) gravity and (b) fiction.

Given Data : $m = 3.35*10^{-5}$ kg, $h = 100m$, $W_{gravity} = ?$ $W_{friction} = ?$

$$W_{gravity} = \vec{F}.\vec{d} = mgh\cos\theta = mghcos0^\circ = 3.35*10^{-5}*9.8*100 = 0.0328\,J$$

$$W_{friction} = \vec{F}.\vec{d} = mgh\cos\theta = mghcos180^\circ = -3.35*10^{-5}*9.8*100 = -0.0328\,J$$

4.3: Ten bricks, each 6.0 cm thick and mass 1.5kg, lie flat on a table. How much work is required to stack them one on the top of another?

Given data : Mass of brick $= m = 1.5$ kg, $h = 6cm = 6/100 = 0.06m$, $W = ?$

$$W = 0 + mgh + 2mgh + 3mgh + 4mgh + 5mgh + 6mgh + 7mgh + 8mgh + 9mgh$$

$$W = 45mgh = 45*1.5*9.8*0.06 = 39.69J \approx 40J$$

4.4: A car of mass 800kg travelling at 54kmh^{-1} is brought to rest in 60 meters. Find the average retarding force on the car. What has happed to original kinetic energy?

Given Data : mass $= m = 800kg$, $v_i = 54Km/h = 54*1000/3600 = 15$ m/s, $v_f = 0$, $d = 60m$, $F = ?$, $K.E = ?$

according to work energy principle $Fd = \frac{1}{2}m(v_f^2 - v_i^2) \Rightarrow F = \frac{1}{2d}m(v_f^2 - v_i^2)$

$$F = \frac{1}{2*60}800*(0^2 - 15^2) = -1500N$$ - ive sign shows the retarding force,

As velocity of body is decreasing so kinetic energy will be decrease and becomes zero due to frictional force.

4.5: A 1000 kg automobile at the top of an incline 10 metre high and 100 m long is released and rolls down the hill. What is its speed at the bottom of the incline if the average retarding force due to friction is 480 N?

Given Data : $m = 1000kg$, height $= h = 10m$, $s = 100$ m, $f = 480$ N $v_f = ?$

Using WE principle $Fd = \frac{1}{2}m(v_f^2 - 0) \Rightarrow F = \frac{1}{2d}mv_f^2 \Rightarrow v^2 = \frac{2Fd}{m}$

$$v = \sqrt{\frac{2Fd}{m}} = \sqrt{\frac{2*480*100}{1000}} = 9.9 \approx 10m/s$$

4.6: 100 m^3 of water is pumped from a reservoir into a tank 10 m higher than the reservoir, in 20 minutes. If density of water is 100kg m^{-3}, find (a) the increase in P.E. (b) the power delivered by the pump.

Given Data : Volume of water $= V = 100m^3$, $h = 10m$, $t = 20$ min $= 20*60 = 1200sec$, $\rho = 1000kgm^{-3}$, $P.E = ?$ $P = ?$

for mass Density $=$, mass/volume $\Rightarrow$ mass $=$ density $*$ volume $= 1000*100 = 10^5$ kg

$$P.E = mgh = 10^5*9.8*100 = 9.8*10^6\ J,\ Power = \frac{W}{t} = \frac{P.E}{t} = \frac{9.8*10^6}{1200}8.2*10^3 Watt = 8.2KW$$

4.7: A force (thrust) of 400 N is required to overcome road friction and air resistance in propelling an automobile at 80kmh^{-1}. What power (kW) must the engine develop?

Given Data : $F = 400$ N, velocity $= v = 80Km/h = 80*100/3600 = 22.22$ m/s, Power $= ?$

$$P = \vec{F}.\vec{v} = Fv\cos\theta = Fv\cos0^\circ = 400*22.22 = 8888watt = 8888/1000 = 8.9KW$$

4.8: How large a force is required to accelerate an electron $\left(m = 9.1\times10^{-31}kg\right)$ from rest to a speed of $2.0\times10^7 ms^{-1}$ through a distance of 5.0 cm?

Given Data : mass $= m = 9.1*10^{-31}$kg, $v_i = 0$, $v_f = 2*10^7$ m/s, $d = 5cm = 5*10^{-2}$ m, $F = ?$

using work energy principle $Fd = \frac{1}{2}m(v_f^2 - v_i^2) \Rightarrow F = \frac{1}{2d}m(v_f^2 - v_i^2)$

$$F = \frac{1}{2*5*10^{-2}}9.1*10^{-31}((2*10^7)^2 - 0^2) = 3.6*10^{-15}\ N$$

4.9: A diver weighing 750 N dives from a board 10 m above the surface of a pool of water. Use the conservation of mechanical energy to find his speed at a point 5.0m above the water surface, neglecting air friction.

$$\text{Given Data}: W = 750\ \text{N}, h_1 = 10\ \text{m}, h_2 = 5\ \text{m}, v = ?$$

$$\text{As loss of potential energy} = \text{gian in kinetic energy} \Rightarrow mg(h_1 - h_2) = 1/2mv^2$$

$$v = \sqrt{2g(h_1 - h_2)} = \sqrt{2*9.8(10-5)} = 9.9 m/s$$

4.10: A child starts from rest at the top of a slide of height 4.0m. (a) What is his speed at the bottom if the slide is frictionless? (b) If he reaches the bottom, with a speed of 6 ms^{-1}, what percentage of his energy at the top of the slide is lost as a result of friction?

$$\text{Given Data}: \text{height} = h = 4\text{m}, \text{speed at bottom} = v = ?\ \%\text{ age of total energy lost} = ?(\text{if } v = 6\ \text{m/s})$$

$$\text{As loss of P.E} = \text{Gain in K.E} \Rightarrow mgh = 1/2mv^2 \Rightarrow v^2 = 2gh \Rightarrow v = \sqrt{2gh} = \sqrt{2*9.8*4} = 8.8 ms^{-1}$$

$$\%\text{ loss of Energy} = \frac{\text{loss of energy}}{\text{total energy}} * 100 = \frac{1/2mv^2 - 1/2mv'^2}{1/2mv^2} = \frac{v^2 - v'^2}{v^2} = \frac{8.8^2 - 6^2}{8.8^2} * 100 = 54\%$$

Multiple choice questions

1) Which of these is example of conservative forces?

a) Gravitational force	b) Elastic spring force	c) Electric force	**d) <u>All of these</u>**

2) Which of these is example of non-conservative force?

a) Frictional force	b) Air resistance	c) Propulsion force of rocket	**d) <u>All of these</u>**

3) What is the power of jumbo jet air craft?

a) <u>$1.3*10^8$ watt</u>	b) $1.1*10^5$ watt	c) $2*10^3$ watt	d) $7.5*10^{-4}$ watt

4) What is the power of car at 90kmh^{-1}

a) $1.3*10^8$ watt	**b) <u>$1.1*10^5$ watt</u>**	c) $2*10^3$ watt	d) $7.5*10^{-4}$ watt

5) What is the power of electric heater

a) $1.3*10^8$ watt	b) $1.1*10^8$ watt	**c) <u>$2*10^3$ watt</u>**	d) $7.5*10^{-4}$ watt

6) What is the power of pocket calculator?

a) $1.3*10^8$ watt	b) $1.1*10^8$ watt	c) $2*10^3$ watt	**d) <u>$7.5*10^{-4}$ watt</u>**

7) What is the power of color TV?

a) 100 watt	**b) <u>120 watt</u>**	c) 140 watt	d) 160 watt

8) What is the power of flash light(two cells)

a) 0.5 watt	**b) <u>1.5 watt</u>**	c) 2.5 watt	d) 3.5 watt

9) How much energy is used to make a car

a) <u>$9*10^9$ J</u>	b) 1000 J	c) $9*10^{15}$ J	d) $1*10^{12}$ J

10) A car uses about how much energy from petrol in its life time?

a) $9*10^9$ J	b) 1000 J	c) $9*10^{15}$ J	**d) <u>$1*10^{12}$ J</u>**

11) How much energy is obtained from kinetic energy of car at 90 km/h

a) $30*10^9$ J	b) $5*10^7$ J	**c) <u>$1*10^6$ J</u>**	d) $3*10^2$ J

12) What is the approximate energy value obtained from burning 1 ton coal?

a) <u>$30*10^9$ J</u>	b) $5*10^7$ J	c) $1*10^6$ J	d) $3*10^2$ J

13) How much energy is obtained from burning 1 liter of petrol

a) $30*10^9$ J	**b) <u>$5*10^7$ J</u>**	c) $1*10^6$ J	d) $3*10^2$ J

14) How much energy is obtained from running person at 10km/h

a) $30*10^9$ J	b) $5*10^7$ J	c) $1*10^6$ J	**d) <u>$3*10^2$ J</u>**

15) How much energy is obtained from fission of one atom of uranium?

a) $30*10^9$ J	b) $5*10^7$ J	**c) <u>$1.8*10^{-11}$ J</u>**	d) $3*10^2$ J

16) What is the approximate energy value obtained from kinetic energy of molecule of air

a) $30*10^9$ J	**b) $\underline{6*10^{-21}\ J}$**	c) $1*10^6$ J	d) $3*10^2$ J

17) All the food you eat in one day has about the same energy as --- liter of petrol

a) $\frac{1}{2}$	**b) $\frac{1}{3}$**	c) $\frac{1}{4}$	d) $\frac{1}{5}$

18) There is more energy reaching Earth in ---days of sun light than in all the fossil fuels on Earth

a) 5	**b) <u>10</u>**	c) 15	d) 20

19) More coal has been used since --- then was used in the whole of history before that

a) <u>1945</u>	b) 1940	c) 1950	d) 1955

20) Escape speed for Moon is

a) <u>2.4 km/s</u>	b) 4.3 km/s	c) 5 km/s	d) 10.4 km/s

21) Escape speed for Mercury

a) 2.4 km/s	**b) <u>4.3 km/s</u>**	c) 5 km/s	d) 10.4 km/s

22) Escape speed for Mars is

a) 2.4 km/s	**b) <u>5 km/s</u>**	c) 10.4 km/s	d) 11.2 km/s

23) Escape speed for Venus is

a) <u>10.4 km/s</u>	b) 11.2 km/s	c) 22.4 km/s	d) 25.4 km/s

24) Escape speed for Uranus is

a) 10.4 km/s	b) 11.2 km/s	**c) <u>22.4 km/s</u>**	d) 25.4 km/s

25) Escape speed for Neptune

a) 10.4 km/s	b) 11.2 km/s	c) 22.4 km/s	**d) <u>25.4 km/s</u>**

26) Escape speed for Saturn is

a) 10.4 km/s	**b) <u>37 km/s</u>**	c) 22.4 km/s	d) 25.4 km/s

27) Escape speed for Jupiter

a) 10.4 km/s	b) 11.2 km/s	**c) <u>61 km/s</u>**	d) 25.4 km/s

28) Escape speed is maximum for planet?

a) Moon	b) Mercury	**c) <u>Jupiter</u>**	d) Saturn

29) Escape speed is least for which planet?

a) <u>Moon</u>	b) Mercury	c) Mars	d) Jupiter

30) Sun is the original source of

a) Biomass	b) Fossil fuels	c) Wind	**d) <u>All of these</u>**

31) Which of these is renewable energy source?

a) Hydroelectric	b) Wind	c) Tides	**d) <u>All of these</u>**

32) Which of these is non-renewable energy source

a) Coal	b) Natural gas	c) Oil, uranium	**d) <u>All of these</u>**

33) Tidal effect can distort the continents pulling land up and down by as much as

a) 15 cm	b) 20 cm	**c) <u>25 cm</u>**	d) 30 cm

34) Original source of tides is

a) Sun	b) Earth	**c) <u>Moon</u>**	d) None

35) Original source of geothermal energy

a) Sun	b) Moon	**c) <u>Earth</u>**	d) None

Chapter = 04

Previous all Punjab Boards Exam Solved MCQs

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	Questions	Option A	Option B	Option C	Option D
1)	If direction of force and displacement are perpendicular then work will be	Minimum	**Zero**	Maximum	Infinity
2)	A stone is thrown up from the surface of earth when it reaches at maximum height its kinetic energy is equal to	Mgh	$\frac{1}{2} mv^2$	2mgh	**Zero**
3)	Which is renewable source of energy?	Coal	Natural gas	**Sunlight**	Uranium
4)	Which one is non renevable source of energy	Wind	Biomass	**Coal**	Sunlight
5)	Which one is conservative force?	**Electric**	Tension in string	Propulsion force of motor	Normal force
6)	1 KWh=?	$3.6*10^5$ J	**$3.6*10^6$ J**	$3.6*10^7$J	$3.6*10^8$J
7)	The dimension of work are	$[MLT^{-2}]$	**$[ML^2T^{-2}]$**	$[MLT^{-1}]$	$[ML^{-2}T^{-2}]$
8)	Source of tidal energy is	**Moon**	Sun	Earth	Uranium
9)	A body at rest may have	**Energy**	Momentum	K.E	Torque
10)	Which one is not the unit of work	Watt second	Nm	Joule	**Kgm/s**
11)	When do high tides occur in the ocean	**When moon is b/w sun and earth**	On a rainy day	When there is full moon	During day time
12)	Nonrenewable source of energy is	**Uranium**	Wind	Biomass	Sunlight
13)	Escape velocity on the surface of earth is given by Vesc=?	$v = \frac{2\pi R}{T}$	$v = \sqrt{GM/R}$	$v = \sqrt{2gR}$	$v = \sqrt{\frac{2GM}{R}}$
14)	To evaluate gravitational P.E , final point must be consider at	0 m	1000Km	**Infinity**	None of these
15)	6 joule of work is done in 3 sec then power is	6Watt	3 watt	18 Watt	**2 watt**
	P=work/time=6/3=2watt				
16)	Work done is maximum if the angle between the force and displacement is	**0°**	30°	180°	90°
17)	Escape velocity of a body of mass 1000 kg is 11 km/s, if the mass of body is doubled then escape velocity is	**11 km/s**	5.5 km/s	22 km/s	44 km/sec
	Escape velocity is independent of mass				
18)	Killo watt hour is the unit of	Power	Force	**Energy**	Weight
19)	1KWh=?	0.36 MJ	**3.6MJ**	36MJ	360MJ
20)	As we move up a body above the surface of earth, the change in potential energy will be	Negative	**Positive**	Zero	Infinity
21)	Rate of doing work is known as	Impulse	Energy	**Power**	Momentum
22)	Which one is biggest unit of energy and commercial unit	Erg	Joule	Watt hour	**Killo watt hour**
23)	Joule is a unit of	K.E	P.E	Heat energy	**All of these**
24)	Kinetic energy can be defined as dot product of	Momentum and force	Force and velocity	**Average momentum and velocity**	None of these
25)	If mass of moving body is doubled then its kinetic energy becomes	**2 times**	4 times	8 times	16 times
26)	A field will be conservative when work done	By centripetal force is zero	By a frictional force is negative	**In closed path is zero**	None of these

27)	Power is equal to the dot product of force and	Displacement	Acceleration	**Velocity**	Position vector
28)	Value of escape velocity for the surface of the earth is 11 km/sec. Its value for surface of the moon is	11 km/sec	**2.4 km/sec**	10.4 km/sec	4.3 km/sec
29)	KW/m^2 is the unit of	Power	**Intensity**	Energy	work
30)	The area under the curve force displacement graph represents	Force	Displacement	**Work**	Power
31)	If velocity is doubled then	Momentum increase 4 times and k.E 2 times	Momentum and K.E remains same	Momentum increase 2 times and K.E remains same	**Momentum increase 2 times and K.E increase 4 times**
	Momentum is directly to velocity and kinetic energy is directly to square of velocity				
32)	If by some means the diameter of earth increases to 4 times the escape speed will becomes	Same	**Double**	Half	One fourth
	As escape speed is directly proportional to sq.rt of radius/diameter, so sq.rt of 4 is two				
33)	Solar cell converts light energy into	Heat energy	Chemical energy	**Electrical energy**	Atomic energy
34)	A body of mass 2kg moving with velocity of 4m/s has K.E equal to	**16J**	8J	32J	2J
	As m=2kg, v=4 m/s, put in formula $K.E=1/2\ mv2=1/2*2*4^2=16$				
35)	The value of solar constant is	**1.4 KW/m^2**	1 KW/m^2	4.1 KW/m^2	0.1 KW/m^2
36)	Work will be negative when angle is	<90°	**>90°**	0°	45°
37)	Work has dimension like	**Torque**	Momentum	Velocity	Power
38)	Earth receives large amount of energy directly from	Wind	Water	**Sun**	Moon
39)	Original source of energy for biomass is	Earth	Moon	**Sun**	Star
40)	A layer of rock holding water that allows water percolate through it with pressure is called	Geyser	**Aquifer**	Steam vent	Hot spring
41)	The value of escape velocity is	1 Km/h	**11 Km/s**	1.1 Km/h	1.1 m/s
42)	3 J of work is done in 3 sec then power is	6W	3W	18 W	**1W**
	P=work/time=3/3=1watt				
43)	All the food we eat in one day has about the same energy as:	One liter of petrol	½ liter of petrol	**1/3 liter of petrol**	¼ liter of petrol
44)	The work done is negative when angle between force and displacement is	45°	90°	**180°**	0°
45)	On a clear day at noon, the intensity of solar energy reaching the earth's surface is about	1.4 kWm-2	**1.0 kWm-2**	1.4 Wm-2	1.4 kWm-2
46)	Bio mass is converted into fuel by	Evaporation	Scattering	Reflection	**Fermentation**
47)	Which of these is not conservative force?	**Frictional force**	Gravitational force	Electric force	Elastic restoring force
48)	Escape velocity is independent of	**Mass**	Radius	Gravitational acceleration	All of these
49)	A body has P.E=mgh when it is height h from ground, at the point distance x below from top, its P.E will be	mgx	mgh	**mg(h-x)**	mg(h+x)
50)	The dimension of power is	$[MLT^{-2}]$	**$[ML^2T^{-3}]$**	$[MLT^{-1}]$	$[ML^{-2}T^{-2}]$

51)	If 50 kg crate is pushed through 2m across the floor with force of 50 N, work will be	245 J	**100 J**	500 J	50 J
52)	Work done will be zero if angle between force and displacement is:	0°	**270°** Put in W=Fdcosθ	60°	360°
53)	100 joules work has been done by an agency in 10 seconds. What is power of agency	1000 watt	0.10 watt.	100	**10 watt**. Apply P=W/t
54)	Escape velocity for mars is	10.4 km/s	2.4 km/s	4.3 km/s	**5 km/s**
55)	The escape velocity corresponds to _____ energy gained by body, which carries it to an infinite distance from the surface of earth.	Total	Initial kinetic.	**Absolute Potential**	None of these
56)	The power needed to lift a mass 5000g to height 1m in 2 sec	2.45 W	**24.5 W**	245 W	2.45 KW
	P=W/t=mgh/t= 5*9.8*1/2=49/2=24.5 W				
57)	If a body of mass 5kg is raised vertically through a distance of 1m, then work done is	**49 J**	4.9 J	490 J	0.49 J
	W=Fd=mgh=(5)(9.8)(1)=49J				
58)	The consumption of energy by 60-watt bulb in 2 seconds is:	20 J	30 J	0.02 J	**120 J**
	POWER =energy/time, Energy = power*time= 60*2=120 J				
59)	If a certain force acts on an object and changes its kinetic energy from 65 J to 130 J, then work done by the force will be	92.5 J	**65 J**	97.5 J	130 J
	Apply work energy principle as work done is equal to change in kinetic energy so=130-65=65J				