Class: XI
Subject: Physics
Topic: Work Energy and Power
No. of Questions: 20

Q1. A man pushes against a wall but fails to move it. He did

a. negative work
b. positive but not maximum work
c. maximum positive work
d. no work at all

Sol: d

Work done $(W) = \vec{\mathbf{F}} \cdot \vec{\mathbf{s}}$

$= Fs \cos\theta$

When a man pushes against a wall but fails to move it, then displacement of wall $(\vec{\mathbf{s}}) = 0$

$\therefore$ Work done $(W) = F \times 0 \times \cos\theta$

$= 0$

Therefore, man does no work at all.

Q2. Which of the following options is a form of energy?

a. Light
b. Pressure
c. Momentum
d. Force

Sol: a

Light is a form of energy.

Q3. Water is falling on the blades of a turbine at a rate of 6000 kg/min. The height of the fall is 100 m. The power given to the turbine is (Take g = 10 m/s^2)

a. 10 kW
b. 6 MW
c. 100 kW
d. 150 kW

Sol: c

Power = $\frac{\text{energy}}{\text{time}}$

= $\frac{mgh}{t}$ = $\frac{6000 \times 10 \times 100}{60}$

Power = 100 kW

Q4. A particle of mass 100 g is thrown vertically upwards with a speed of 5 m/s. The work done by the force of gravity, during the time the particle goes up is

a. 0.5 J
b. 1.25 J
c. 1.25 J
d. 0.5 J

Sol: b

$- mgh = - mg(v^2/2g)$

By solving we will get - 1.25 J

Q5. When a body moves in a circular path, no work is done by the force, since

a. force and displacement are perpendicular to each other
b. the force is always away from the center
c. there is no displacement
d. there is no net force

Sol: a

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When a body moves on a circular path then force and distance are perpendicular to each other. Therefore, work done by the force is

$$W = F \cdot d \cos\theta$$
$$= F \cdot d \cos 90^\circ \quad (\because \theta = 90^\circ)$$
$$= 0 \quad (\because \cos 90^\circ = 0)$$

Q6. A particle accelerating uniformly has velocity 'v' at time 't_1'. What is work done in time 't'?

a. $\frac{1}{2}\frac{mv^2}{t_1^2}t^2$

b. $\frac{1}{2}\left(\frac{mv}{t_1}\right)^2 t^2$

c. $\frac{mv^2}{t_1^2}t^2$

d. $\frac{2mv^2}{t_1^2}t^2$

e.

Sol: a

Velocity of particle accelerating uniformly in time t_1,

$$v = at_1$$

$$\Rightarrow \quad a = \frac{v}{t_1}$$

Velocity of particle in time t,

$$v' = at = \frac{vt}{t_1}$$

According to work-energy theorem,
work done = change in kinetic energy

i.e., $W_{ext} = \Delta K$

or $W_{ext} = \frac{1}{2}mv'^2 - 0$

$$= \frac{1}{2}m\left(\frac{vt}{t_1}\right)^2$$

$$= \frac{1}{2}\frac{mv^2}{t_1^2}t^2$$

Q7. Two objects of masses 1 kg and 2 kg are moving along the same line and direction with velocities of 15 ms^{-1} and 10 ms^{-1}, respectively. After they collide, the first object moves at a velocity of 10 ms^{-1}, the velocity of the second object is

a. 15 ms^{-1}
b. 12.5 ms^{-1}
c. 10 ms^{-1}
d. 8.5 ms^{-1}

Sol: b

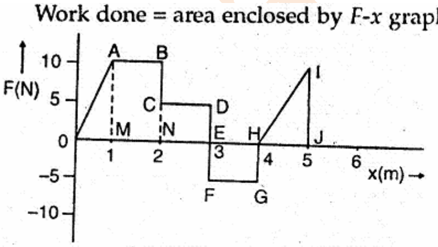
$m_1 = 1$ kg $m_2 = 2$ kg $u_1 = 15$ m/s $u_2 = 10$ m/s
$v_1 = 10$ m/s $v_2 = ?$
According to law of conservation of momentum
$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$ $1\times10+2\times v_2=1\times15+2\times10$
By solving, $v_2 = 12.5$ m/s

Q8. The relationship between the force 'F' and position 'x' of a body is as shown in the figure. What will be the work done in displacing the body from 'x = 1' m to 'x = 5' m?

a. 30 J
b. 15 J
c. 25 J
d. 29 J

Sol: b

Work done = area enclosed by F-x graph.



= area of $ABNM$ + area of $CDEN$ − area of $EFGH$ + area of HIJ

$= 1\times10+1\times5-1\times5+\frac{1}{2}\times1\times10$

$= 10+5-5+5 = 15$ J

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Q9. A body of mass 'm' is accelerated uniformly from rest to a speed 'v' in a time 'T'. The instantaneous power delivered by the body as a function of time, is given by

a. $\frac{mv^2}{T^2}t$
b. $\frac{mv^2}{T^2}t^2$
c. $\frac{1}{2}\frac{mv^2}{T^2}t$
d. $\frac{1}{2}\frac{mv^2}{T^2}t^2$

Sol: a

$$v = 0 + aT \Rightarrow a = \left(\frac{v}{T}\right)$$

Velocity at any time $t = \left(\frac{v}{T}\cdot t\right)$

$$P = F\cdot v = \frac{mv}{T}\cdot\frac{v}{T}\cdot t = \frac{mv^2}{T^2}\cdot t$$

Q10. The momentum of a body increases by 20%. What is the percentage increase in its kinetic energy?

a. 36
b. 44
c. 52
d. 60

Sol: b

$KE = \frac{1}{2} mv^2$
$P = mv$
Therefore, $KE = \frac{1}{2} (mv)^2/m = p^2/(2m)$
Considering the mass to be constant, if the momentum is increased by 20%, let the new momentum be,
$P^/ = P + 0.2P = 1.2P$
The new kinetic energy is, $KE^/ = (P^/)^2/(2m)$

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=> $KE^/ = (1.2)^2[P^2/(2m)] = 1.44KE$
=> $(KE^/)/KE = 1.44$
=> $(KE^/ - KE)/KE = 0.44$
=> $(KE^/ - KE)/KE \times 100\% = 44\%$

Q11 A 20 g bullet pierces through a plate of mass $M_1 = 1$ kg and then comes to rest inside a second plate of mass $M_2 = 2.98$ kg. It is found that the two plates, initially at rest, now move with equal velocities. What is the percentage loss in the initial velocity of the bullet when it is between M_1 and M_2. Neglect any loss of material of the plates due to the action of bullet?

a. 25%
b. 35%
c. 40%
d. 60%

Sol: a

If v_1 is the velocity of the bullet after pasing through M_1(when it is between M_1 and M_2) and v_2 is the velocity of the plates $M_1$and M_2 due to the interaction of the bullet with them.
By conservation of momentum for the system consisting of bullet and plate of mass M_1
$mv + M_1*0 = mv_1 + 1 * v_2$
$0.02v= 0.02v_1 +1*v_2$ -----------eq 1
and for the system consisting of bullet and plate of mass M2
$mv_1 = (M_2+m)v_2$so, $0.02v_1 = 3v_2$ --------- eq 2
Put value of v_2 from eq 2 in 1
$0.02v = 0.02v_1 + 0.02v_1$v-= v1+ $(1/3)v_1$
$v_1 /v = 3/4$
v% $\frac{\Delta v}{v} = \frac{v - v_1}{v} * 100 \frac{v - \frac{3}{4}v}{v} * 100 = 25$ %

Q12 A car is moving along a straight road. If its engine is delivering constant power, then the distance covered by the car in time t is proportional to

a. $t^{1/2}$
b. $t^{2/3}$
c. $t^{3/2}$
d. t^2

Sol: c

P = F.V and F = ma
So, P = maV

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$P = m\frac{dv}{dt}V$..........(1)

$P = m\frac{dv}{dx}.\frac{dx}{dt}V$

$P = m\frac{dv}{dx}.V^2$

$\int P\,dx = \int mV^2\,dv$

$Px = \frac{mV^3}{3}$ ....(2)

In (1),

$P = m\frac{dv}{dt}.V$

$Pt = \frac{mV^2}{2}$

$\sqrt{\frac{2Pt}{m}} = V$

Put in (2),

$Px = \frac{m}{3}(\frac{2Pt}{m})^{\frac{3}{2}}$

$x \propto t^{3/2}$

Q13 Find the work done by a force given (in N) by $F_x = (5x - 4)$, when this force acts on a particle that moves from x = 1 m to x = 3 m

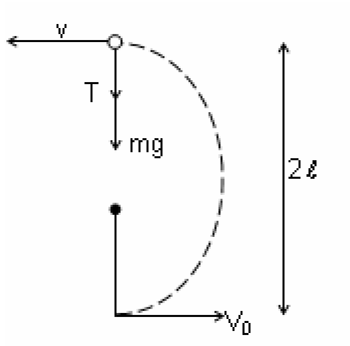
a. 12 J
b. 16 J
c. 3 J
d. 2 J

Sol: a

$$W = \int_1^3 (5x-4)dx$$

$$W = [5\frac{x^2}{2} - 4x]_1^3 = 12J$$

Q14 A mass m is attached to the end of a rod of length l. The mass goes around a vertical circular path with the other end hinged at the centre. What should be the minimum velocity of mass at the bottom of the circle so that the mass completes the circle?



a. $\sqrt{4gl}$

b. $\sqrt{3gl}$

c. $\sqrt{5gl}$

d. $\sqrt{gl}$

Sol: c

Apply the law of conservation of energy.

$$\frac{1}{2}mv_o^2 = \frac{1}{2}mv^2 + mg(2l)$$

$$mv^2 = mv_0^2 - 4mgl \quad \text{-----(1)}$$

As the bob is moving in a circle, its acceleration towards the centre is $\frac{v^2}{l}$

Apply Newton's second law,

$$mg + T = m\frac{v^2}{l} \quad \text{----(2)}$$

Putting the value of mv^2 from eq. (1) in eq. (2),we get

$$mg + T = \frac{mv_o^2 - 4mgl}{l}$$

Solving we get, $mv_o^2 = 5mgl + Tl$

For v_o to be minimum, T should be minimum.

So, $mv_o^2 = 5mgl$

$v_o = \sqrt{5gl}$

Q15. An automobile travelling with a speed of 60 km/hr can stop within a distance of 20 m. If the car travels twice as fast, i.e. 120 km/hr, then the automobile will stop within a distance of

a. 20 m
b. 40 m
c. 60 m
d. 80 m

Sol: d

$u = 60 \text{ km/hr} = \frac{50}{3} \text{ m/s}$

From equation

$$v^2 = u^2 - 2\alpha s$$

$$0 = \left(\frac{50}{3}\right)^2 - 2\alpha \times 20 \quad 12.$$

$$\alpha = \frac{125}{18} \text{ m/s}^2 \quad 13.$$

when $u = 2u$

$$= 2 \times \frac{50}{3}$$

$$= \frac{100}{3} \text{ m/s,}$$

then $0 = \left(\frac{100}{3}\right)^2 - 2 \times \frac{125}{18} s$

$\Rightarrow s = 80 \text{ m}$

Q16. The displacement x of a particle varies with time t as $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will

a. go on decreasing with time
b. be independent of α and β
c. drop to zero when α = β
d. go on increasing with time

Sol: d

$$x = ae^{-\alpha t} + be^{\beta t}$$

$$v = \frac{dx}{dt} = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$$

$$\frac{dv}{dt} = a\alpha^2 e^{-\alpha t} + b\beta^2 e^{\beta t}$$

$$\frac{dv}{dt} > 0$$

v is increasing function of time.

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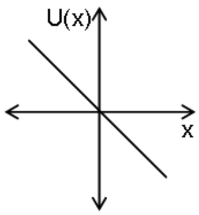
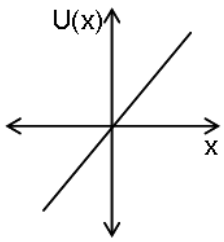
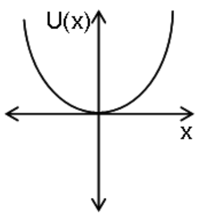
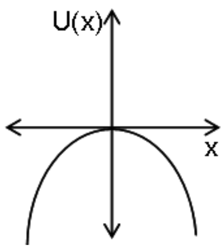
Q17. A particle is placed at the origin and a force F = Kx is acting on it (where K is positive constant). If u (0) = 0, the graph of u(x) versus x will be (where u is potential energy function)

a. 

b. 

c. 

d. 

Sol: d

Given, $F = kx$ where k is positive constant.

Force, $F = \frac{-dU(x)}{dx}$

or $\frac{dU(x)}{dx} = -kx$

or $dU(x) = -kx\,dx$

Integrating both the sides,

$U(x) = -\int kx\,dx = -\frac{1}{2}kx^2$

or $$x^2 = -\frac{2}{k}U(x) \quad ...(i)$$

Comparing Eq. (i) with the standard equation of parabola, which is given by

$$x^2 = 4ay$$

we conclude that the graph of $U(x)$ versus x satisfies the graph of parabola.

Since the equation (i) has minus sign, therefore the graph will be open downwards along $U(x)$.

Q18. A body constrained to move in y-direction is subjected to a force $\vec{F} = 2\hat{i} + 15\hat{j} + 6\hat{k}$ N. The work done by this force in moving the body through a distance of 10 m along y-axis is

a. 100 J
b. 150 J
c. 120 J
d. 200 J

Sol: b

150 J
Displacement = 10j (along y - axis only)
Force $\vec{F} = 2\hat{i} + 15\hat{j} + 6\hat{k}$
Work = F . D = 10 x 15 = 150 J

Q19. Directions: An object of mass m is whirled with a constant speed v in a vertical circle with centre O and radius R. T_1, T_2, T_3 and T_4 are the tensions in the string when the object is at A (top of the circle), B, C (the lowermost point of the circle) and D respectively (as shown in the figure).

The minimum speed the object must have at the highest point A to complete the circle is

a. $\sqrt{\frac{Rg}{2}}$
b. $\sqrt{Rg}$
c. $\sqrt{2Rg}$
d. $2\sqrt{Rg}$

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Sol: b

In order to keep a body of mass m in a circular path, the centripetal force, at the highest point A, must at least be equal to the weight of the body. Thus

$$\frac{mv_A^2}{R} = mg \quad \text{or} \quad v_A = \sqrt{Rg}$$

gives the minimum speed the body must have at the highest point so that it can complete the circle. Hence the correct choice is (2).

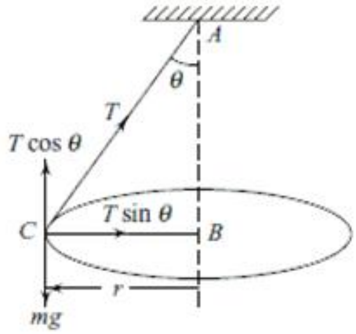
Q20. Directions: A conical pendulum consists of a string of length L, fixed at one end and carrying a body of mass m at the other end. The mass is revolved in a circle in the horizontal plane about a vertical axis passing through the fixed end of the string. The angular frequency of revolution of the body is ω. The string makes an angle θ with the vertical axis.

The tension in the string is

a. $\frac{m\omega^2}{L}$
b. $\frac{L\omega^2}{m}$
c. $m\omega^2 L$
d. $m\omega L^2$

Sol: c

Let T be tension in the string. Figure shows the forces acting on the system. Tension T can be resolved into two mutually perpendicular components.



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The horizontal component $T \sin \theta$ provides the centripetal force for circular motion and the vertical component $T \cos \theta$ balances the weight mg.

Thus

$$T \cos \theta = mg \qquad (1)$$

and $$T \sin \theta = \frac{mv^2}{r} = m\omega^2 r$$

But $r = L \sin \theta$. Therefore,

$$T \sin \theta = m\omega^2 L \sin \theta \text{ or } T = m\omega^2 L \qquad (2)$$

Hence the correct choice is (3).