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Class: XI
Subject: Physics
Topic: Description of Motion in One Dimension
No. of Questions: 30

Q1. A car, starting from rest, has a constant acceleration a_1 for a time interval t_1 during which it covers a distance s_1. In the next time interval t_2, the car has a constant retardation a_2 and comes to rest after covering a distance s_2 in time t_2. Which of the following relations is correct?

A. A1/a2/=s1/s2=t1=t2

B. A1/a2=s2/s1=t1/t2

C. A1/a2=s1/s2=t2/t1

D. A1/a2=s2/s1=t2/t1

Sol.: D

or $$s_1 = \frac{1}{2} a_1 t_1^2 \qquad \text{(i)}$$

The distance covered in the next time interval t_2 is given by

$$-2a_2 s_2 = 0 - a_1^2 t_1^2$$

$(\because v = 0 \text{ and } u = a_1 t_1 \text{ now})$

or $$s_2 = \frac{1}{2} \frac{a_1^2}{a_2} t_1^2 = \frac{1}{2} \frac{a_2^2 t_2^2}{a_2}$$

$$(\because a_1 t_1 = a_2 t_2)$$

or $$s_2 = \frac{1}{2} a_2 t_2^2 \qquad \text{(ii)}$$

From (i) and (ii) we get

$$\frac{s_1}{s_2} = \frac{a_1 t_1^2}{a_2 t_2^2} = \frac{a_2}{a_1} \frac{a_1^2 t_1^2}{a_2^2 t_2^2} = \frac{a_2}{a_1} \qquad (\because a_1 t_1 = a_2 t_2)$$

Thus we have $\frac{s_2}{s_1} = \frac{a_1}{a_2} = \frac{t_2}{t_1}$

Q2. The distance x covered by a body moving in a straight line in time t is given by the relation
$2x^2 + 3x = t$
If v is the velocity of the body at a certain instant of time, its acceleration will be

A. $-v^3$
B. $-2v^3$
C. $-3v^3$
D. $-4v^3$

Sol. D

Differentiating $2x^2 + 3x = t$ with respect to t we have

$$4x\frac{dx}{dt} + \frac{3dx}{dt} = 1 \qquad \text{(i)}$$

Now $\frac{dx}{dt} = v$. Therefore, $4xv + 3v = 1$ or $4x + 3 = 1/v$. Differentiating Eq. (i) with respect to time t, we have

$$4\left(\frac{dx}{dt}\right)^2 + 4x\frac{d^2x}{dt^2} + 3\frac{d^2x}{dt^2} = 0$$

or $$4v^2 + 4xa + 3a = 0$$

or $$a = -\frac{4v^2}{4x+3} \qquad \text{(ii)}$$

where $a = \frac{d^2x}{dt^2}$ is the acceleration. But $4x + 3 = 1/v$. Using this in Eq. (ii) we get $a = -4v^3$.

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Q3. A car was moving on a straight horizontal road with speed v. When brakes were applied to give a constant retardation a, the car was stopped in a shortest distance S. If the car is moving on the same road with speed 3v and the same retardation a is applied, then the shortest distance in which the car is stopped is given by

A. 3 S
B. 6 S
C. 9 S
D. 27 S

Sol. C

The shortest stopping distance S is given by

$$0 - v^2 = -2\,aS$$

or $S = \dfrac{v^2}{2a}$. Thus, for a given value of a, $S \propto v^2$. If v is increased by a factor of 3, S will increase by a factor $(3)^2 = 9$.

Q4. A person aims a gun at a target located at a horizontal distance of 100 m. If the gun imparts a horizontal speed of 500 $ms^{-1}$to the bullet, at what height above the target must he aim his gun in order to hit it? Take g = 10 ms^{-2}.

A. 10 cm
B. 20 cm
C. 50 cm
D. 100 cm

Sol. B

The bullet covers a distance of 100 m in time $t = 100/500 = 0.2$ s. The vertical downward distance moved in time $t = 0.2$ s is $\dfrac{1}{2}\,gt^2 = \dfrac{1}{2} \times 10 \times (0.2)^2$ $= 0.2$ m $= 20$ cm. Hence the correct choice is (2).

Q5. From the top of a tower of height 40 m, a ball is projected upwards with a speed of 20 m/s at an angle of elevation of 30°. The ratio of the total time taken by the ball to hit the ground to its time of flight (time taken to come back to the same elevation) is
(Take $g = 10\ m/s^2$)

A. 2 : 1
B. 3 : 1
C. 3 : 2
D. 1.5 : 1

Sol. A

The time of flight $t_f = \dfrac{2u\sin\theta}{g} = \dfrac{2\times 20\times 0.5}{10} =$ 2 s. The initial downward velocity = 20 sin 30° = 10 ms^{-1}. The time taken to fall through a height of 40 m with velocity 10 ms^{-1} is given by

$$40 = 10\times t + \frac{1}{2}\times 10\times t^2$$

or $$t^2 + 2t - 8 = 0$$

which gives t = 2s. Hence the total time to hit the ground $= t_f + t = 2 + 2 = 4$ s.

Q6. A gun kept on a straight horizontal road is used to hit a car travelling on the same road away from the gun at a uniform speed of 14.41 ms^{-1}. The car is at a distance of 150 m from the gun when it is fired at an angle of 45° to the horizontal. With what speed should the shell be projected so that it hits the car? Take $g = 10\ ms^{-2}$.

A. 20 ms^{-1}
B. 30 ms^{-1}
C. 40 ms^{-1}
D. 50 ms^{-1}

Sol. D

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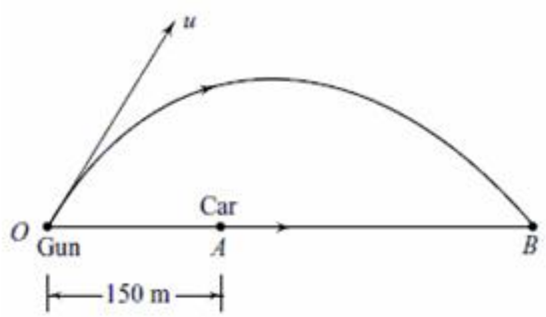
Let at $t = 0$, O and A are the positions of the gun and the car (Fig.). Let us say that at time $t = t_0$, the shell and the car reach B simultaneously so that the shell hits the car when it is at a distance OB from the gun. Let u be the speed of projection of the shell. Then, initial horizontal component of velocity of the shell $= u \cos 45° = \frac{u}{\sqrt{2}}$, and initial vertical

component $= u \sin 45° = u/\sqrt{2}$. Therefore, the time of flight $= \frac{2u}{\sqrt{2}g} = \sqrt{2}u/g$. The car takes this time to cover the distance AB while the shell covers the distance OB in this time. Now $OB = OA + AB =$ 150 m + AB. Distance AB is given by



Q7. A gun kept on a straight horizontal road is used to hit a car travelling on the same road away from the gun at a uniform speed of 14.14 ms^{-1}. The car is at a distance of 150 m from the gun when it is fired at an angle of 45° to the horizontal. What is the distance of the car from the gun when the shell hits it?

A. 250 m
B. 750 m
C. 500 m
D. 1000 m

Sol. A

The distance of the car from the gun when the shell hits is

$$OB = \frac{u^2}{g} = \frac{50 \times 50}{10} = 250 \text{ m}$$

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Q8. A body thrown along a frictionless inclined plane of angle of inclination 30° covers a distance of 40 m along the plane. If the body is projected with same speed at an angle of 30° with the ground, it will have a range of ________ (Take g = 10 ms^{-2})

A. 20 m
B. 28.28 m
C. 34.46 m
D. 40 m

Sol. C

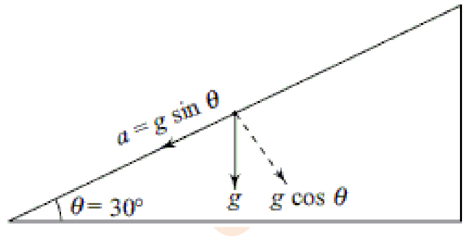
Let u be the initial speed with which the body is thrown along the inclined plane. As shown in Fig. the effective deceleration is given by

$$a = g \sin \theta$$

$$= g \sin 30° = \frac{g}{2} = 5 \text{ ms}^{-2}$$

The body stops after covering a distance, say, s along the plane, which is given by $-2as = 0 - u^2$ or $u = \sqrt{2as} = \sqrt{2 \times 5 \times 40} = 20 \text{ ms}^{-1}$. A projectile projected at angle $\theta = 30°$ with this speed will have a range of

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{20 \times 20 \times \sin 60°}{10} = 20\sqrt{3} \text{ m}$$



Q9. A body, projected with a certain kinetic energy, has a horizontal range R. The kinetic energy will be minimum at a position of the projectile when its horizontal range is

A. R
B. 3R/4
C. R/2
D. R/4

Sol. C

Kinetic energy is minimum when the projectile is at the highest point of its trajectory. At the highest point, its range = half the horizontal range. Hence the correct choice is (3).

Q10. Four projectiles are projected with the same speed at angles 20°, 35°, 60° and 75° with the horizontal. The range will be the longest for the projectile whose angle of projection is

A. 75°
B. 35°
C. 20°
D. 60°

Sol. B

Range $R = u^2 \sin 2\theta/g$. For the same u, $R \propto \sin 2\theta$. Since $\sin 2\theta$ is the largest for $\theta = 35°$, the correct choice is (2).

Q11. The maximum height attained by a projectile is increased by 10% by increasing its speed of projection, without changing the angle of projection. The percentage increase in the horizontal range will be

A. 20%
B. 15%
C. 10%
D. 5%

Sol. C

We know that $h = \dfrac{u^2 \sin^2\theta}{2g}$. The increase δh in h when u changes by δu can be obtained by partially differenting this expression. Thus

$$\delta h = \frac{2u\delta u \sin^2\theta}{2g}$$

$$\therefore \qquad \frac{\delta h}{h} = \frac{2\delta u}{u}$$

Since h is increased by 10 %, $\dfrac{\delta h}{h} = 0.1$. Therefore,

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Q12. The maximum height attained by a projectile is increased by 10% by increasing its speed of projection, without changing the angle of projection. What is the percentage increase in the time of flight of the projectile?

A. 20%
B. 15%
C. 10%
D. 5%

Sol. D

The time of flight is $T = \frac{2u\sin\theta}{g}$. Therefore

$\delta T = \frac{2\delta u \sin\theta}{g}$

which give $\frac{\delta T}{T} = \frac{\delta u}{u}$

But $\frac{\delta u}{u} = 0.05$. Therefore $\frac{\delta T}{T} = 0.05$

or $\delta T = 0.05\ T$. Hence T increases by 5%.

Q13. The speed of projection of projectile is increased by 5%, without changing the angle of projection. The percentage increase in the range will be

A. 2.5%
B. 5%
C. 7.5%
D. 10%

Sol. D

We have seen above that $\frac{\delta R}{R} = \frac{2\delta u}{u} = 2 \times 0.05$

$= 0.1 \left(\because \frac{\delta u}{u} = 0.05\right)$ or $\delta R = 0.1\ R$. Hence, R will increase by 10%.

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Q14. A projectile attains a certain maximum height when projected from the earth. If it is projected at the same angle and with the same initial speed from the moon, where the acceleration due to gravity is one-sixth that on the earth, by what factor will the maximum height of the projectile increase?

A. 1.732
B. 3
C. 2.45
D. 6

Sol. D

Let h_e and h_m be the maximum heights attained by the projectile when projected from earth and moon respectively. Now

$$h_e = \frac{u^2 \sin^2 \theta}{2g_e} \text{ and } h_m = \frac{u^2 \sin^2 \theta}{2g_m} \text{ which give}$$

$$\frac{h_m}{h_e} = \frac{g_e}{g_m} = 6.$$

Q15. A body is projected horizontally from a point above the ground. The motion of the body is described by the equations

$x = 2\,t$

and $y = 5\,t^2$

where, x and y are the horizontal and vertical displacements (in m) respectively at time t. The trajectory of the body is

A. a straight line
B. a circle
C. an ellipse
D. a parabola

Sol. D

Given $x = 2t$ and $y = 5t^2$. Eliminating t we get $y = \frac{5x^2}{4}$, i.e. $y \propto x^2$. Hence, the trajectory of the body is parabolic.

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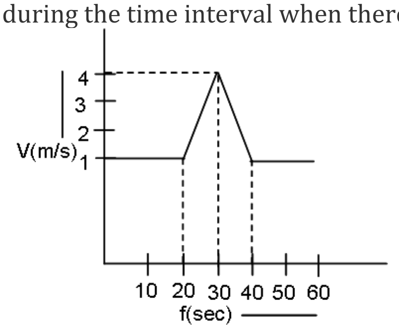
Q16. A block is placed on the top of a smooth inclined plane of inclination x kept on the floor of a lift. When the lift is descending with a retardation a, the block is released. The acceleration of the block relative to the inclined plane is

A. g sin x
B. a sin x
C. (g – a) sin x
D. (g + a) sin x

Sol. D

When the lift is descending with a retardation (negative acceleration) a, the effective value of g is $g_{eff} = g + a$. The component of this acceleration along the inclined plane is $g_{eff} \sin\theta = (g + a)\sin\theta$.

Q17. Velocity-time (v - t) graph for a moving object is shown in the figure. Total displacement of the object during the time interval when there is non-zero acceleration and retardation is



A. 60 m
B. 50 m
C. 40 m
D. 30 m

Sol.: B

Between time interval 20 s to 40 s, there is non-zero acceleration and retardation. Hence, distance travelled during this interval

= Area between time interval 20 s to 40 s

$= \frac{1}{2} \times 20 \times 3 + 20 \times 1 = 30 + 20 = 50$ m

Q18. A car moving with a speed of 50 km/h, can be stopped by brakes after at least 6 m. If the same car is moving at a speed of 100 km/h, the minimum stopping distance is

A. 12 m
B. 18 m
C. 24 m
D. 6 m

Sol. C

Energy = Work done by force (F)

$$\Rightarrow \frac{1}{2}m.(50)^2 = (F)(6) \quad \Rightarrow F = \frac{2500m}{2\times 6}$$

For $v = 100 km/hr$ $\frac{1}{2}.m(100)^2 = (F)(S)$

$$\Rightarrow \frac{1}{2}m(100)^2 = \left(\frac{2500m}{2\times 6}\right)S$$

$$\Rightarrow S = \frac{100\times 100\times 6\times 2}{2500\times 2} = 24m$$

Q19. A metro train starts from rest, and in 5 s attains a speed of 108 km/h. After that, it moves with constant velocity and comes to rest after travelling 45 metres with uniform retardation. If the total distance travelled is 395 metres, find the total time of travelling.

A. 12.2 s
B. 15.3 s
C. 9 s
D. 17.2 s

Sol. D

Given, $v = 108$ km/h $= 30$ m/s

For first equation of motion

$$v = u + at$$

$\therefore$ $30 = 0 + a \times 5$ $(\because u = 0)$

or $a = 6$ m/s^2

So, distance travelled by metro train in 5 s

$$s_1 = \frac{1}{2}at^2 = \frac{1}{2} \times (6) \times (5)^2 = 75 \text{ m}$$

Distance travelled before coming to rest

$= 45$ m

So, from third equation of motion

$$0^2 = (30)^2 - 2a' \times 45$$

or $$a' = \frac{30 \times 30}{2 \times 45} = 10 \text{ m/ s}^2$$

Time taken in travelling 45 m is

$$t_3 = \frac{30}{10} = 3\text{ s}$$

Now, total distance = 395 m

i.e., $75 + s' + 45 = 395\text{ m}$

or $s' = 395 - (75 + 45) = 275\text{ m}$

$\therefore$ $t_2 = \frac{275}{30} = 9.2\text{ s}$

Hence, total time taken in whole journey

$$= t_1 + t_2 + t_3$$
$$= 5 + 9.2 + 3$$
$$= 17.2\text{ s}$$

Q20. The speed of the car is reduced to one-third of its original speed in travelling a distance s. Later, the car is brought to rest. The distance covered is

A. 9 s
B. (8/9) s
C. (9/8) s
D. 3 s

Sol. C

Q21. A railway train 400m long is going from New Delhi railway station to Kanpur. Can we consider railway train as a point object

Sol. Yes, because length of the train is smaller as compared to the distance between New Delhi and Kanpur.

Q22. Shipra went from her home to school 2.5km away. On finding her home closed she returned to her home immediately. What is her net displacement? What is the total distance covered by her?

Sol. Displacement = 0
Distance = 2.5km + 2.5km = 5.0km.

Q23. Can speed of an object be negative? Justify

Sol. No speed of an object can never be negative because distance is also always positive.

Q24. What causes variation in velocity of a particle?

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Sol. Velocity of a particle changes
(1) If magnitude of velocity changes
(2) If direction of motion changes.

Q25. Figure. Shows displacement – time curves I and II. What conclusions do you draw from these graphs?

Sol. (1) Both the curves are representing uniform linear motion.
(2) Uniform velocity of II is more than the velocity of I because slope of curve (II) is greater.

Q26. Displacement of a particle is given by the expression x = $3t^2 + 7t - 9$, where x is in meter and t is in seconds. What is acceleration?

Sol . $x = 3t^2 + 7t - 9$

$v = \frac{dx}{dt} = 6t + 7\ m/s$

$a = \frac{d\vartheta}{dt} = 6m\ /\ s^2$

Q27. A particle is thrown upwards. It attains a height (h) after 5 seconds and again after 9s comes back. What is the speed of the particle at a height h?

Sol.

$s = ut + \frac{1}{2}at^2$

As the particle comes to the same point as 9s where it was at 5s.The net displacement at 4s is zero.

$0 = v \times 4 - \frac{1}{2}(g) \times (4)^2$

$4v = \frac{1}{2} \times 9.8 \times 16$

$v = 2 \times 9.8$

$v = 19.6m\ /\ s$

Q28. A police jeep on a petrol duty on national highway was moving with a speed of 54km/hr. in the same direction. It finds a thief rushing up in a car at a rate of 126km/hr in the same direction. Police sub – inspector fired at the car of the thief with his service revolver with a muzzle speed of 100m/s. with what speed will the bullet hit the car of thief?

Sol.

Vpl = 54km/hr = 15m/s V_{TC} = 126km/hr = 35m/s

Muzzle speed of the bullet $v_b = 100m / s.$

V_{CP} = 35 – 15 = 20m/s. V_{CP} = Velocity of car w.r.t. police

V_{BC}= 100 – 20 = 80 m/s V_{BC} = Velocity of bullet w.r.t car

Thus bullet will hit the car with a velocity 80m/s.

Q29. Establish the relation $Snth$ �� u �� $a/2\ (2n$ � $1)$ where the letters have their usual meanings.

Sol.

$Snth = Sn - Sn_{-1}$

$S_n = un + \frac{1}{2}\ am^2$

$S_{n-1} = u(n-1) + \frac{1}{2}a(n-1)^2$

$Snth = un + \frac{1}{2}an^2 - u(n-1) - \frac{1}{2}a(n-1)^2$

$un + \frac{1}{2}an^2 - un + u - \frac{1}{2}an^2 - \frac{1}{2}a + na$

$Snth = u - \frac{1}{2}a + na$

$= u + \frac{a}{2}(2n-1)$

Hence proved.

Q30. A stone is dropped from the top of a cliff and is found to ravel 44.1m diving the last second before it reaches the ground. What is the height of the cliff? g = 9.8m/s^2

Sol. Let h be the height of the cliff

N be the total time taken by the stone while falling

U = 0

A = g = 9.8m/s^2

$Snth = 4 + \frac{a}{2}(2n-1)$

$44.1 = 0 + \frac{9.8}{2}(2n-1)$

$n = \frac{10}{2} = 55$

Height of the cliff

$h = ut + \frac{1}{2}at^2$

$h = un + \frac{1}{2}gn^2$

$h = 0 \times 5 + \frac{1}{2}9.8 \times (5)^2$

$h = 4.9 \times 25$

$h = 122.5m$