Short Answer Type Questions – I

Q.1. What is conservative force?

Ans. Conservative force is a force if work done by or against the force in moving a body depends only on the initial & find positions of the body and not on the nature of path followed between initial and final position, e.g., gravitational force, electrostatic force between two electric charges, all central force, etc.

Q.2. What is instantaneous power?

Ans. Instantaneous power is defined as the limiting value of the average power when time tends to zero.

In general $$P = \frac{dW}{dt} = \frac{\vec{F}.\overrightarrow{dr}}{dt}$$

$$\vec{F}\frac{\overrightarrow{dr}}{dt} = \vec{F}.\vec{v}$$

where, v is instantaneous velocity.

Q.3. A man can jump higher on moon than on earth with same effort. Can a runner improve his timing for 100 m race on moon as compared to that on earth?

Ans. Man can jump higher on moon because the acceleration due to gravity on moon is less than that on the earth. But acceleration due to gravity does not affect the horizontal motion. Hence, the runner can't improve his timing on the moon for 100 m race.

Q.4. Mountain roads rarely go straight up the slop but wind up gradually, why?

Ans. If roads were to go straight up, the slope (θ) would have been large, the frictional force (μmg cos θ) would be small. The wheels of the vehicle would slip. Also for going up a large slope a greater power shall be required.

Q.5. What are the two laws of conservation of energy?

Ans. There are two laws:

(i) Law of conservation of energy: For an isolated system or body in presence of conservative forces the sum of KE and PE at any point remains constant throughout the motion.

(ii) Law of conservation of total energy : If the forces are conservative and non-conservative both, it is not the mechanical energy alone which is conserved, but it is the total energy, may be heat, light, sound, or mechanical etc., which is conserved.

Q.6. What is the relation between linear momentum and KE.

Ans. We know that, KE of a particle,

$$K = \frac{1}{2}mv^2$$

where m is the mass of particle and v is the velocity

$$K = \frac{1}{2}\frac{mv^2 \times m}{m}$$

$K = \frac{1}{2}\frac{(mv)^2}{m}$

$K = \frac{p^3}{2m}$ {∵ p = mv}

∴ $p = \sqrt{2mK}$

Q.7. What are the limitations of work energy theorem?

Ans. Although this theorem can be used to solve different types of problems in physics yet it does not give complete information about the real cause of motion (i.e., dynamics of Newton's second law of motion).

It is called scalar form of Newton's second law of motion.

Q.8. Give conditions for elastic collision.

Ans. In an elastic collision,

(a) Total momentum is conserved, i.e., total final momentum is equal to the total initial momentum.
(b)Total mechanical energy is conserved, i.e., total final energy is equal to the total initial energy.
(c) Total kinetic energy is conserved, i.e., total final kinetic energy is equal to the total initial kinetic energy.
(d) All the forces are of conservative nature, i.e., work done does not depend upon the actual paths.

Q.9. An aeroplane's velocity is doubled.

(a) What happened to its momentum? Is the law of conservation of momentum obeyed?
(b) What happens to its kinetic energy? Is the law of conservation of energy obeyed?

Ans. (a) The momentum of aeroplane will be doubled. Yes, the law of conservation of momentum will also be obeyed because increase in momentum of aeroplane is simultaneously accompanied by increase in momentum of exhaust gases.

(b) K.E. becomes four times.

Yes, the law of conservation of energy is obeyed with the increase in K.E. coming from the chemical energy of fuel, i.e., from the burning of its fuel.

Q.10. In a thermal station, coal is used for the generation of electricity. Mention how energy changes from one form to the other before it is transformed into electrical energy?

Ans. When coal is burn, heat energy is produced which converts water into steam. This stream rotates the turbine and thus heat energy is converted into mechanical energy of rotation. The generator converts this mechanical energy into electrical energy.

Q.11. Body B_1 collides with boy B_2 of same mass but at rest, what will happen to them?

Ans. When body (B_2) is at rest, we get

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2} u_1$$

and $$v_2 = \frac{2m_1}{m_1 m_2} u_1$$

Putting $m_1 = m_2 = m$, we get $v_1 = 0$ and $v_2 = u_1$, i.e., body B_1 comes to rest whereas body B_2 moves with the velocity of body B_1.

Q.12. A mass m is fixed to the lower most point of spring kept in vertical direction which is stretched slowly by a length l. When the system comes to equilibrium. If this arrangement has a sudden fall of mass. What can be the maximum stretch?

Ans. In slow operation, weight acts on the centre of gravity of the spring.

In free fall the same weight acts at the lower most end of the spring. The same spring can now have change in double of length, i.e., $2l$.

Q.13. Is kinetic energy a scalar or a vector? Give its S.I. unit and dimensional formula.

Ans. Kinetic energy is a scalar.

S.I. unit of kinetic energy is joule (J)

Dimensional formula of kinetic energy is $[ML^2T^{-2}]$.

Q.14. A bullet weighing 10 g is fired with a velocity of 800 ms^{-1}. After passing through a mud wall 1 m wall thick, its velocity decreases to 100 ms^{-1}. Find the average resistance offered by the mud wall.

Ans. Using $$F.s = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

where $$m = 10 \text{ g} = \frac{10}{1000} \text{ kg}$$

$$= 0.01 \text{ kg}$$

and $v = 100$ ms^{-1}, $u = 800$ ms^{-1}

and $s = 1$ m,

we get $$F = \frac{1}{2} \times 0.01 \times (100^2 - 800^2)$$

$$= -3150 \text{ N.}$$

Q.15. Chemical, gravitational and nuclear energies are nothing but potential energies for different types of forces in nature. Explain this statement clearly with examples.

Ans. A system of particles has potential energy when these particles are held at certain distance apart against some force. For example, chemical energy is due to the chemical bonding between the atoms. Gravitational energy arises when the objects are held at some distance against the gravitational attraction. Nuclear energy arises due to the nuclear force acting between the nuclear particles.

Q.16. What went wrong at the Soviet atomic power station at Chernobyl?

Ans. In this reactor, graphite was used as moderator. The fuel elements were cooled by water and steam was produced from within the reactor. Both water and the steam came in contact with hot graphite. Due to this hydrogen and carbon-monoxide CO were released. When they come in contact with air, there is a big explosion.

Q.17. Is collision possible even without actual contact of the colliding particles?

Ans. Yes, such collision is called collision at a distance. The collision between sub atomic particles (like protons and neutrons) are the examples of such collisions.

Q.18. Nuclear fission and fusion reaction are the examples of conversion of mass into energy. Can we say that "strictly speaking, mass converted into energy even in the exothermic chemical reaction"?

Ans. Yes, mass is converted into mass energy in an exothermic chemical reaction also.

But the mass change in a chemical reaction is about a million times less than in a nuclear reaction.

Q.19. How fast moving neutrons can be quickly slowed down by passing through heavy water?

Ans. Heavy water (D_2O) contains deuterium atom, i.e. hydrogen nuclei. They have nearly the same mass as those of neutrons. So, when neutrons strike against deuterium atoms, most of K.E. of the neutron is transferred to the deuterium atoms and thus neutrons get slowed down.

Q.20. What would be the effect on the potential energy of the system of two electrons when they are brought closer?

Ans. Work has to be done to overcome the force of repulsion. Thus work done will stored in the form of P.W. So, it increase the potential energy of the system.

Q.21. A truck and a car moving with the same K.E. on a straight road. their engines are simultaneously switched off. Which one will stop at a lesser distance?

Ans. The vehicle stops when its K.E. is spent in working against the force as friction between the tyres and the road. This force of friction varies directly with the weight of the vehicle.

As, K.E. = work done

= Force of friction × distance

or $E = f \times s$

or $s = E/f$

For given K.E., s, will be smaller where F is larger is such as in the case of truck.

Q.22. A body is heated by giving amount of heat energy? Will its mass increase or decrease or remain constant? If it increase or decrease then by how much?

Ans. The variations in mass depends on the nature of body. For most solids, there is no variations in mass of heating. However, if the solid is volatile then on heating some loss of mass occurs due to evaporation.

Q.23. A football kicked by a player leaves the ground and after travelling in air reached the ground and comes to stop at some other position on the ground. Identify the energy transformation in this process. Is energy of the ball conserved?

Ans. Kinetic energy imparted to the ball is converted into potential energy at the highest point and small part of it remains kinetic. Then it is converted into kinetics. Then it is converted into kinetic energy when it hits the ground. This energy is used up in overcoming the friction against air and the ground. Due to dissipation of energy in overcoming friction against air and ground, the kinetic energy of the ball is not conserved.

Q.24. A small stone, of mass 200 g, is tied to one end of string of length 80 cm. Holding the other end in hand, the stone is whirled into a vertical circle. What is the minimum speed, that needs to be imparted, at the lowest point of the circular path, so that the stone is just able to complete the vertical circle? What would be the tension in the string at the lowest point of circular path? (Take g = 10 ms^{-2})

Ans. We know that

v_{min} = minimum speed needed at the lowest point, so that particle is just able to complete vertical circle = $\sqrt{5gl}$

Hence $v_{min} = \sqrt{5 \times 10 \times 0.8}$ ms^{-1}

$= 6.32$ ms^{-1}

Also T_1 = Tension in the string at the lowest point of its circular path

$= \frac{mv_1^2}{l} + mg = 6\ mg$

$= 6 \times 0.2 \times 10$ N

$= 12$ N

Q.25. A massless string of length 1.2 m, has a breaking strength of 2 kg wt. A stone of mass 0.4 kg, tied to one end of the string, is made to move in a vertical circle, by holding the other end in the hand. Can the particle describe the vertical circle? (Take g = 10 ms^{-2})

Ans. We are given that

T_{max} = maximum tension in the string so that it does not break = 2 kg wt = 2 × 10 N = 20 N

Let T_1 be the tension in the string when the stone is in its lowest position of its circular path. We know that

$$T_1 = \frac{mv_1^2}{l} + mg.$$

T_1 would have its minimum value when v_1 equal to its minimum value = $\sqrt{5gl}$, needed by the stone, to complete its vertical circular path.

Hence $(T_1)_{min} = \frac{mv_{min}^2}{l} + mg = 6mg$

$= 6 \times 0.4 \times 10$

$= 24$ N

We thus see that $(T_1)_{min}$ is more than the breaking strength of the string. Hence the particle cannot describe the vertical circle.

Q.26. A small stone, of mass 0.2 kg, tied to a massless, inextensible string, is rotated in vertical circle of radius 2 m. if the particle is just able to complete the vertical circle, what is its speed at the highest point of its circular path? How would this speed get effected if the mass of the stone is increased by 50%? (Take g = 10 ms^{-2})

Ans. Let v_1 be the speed of the stone at the lowest point of its vertical circle. Since the stone is just able to complete the vertical circle, we have

$$v_1 = \sqrt{5gr}$$

$$= \sqrt{5 \times 10 \times 2} \text{ ms}^{-1}$$

$$= 10 \text{ ms}^{-1}$$

Let v_2 be the speed of the stone, at the highest point, on its circular path. Then

$$v_2^2 = v_1^2 - 4gr$$

$$= (10^2) - 4 \times 10 \times 2$$

$$= 100 - 80 = 20$$

$$v_2 = \sqrt{20} \text{ ms}^{-1} = 4.47 \text{ ms}^{-1}$$

It is thus seen that the value of v_2, does not depend on the mass (m) of the stone. Hence v_2 would remains the same when the mass of the stone increase by 50%.

Q.27. A bucket, containing 4 kg of water, is tied to a rope of length 2.5 m and rotated in a vertical circle in such a way that the water in its just does not spill over when the bucket is in its 'upside down' position. What is the speed of bucket ay the (a) highest, and (b) lowest point of its circular path. (Take g = 10 ms^{-2})

Ans. Let v_1 be the speed of the bucket at the highest point of its circular path. Then

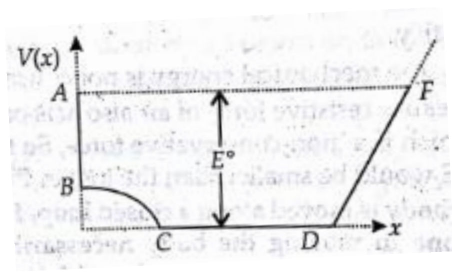
$$v_1 = \sqrt{gr}$$

$$= \sqrt{5 \times 10 \times 2.5} \text{ ms}^{-1}$$

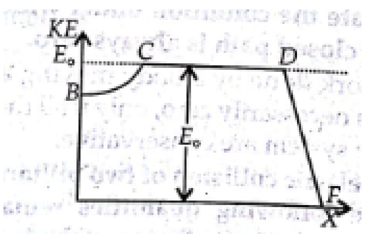
$$= \sqrt{125} \text{ ms}^{-1}$$

$$= 11.18 \text{ ms}^{-1}$$

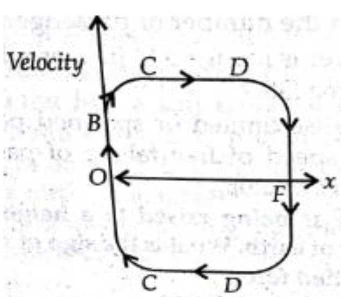
Q.28. A graph of potential energy V(x) verses x is shown in Fig. A particle of energy E_0 is executing motion in it. Draw graph of velocity and kinetic energy versus x for one complete cycle AFA.



Ans.



(a) Kinetic energy versus x.



(b) Velocity versus x.

Q.29. A ball of mass m, moving with a speed $2v_0$ collides inelastically (e>0) with an identical ball at rest. Show that

(a) For head-on collision, both the balls move forward.
(b) For a general collision, the angle between the two velocities of scattered balls is less than 90^o.

Ans. (a) For head on collision

Let V_1, V_2 be the velocities of two balls after collision.

Conservation of momentum

⇨ $$2mv_0 = mv_1 + mv_2$$

or $$2v_0 = v_1 + v_2$$

and $$e = \frac{v_2 - v_1}{2v_0} \Rightarrow v_2 = v_1 + 2v_0 e$$

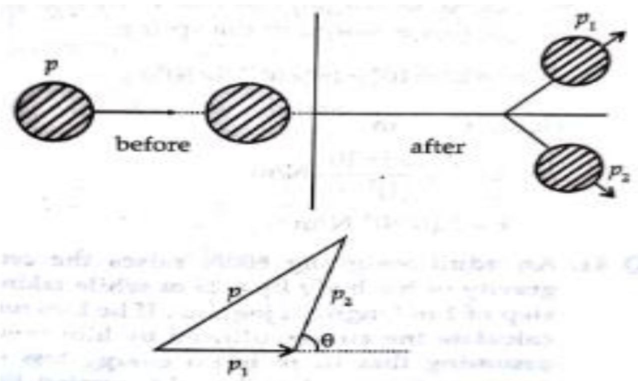
∴ $$2v_1 = 2v_0 - 2ev_0$$

∴ $$v_1 = v_0(1 - e)$$

Since e < 1 ⇨ v, has the same sign as v_0, therefore the ball moves on after collision.

(b) Conservation of momentum ⇨ $p = p_1 + p_2$

But KE is lost ⇨ $\frac{p^2}{2m} > \frac{p_1^2}{2m} + \frac{p_2^2}{2m}$



KE > KE_1 + KE_2 ⇨$\frac{p^2}{2m} > \frac{p_1^2}{2m} + \frac{p_2^2}{2m}$

⇨ $\therefore p > p_1^2 + p_2^2$

Thus p, p_1 and p_2 are related as shown in the figure.

θ is acute (less than 90º)

($p^2 = p_1^2 + p_2^2$ would give θ = 90º)

Q.30. Consider a one-dimensional motion of a particle with total energy E. there are four regions A, B, C and D in which the relation between potential energy V, kinetic energy (k) and total energy E is as given below:

Region A : V > E
Region B : V < E
Region C : K > E
Region D : K > E

State with reason in each case whether a particle can be found in the given region or not.

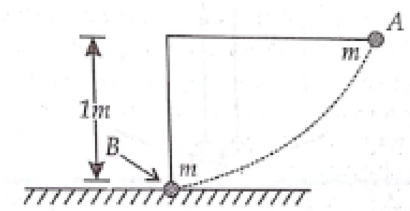
Ans. Region A : No, V > E ⇨ E = V + K, K = E – V ⇨ V > E, so K < 0 as KE will become negative.

Region B : Yes, V < E, K = E – V, K > 0, total energy can be greater than PE for non-zero K.E.

Region C : Yes, K > 0, V = E – K, V < 0, KE can be greater than total energy if its PE is negative.

Region D : Yes, V > K, K = E – V as PE can be greater than KE.

Q.31. The bob A of a pendulum released from horizontal to the vertical hits another bob B of the same mass at rest on a table as shown in Fig.



If the length of the pendulum is 1 m, calculate

(a) The height to which bob A will rise after collision.

(b) The speed with which bob B starts moving.

(c) Neglect the size of the bobs and assume the collision to be elastic.

Ans. (a) When ball A strike to an identical ball at rest then ball A transfer its entire momentum to the ball on the table and does not rise at all.

(b) $\frac{1}{2}mv^2 = mgh$

or $v = \sqrt{2gh}$,

here, g = 9.8 m/s^2 ,

h = 1m

Putting values we get

v = 4.43 m/s

Q.32. A raindrop of mass 1.00 g falling from a height of 1 km hits the ground with a speed of 50 ms^{-1}. Calculate

(a) The loss of P.E. of the drop.
(b) The gain in K.E. of the drop.
(c) Is the gain in K.E. equal to loss of P.E.? If not why.

Take g = 10 ms^{-2}

Ans. Given mass of rain drop, (m) = 0.001 kg

= 1.0 × 10^{-3} kg

Height, h = 1 km = 1000 m

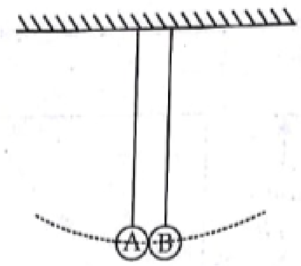
(a) Loss PE = mgh = 1 × 10^{-3} × 10 × 10^3 = 10 J

(b) Gain in KE = $\frac{1}{2}mv^2$ = $\frac{1}{2}$ × 10^{-3} × 2500 = 1.25 J

(c) No, because a part of PE is used up in doing work against the viscous drag of air.

Q.33. Two pendulums with identical bobs and lengths are suspended from a common support such that in rest position the two bobs are in contact (Fig.). One of the bobs is released after being displaced by 10^o so that it collides elastically head-on with the other bob.

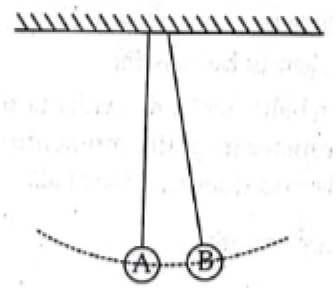
(a) Describe the motion of two bobs.
(b) Draw a graph showing variation in energy of either pendulum with time, for $0 \le t \le 2T$. Where T is the period of each pendulum.



Ans. (a) At = t = 0, A is at lowest position and B is at highest position as. K.E. of both bobos are zero while potential energy of B is maximum and A is zero.

Now bob is released.

After collision



At t = $\frac{T}{4}$, B reaches to A and collide elastically as both boobs are identical. The energies are

$KE_B = E$, $KE_A = 0$, $PE_A = 0$, $PE_B = 0$

At t = $\frac{2T}{4}$, A reaches maximum height and B remains at its lowest position.

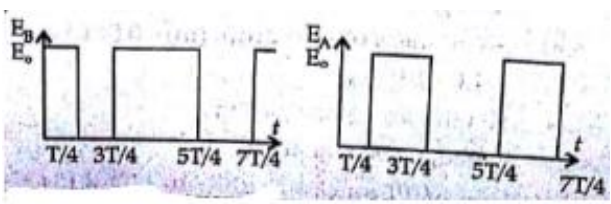
$KE_A = 0$, $KE_B = 0$, $PE_A = E$, $PE_B = 0$

At t = $\frac{3T}{4}$, Bob A hits B which was at rest elastically & A becomes at rest, B moves upward.

$KE_A = 0$, $KE_B = E$, $PE_A = 0$, $PE_B = 0$

$E_A = 0, E_B = E$

(b)



Q.34. Suppose the average mass of raindrops is 3.0 × 10^{-5} kg and their average terminal velocity 9 m s^{-1}. Calculate the energy transferred by rain to each square metre of the surface at a place which receives 100 cm of rain in a year.

Ans. Given : m = 3.0 × 10^{-5} kg,

ρ = 1.0 × 10^3 kg/m^3,

v = 9 m/s

A = 1 m^2

h = 100 cm ⇨ V = 1m^3

M = ρV = 10^3 kg,

Energy transferred by rain,

E = $\frac{1}{2}mv^2$ = $\frac{1}{2}$ × 10^3 × $(9)^3$ = 4.05 × 10^4 J.

Q.35. An engine is attached to a wagon through a shock absorber length 1.5m. The system with a total mass of 50,000 kg is moving with a speed of 36 km/h when the brakes are applied to bring it to rest. In the process of the system being brought to rest, the spring of the shock absorber gets compressed by 1.0 m. If 90% of energy of the wagon is lost due to friction, calculate the spring constant.

Ans. m = 50,000 kg,

v = 36 × $\frac{5}{18}$ m/s = 10 m/s

KE = $\frac{1}{2}mv^2$ = $\frac{1}{2}$ × 5 × 10^4 × 10^2 J

= 2.5 × 10^6 J

90% of KE of wagon lost due to friction and only 10% of this is stored in spring.

$\frac{1}{2}kx^2$ = 2.5 × 10^4 = 10% of 2.5 × 10^6 J

Here, x = 1 m

so, $k = \frac{2\times2.5\times10^4}{(1)^2}$ N/m

k = 5.0 × 10^4 N/m

Q.36. An adult weighing 600 N raises the centre of gravity of his body by 0.25 m while taking each step of 1 m length in jogging. If he jogs for 6 km, calculate the energy utilized by him in jogging assuming that there is no energy loss due to friction of ground and air. Assuming that the body of the adult is capable of converting 10% of energy intake in the form of food, calculate the energy equivalents of food that would be required to compensate energy utilized for jogging.

Ans. mg = 600 N, g = 10 m/s^2, h = 0.25 m

No. of steps in 6 km = $\frac{6000\ m}{1\ m/step}$ = 6000 steps

In 6 km there are 6000 steps.

∴ E = 6000$(mg)h$

= 6000×600×0.25 J

= 9 × 10^5 J

This is 10% of intake energy

∴ Intake energy = 10E = 9×10^6 J.

Q.37. On complete combustion a litre of petrol gives off heat equivalent to 3 × 10^7 J. In a test drive a car weighing 1200 kg, including the mass of driver, runs 15 km per litre while moving with a uniform speed on a straight track. Assuming the friction offered by the road surface and air to the uniform, calculate the force of friction acting on the car during the test drive, if the efficiency of the car engine were 0.5.

Ans. ∴ Energy given by car in 1 litre petrol

= 0.5 × 3 × 10^7 J

= 1.5 × 10^7 J

With 0.5 efficiency, 1 litre generates 1.5 × 10^7 J. which is used for 15 km drive.

Fd = 1.5 × 10^7 J, where d = 1.5 × 10^4 m

Force of friction F = $\frac{1.5\times10^7\ \mathrm{J}}{1.5\ \times10^4\mathrm{m}}$

F = 10^3 N