PHYSICS

The following question given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q. 1 **Assertion :** When a force of 20 N displaces a body by 5 m then work done by this force must be 100 J for every observer watching that body.

Reason : Work done on a body depends on the observer that is observing the body.

[D]

Q.2 **Assertion :** The work-energy theorem is independent of Newton's second law.

Reason : According work energy theorem net work done on a body is equal to change in its kinetic energy. **[D]**

Q. 3 **Assertion :** The work done in bringing a body down from the top to the base along a frictionless incline plane is the same as the work done in bringing it down from the vertical side.

Reason : The gravitational force on the body along the inclined plane is the same as that along the vertical side. **[B]**

Q.4 **Assertion :** When a spring is elongated work done by spring is negative but when it compressed work done by spring is positive.

Reason : Work done by spring is path independent. **[D]**

Q.5 **Assertion :** When a force of 20 N displaces a body by 5 m then for every observer watching that body work done on the body is 100 J.

Reason : Work done on a body by a force depends on the observer that is watching the body. **[D]**

Q.6 **Assertion :** When the force of 100 N displaces a body by 5 m the work done by this force is 500 J for every observer watching that body.

Reason : Work done by a force depends on the observer that watching the body. **[D]**

Q.7 **Assertion** : Work done by or against force of friction in moving a body through any round trip is zero.

Reason : This is because friction is a conservative force. **[D]**

Q.8 **Assertion** : Work done in moving a body over a smooth inclined plane does not depend upon slope of inclined plane, provided its height is same.

Reason : $W = mgh = mg\ell \sin\theta$ **[A]**

Q.9 **Assertion** : For stable equilibrium Force has to be zero and potential energy should be minimum.

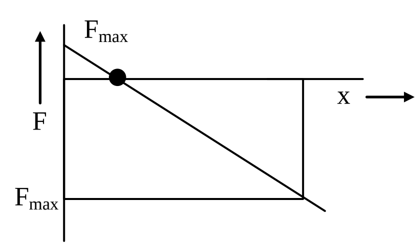
Reason : For equilibrium, it is not necessary that the force is not zero. **[C]**

Q.10 **Assertion** : Mass and energy are not conserved separately, but are conserved as a single entity called 'mass-energy'.

Reason : This is because one can be obtained at the cost of the other as per Einstein equation.

[A]

Q.11 **Assertion** : For the graph (given) force (F) versus distance (x) the graph of kinetic energy versus distance is a hyperbola :



Reason : Force is equal to kinetic energy gradient $F = \frac{dk}{dx}$. **[A]**

Q.12 **Assertion :** The work done by all forces on a system equals to the change in kinetic energy of that system. This statement is true even if non-conservative forces act on the system.

Reason : The total work done by internal forces may be positive. **[B]**

Sol. Both (A) & (R) are true. The work done by all forces on a system is equal to change in its kinetic energy, irrespective of fact whether work done by internal forces is positive, is zero or is negative.

Q.13 **Statement I :** Work done by or against the friction in moving the body through any round trip is zero.

Statement II : This is because friction is a conservative force. **[D]**

Q.14 **Statement I :** Work done in moving a body over a smooth inclined plane does not depend upon slope of inclined plane, provided its height is same.

Statement II : W = mgh = mglsinθ **[A]**

Q.15 **Assertion :** A bus and a car having same K.E. are brought to rest by application of brake. Assume that by application brake rotational motion of wheel ceases and wheels start sliding. If co-efficient of friction is same between road and wheels of bus as well as car, both will stop in same distance.

Reason : Retardation of bus and car will be same.

Sol. **[D]**

(A) is false but (R) is true.

Retardation of both (car and bus) = μg

Distance travelled by vehicle = $\dfrac{v^2}{\mu g} = \dfrac{2K}{m\mu g}$

K : K.E. of vehicles

m : Mass of vehicles

Q.16 **Statement I:** Work done by or against gravitational force in moving a body from one point to another is independent of the actual path followed between the two points.

Statement II: Gravitational forces are conservative forces. **[A]**

Sol. Work done by or against conservation force does not depend on path.

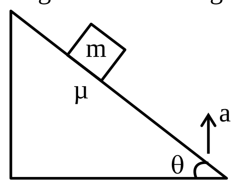
Q.17 **Assertion :** When a spring is elongated work done by spring is negative but when it compressed work done by spring is positive.

Reason : Work done by spring is path independent.

Sol.[D] Conceptual.

PHYSICS

Q.1 A block of mass m = 1 kg is at rest with respect to a rough wedge as shown in figure.



The wedge starts moving up from rest with an acceleration of $a = 2 m/s^2$ and the block remains at rest with respect to wedge then in 4 sec. of motion of wedge work done on block (assume angle of inclination of wedge is $\theta = 30^o$ and $g = 10 m/s^2$) –

Column I	**Column II**
(A) By gravity (in magnitude)	(P) 144 J
(B) By normal reaction	(Q) 32 J
(C) By friction	(R) 160 J
(D) By all the forces	(S) 48 J

(A) → R **(B)** → P **(C)** → S **(D)** → Q

Q.2 A body of mass 72 kg is lifted by 15 m with an acceleration of g/10 by an ideal string. If work done by tension in string is W_1, magnitude of work done by gravitational force is W_2, kinetic energy when it has lifted in K and speed of mass when it has lifted is v then : (data in column is given in SI units) ($g = 10 m/s^2$)

Column-I	**Column-II**
(A) W_1	(P) 10800
(B) W_2	(Q) 1080
(C) K	(R) 11880
(D) v	(S) 5.47

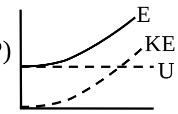
(A) → R (B) → P (C) → Q (D) → S

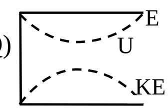
Q.3 Match the physical situation on the left with the graph on the right. The graphs depict the variation of total energy (solid), potential energy (long dashes) and kinetic energy (short dashes) with time.

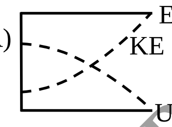
Column-I

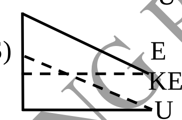
(A) A mass of a spring released from compression until it reaches its furthest extension.
(B) An object falling at terminal velocity
(C) An object undergoing free fall.
(D) An object being pulled on a level, frictionless surface by a constant force in the horizontal direction.

Column-II

(P) 

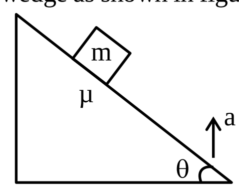
(Q) 

(R) 

(S) 

A → Q, B → S, C → R, D → P

Q.4 A block of mass m = 1 kg is at rest with respect to a rough wedge as shown in figure.



The wedge starts moving up from rest with an acceleration of $a = 2 m/s^2$ and the block remains at rest with respect to wedge then in 4 sec. of motion of wedge work done on block (assume angle of inclination of wedge is $\theta = 30^o$ and $g = 10 m/s^2$) –

Column I	**Column II**
(A) By gravity (in magnitude)	(P) 144 J
(B) By normal reaction	(Q) 32 J
(C) By friction	(R) 160 J
(D) By all the forces	(S) 48 J

Sol. **A → R, B → P, C → S, D → Q**

$S = \frac{1}{2} \times 2 \times 16 = 16$ m

$| W_g | = mg S =$

$W_N = m(g + a) \cos^2\theta . S$

$W_f = m(g + a) \sin^2\theta . S$

Q.5 Match the Column-I with Column-II :

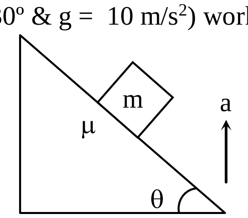
Column I	**Column II**
(A) An electron moves in an orbit in a Bohr atom	**(P)** Total Energy $= \frac{\text{Potential Energy}}{2}$
(B) As a satellite moves in a circular orbit around total earth	**(Q)** Kinetic Energy = Magnitude of Energy

(C)	In Rutherford's α-scattering experiment, as an α-particle moves in the electric field of a nucleus	**(R)**	Motion is under a central force
(D)	As an object, released from some height above ground, falls towards earth, assuming negligible air resistance	**(S)**	Mechanical energy is conserved

A $\rightarrow$ P, Q, R, S **B $\rightarrow$ P, Q, R, S**

C $\rightarrow$ R, S **D $\rightarrow$ R, S**

Q.6 A block of mass m = 1 kg is at rest with respect to a rough wedge as shown.The wedge starts moving up from rest with an acceleration of a = 2 m/s^2 and the block remains at rest with respect to wedge. Then in 4 sec of motion (if θ = 30º & g = 10 m/s^2) work done on block.



Column-I	**Column-II**
(A) By gravity (in magnitude)	(P) 144J
(B) By normal reaction	(Q) 32 J
(C) By frictional force	(R) 160 J
(D) By all the forces	(S) 48 J

Sol. **A $\rightarrow$ R, B $\rightarrow$ P, C $\rightarrow$ S, D $\rightarrow$ Q .**

N = m (g + a) cos θ = 6 $\sqrt{3}$N

f = m (g + a) sin θ = 6 N

mg = 10 N

Now, S = $\frac{1}{2}$ at^2 = 16m

$\therefore$ W_N = N.S cos θ = 144J

W_f = f. s sin θ = 48 J

$|W_g|$ = mg.s = 160 J

$W_{net} = W_g + W_N + W_f$

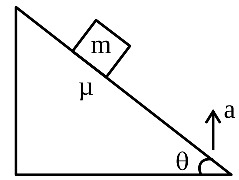
= – 160 + 144 + 48 = 32 J

Q.7 A body of mass 72 kg is lifted by 15 m with an acceleration of g/10 by an ideal string. If work done by tension in string is W_1, magnitude of work done by gravitational force is W_2, kinetic energy when it has lifted in K and speed of mass when it has lifted is v then : (data in column is given in SI units) (g = 10 m/s^2)

Column-I	**Column-II**
(A) W_1	(P) 10800
(B) W_2	(Q) 1080
(C) K	(R) 11880
(D) v	(S) 5.47

Ans. **A $\rightarrow$ R ; B $\rightarrow$ P ; C $\rightarrow$ Q ; D $\rightarrow$ S**

Q.8 A block of mass m = 1 kg is at rest with respect to a rough wedge as shown in figure.



The wedge starts moving up from rest with an acceleration of a = 2m/s^2 and the block remains at rest with respect to wedge then in 4 sec. of motion of wedge work done on block (assume angle of inclination of wedge is θ = 30º and g = 10 m/s^2) –

Column I	**Column II**
(A) By gravity (in magnitude)	(P) 144 J
(B) By normal reaction	(Q) 32 J
(C) By friction	(R) 160 J
(D) By all the forces	(S) 48 J

Ans. A $\rightarrow$ R ; B $\rightarrow$ P ; C $\rightarrow$ S ; D $\rightarrow$ Q

Q.9 A single conservative force acts on a body of mass 1 kg that moves along the x-axis. The potential energy U(x) is given by U(x) = 20 + (x–2)^2 where x is in meters. At x = 5.0 m the particle has a kinetic energy of 20 J then –

Column-I	**Column-II**
(A) minimum value of x in meters	(P) 29
(B) maximum value of x in meters	(Q) 7.38
(C) maximum potential energy in joules	(R) 49
(D) maximum kinetic Energy in joules	(S) – 3.38

Ans. **A $\rightarrow$ S ; B $\rightarrow$ Q ; C $\rightarrow$ R ; D $\rightarrow$ P**

Q.10 **Column II** shows five systems in which two object are labelled as X and Y. Also in each case a point P is shown. **Column I** gives some statements about X and/or Y. Match these statements to the appropriate system(s) from **Column II**. **[IIT-2009]**

Column I

(A) The force exerted by X on Y has a magnitude Mg.

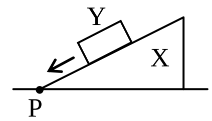
(B) The gravitational potential energy of X continuously increasing.

(C) Mechanical energy of the system X + Y is continuously decreasing.

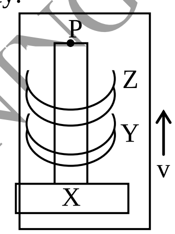
(D) The torque of the weight of Y about point P is zero.

Column II

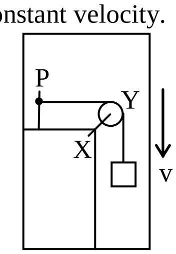
(p) Block Y of mass M left on a fixed inclined plane X, slides on it with a constant velocity.



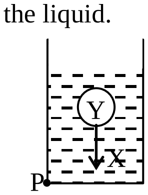
(q) Two ring magnets Y and Z, each of mass M, are kept in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system is in a lift that is going up with a constant velocity.



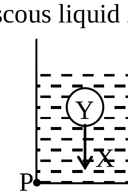
(r) A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes over the pulley and is fixed at point P of the table. The whole system is kept in a lift that is going down with a constant velocity.



(s) A sphere Y of mass M is put in a non viscous liquid X kept in a container at rest. The sphere is released and it moves down in the liquid.



(t) A sphere Y of mass M is falling with its terminal velocity in a viscous liquid X kept in a container.



Ans. **A $\rightarrow$ p, t ; B $\rightarrow$ q, s, t ; C $\rightarrow$ p, r, t ; D $\rightarrow$ q**

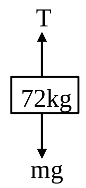
Q.11 A body of mass 72 kg is lifted by 15 m with an acceleration of g/10 by an ideal string. If work done by tension in the pulling ideal rope is W_1, magnitude of work done by gravity is W_2, kinetic energy when it has lifted is K and speed of mass when it has lifted is v then : (Data in column is given in SI units and use g = 10 m/s^2)

Column-I	**Column-II**
(A) W_1	(P) 10800
(B) W_2	(Q) 1080
(C) K	(R) 11880
(D) v	(S) 5.47

Ans. **A → R ; B → P ; C → Q ; D → S**

T – mg = ma

∴ T = m(g + a)



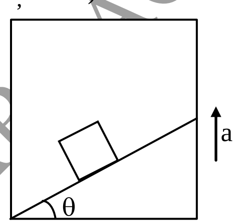
$\therefore W_1 = m(g + a) \times h$

$= 72 \times \left(g + \frac{g}{10}\right) \times 15 = 11880$ J

$W_2 = mgh = 72 \times 10 \times 15 = 10800$ J

$\therefore W_{Net} = K = 11880 - 10800 = 108$ J

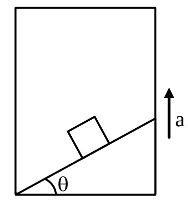
Q.12 A block of mass m is stationary with respect to a rough wedge as shown in figure. Starting from rest in time t, (m = 1kg, θ = 30º, a = 2m/s^2, t = 4s) work done on block:



Column-I	**Column-II**
(A) By gravity	(P) 144 J
(B) By normal reaction	(Q) 32 J
(C) By friction	(R) 56 J
(D) By all the forces	(T) None

Ans. A → T; B → P; C → S; D → Q

Q.13 A block of mass m is stationary with respect to a rough wedge as shown in figure. Starting from rest in time t, (m = 1kg, θ = 30º, a = 2 m/s^2, t = 4s) work done on block-



Column -I	Column-II
(A) By gravity	(P) 144 J
(B) By normal reaction	(Q) 32 J
(C) By friction	(R) 56 J
(D) By all the forces	(S) 48 J
	(T) None

Sol. [A → T ; B → P; C → S; D → Q]

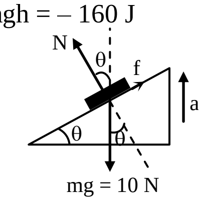
In t = 4 sec, v = at = 8 m/s

$S = \frac{1}{2}at^2 = 16$ m

$KE = \frac{1}{2}mv^2 = 32$ J

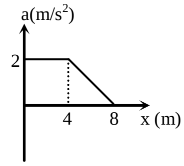
From W – E theorem, Total work = 32 J

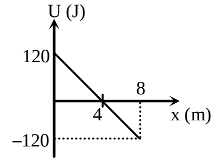
$W_g = -mgh = -160$ J



N cos 30º + f sin 30 º – 10 = ma = 2

Q.14 Acceleration versus x and potential energy versus x graph of a particle moving along x-axis is as shown in figure. Mass of the particle is 1 kg and velocity at x = 0 is 4 m/s. Match the following at x = 8 m -





Column -I	Column-II
(A) Kinetic energy	(P) 120 J
(B) Work done by conservative	(Q) 240 J

	forces		
(C)	Total work done	(R)	128 J
(D)	Work done by external forces	(S)	112 J
		(T)	None

Sol. A $\rightarrow$ R; B $\rightarrow$ Q; C $\rightarrow$ P; D $\rightarrow$ T

Q.15 Match the following :

Table- 1	Table- 2
(A) Work done by all the forces	(P) Change in potential energy
(B) Work done by conservative forces	(Q) Change in kinetic energy
(C) Work done by external forces	(R) Change in mechanical energy
	(S) None

Sol. (A) $\rightarrow$ (Q), (B) $\rightarrow$ (S), (C) $\rightarrow$ (R)

Q.16 A particle is suspended from a string of length R. It is given a velocity u = $3\sqrt{gR}$ at the bottom. Match the following :

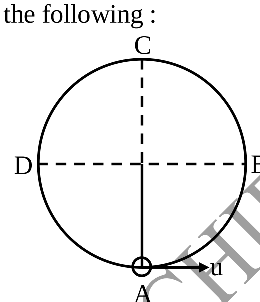


Table-1	Table-2
(A) Velocity at B	(P) 7 mg
(B) Velocity at C	(Q) $\sqrt{5gR}$
(C) Tension in string at B	(R) $\sqrt{7gR}$
(D) Tension in string at C	(S) 5 mg

Sol. (A) $\rightarrow$ (R), (B) $\rightarrow$ (Q), (C) $\rightarrow$ (P), (D) $\rightarrow$ (T)

Q.17 A force F = kx (where k is a positive constant) is acting on a particle. Work done :

Table-1	Table-2
(A) In displacing the body from x = 2 to x = 4	(P) Negative
(B) In displacing the body from x = – 4 to x = – 2	(Q) Positive
(C) In displacing the body from x = – 2 to x = + 2	(R) Zero

Sol. (A) $\rightarrow$ (Q), (B) $\rightarrow$ (P), (C) $\rightarrow$ (R)

Q.18 In the system shown in figure, mass m is released from rest from position A. Suppose potential energy of m at point A with respect to point B is E. Dimensions of m are negligible and all surfaces are smooth. When mass m reaches at point B.

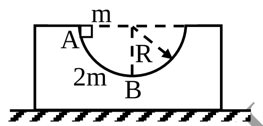


Table-1	Table-2
(A) Kinetic energy of m	(P) E/3
(B) Kinetic energy of 2m	(Q) 2E/3
(C) Momentum of m	(R) $\sqrt{\frac{4}{3}mE}$
(D) Momentum of 2m	(S) $\sqrt{\frac{2}{3}mE}$
	(T) None

Sol. (A) $\rightarrow$ (Q), (B) $\rightarrow$ (P), (C) $\rightarrow$ (R), (D) $\rightarrow$ (R)

Q.19 A body is moved along a straight line by a machine delivering a power proportional to time ($P \propto t$). Then match the following :

Table-1	Table-2
(A) Velocity is proportional to	(P) t
(B) Displacement is proportional to	(Q) t^2
(C) Work done is proportional to	(D) t^3

Sol. (A) $\rightarrow$ (P), (B) $\rightarrow$ (Q), (C) $\rightarrow$ (Q)

Q.20 A pendulum is released from point A as shown in figure. At some instant net force on the bob is making an angle θ with the string. Then Match the following :

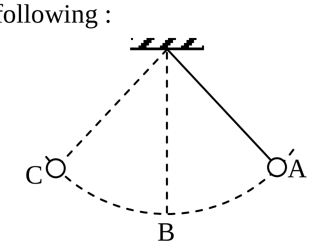


Table-1	Table-2
(A) For θ = 30º	(P) Particle may be moving along BA
(B) For θ = 120º	(Q) Particle may be moving along CB
(C) For θ = 90º	(R) Particle is at A

(D) For $\theta = 0^o$	(S) Particle is at B
	(T) None

Sol. (A) $\rightarrow$ (Q, P), (B) $\rightarrow$ (T), (C) $\rightarrow$ (R), (D) $\rightarrow$ (S)

Q.1 Consider two observers moving with respect to each other at a speed v along a straight line. They observe a block of mass m moving a distance ℓ on a rough surface. Which of the following quantities will be different as observed by the two observer –
(A) kinetic energy of block
(B) work done by friction
(C) Total work done on the block
(D) acceleration of block.

Sol. **[A, B, C]**
Conceptual

Q.2 A man of mass m is standing on a stationary flat trolly of mass M. The trolly can move without friction on the horizontal rails. The man starts walking with speed v relative to trolley, then work done hy him (the trolly can move only along the rails) -

(A) is greater than $\frac{1}{2}mv^2$ if he walks along rails

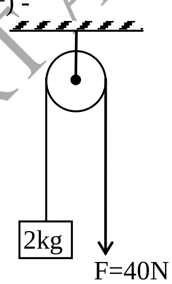
(B) is less than $\frac{1}{2}mv^2$ if he walks along rails

(C) is equal to $\frac{1}{2}mv^2$ if he walks normal to rails

(D) None of above

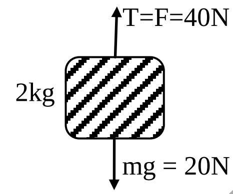
Sol. **[B,C]**
Conceptual

Q.3 A block of mass 2 kg is hanging over a smooth and light pulley through a light string. The other end of the string is pulled by a constant force F = 40 N. The kinetic energy of the particle increase 40 J in a given interval of time. Then : ($g = 10\ m/s^2$) -



(A) tension is the string is 40 N
(B) displacement of the block in the given interval of time is 2m
(C) work done by gravity is – 20J
(D) work done by tension is 80 J

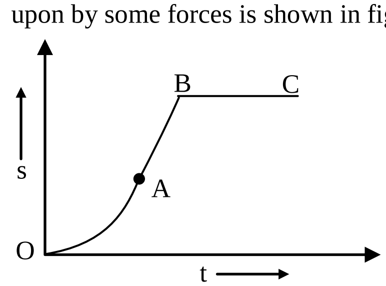
Sol. **[A,B,D]**
(Moderate) Free body diagram of block is as shown in figure. From work – energy theorem



$W_{net} = \Delta KE$
or $(40 - 20)s = 40$
$\therefore\ s = 2m$
work done by gravity is $-20 \times 2 = -40J$
and work done by tension is $40 \times 2 = 80$ J

Q.4 The potential energy U in joule of a particle of mass 1 kg, moving in the XY plane, obeys the law U = 3x + 4y, where (x, y) are the coordinates of the particle in metre. If the particle is at rest at (6, 4) at time t = 0, then
(A) the particle has constant acceleration
(B) the work done by the external force from the position of rest of the particle and the instant of the particle crossing X-axis, is 25 joule
(C) the speed of the particle when it crosses the Y-axis is 10 m/s
(D) the coordinates of the particle at time t = 4s are (–18, –28) **[All]**

Q.5 The displacement-time graph of a body acted upon by some forces is shown in figure.



Select the correct alternative(s) :
(A) Work done by the forces during BC is zero
(B) Work done by the forces during AB is zero
(C) Work done by the forces during AB is positive
(D) Work done by the forces during OA is positive (OA is a part of a parabola)
[A,B,D]

Q.6 A block is suspended by an ideal spring of force constant K. If the block is pulled down by applying a constant force F and if maximum displacement of block from its initial position of rest is δ, then

(A) $\frac{F}{K} < \delta < \frac{2F}{K}$

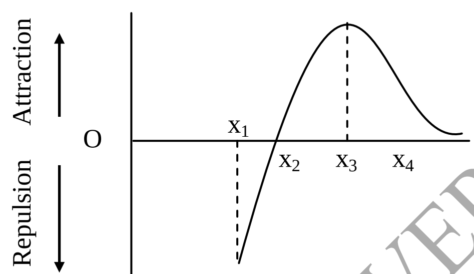
(B) $\delta = \frac{2F}{K}$

(C) Work done by force F is equal to $F\delta$

(D) Increase in energy stored in spring is $\frac{1}{2}K\delta^2$

[B,C]

Q.7 Figure shows net interaction force between two particles A and B against the distance between them, when the distance between them varies from x_1 to x_4 ? Then



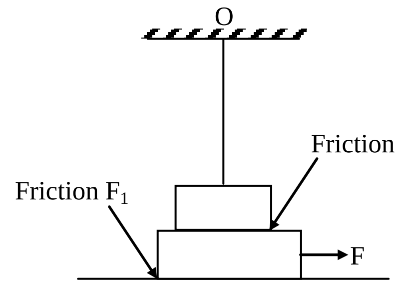
(A) potential energy of the system increases from x_1 and x_2

(B) potential energy of the system increases from x_2 and x_3

(C) potential energy of the system increases from x_3 and x_4

(D) kinetic energy increases from x_1 to x_2 and decreases from x_2 to x_3 **[B,C,D]**

Q.8 A horizontal plane supports a plank with a block placed on it as shown in figure. A light elastic cord is attached to a fixed point O. Initially, the cord is unstretched and vertical. The plank is slowly shifted to the right until the block starts sliding over it. It occurs at the moment when the cord deviates from vertical by an angle $\theta = \theta_0$. work done by the force F equals–



(A) energy lost against friction F_1 plus strain energy in cord

(B) work done against total friction acting on the plank alone

(C) work done against total friction acting on the plank plus strain energy in cord

(D) work done against total friction acting on the plank plus strain energy in cord minus work done by friction acting on the block

[A,B,D]

Q.9 A projectile of mass m is fired from the ground with an initial speed u at an angle θ with the horizontal. Then-

(A) The speed of the projectile at an altitude h from the ground will be $\sqrt{u^2 - 2gh}$

(B) The speed of the projectile at an altitude h from the ground will be $\sqrt{2gh}$

(C) The maximum negative work done by gravity is $(mu^2 \sin^2\theta)/2$

(D) Net work done by force of gravity on the projectile is zero **[A,C,D]**

Q.10 Kinetic energy of a particle is continuously increasing with time. It means-

(A) resultant force always acts along the direction of motion

(B) its height above the ground level may be decreasing

(C) resultant force is at an angle less than 90º to the direction of motion

(D) power associated with resultant force is not equal to zero **[B,C,D]**

Q.11 The potential energy of a particle of mass 5 kg, moving in the xy plane, is given by U = –7x + 24y J, where x and y being in metres. Initially (at t = 0), the particle is at the origin and has velocity v = $(14.4\hat{i} + 4.2\hat{j})$ m/s. Then-

(A) the speed of the particle at t = 4s, is 25 m/s

(B) the acceleration of the particle is 5 m/s^2

(C) the direction of acceleration of the particle is perpendicular to its direction of motion, initially

(D) the direction of acceleration of the particle is along the direction of motion, initially

[A,B,C]

Q.12 A pump motor is used to deliver water at a certain rate from a given pipe. To obtain n times water from the same pipe in the same time

(A) force exerted by the motor should be increased n^2 times

(B) force exerted by the motor should be increased n times

(C) power of the motor must be increased n^3 times

(D) power of the motor must be increased n^2 times **[A,C]**

Q.13 A man pushes a block of 30 kg along a level floor at constant speed with a force directed at 45º below the horizontal. If the coefficient of friction is 0.20, then-

(A) net force on the block is zero

(B) work done by the man on the block in pushing it through 10 m is 750 J

(C) work done by the force of gravity is zero

(D) work done by all the forces exerted by the surface on the block in 20 metres is –1500 J

[All]

Q.14 A block of mass 2 kg is hanging over a smooth and light pulley through a light string. The other end of the string is pulled by a constant force F = 40 N. The kinetic energy of the particle increases 40 J in a given interval of time. Then- ($g = 10\ m/s^2$)

(A) tension in the string is 40 N

(B) displacement of the block in the given interval of time is 2 m

(C) work done by gravity is –20 J

(D) work done by tension is 80 J **[A,B,D]**

Q.15 If the kinetic energy of a body is directly proportional to time t, the magnitude of the force acting on the body is–

(A) directly proportional to $\sqrt{t}$

(B) inversely proportional to $\sqrt{t}$

(C) directly proportional to the speed of the body

(D) inversely proportional to the speed of the body **[B,D]**

Q.16 A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane. It follows that-

[IIT-1987]

(A) Its velocity is constant

(B) Its acceleration is constant

(C) Its kinetic energy is constant

(D) It moves in a circular path **[C,D]**

Q. 17 If force is always perpendicular to motion :

(A) Kinetic energy perpendicular constant

(B) Work done is zero

(C) Velocity is constant

(D) Speed is constant **[A,B,D]**

Q.18 Work done by force of friction –

(A) May be positive

(B) May be negative

(C) May be zero

(D) None of these **[A,B,C]**

Q.19 Which of the following may be negative-

(A) Kinetic energy

(B) Potential energy

(C) Mechanical energy

(D) None of these **[B, C]**

Q.20 Which of the following may not be conserved ?

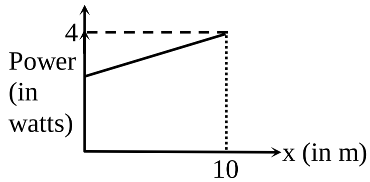
(A) Energy

(B) Potential energy

(C) Mechanical energy

(D) Kinetic energy **[B, C, D]**

Q.1 A particle of mass $\frac{10}{7}$ Kg is moving in the positive direction of x. Its initial position x = 0 & initial velocity is 1 m/s. The velocity at x = 10 is -



Sol. Area under P – x graph = $\int P dx$

$$= \int \left(\frac{mdN}{dt}\right) vdx$$

$$= \int_1^v mv^2 dv = \left[\frac{mv^3}{3}\right]_1^V$$

$$= \frac{10}{7\times3}(v^3 - 1) \qquad \ldots(1)$$

from graph, area = $\frac{1}{2}$ × (2 + 4) × 10 = 30 …(2)

from (1) & (2)

$\frac{10}{7\times3}(v^3 - 1) = 30$

$\Rightarrow$ v = 4m/s

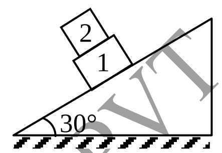
Q.2 A man is throwing bricks of mass 2 kg onto a floor of height 2m. Bricks reaches to floor with speed $2\sqrt{10}$ m/s. Man throws 10 bricks in a minute. If power of man is W watt then $\frac{3}{10}$W is equal to –

Sol. **[4]**

Work done by man on bricks = n (mgh + $\frac{1}{2}$ mv^2)

$$\therefore P = \frac{10\left(2\times10\times2+\frac{1}{2}\times2\times(2\sqrt{10})^2\right)}{60} = \frac{40}{3} \text{ W}$$

Q.3 An over head tank of capacity 10 k litre is kept at the top of building 15 m high. Water falls in tank with speed $5\sqrt{2}$ m/s. Water level is at a depth
5 m below ground. The tank is to be filled in 1/2 hr. If efficiency of pump is 67.5% electric power used in hecto watt is -



Sol. **[2]**

Work done by motor

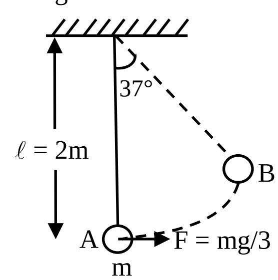
= mgh + $\frac{1}{2}$ mv^2 = 225 × 10000 Joule

Power of motor = $\frac{225\times10000}{1800}$ W

$\therefore$ Electric power used

= $\frac{225\times10000}{1800} \times \frac{100}{67.5} \approx 200$ W

Q.4 A pendulum of mass m = 2kg is pulled from position 'A' by applying a constant horizontal force F = mg/3. Velocity (in m/s) at point 'B' shown in figure -



Sol. **[0]**

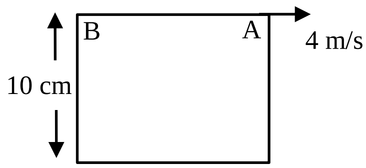
$W_{net} = \Delta K$

$\Rightarrow (F \sin\theta . \ell - mg\ell(1 - \cos\theta) = \frac{1}{2} mv^2$

where θ = 37º , F = $\frac{mg}{3}$

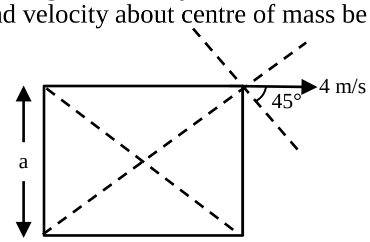
$\Rightarrow v = \left\{\frac{2\ell}{5m}(3F - mg)\right\}^{\frac{1}{2}} = 0$

Q.5 A cube of mass 3kg is kept on a frictionless horizontal surface. The block is given an impulse so that point 'A' acquires velocity 4 m/s in the direction shown. If speed of point B is $4\sqrt{2}$ m/s, K.E. of block (in Joule) minus 10 Joule is -



Sol. **[6]**

Let angular velocity about centre of mass be 'ω' and velocity about centre of mass be V_{cm}.



$\omega = \dfrac{V_A \cos 45°}{(a/\sqrt{2})}$ = 40 rad/sec (a = 10 cm)

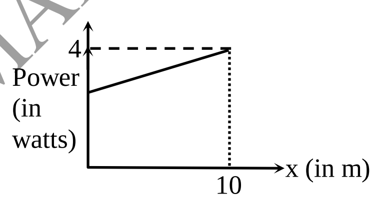
$V = V_A \sin 45° = 2\sqrt{2}$ m/s

$\therefore$ K.E. = $\frac{1}{2} MV_{cm}^2 + \frac{1}{2} I\omega^2 = 16$ J

Q.6 A ball of mass 1 kg is dropped from height 10 m. If hits the ground with speed 8 m/s, magnitude of work done by air friction is (in Joule) minus 60 joule is -

Sol. **[8]**

Q.7 A particle of mass $\frac{10}{7}$ Kg is moving in the positive direction of x. Its initial position x = 0 & initial velocity is 1 m/s. The velocity at x = 10 is -



Sol. **[4]**

Area under P – x graph = $\int P dx$

$= \int \left(\frac{mdN}{dt}\right) v dx$

$= \int_1^v mv^2 dv = \left[\frac{mv^3}{3}\right]_1^V$

$= \frac{10}{7\times 3}(v^3 - 1)$ …(1)

from graph, area = $\frac{1}{2} \times (2+4) \times 10 = 30$ …(2)

from (1) & (2)

$\frac{10}{7\times 3}(v^3 - 1) = 30$

$\Rightarrow$ v = 4m/s

Q. 8 A block of mass m = 1kg moving on horizontal surface with speed u = 2m/s enters a rough horizontal patch ranging from x = 0.10 m to x = 2.00m. If the retarding force f_r on the block in this range is inversely proportional to x over this range i.e.

$f_r = \frac{-k}{x}$ 0.10 < x < 2.00

= 0 for x < 0.10 and x > 2.00

If k = 0.5 J then the speed of this block as it crosses the patch is (use ℓn 20 = 3) in m/s is –

Sol. **[0001]** $W = \int f_r\, dx = -k \log_e \frac{2}{0.1} = -1.5$ J

$\therefore$ W = ΔK

$\frac{1}{2} \times 1 \times v^2 - \frac{1}{2} \times 1 \times 4 = -1.5$

Q.9 A particle moves in a straight line with its retardation proportional to its displacement 'x'. Change in kinetic energy is proportional to n^{th} power of x, where n is -

Sol. **[2]**

$a \propto x$

$W_{net} = F.x$

$\propto a.x$

$\propto x^2$

$\therefore \Delta K \propto x^2$

Q.10 A particle of mass 10^{-2} kg is moving along the positive x-axis under the influence of a force $F(x) = -K/(2x^2)$ where $K = 10^{-2}$ Nm^2. At time t = 0 it is at x = 1.0 m and its velocity is v = 0. Find its velocity when it reaches x = 0.50 m.

Sol.[1] $F = \frac{-k}{2x^2} \Rightarrow F = -\frac{10^{-2}}{2x^2}$

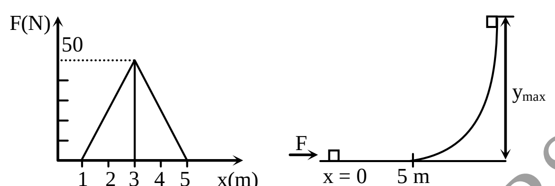
$$a = \frac{F}{m} = \frac{10^{-2}}{(10^{-2})2x^2} \Rightarrow a = \frac{-1}{2x^2} = v\frac{dv}{dx}$$

$$-\int_1^{0.5} \frac{dx}{2x^2} = \int_0^v v dv \Rightarrow -\frac{1}{2}\int_1^{0.5} x^{-2}dx = \frac{v^2}{2}$$

$$\Rightarrow \frac{-1}{2}\left[\frac{-1}{x}\right]_1^{0.5} = \frac{v^2}{2} \Rightarrow \frac{1}{2}\left[\frac{1}{0.5}-1\right] = \frac{v^2}{2}$$

$\Rightarrow$ v = 1 m/s

Q.11 A force shown in the F – x graph is applied to a 5 kg cart, which then coast up a ramp as shown. Calculate the maximum height , y_{max}, at which cart can reach? (g = 10 m/s^2)



Sol.[2] As per graph, the velocity at point,

x = 5 is $v = \sqrt{40}$ m/s

Energy conservation, $\frac{1}{2} \times m \times 40 = m \times 10 \times h$

h = 2m

Q.12 A man is drawing water from a well with a bucket which leaks uniformly. The bucket when full weights 20 kg and when it arrives the top only half the water remains. The depth of the water is 20 m. What is the work done?

Sol. 3000

Q.13 A person is painting his house walls. He stands on a ladder with a bucket containing paint in one hand and a brush in other. Suddenly the bucket slips from his hand and falls down on the floor. If the bucket with the paint had a mass of 6.0 kg and was at a height of 2.0 m at the time it slipped, how much gravitational potential energy is lost together with the paint?

Sol. 0118

Q.1 A overhead tank of capacity 1000 liter has to be filled in $\frac{1}{2}$ hour using water pump. Tank is kept at a height 10 m above ground and water level is 10 m below ground. The opening of inlet pipe inside tank is 1.11 cm^2. Assuming the efficiency of motor to be 60%, the electric power used is (Neglect viscosity) -

(A) 118 W (B) 130 W

(C) 146 W (D) 198 W **[D]**

Sol. Volume rate of water filling tank :

$Av = \frac{1000 \times 10^{-3}}{1800} \Rightarrow v = 5$ m/s

$\therefore$ work done by pump in filling the tank

$W = mgh + \frac{1}{2}mv^2$

[m = 1000 kg, h = 20 m, v = 5 m/s]

$= 2.125 \times 10^5$

$\therefore P = \frac{2.125 \times 10^5}{1800}$ W

$\therefore$ Electric power used $= \frac{10}{6} \times P = 198$ W

Q.2 A force $\vec{F} = 8\hat{i} - 6\hat{j} - 10\hat{k}$ Newton produces an acceleration of 1 m s^{-2} in a body. The mass of the body is -

(A) 10 kg (B) $10\sqrt{2}$ kg

(C) $10\sqrt{3}$ kg (D) 200 kg **[B]**

Sol. $m = \frac{|\vec{F}|}{a} = \frac{\sqrt{8^2 + 6^2 + 10^2}}{1}$

Q.3 The linear momentum of a particle varies with time t as :

$p = a + bt + ct^2$

Which of the following statements is correct ?

(A) Force varies with time in a quadratic manner

(B) Force is time-dependent

(C) The velocity of the particle is proportional to time

(D) The displacement of the particle is proportional to time. **[B]**

Sol. $P = a + bt + ct^2$

$F = \frac{dP}{dt} = 0 + b + 2ct$

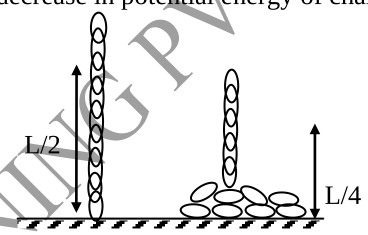
Q.4 A man places a chain (of mass 'm' and lenght 'ℓ') on a table slowly. Initally the lower end of the chain just touches the table. The man drops the chain when half of the chain is in vertical position. Then work done by the man in this process is :

(A) $-mg\frac{\ell}{2}$ (B) $-\frac{mg\ell}{4}$

(C) $-3\frac{mg\ell}{8}$ (D) $-\frac{mg\ell}{8}$

Sol. **[C]**

The work done by man is negative of magnitude of decrease in potential energy of chain.



$\Delta U = mg\frac{L}{2} - \frac{m}{2}g\frac{L}{4} = 3\,mg\frac{L}{8}$

$\therefore W = -\frac{3mg\ell}{8}$

Q.5 A body is displaced from (0, 0) to (1m, 1m) along the path x = y by a force $\vec{F} = (x^2\hat{j} + y\hat{i})N$. The work done by this force will be –

(A) $\frac{4}{3}$J (B) $\frac{5}{6}$J

(C) $\frac{3}{2}$J (D) $\frac{7}{5}$J

Sol. **[B]**

$W = \int_{(0,0)}^{(1,1)} \vec{F}.\vec{d}x$

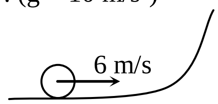
Here $\vec{d}s = dx\hat{i} + dy\hat{j} + dz\hat{k}$

$\therefore W = \int_{(0,0)}^{(1,1)} (x^2dy + ydx)$

$= \int_{(0,0)}^{(1,1)} (x^2dy + x.dx)$ (as x = y)

$\therefore W = \left[\frac{y^3}{3} + \frac{x^2}{2}\right]_{(0,0)}^{(1,1)} = \frac{5}{6}$ J

Q.6 A disc of radius 0.1 m rolls without sliding on a horizontal surface with a velocity of 6 m/s. It then ascends a smooth continuous track as shown in figure. The height upto which it will ascend is : ($g = 10\ m/s^2$)



(A) 2.4 m (B) 0.9 m

(C) 2.7 m (D) 1.8 m

Sol. **[D]** Let m be the mass of the disc. Then translational kinetic energy of the disc is :

$K_T = \frac{1}{2} mv^2$ ... (1)

When it ascends on a smooth track its rotational kinetic energy will remain same while translational kinetic energy will go on decreasing. At highest point.

KT = mgh

or $\frac{1}{2} mv^2 = mgh$

or $h = \frac{v^2}{2g} = \frac{(6)^2}{2 \times 10} = 1.8$ m

Q. 7 Power applied to a particle varies with time as $P = [3t^2 - 2t + 1]$ watts. Where t is time in seconds. Then the change in kinetic energy of particle between time t = 2s to t = 4s is –

(A) 46 J (B) 52 J

(C) 92 J (D) 104 J

Sol. **[A]**

$\Delta K = \int_2^4 P dt = [t^3 - t^2 + t]_2^4 = 46J$

Q.8 A block of mass 2 kg is kept at origin at t = 0 and is having velocity $4\sqrt{5}$ m/s in positive x-direction. The only force acting on it is a conservative and its potential energy is defind as

$U = - x^3 + 6x^2 + 15$ (SI units). Its velocity when its acceleration is minimum after t = 0 is-

(A) 8 m/s (B) 4 m/s

(C) $10\sqrt{24}$ m/s (D) 20 m/s

Sol. **[A]**

$F = -\frac{dU}{dx} \Rightarrow F = 3x^2 - 12x$

Now F = min. $\Rightarrow \frac{dF}{dx} = 0 \Rightarrow x = 2$ m

$U_i + K_i = U_f + K_f$

$15 + \frac{1}{2} \times 2 \times 80 = [-(2)^3 + 6 \times (2)^2 + 15] + \frac{1}{2} \times 2 \times v^2$

$v^2 = 64$

v = 8m/sec

Q.9 Power applied to a particle varies with time as $P = (3t^2 - 2t + 1)$ watts, where t is time in seconds. Then the change in kinetic energy between time t = 2s to t = 4s is-

(A) 46 J (B) 52 J

(C) 92 J (D) 104 J

Sol. **[A]**

$P = 3t^2 - 2t + 1$ $\frac{dK}{dt} = P$

$\Rightarrow \Delta K = \int_2^4 P dt = 46$ J

Q.10 A particle moves in a straight line with its retardation proportional to its displacement 'x'. Change in kinetic energy is proportional to –

(A) x^2 (B) e^x

(C) x (D) $\log_e x$ **[A]**

Sol. $a \propto x$

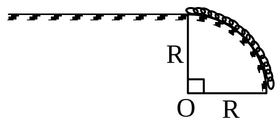
$W_{net} = F.\ x$

$\propto a.x$

$\propto x^2$

$\therefore \Delta K \propto x^2$

Q.11 A chain of length $\ell < \frac{\pi R}{2}$ is placed on a smooth surface whose some part is horizontal and some part is quarter circular of radius r in the vertical plane as shown. Initially the whole part of chain lies in the circular part with one end at topmost point of circular surface. If the mass of chain is m, then work required to pull very slowly the whole chain on horizontal part is –



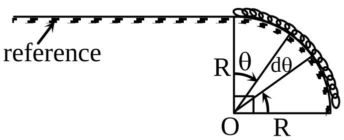
(A) $\frac{m}{\ell} gR^2 \left[\sin\left(\frac{\ell}{R}\right)\right]$

(B) $\frac{m}{\ell} gR^2 \left[\cos\left(\frac{\ell}{R}\right)\right]$

(C) $\frac{m}{\ell} gR^2 \left[\left(\frac{\ell}{R}\right) - \sin\left(\frac{\ell}{R}\right)\right]$

(D) $\frac{m}{\ell} gR^2 \left[\left(\frac{\ell}{R}\right) - \cos\left(\frac{\ell}{R}\right)\right]$ **[C]**

Sol.



$$dU_i = -\left(\frac{m}{\ell} Rd\theta\right) \times g \times R[1 - \cos\theta]$$

$$dU_i = -\frac{mgR^2}{\ell}[1 - \cos\theta]d\theta$$

$$\therefore \quad U_i = -\frac{mgR^2}{\ell}\left[\left(\frac{\ell}{R}\right) - \sin\left(\frac{\ell}{R}\right)\right]$$

and $U_f = 0$ $\therefore$ $W_{ext} = \Delta U$

Q.12 Water from a stream is falling on the blades of a turbine at the rate of 100 kg/sec. If the height of the stream is 100 m, then the power delivered to the turbine is -

(A) 100 kW (B) 100 W

(C) 10 kW (D) 1 kW **[A]**

Sol. $P = \frac{\text{Energy}}{\text{time}} = \frac{dm}{dt} gh = 100 \times 10 \times 100$

$= 100$ kW

[P = $\frac{\text{Åtkz}}{\text{le;}} = \frac{dm}{dt} gh = 100 \times 10 \times 100$

$= 100$ kW]

Q.13 A pump motor is used to deliver water at a certain rate from a given pipe. To obtain 'n' times water from the same pipe in the same time the amount by which the power of the motor should be increased –

(A) $n^{1/2}$ (B) n^2

(C) n^3 (D) n **[C]**

Sol. Volume delivered per sec. = Av

mass delivered per sec = Avd

momentum delivered per sec = Av^2d = force

power = force × velocity= Av^3d

i.e. power $\propto v^3$

Q.14 Power developed by a person on eating 100 g of ice per minute is –

(A) 130 W (B) 560 cal/sec

(C) 560 J/sec (D) none of these **[C]**

Sol. W = 100 × 80 × 4.2 J

$$P = \frac{dW}{dt} = \frac{100 \times 80 \times 4.2}{60} \text{ J/sec}$$

P = 560 J/sec

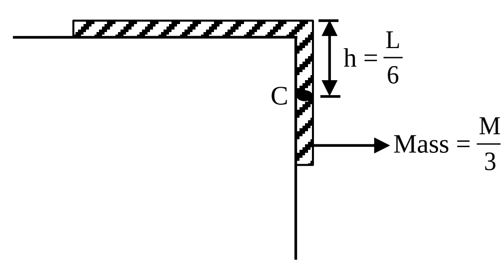
Q.15 A uniform chain of length L and mass M is lying on a smooth table and one-third of its length is hanging vertically down over the edge of the table. If g is acceleration due to gravity, the work required to pull the hanging part on to the table is –

(A) MgL (B) MgL/3

(C) MgL/9 (D) MgL/18 **[D]**

Sol. Mass of hanging portion is $\frac{M}{3}$ (one-third) and centre of mass c, is at a distance $h = \frac{L}{6}$ below the table top.

Therefore, the required work done is,



$$W = mgh = \left(\frac{M}{3}\right)(g)\left(\frac{L}{6}\right) = \frac{MgL}{18}$$

Q.16 A particle of mass **m** is moving in a circular path of constant radius **r** such that its centripetal acceleration $\mathbf{a_c}$ is varying with time t as $\mathbf{a_c} = k^2 rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is –

(A) $2\pi\ mk^2\ r^2$
(B) $mk^2\ r^2t$
(C) $\frac{(mK^4 r^2 t^5)}{3}$
(D) Zero **[B]**

Sol. $a_c = k^2\ rt^2$

or $\frac{v^2}{r} = k^2\ rt^2$

or v = krt

Therefore, tangential acceleration, $a_t = \frac{dv}{dt} = kr$

or Tangential force,

$F_t = ma_t = mkr$

Only tangential force does work.

Power = F_t v = (mkr) (krt)

or Power = $mk^2 r^2 t$

Q.17 The ratio of work done by the internal forces of a car in order to change its speed from 0 to V, from V to 2V is (Assume that the car moves on a horizontal road) -

(A) 1
(B) 1/2
(C) 1/3
(D) 1/4

[C]

Sol. Work done in changing speed from 0 to V is -

$\Delta W_1 = \frac{1}{2}\ mV^2$

work done in changing the speed from V to 2V is

$\Delta W_2 = \frac{1}{2} m\,(2V)^2 - \frac{1}{2}\ mV^2 = \frac{1}{2}\ 3\ mV^2$

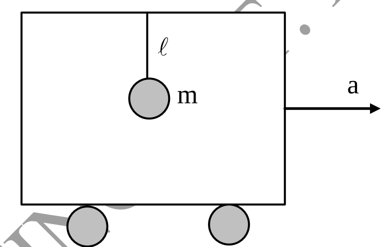
$\therefore \frac{\Delta W_1}{\Delta W_2} = \frac{1}{3}$

Q.18 A sping balance is adjusted at zero. Elastic collisions are brought about by dropping particles of one gram each on the pan of the balance. They recoil upwards without change is their velocities. If the height of fall of particles is 2 meter and the rate of particle dropping is 100 per seconds, then the reading of the balance is –

(A) 128 gm wt.
(B) 1252 gm wt.
(C) 625 gm wt.
(D) 1.25 gm wt. **[A]**

Sol. W=2mvn,v= $\sqrt{2h}$

Q.19 A pendulum of mass m and length ℓ is suspended from the ceiling of a trolley which has a constant acceleration **a** in the horizontal direction as shown in figure. Work done by the tension is–



(A) $-mg\ell(1 - \cos\theta)$
(B) $ma\ell \sin\theta$
(C) $ma\ell \cos\theta$
(D) zero **[D]**

Q.20 The displacement x of a body of mass 1kg on horizontal smooth surface as a function of time t is given by $x = t^4/4$. The work done in the first one second is–

(A) $\frac{1}{4}$ J
(B) $\frac{1}{2}$ J
(C) $\frac{3}{4}$ J
(D) $\frac{5}{4}$ J **[B]**

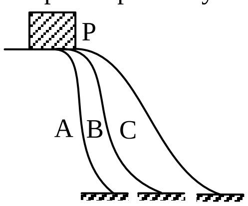
Q.21 A body moves a distance of 10m along a straight line under the action of a force of 5N. If the work done is 25 J , the angle which the force makes with the direction of motion of the body is-

(A) 0°
(B) 30°
(C) 60°
(D) 90° **[C]**

Q.22 A heavy box of 40 kg is pushed along 20 m by two coolies over a railway platform whose coefficient of friction with the box is 0.4. The work done by the two coolies (take g = 10 m/s^2 and assume that forces applied to be horizontal) is-

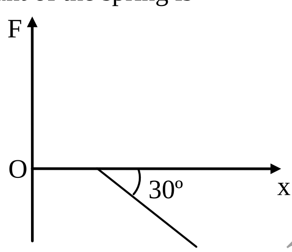
(A) + 3200 J
(B) –3200 J
(C) + 1600 J
(D) –1600 J **[A]**

Q.23 A greased block P may slide along any of the three frictionless slopes A, B, or C, to reach the ground. The work done on the block by the block's weight Mg, are W_A , W_B , and W_C for the three slopes respectively. Then-



(A) $W_A < W_B < W_C$
(B) $W_A > W_B > W_C$
(C) $W_A = W_B = W_C$
(D) None of the above **[C]**

Q.24 In a spring , it is found that the spring force F and the extension in the spring x are related as shown in figure. Then the value of the force constant of the spring is



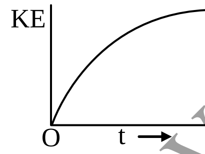
(A) $\sqrt{3}$ (B) $\sqrt{3}/2$
(C) $\frac{1}{\sqrt{3}}$ (D) $\frac{1}{2}$ **[C]**

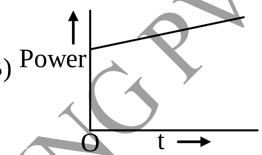
Q.25 If v, P and K denote the velocity, momentum and kinetic energy of a particle then–
(A) P = dK/dv
(B) P = dK/dt
(C) P = dv/dt
(D) P = (dK/dv) (dK/dt) **[B]**

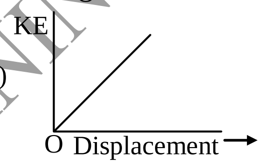
Q.26 A 5.0 kg block is thrust up a 30° incline with an initial speed v of 6.0 m/s. It is found to travel a distance d = 2.0 m up the plane as its speed gradually decreases to zero. then the loss in mechanical energy of the block due to friction in this process is
(A) 8 J (B) 41 J
(C) 49 J (D) 90 J **[B]**

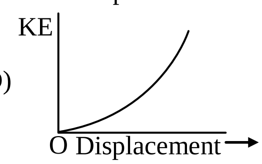
Q.27 If a man increases his speed by 2 m/sec, his K.E. is doubled. The original speed of the man is
(A) $(2+\sqrt{2})$ m/s (B) $(2 + 2\sqrt{2})$ m/s
(C) 4 m/s (D) $(1 + \sqrt{2})$ m/s **[C]**

Q.28 A block is resting over a smooth horizontal plane. A constant horizontal force starts acting on it at t =0 .Which of the following graphs is/are correct ?

(A)


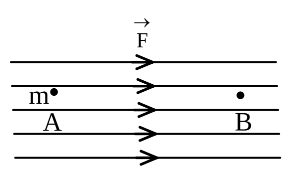
(B)


(C)


(D)


[B]

Q.29 In a region of space a constant force F newton acts on a particle of mass m, which is released from rest at point A. When the particle reaches B its -



(A) potential energy (PE) increases but kinetic energy (KE) decreases.
(B) PE decreases but KE increases.
(C) PE remains constant but KE increases.
(D) PE decreases but KE remains constant **[A]**

Q.30 The linear momentum of a body is increased by 50 % , then the increase in the kinetic energy will be
(A) 25% (B) 50 %
(C) 100 % (D) 125 % **[D]**

Q.31 A bus and a car, moving with the same speed are brought to rest by applying the same retarding force then

(A) bus will come to rest in a shorter distance

(B) car will come to rest in a shorter distance

(C) both will come to rest in the same distance

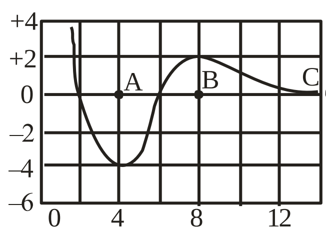
(D) none of the above **[B]**

Q.32 A long spring , when stretched by a distance x, has the potential energy U. On increasing the stretching to nx , the potential energy of the spring will be –

(A) U/n (B) nU

(C) n^2U (D) U/n^2 **[C]**

Q.33 For the potential energy function shown in fig. there will be an unstable equilibrium at position



(A) A

(B) B

(C) C

(D) none of the above **[B]**

Q.34 A body of mass 2 kg is thrown up vertically with a kinetic energy of 490 J. If g = 9.8 m/s^2, the height at which the kinetic energy becomes half its original value is-

(A) 10 m (B) 12.5 m

(C) 25 m (D) 50 m **[B]**

Q.35 The work done by the external forces on a system equals the change in the :-

(A) total energy (B) kinetic energy

(C) potential energy (D) none of these **[A]**

Q.36 Energy required to accelerate a car from 10 to 20 ms^{-1} compared with that required to accelerate from 0 to 10 ms^{-1} in the same interval of time covering the same distance, is.

(A) twice (B) four times

(C) three times (D) same **[C]**

Q.37 If a simple pendulum of length ℓ has the maximum angular displacement (θ) then the maximum KE of its bob of mass m is –

(A) (1/2) m (ℓ /g) (B) (1/2) m (g / ℓ)

(C) mgℓ (1 – cos θ) (D) (1/2) mgℓ sin θ

[C]

Q.38 Two springs A and B ($k_A = 2k_B$) are stretched by applying forces of equal magnitudes at the four ends. If the energy stored in A is E, then energy that in B is-

(A) E/ 2 (B) 2E (C) E (D) E/4

[B]

Q.39 A block of mass m = 1kg moving on horizontal surface with speed u = 2m/s enters a rough horizontal patch ranging from x = 0.10 m to x = 2.00m. If the retarding force f_r on the block in this range is inversely proportional to x over this range i.e.

$f_r = \frac{-k}{x}$ $\quad 0.10 < x < 2.00$

$= 0$ $\quad$ for $x < 0.10$ and $x > 2.00$

If k = 0.5 J then the speed of this block as it crosses the patch is (use ℓn 20 = 3)

(A) 2.65 m/s (B) 1 m/s

(C) 1.5 m./s (D) 2 m/s **[B]**

Q.40 An engine pumps a liquid of density 'd' continuously through a pipe of area of cross section A. If the speed with which the liquid passes through a pipe is v. then the rate at which the kinetic energy is being imparted to the liquid is

(A) $Adv^3/2$ (B) (1/2) Adv

(C) $Adv^2/2$ (D) Adv^2 **[A]**

Q.41 A block of mass M is allowed to slide down a fixed smooth inclined plane of angle θ and length ℓ .What is the power developed by the force of gravity when the block reaches the bottom ?

(A) $\sqrt{2m^2\ell(g\sin\theta)^3}$ (B) (2/3) m^3 ℓ g^2 sin θ

(C) $\sqrt{(2/3)m^2t^2 g\cos\theta}$ (D) (1/3) $m^3 \ell g^2 \sin\theta$

[A]

Q.42 A body of mass m is projected at an angle θ to the horizontal with initial velocity u. The mean power developed by the gravity over the time of flight is–

(A) mgu sinθ (B) mgu cosθ

(C) mg(gt – u) (D) zero **[D]**

Q.43 An object of mass (m) is located on the horizontal plane at the origin O. The body acquires horizontal velocity V. The mean power developed by the frictional force during the whole time of motion is (μ = frictional coefficient)–

(A) μmgV (B) $\frac{1}{2}$ μmgV

(C) μ mg $\frac{V}{4}$ (D) $\frac{3}{2}$ μmgV **[B]**

Q.44 A 50 kg girl is swinging on a swing from rest. Then the power delivered when she was moving with a velocity of 2 m/s upwards in a direction making an angle 60º with the vertical is –

(A) 980 W (B) 490 W

(C) 490W (D) 245 W **[B]**

Q.45 From a water fall, water is pouring down at the rate of 100 kg per second on the blades of turbine. If the height of the fall is 100 m, the power delivered to the turbine is approximately equal to –

(A) 100 kW (B) 10 kW

(C) 1 kW (D) 100 W **[A]**

Q.46 A bus of mass 1000 kg has an engine which produces a constant power of 50 kW. If the resistance to motion, assumed constant, is 1000 N. The maximum speed at which the bus can travel on level road and the acceleration when it is travelling at 25 m/s , will respectively be -

(A) 50 m/s , 1.0 m/s^2 (B) 1.0 m/s , 50 m/s^2

(C) 5.0 m/s, 10 m/s^2 (D) 10 m/s , 5 m/s^2

[A]

Q.47 It is found that the force required to row a boat in a river is proportional to the speed of the boat. When the speed of the boat is kept v km / hr, the power expended by the boat engine is 24 horse power. What shall be the power required, if one wishes to row the boat at a speed 2v km/hr –

(A) 48 hp (B) 96 hp

(C) 144 hp (D) 192 hp **[B]**

Q.48 Power applied to a particle varies with time as P = [$3t^2$ – 2t + 1] watts. Where t is time in seconds. Then the change in kinetic energy of particle between time t = 2s to t = 4s is –

(A) 46 J (B) 52 J

(C) 92 J (D) 104 J **[A]**

Q.49 A 60 cm diameter hand wheel is rotated by exerting a force of 30 newton at the outer rim. If the wheel is turned through 1/2 revolution, then the work done is -

(A) zero (B) 18.0 joule

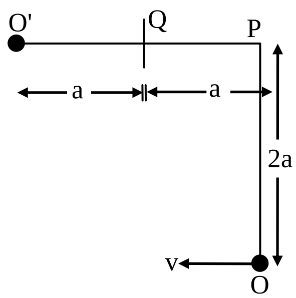
(C) 28.3 joule (D) 56.5 joule **[C]**

Q.50 A small block of mass m is kept on a rough inclined surface of inclination θ fixed in an elevator. The elevator goes up with a uniform velocity v and the block does not slide on the wedge. The work done by the force of friction on the block in time t will be –

(A) zero (B) mgvt $\cos^2\theta$

(C) mgvt $\sin^2\theta$ (D) mgvt sin 2θ **[C]**

Q.1 A particle of mass m is attached to the end of a light inextensible string of length 2a, the other end of which is attached to a fixed point P. The particle is projected horizontally from the point 2a below P with speed v. As it comes in level with P, a peg distant a from P catches the string. In the subsequent motion, the particle can just describe a full circle about Q. Find v. (see figure).

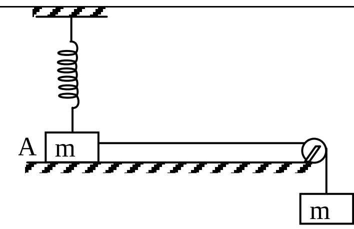


Ans. $v = \sqrt{7ag}$

Q.2 A particle moves along the x-axis from x = 0 to x = 5 m under the influence of a force F(in N) given by $F = 3x^2 - 2x + 7$. Calculate the work done by this force.

Sol. 135 J

Q.3 Figure shows two blocks A and B, each having a mass of 320 g connected by a light string passing over a smooth light pulley. The horizontal surface on which the block A can slide is smooth. The block. A is attached to a spring of spring constant 40 N/m whose other end is fixed to a support 40 cm above the horizontal surface. Initially, the spring is vertical and unstretched when the system is released to move. Find the velocity of the block A at the instant it breaks off the surface below it. Take $g = 10\ m/s^2$.



Ans. 1.5 m/s

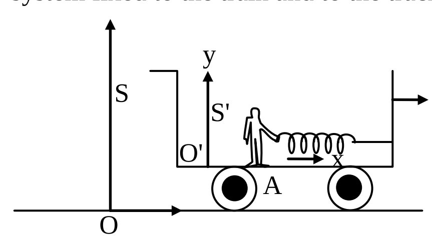
Q.4 A body of mass m is hauled from the Earth's surface by applying a force F varying with the height of ascent y as F = 2 (ay – 1) mg, where a is a positive constant. Find the work performed by this force and the increment of the body's potential energy in the gravitational field of the Earth over the first half of the ascent.

Ans. $A = \frac{3mg}{4a}, \Delta U = \frac{mg}{2a}$

Q.5 A smooth sphere of radius R is made to translate in a straight line with a constant acceleration a. A particle kept on the top of the sphere is released from there at zero velocity with respect to the sphere. Find the speed of the particle with respect to the sphere as a function of the angle θ it slides.

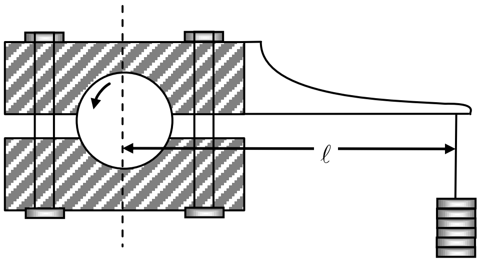
Ans. $[2R\,(a \sin\theta + g - g \cos\theta)]^{1/2}$

Q.6 A x'man stretches a spring attached to the front wall of a railway carriage through a distance ℓ in time τ opposite to the motion of the carriage, during which the train it self moved through L. What will be the work done by the man in a system fixed to the train and to the track.



Ans. $\frac{1}{2}K\ell^2$, work done is same in both the frames

Q.7 The power of an engine is frequently determined experimentally with the aid of the so-called absorption dynamometer which consists of two shoes tightly gripping the shaft of the engine. A lever with a weight on the end is attached to one of the shoes (Fig.). The weight is selected so as to equalize the force of friction and hold the lever in a horizontal position.



Determine the power of the engine if the number of shaft revolutions is n = 60 rpm, the length of the lever from the centre of the shaft is ℓ = 1m and the weight Q = 50 kgf. Disregard the weight of the lever.

Sol. **4.2 hp**

Q.8 A body of mass m is pushed with the initial velocity v_0 up an inclined plane set at an angle α to the horizontal. The friction coefficient is equal to k. What distance will the body cover before it stops and what work do the friction forces perform over this distance ?

Ans. $v_0^2/2g\ (\sin\alpha + k\cos\alpha)$, $A = -mv_0^2 k/2\ (k+\tan\alpha)$

Q.9 A system consists of two springs connected in series and having the stiffness coefficient k_1 and k_2. Find the minimum worked to be performed in order to stretch this system by $\Delta\ell$.

Ans. $A_{min} = \frac{1}{2} k (\Delta\ell)^2$, where $k = \frac{k_1 k_2}{k_1 + k_2}$

Q.10 A block of mass 2.0 kg is pulled up on a smooth incline of angle 30º with the horizontal. If the block moves with an acceleration of 1.0 m/s^2, find the power delivered by the pulling force at a time 4.0 s after the motion starts. What is the average power delivered during the 4.0 s after the motion starts ?

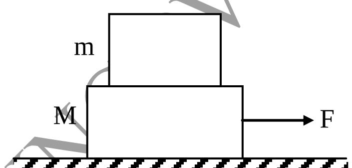
Ans. 47 W, 24 W

Q.11 A motorcycle whose mass including rider is 200 kg can go at 10 m/s up a plane of inclination 1 in 14 and 20 m/s down the same plane. If the resistance varies as the square of the speed and the power developed by the machine is constant, find the power developed.

Ans. 2KW

Q.12 A block of mass m is kept over another block of mass M and the system rests on a horizontal surface, (figure). A constant horizontal force F acting on the lower block produces an acceleration $\frac{F}{2(m+M)}$ in the system, the two blocks always move together.

(a) Find the coefficient of kinetic friction between the bigger block and the horizontal surface. (b) Find the frictional force acting on the smaller block. (c) Find the work done by the force of friction on the smaller block by the bigger block during a displacement d of the system.



Ans. (a) $\frac{F}{2(M+m)g}$ (b) $\frac{mF}{2(M+m)}$ (c) $\frac{mFd}{2(M+m)}$

Q.13 A small body of mass m is located on a horizontal plane at the point O. The body acquires a horizontal velocity v_0. Find:

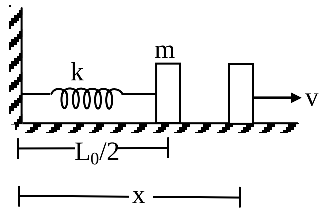
(a) the mean power developed by the friction force during the whole time of motion, if the friction coefficient k = 0.27, m = 1.0 kg, and v_0 = 1.5 m/s ;

(b) the maximum instantaneous power developed by the friction force, if the friction coefficient varies as $k = \alpha x$, where α is a constant, and x is the distance from the point O.

Ans. (a) $\langle P \rangle = -kmgv_0/2 = -2W$

(b) $P_{max} = -\frac{1}{2} mv_0^2 \sqrt{\alpha g}$

Q.14 A block of mass m is pushed against a spring of spring constant k fixed at one end to a wall. The block can slide on a frictionless table as shown in figure. The natural length of the spring is L_0 and it is compressed to half its natural length when the block is released. Find the velocity of the block as a function of its distance x from the wall.



Ans. $v = \sqrt{\frac{k}{m}}\left[\frac{L_0^2}{4} - (L_0 - x)^2\right]^{1/2}$, when $x \le L_0$;

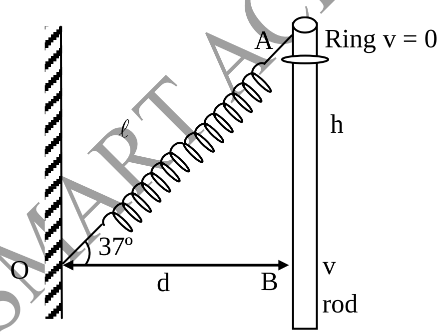
$v = \sqrt{\frac{k}{m}}\frac{L_0}{2}$, when $x \ge L_0$

Q.15 An object is attached to a vertical spring and slowly lowered to its equilibrium position. This stretches the spring by an amount d. If the same object is attached to the same vertical spring but permitted to fall instead, through what distance does it stretch the spring ?

Ans. 2d

Q.16 One end of a light spring of natural length d and spring constant K is fixed on a rigid wall and the other is fixed to a smooth ring of mass m which can slide without friction in a vertical rod fixed at a distance d from the wall. Initially the spring makes an angles of 37º with the horizontal as shown in figure. When the system is released from rest, find the speed of the ring when the spring becomes horizontal.

[sin 37º = 3/5]

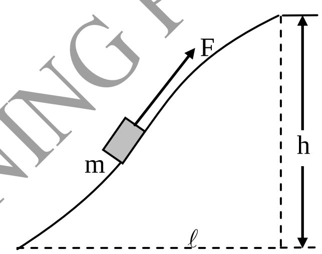


Ans. $v = d\sqrt{\left(\frac{3g}{2d} + \frac{K}{16\,m}\right)}$

Q.17 A uniform chain of length ℓ and mass m overhangs a smooth table with its two third part lying on the table. Find the kinetic energy of the chain as it completely slips off the table.

Ans. $\frac{4}{9}\,mg\ell$

Q.18 A body of mass m was slowly hauled up the hill (fig). by a force F which at each point was directed along a tangent to the trajectory. Find the work performed by this force, if the height of the hill is h, the length of its base ℓ, and the coefficient to friction k.



Ans. $A = mg\,(h + k\ell)$

Q.19 Two cylindrical vessels of equal cross-sectional area A contain water upto heights h_1 and h_2. The vessels are interconnected so that the levels in them become equal. Calculate the work done by the force of gravity during the process. The density of water is ρ.

Ans. $\rho A \left(\frac{h_1 - h_2}{2}\right)^2 g$

Q.20 A body of mass m is thrown at an angle α to the horizontal with initial velocity v_0. Find the mean power imparted by gravity over the whole time of motion of body and the instantaneous power of gravity as a function of time.

Ans. zero