PHYSICS

MECHANICS

Chapter 01: Motion in one-dimension:-

- **Basic definitions.**
- **Equations of motion(Both horizontal & vertical motions).**
- **Graphical representation(*x-t*, *v-t* and *a-t*) & Significance of different graphs.**
- **Concept of relative velocity.**

Chapter 02: Newton's laws of motion:-

- Basic definitions: inertia,momentum,force, impulse, etc.,
- Statements of the three laws.
- Equations F=ma, F=k*x*,p=mv ,etc.,
- Conservation of linear momentum.
- Inertial & Non-inertial frames of reference.
- Apparent weight.

Chapter 03 : Friction:-

- Concepts of Static ,Kinetic and rolling friction.
- Basic relations involving frictional forces.
- Advantages and drawbacks of friction.

01. A car goes from A to B with a speed of 40 km/hr and returns from B to A with a speed of 60 km/hr. Its average velocity and average speed, during the whole journey is

1) 50 & 50kmph
2) 0 & 48kmph
3) 48 & 0 kmph
4) 40 & 60 kmph

Solution: 1.Averagevelocity=Displacement/time=**0**

2.Let t_1 and t_2 be the time taken to travel from A to B and B to A .

t_1=AB/40 and t_2=BA/60. So Total time= $t_1 + t_2$

= AB/40 + AB/60 =100AB/2400 =AB/24.

Total distance = 2AB.

Average speed=2AB/AB/24=**48km/hr**.

Hence the correct answer is (2).

02. A train of length 150m is going north at a speed of $10ms^{-1}$. A parrot flies at a speed of $5ms^{-1}$ towards south parallel to the railway track. The time taken by the parrot to cross the train is

1) 12s 2) 8s

3) 15s 4) 10s

Solution: As the train and the parrot are moving in opposite directions, the relative velocity of the parrot w.r.t. the train

$=[10-(-5)]=15ms^{-1}$

Time taken by the parrot to cross the train=150/15=**10s**

Hence the answer is (4)

03. Which of the following observers is inertial?

1) A child revolving in a merry-go-round
2) A driver in a car moving with a uniform velocity
3) A pilot in an aircraft which is taking off
4) A passenger in a train which is slowing down to stop

Solution: If you observe the situations carefully, it is obvious that ‘ a driver in a car moving with uniform velocity’ is the only case of inertial frame (it obeys the law of inertia).

Hence the correct answer is (2)

04. A car moving with a speed of 40kmph can be stopped by applying brakes after at least 2m. If the same car is moving with a speed of 80kmph, what is the minimum stopping distance?

1) 2m
2) 4m
3) 6m
4) 8m

Solution: Using the equation of motion, $v^2=u^2+2as$ and taking $u=0$, we can observe that

$v^2 \alpha 2as$.

But 'a' is constant. So $v^2 \alpha s$

$S_2/S_1= v_2^2/ v_1^2$ which gives

$S_2= S_1 v_2^2/ v_1^2=2m x (80)^2/ (40)^2=8m$.

Therefore right option is (4)

05. The acceleration 'a' (in ms^{-2}) of a body, starting from rest varies with time 't' (in s) according to the relation $a = 3t + 4$, the velocity (in ms^{-1}) of the body at time $t = 2s$, will be

1) 10 2) 12
3) 14 4) 16

Solution: Given that $a=3t+4$

i.e., $dv/dt = 3t+4$.

So $dv = 3t+4\ dt$.

Integrating on both sides we get,

$v = 3t^2+4t$. Now at $t=4s$,

$v=3x2^2/2+4x2 = 14ms^{-1}$.

The correct option is (3)

06. A force vector F = 6i-8j+10k (N) applied to a body accelerates it by $\sqrt{2}ms^{-2}$. The mass of the body (in kg) is

1) $10\sqrt{2}$
2) $2\sqrt{10}$
3) 10
4) 20

Solution: The magnitude of the force

$$F = \{(6)^2 + (-8)^2 + (10)^2\}^{1/2}$$

$$= \{36+64+100\}^{1/2}$$

$$= \{200\}^{1/2} = 10\sqrt{2}N$$

Using F=ma, $m = F/a = 10\sqrt{2}/\sqrt{2} =$ 10kg.

Hence correct choice is (3)

07. A body A is at rest and a body B is moving with a uniform velocity of $40 ms^{-1}$. Force F_1 acts on A and F_2 acts on B for 10s. The velocity of A and B now is $40 ms^{-1}$ and $100 ms^{-1}$ respectively. If A and B are of masses in the ratio1:2 , then

1) $F_1 = F_2$

2) $F_1 = 2 F_2$

3) $F_1 = F_2/2$

4) $F_1 = F_2/3$

Solution: From Newton's second law,

$F = m(v-u)/t$.

The force on A, $F_1 = m_1 (40-0)/10$--- (i)

The force on B, $F_2 = m_2 (100-40)/10$--- (ii)

Hence $F_1/F_2 = 4m_1/ 6m_2$

$= 4/6 \times 1/2$

$= 1/3$ $\{ m_1/ m_2 = 1/2\}$

So $F_1 = F_2/3$

Correct answer is (4)

08. A rope which can withstand a maximum tension of 400N is hanging from a tree. If a monkey of mass 30kg climbs on the rope, in which of the following cases will the rope break? ($g=10ms^{-2}$). Neglect the mass of the rope.

1) The monkey climbs up with a uniform speed of $5ms^{-1}$

2) The monkey climbs up with a uniform acceleration of $2\ ms^{-2}$

3) The monkey climbs up with a uniform acceleration of $5ms^{-2}$

4) The monkey climbs down with a uniform acceleration of $5ms^{-2}$

Solution: Given that the maximum tension the rope can withstand is 400N.

In case 1) the tension developed in the rope=mg=30x10=300N.

In case 2) the tension developed in the rope=m (g+a) =30(10+2) =360N.

In case 3) the tension developed in the rope =m (g+a) =30(10+5) =450N

&

In case 4) the tension developed in the rope =m (g-a) = 30(10-5) =150N.

Obviously, in case 3 the rope breaks.

So correct option is (3)

09.A rope of length 10m and linear density $0.5kgm^{-1}$ is lying lengthwise on a horizontal smooth floor. It is pulled by a force of 25N.The tension in the rope at a point 8m away from the point of application, is

1) 20N
2) 15N
3) 10N
4) 5N

Solution: Total mass of the rope=10x0.5=5kg.

Acceleration=F/m=25/5=5ms^{-2}

Mass upto 8m =8x0.5=4kg.

Force acting on it=4x5=20N.

So the remaining tension is

25N-20N=5N.

Hence the right choice is (4)

10. A shell explodes into 3 fragments of equal masses. Two fragments fly off at right angles to each other with speeds of $9ms^{-1}$ and $12ms^{-1}$. What is the speed of the third fragment (in $ms^{-1)}$?

1) 9 **2) 12**

3) 15 **4) 18**

Solution: The total momentum of the shell before it explodes=0

Let 'm' be the mass of each fragment. The momentum of the first two fragments are p_1=9m andp_2=12m respectively, and as they are flying at right angles to each other, the resultant momentum of these two fragments=p=$\{(9m)^2+(12m)^2\}^{1/2}$=15m.

Now, to conserve momentum, the third fragment must have a momentum p_3 of magnitude equal to that of resultant. Hence, p_3=15m i.e., mv_3=15m. This shows that $v_3=15\ ms^{-1}$

So the correct option is (3)

11. A car is moving along a straight road with a speed of $20ms^{-1}$. If the coefficient of static friction between the tyre and the road is 0.5, the shortest distance in which the car can be stopped is (g =10 ms^{-2})

1) 30m
2) 40m
3) 20m
4) 50m

Solution: Frictional force F= µmg.

So the retardation needed is F/m=µg

Let 'x' be the minimum distance , then using

$v^2 - u^2 = 2ax$, we get $(0)^2 - (20)^2 = 2(-\mu g)x$

$400 = 2(0.5 \times 10)x$

Which gives 'x' = 40m

Correct option is (2)

12. The fast moving vehicles are given special shapes(streamlined) to reduce

1)limiting friction
2)static friction
3)dry friction
4) wet friction

Solution: It is knowledge based. The frictional force between Solid and a Fluid (Air) is called Wet friction.

Correct option is (4)

13. A body of mass 6kg rests in limiting equilibrium on an inclined plane whose slope is 30^0. If the plane is raised to a slope of 60^0, then the force in 'kgwt' along the plane required to support it is ($g=10ms^{-2}$)

1) 3

2) $2\sqrt{3}$

3) $\sqrt{3}$

4) 2

Solution: When the slope is 30^0, we have $\mu = \tan\Theta$

$= \tan 30^0 = 1/\sqrt{3}$

When the slope is raised , force required to support the body is $= mg \sin \Theta - \mu mg \cos \Theta$

So $F = 6x10x\sin 60^0 - (1/\sqrt{3})6x10x\cos 60^0$

$= 60x(\sqrt{3}/2) - 60x(1/\sqrt{3})x1/2$

$= 30\sqrt{3} - 30/\sqrt{3} \quad = 20\sqrt{3}N =$ **$2\sqrt{3}$ kgwt**

Correct option is (2)

14. Two balls are dropped from the same point after an interval of 1 second,what will be their separation 3 seconds after the release of the second ball? (g=10 ms^{-2})

1) 25 m
2) 30m
3) 35m
4) 40m

Solution:

For the first ball, t=4s and hence

$h_1 = 1/2gt^2 = 1/2 \times 10 \times 4^2 = 80m$.

For the second ball, t=3s and

$h_2 = 1/2gt^2 = 1/2 \times 10 \times 3^2 = 45m$.

Hence the separation between the two balls

$= h_1 - h_2 = 80m - 45m = 35m$.

So the correct option is (3)

15. A stone falls freely from rest and the total distance covered by it in the last second of its motion equals the distance covered by it in the first 3 seconds of its motion. The stone remains in the air for

1) 6 s
2) 5s
3) 7s
4) 4s

Solution: Given u=0 and $S_n=S_3$

Therefore $u+a/2(2n-1) = ut+1/2at^2$

i.e., $0+a/2(2n-1) = 0 + 1/2a\,(3)^2$, which gives **n=5**.

Hence the correct choice is (2)

16. A body, starting from rest, moves in a straight line with a constant acceleration '*a*' for a time interval '*t*' during which it travels a distance S_1 . It continues to move with the same acceleration for the next interval 't' during which it travels a distance S_2. The relation between S_1 and is S_2

1) $S_2 = S_1$
2) $S_2 = 2 S_1$
3) $S_2 = 3 S_1$
4) $S_2 = 4 S_1$

Solution: During the first time interval't', $u=0$ and $S=S_1$. Then $S_1=1/2at^2$--------------- (i)

The velocity gained by the body at the end of this interval of time, $v=at$---------------- (ii);

And this will be the initial velocity for the next interval of time't'.

Hence $S_2=at(t)+1/2at^2=at^2+1/2at^2=3/2\ at^2$---(iii)

From (ii) and (iii) we get $S_2=3\ S_1$

So the correct choice is (3)

17. Displacement (x) of a particle is related to time (t) as $x = at + bt^2 - ct^3$, where a, b and c are constants of motion. The velocity of the particle when its acceleration is zero is given by

1) $a + b/c^2$
2) $a + b^2/2c$
3) $a + b^2/3c$
4) $a + b^2/4c$

Solution: Given, $x = at + bt^2 - ct^3$

Differentiating w.r.t 't' we get $dx/dt = v = a + 2bt - 3ct^2$

Again $d^2x/dt^2 = a' = 2b - 6ct$

As per the problem, $a' = 0$

i.e., $2b - 6ct = 0$ which gives $t = b/3c$

Substituting in (i) and simplifying we get

$v = a + b^2/3c$.

Correct answer is (3)

18. A doll is dropped from the 25 th storey of a hotel building and it reaches the ground in 5 sec. In the first second, it passes through how many storeys of the building? ($g = 10 ms^{-2}$)

1) 1
2) 2
3) 3
4) 4

Solution: Let 'h' be the height of each storey. Then the total height of the 25 storeys is 25h.

Taking $u=0$, $g=10 ms^{-2}$ and $t=5s$, and using the equation of motion $S=ut+1/2at^2$,

$25h=0x5+1/2x10x(5)^2=125$. This gives $h=5m$.

Let 'n' be the total number of storeys through which the doll passes in 1s, then, $n \, x \, 5=0+1/2x10x(1)^2$

n=1.

Hence the correct answer is (1)

19. A motor boat covers the given distance in 4 hrs moving downstream on a river. It covers the same distance in 12 hrs moving upstream. The time it takes to cover the same distance in still water is

1) 9 hrs
2) 7 hrs
3) 6 hrs
4) 8 hrs

Solution: Let ‘u’ be the speed of the boat in still water and ‘ u_s’ be the speed of the stream respectively.

For Downstream motion of the boat,

$u + u_s = S/4$--- (i); S is the distance covered.

For Upstream motion of the boat,

$u - u_s = S/12$--- (ii). $2u = 16S/48$ or $u = S/6$. But $u = S/t$; t is the time taken to cover the same distance(S) in still water.

Hence $S/t = S/6$ which implies **t=6 hrs**.

So the choice is (3)

20. The splash is heard 2.05s after a stone is dropped into a well of depth19.6m.The velocity of sound is ($g = 9.8\ ms^{-2}$),

1) $352ms^{-1}$
2) $342ms^{-1}$
3) $392ms^{-1}$
4) $372ms^{-1}$

Solution: Let the time taken by the stone to reach the water surface be 't'.

Using , h= ut+ (1/2)gt^2 and taking u=0,

t = (2h/ g)$^{1/2}$ = (2x19.6/9.8) $^{1/2}$ = 2s

Hence the splash produced takes a time of (2.05-2)s=0.05s to reach the observer.

Speed of sound= Distance/Time=19.6/0.05 =392 ms^{-1}

Correct option is (3)

21. A person weighing 52kg is standing in a lift moving up with a constant acceleration of $2.5ms^{-2}$. The apparent weight of the person is ($g=10ms^{-2}$)

1) 65kg
2) 45kg
3) 60kg
4) 75kg

Solution: **The apparent weight of a person inside a lift (moving Upwards),**

$$W' = W\,(1 + a/g);$$

W- Real weight of the person, a- Acceleration of the lift and g-Acceleration due to gravity.

$$\text{Here } W' = 52(1 + 2.5/10)$$

$$= 52(1 + 0.25)$$

$$= 52(1.25) = 65\text{kg.}$$

Hence the right answer is (1)

22. A truck carrying sand is moving on a smooth horizontal road with a uniform speed $15ms^{-1}$. If a mass of 0.015kg of sand leaks in a time 10s from the bottom of the truck, the force needed to keep the truck moving at its uniform speed is

1) 0.0225N
2) 0.01125N
3) 0.3375N
4) Zero

Solution: The force exerted by the leaking sand on the truck= The rate of change of momentum= ($\Delta m/\Delta t$) u = 0.015/10x15= 0.0225N.

The sand falling vertically downward will exert this force on the truck in vertically upward direction. This perpendicular force can do NO work on the truck. Since the friction is absent, No force is needed to keep the truck moving at a constant speed in the horizontal direction.

Hence the correct choice is (4)

23. 80 railway wagons all of same mass 4000kg are pulled by an engine with a force of $4x10^5$N.The tension (in N) in the coupling between 30th and 31st wagons, from the engine is

1) $2.5x10^5$ 2)$1.25x10^5$

3) $1.5x10^5$ 4) $1.0x10^5$

Solution: From Newton's second law,

F = ma i.e., $4x10^5 = 80x\ 4000xa$

$a=4x10^5/80x4000=1.25ms^{-2}$

Tension developed in the coupling between 30^{th} and 31^{st} wagon will be due to mass of remaining 50 wagons. Now, mass of the remaining 50 wagons

$=50x4000kg=2x10^5kg$.

Hence required tension$=2x10^5x1.25 = 2.5x10^5N$.

So the correct option is (1)

24. A rocket of mass 6 tons is set for vertical firing. If the exhaust speed be 1km per second how much gas must be ejected to give the rocket an upward acceleration of $20ms^{-2}$? (Take $g = 10\ ms^{-2}$)

1) 45kg/s
2) 90kg/s
3) 120kg/s
4) 180kg/s

Solution: In a variable mass situation, according to Newton' Second law

$$F = u \times dm/dt$$

$$M(a+g) = u \times dm/dt$$

$$\text{So, } dm/dt = M(a+g)/u = 6000(20+10)/1000$$

$$= 180 \text{ kg/s}$$

Correct option (4)

25.A drunkard is walking on a straight road. He takes 5 steps forward and 3 steps backward and so on. Each step is 1m long and takes 1s.There is a pit on the road 11m away from the starting point. The drunkard will fall into the pit after,

1) 29s

2) 21s

3) 37s

4) 31s

Solution: 5 steps forward-3 steps backward= Displacement of 2m and time taken is 8s.

Another displacement of 2m takes 8s. Now the net displacement=4m ant time is 16. Again for one more displacement of 2m he takes 8s.

Now he is 5m away from the pit, for which he takes 5s. So total time = 8+8+8+5=**29s**

Correct option is (1)

26. A car starts from rest and moves with constant acceleration. The ratio of the distance covered in the n^{th} second and to that covered in 'n' seconds is

1) $[2/n^2-1/n]$
2) $[2/n^2+1/n]$
3) $[2/n-1/n^2]$
4) $[2/n+1/n^2]$

Solution: We have Sn = u +a/2 (2n-1) and

$S(n) = un + 1/2\ n^2$

Taking u=0 ,Sn = a/2 (2n-1) and

$S(n) = 1/2\ n^2$

Dividing and simplifying we get

$Sn/S(n) = [2/n - 1/n^2]$

Correct option (3)

27. A particle is released from the top of tower Of height '3h'. The ratio of the times to fall equal heights 'h', $t_1:t_2:t_3$ is

1) $\sqrt{3}:\sqrt{2}:1$

2) 3:2:1

3) 9:4:1

4) $1:\sqrt{2}-1:\sqrt{3}-\sqrt{2}$

Solution: $h = 1/2 g t_1^2$,

$2h = 1/2 g (t_1 + t_2)^2$ and

$3h = 1/2 g (t_1 + t_2 + t_3)^2$

$t_1 : (t_1 + t_2) : (t_1 + t_2 + t_3) = 1 : \sqrt{2} : \sqrt{3}$

So $t_1 : t_2 : t_3 = 1 : \sqrt{2} - 1 : \sqrt{3} - \sqrt{2}$

Correct option is (4)

28. If μ_R, μ_S and μ_K are coefficients of rolling friction, static friction and static friction respectively, then

1) $\mu_R = \mu_S = \mu_K$

2) $\mu_R < \mu_K < \mu_S$

3) $\mu_R < \mu_S = \mu_K$

4) $\mu_R > \mu_K < \mu_S$

Solution: Knowledge based:

$$\mu_R < \mu_K < \mu_S$$

Correct option: (2)

29. When a stone is thrown up vertically with velocity 'u', it reaches a maximum height of 'h'. If one wishes to triple the maximum height then the stone should be thrown with velocity

1) $\sqrt{3}$ u 2) 3u

3) 9u 4) 3/2u

Solution: From equations of motion, $u^2 \alpha h$.

In the first case $u^2 \alpha h$ and

in the second case $u'^2 \alpha 3h$.

So $u'^2 / u^2 = 3$

or $u' = \sqrt{3} u$.

Correct option is (1)

30. A passenger is at a distance ‘x’ from a bus when the bus begins to move with constant acceleration ‘a’. What is the minimum velocity with which the passenger should run towards the bus to catch it?

1) 2ax
2) ax
3) √ 2ax
4) √ ax

Solution: Suppose the passenger runs with a velocity 'v' to catch the bus in a time 't'.

$vt = x + (1/2)at^2$. Rearranging we get

$1/2at^2 - vt + x = 0$, the roots of which are given by, $t = (v \pm \sqrt{v^2 - 2ax})/a$.

For 't' to be real, $v^2 - 2ax \geq 0$. Hence Minimum speed , $v = \sqrt{2ax}$

Correct option (3)