SECTION – I

SINGLE CHOICE QUESTIONS

1. A particle is projected vertically upwards from O with velocity v and a second particle is projected at the same instant from P (at a height h above O) with velocity v at an angle of projection θ. The time, when the distance between them is minimum, is

   (a) $\frac{h}{2v\sin\theta}$ (b) $\frac{h}{2v\cos\theta}$ (c) $\frac{h}{v}$ (d) $\frac{h}{2v}$

2. A projectile is given an initial velocity of $\hat{i}+2\hat{j}$. The equation of its path is $\left(g=10\text{m/s}^2\right)$

   (a) $y=2x-5x^2$ `(b) $y=x-5x^2$ (c) $4y=2x-5x^2$ (d) $y=2x-25x^2$

3. A particle is projected from the surface of a planet g on the surface of this planet may be assumed to be uniform. The horizontal and vertical displacements x and y (in metre) respectively vary with time t (in second) as

   $$x=10\sqrt{3}t \quad \text{and} \quad y=10t-t^2$$

   where $t = 0$ represents the time when the particle is projected . Then the maximum height attained by the particle is

   (a) 200 m (b) 100 m (c) 50 m (d) 25 m

4. The speed of projectile at its highest point is observed to be half of its speed of projection u. Its range on horizontal plane is

   (a) $\frac{3u^2}{g}$ (b) $\frac{\sqrt{3}}{2}\frac{u^2}{g}$ (c) $\frac{3}{2}\frac{u^2}{g}$ (d) $\frac{u^2}{3g}$

5. A large number of bullets are fired from the same point in all directions with the same speed v. The maximum area on the ground on which these bullets will spread is

   (a) $\pi\frac{v^4}{g^2}$ (b) $\pi^2\frac{v^4}{g^2}$ (c) $\frac{v^4}{g^2}$ (d) $\frac{v^4}{4g^2}$

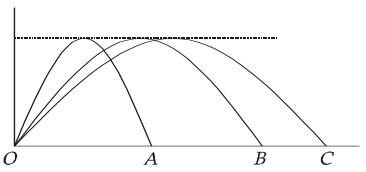
6. Three projectiles A, B and C are thrown from the same point in the plane. Their trajectories are shown in the figure. Then which of the following statements is true ?

   (a) The time of flight is not the same for all three.

   (b) The launch speed is greatest.

   (c) The horizontal velocity component is greatest for particle C.

   (d) none of these.



7. A cannon ball has the same range R on a horizontal plane for two angles of projection. If h_1 and h_2 are the greatest height in the two paths for which this is possible, then

   (a) $R=h_1h_2$ (b) $R=4\sqrt{h_1h_2}$ (c) $R=3\sqrt{h_1h_2}$ (d) $R=\left(h_1h_2\right)^{1/4}$

8. In projectile motion the range R is n times the maximum height. The angle of projection w.r.t. the horizontal is

   (a) $\tan^{-1}\frac{n}{2}$ (b) $\tan^{-1}\frac{2}{n}$ (c) $\tan^{-1}\frac{4}{n}$ (d) $\tan^{-1}\frac{n}{4}$

9. A ball of mass m is projected from the ground with an initial velocity u making an angle θ with the horizontal. Then, choose the incorrect statement :

   (a) the change in velocity between the point of projection and the highest point is $u\sin\theta\hat{j}$ (downward).

   (b) the average velocity averaged over the time of flight is $u\cos\theta\hat{i}$ (horizontal).

   (c) the change in velocity in the complete projectile motion is $-2u\sin\theta\hat{j}$.

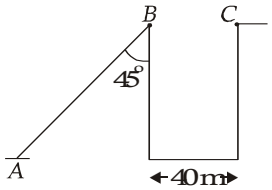
   (d) the rate at which momentum of the ball is changing is constant.

10. Which of the following is largest, when the height attained by the projectile is a maximum ?

(a) range (b) time of flight

(c) angle of projectile with the vertical (d) none of these

11. A body is projected up a smooth inclined plane with velocity V from the point A as shown in the figure. The angle of inclination is 45° and the top is connected to a well of diameter 40 m. If the body just manages to cross the well, what is the value of V? Length of inclined plane is $20\sqrt{2}$m.



(a) 40 ms^{-1} (b) $40\sqrt{2}$ ms^{-1} (c) 20 ms^{-1} (d) $20\sqrt{2}$ ms^{-1}

12. A particle has an initial velocity of $\left(3\hat{i}+4\hat{j}\right)$m/s and a constant acceleration of $\left(4\hat{i}-3\hat{j}\right)$m/s^2. Its speed after one second will be equal to

(a) 0 (b) 10 m/sec (c) $5\sqrt{2}$ m/sec (d) 25 m/sec

13. A particle travels along the arc of a circle of radius R. Its velocity depends on the arc coordinate s as $v = k\sqrt{s}$, where k is a constant. The angle θ between the total acceleration vector and the velocity vector of the particle is given by

(a) $\theta = \sin^{-1}\left(\frac{2s}{R}\right)$ (b) $\theta = \cos^{-1}\left(\frac{2s}{R}\right)$ (c) $\theta = \tan^{-1}\left(\frac{2s}{R}\right)$ (d) $\theta = \cot^{-1}\left(\frac{2s}{R}\right)$

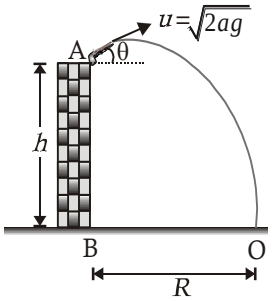
14. A ball rolls off the top of a staircase with a horizontal velocity u ms^{-1}. If the steps are h m high and w m wide the ball will hit the edge of the n^{th} step if

(a) $n = \frac{gw^2}{2hu^2}$ (b) $n = \frac{2hu^2}{gw^2}$ (c) $n = \frac{2u^2}{gw^2h}$ (d) $n = \frac{2hw^2u^2}{g}$

15. Shots are fired at the same instant from the top and bottom of a vertical cliff at angle α and β and they strike an object simultaneously at the same point. If the horizontal distance of the object from the cliff is ℓ and h be the height of the cliff then

(a) $h = \ell(\cot\beta - \cot\alpha)$ (b) $h = \ell(\cos\beta - \cos\alpha)$ (c) $h = \ell(\tan\beta - \tan\alpha)$ (d) $h = \ell(\sin\beta - \sin\alpha)$

16. A particle is projected under gravity with velocity $\sqrt{2ag}$ from a point at a height h above the level plane. The maximum range R on the ground is



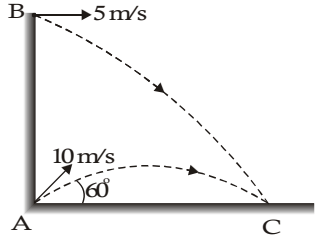
(a) $\sqrt{(a^2+1)h}$ (b) $\sqrt{a^2h}$

(c) $\sqrt{ah}$ (d) $2\sqrt{a(a+h)}$

17. A bomber flying with a horizontal velocity of 500 kmh^{-1} at a vertical height of 5 km above the ground wants to hit a train moving with a velocity of 100 kmh^{-1} in the same direction and in same vertical plane. The angle θ between the line of sight of the target and the horizontal at the instant the bomb shell should be released is approximately

(a) 55° (b) 57° (c) 72° (d) 27°

18. A particle A is projected from the ground with an initial velocity of 10 m/s at an angle of 60° with horizontal. From what height h should an another particle B be projected horizontally with velocity 5 m/s so that both the particles collide on the ground at the point C, assuming that both are projected simultaneously (g = 10 m/s^2)



(a) 10 m (b) 30 m

(c) 15 m (d) 25 m

19. A projectile is thrown in a viscous medium offering resistance equal to one-tenth of acceleration due to gravity. The time of flight of the projectile will

(a) increase by 1% (b) decrease by 1% (c) increase by 2% (d) decrease by 2%

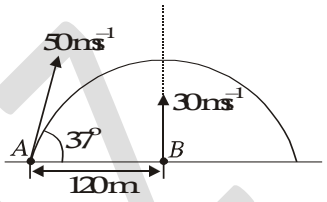
20. The speed of projectile when it is at its greatest height is $\sqrt{2/5}$ times its speed at half the maximum height. The angle of projection is

(a) 30° (b) 60° (c) 45° (d) $\tan^{-1}(3/4)$

SECTION – II

MORE THAN ONE CHOICE QUESTIONS

1. Balls *A* and *B* are thrown from two points lying on the same horizontal plane separated by a distance 120 m. Which of the following statement(s) is(are) correct



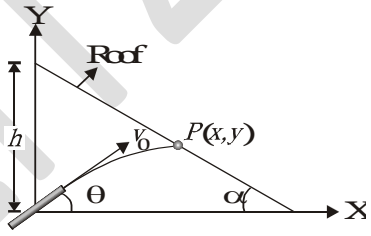
(a) The ball can *never* meet.

(b) The balls *can* meet if the ball *B* is thrown 1*s* later.

(c) The balls can meet if the balls are thrown at the same time.

(d) The two balls meet at a height of 45 m.

2. A projectile is fired upward with velocity v_0 at an angle θ and strikes a point $P(x,y)$ on the roof of the building (as shown). Then,



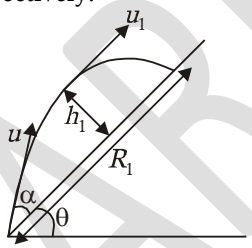
(a) the projectile hits the roof in minimum time if $\theta+\alpha=\frac{\pi}{2}$.

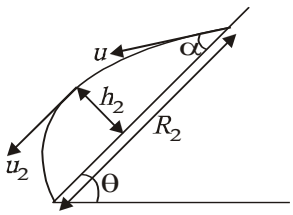
(b) the projectile hits the roof in minimum time if $\theta+\alpha=\frac{\pi}{4}$.

(c) the minimum time taken by the projectile to hit the roof is $t_{\min}=\frac{v_0-\sqrt{v_0^2-2gh\cos^2\alpha}}{g\cos\alpha}$.

(d) the projectile never reaches the roof for $v_0<\sqrt{2gh}\cos\alpha$.

3. Two balls are thrown from an inclined plane at angle of projection α with the plane, one up the plane while the other down the inclined plane (as shown in figure). In the figure, u_1 and u_2 are the speeds when the line of motion of the particle is parallel to the inclined plane and h_1 and h_2 are maximum displacements perpendicular to inclined plane respectively.





(a) $h_1=h_2=\frac{u^2\sin^2\alpha}{2g\cos\theta}$ (b) $T_1=T_2=\frac{2u\sin\alpha}{g\cos\theta}=T$ (c) $R_1-R_2=g\sin\theta T^2$ (d) $u_1=u_2$

4. A boy can throw a some to maximum height of 50 m. To what maximum range can he throw this stone and to what greatest height so that the maximum range is maintained, select the correct choice/choices

(a) maximum range is 100 m (b) maximum height for maximum range is 25 m

(c) maximum range is 200 m (d) maximum height for maximum range is 50 m

5. Two canons installed at the top of a cliff 10 m high fire a shot, each in xy plane with speed $5\sqrt{3}$ ms^{-1} at some interval. One cannon fires at 60° with the horizontal whereas the second fires horizontally.

(a) The x co-ordinate of the point of collision of shots is 5 m and the time taken by first shot is 2s.

(b) The y co-ordinate of the point of collision of shots is $\sqrt{3}$ m and the time taken by second shot is 1s

(c) The x co-ordinate of the point of collision of shots is $5\sqrt{3}$ m and the time taken by second shot is 1 s
(d) The y co-ordinate of the point of collision of shot is 5 m and the time taken by first shot is 2 s.

6. A lift of very broad floor is moving vertically upward with a constant retardation, equal to g. At an instant a stone is projected from a point on the floor of the lift at angle of elevation θ. Then the trajectory of the stone is :

(a) a parabola in the lift-frame
(b) a straight line in he lift-frame
(c) a parabola in the ground frame
(d) a straight line in the ground frame.

7. Mark correct statements

(a) Two particles thrown with same speed from the same point at the same instant but at different angles, can never collide in mid air.
(b) A body projected in a uniform gravitational field follows a parabolic path.
(c) In projectile motion, velocity is never perpendicular to the acceleration
(d) A particle dropped from rest and blown over by a horizontal wind with constant velocity traces a parabolic path.

8. In a projectile motion

(a) increase in linear momentum between the initial and final point is equal to mg.T, downwards
(b) increase in linear momentum between the initial and final point is zero.
(c) angular momentum w.r.t the point of projection continuously changes.
(d) angular momentum w.r.t the point of projection remains constant (T is time of fight)

9. The initial velocity of a particle is $\vec{u} = \left(2\hat{i} + 3\hat{j}\right)$ m/s. A constant force of $\vec{F} = \left(4\hat{i} + \hat{j}\right)$N acts on the particle it follows that :

(a) its velocity is constant
(b) its acceleration is constant
(c) its path is parabolic
(d) it moves in a circular path

10. Two projectiles A and B are projected with same speed at angles 30° and 60° to the horizontal then

(a) $R_A = R_B$ (b) $H_B = 3H_A$ (c) $H_A = 3H_B$ (d) $T_B = \sqrt{3}T_A$

(R stands for range, H for maximum)

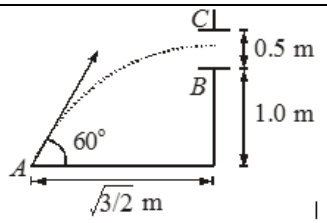
11. A projectile is projected from a point on the horizontal ground, at an angle with the vertical. If the air exerts a constant resistive force,

(a) the path of projectile will be a parabola
(b) at the highest point, the velocity is horizontal.
(c) the time for ascent equals the time for descent.
(d) the total mechanical energy of the projectile is not conserved.

12. Select the correct alternative(s)

(a) In a projectile motion, H/R ratio is equal to (1/4) tanθ
(b) For angles of projection, which exceed or fall short of 45° by equal amounts, the ranges are equal.
(c) In projectile motion, velocity at initial and final points are same.
(d) None of these

13. A ball is dropped onto a pad at A and rebounds with a velocity V_0 at an angle 60° with the horizontal as shown in the figure. The ball will enter the opening BC, if V_0 is



(a) $5ms^{-1}$
(b) $6ms^{-1}$
(c) $7ms^{-1}$
(d) $50ms^{-1}$

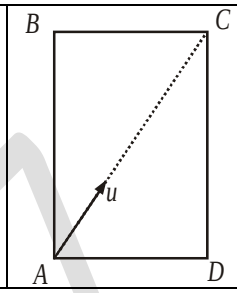
14. A particle is projected vertically upward in vacuum with a speed u

(a) When it rises to half its maximum height, its speed is $u/2$
(b) When it rises to half its maximum height, its speed is $u/\sqrt{2}$
(c) The time taken to rise to half its maximum height is half of the time taken to reach its maximum height.
(d) The time taken to rise to three-fourths of its maximum height is half of the time taken to reach its maximum height.

15. Position of a vibrating particle is defined as : $x = 8\sin\pi t$ and $y = -2\cos 2\pi t$

(a) the path of the particle is parabola
(b) the path of the particle is ellipse
(c) the path of the particle is symmetric about the axis x = 0
(d) the acceleration of the particle is directed towards the origin.

16. Fig. shows an elevator cabin, which is moving downwards with constant acceleration *a*. A particle is projected from corner A, directly towards diagonally opposite corner C. Then



(a) particle will hit C only when a = g.
(b) particle will hit the wall CD if a < g
(c) particle will hit the roof BC if a > g
(d) nothing can be said because numerical data is not given

17. Two particles are projected from the same point on the ground, with same speed simultaneously, at angle α and β with the horizontal. They strike the ground at same point after times t_1 and t_2, respectively. Then :

(a) $\alpha \sim \beta = 90°$ (b) $\frac{t_1}{t_2} = \tan\alpha$ (c) $\frac{t_1}{t_2} = \cot\beta$ (d) $\frac{t_1}{\sin\alpha} = \frac{t_2}{\sin\beta}$

18. Two particles A and B a start simultaneously from the same point and move in a horizontal plane. A has an initial velocity u_1 due east and acceleration a_1 due north. B has an initial velocity u_2 due north and acceleration a_2 due east

(a) They must collide at some point
(b) They will collide only if $a_1u_1 = a_2u_2$
(c) Their paths must intersect at some point
(d) If $u_1 > u_2$ and $a_1 < a_2$, the particles will have the same speed at some point

19. A cart moves with a constant speed along a horizontal circular path. From the cart, a particle is thrown up vertically with respect to earth

(a) The particle will follow the elliptical path
(b) The particle will follow the parabolic path
(c) The particle will land some where on the circular path
(d) The particle will and outside the circular path.

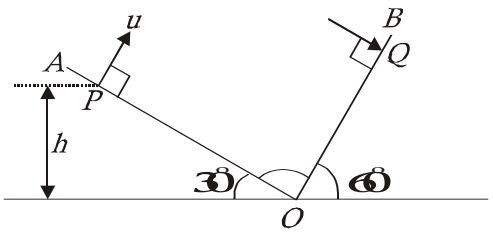
20. Two particles are projected from the same point with eh same speed, at different angles θ_1 and θ_2 to the horizontal. Their times of flight are t_1 and t_2 and they have the same horizontal range. Then

(a) $t_1/t_2 = \tan\theta_1$ (b) $t_1/t_2 = \tan\theta_2$ (c) $t_1/\sin\theta_1 = t_2/\sin\theta_2$ (d) $\theta_1 + \theta_2 = 90°$

SECTION - III

PASSAGE BASED QUESTIONS

I. Two inclined planes *OA* and *OB* having inclination of 30° and 60° with the horizontal respectively, intersect each other at *O* as shown in figure. A particle is projected from point *P* with velocity $u = 10\sqrt{3}$ m/s along a direction perpendicular to plane *OA*. If the particle strikes plane *OB* perpendicularly at *Q*, calculate



1. Velocity with which particle strikes the plane *OB* is

(a) 10 ms^{-1} (b) $10\sqrt{2}$ ms^{-1} (c) $10\sqrt{3}$ (d) $5\sqrt{2}$ ms^{-1}

2. Time of flight,

(a) 1 sec (b) $\sqrt{2}$ sec (c) 2 sec (d) $2\sqrt{2}$ sec

3. Vertical height *h* of *P* from *O*

(a) $10\sqrt{3}$ m (b) 10 m (c) $10\sqrt{2}$ m (d) 5m

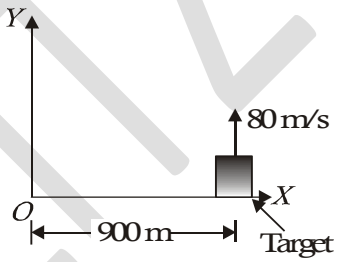
4. Maximum height from *O*, attained by the particle

(a) 15 m (b) 16.25 m (c) 17.4 m (d) $10\sqrt{2}$

5. Distance *PQ*

(a) $10\sqrt{3}$ m (b) $10\sqrt{2}$ m (c) 20 m (d) 15 m

II. A gun that fire shells with a speed of 125 m/s is kept at the origin of the coordinate axes. The *x*-axes and *y*-axis are horizontal while the *z*-axis is vertical. A target located 900 m away from the origin on the *x*-axis starts moving on the horizontal plane parallel to the *y*-axis with a speed of 80 m/s. If the gun is to be fired at the same instant the target starts moving and finally hit the target, then



6. In what direction should the gun fire the shell

(a) $\frac{12\hat{i}+16\hat{j}+14\hat{k}}{25}$ (b) $\frac{12\hat{i}+16\hat{j}+15\hat{k}}{25}$

(c) $\frac{12\hat{i}+16\hat{j}}{25}$ (d) $\frac{12\hat{i}+16\hat{j}+\hat{k}}{25}$

7. What is the velocity of the shell when it lands on the target ?

(a) $\left(60\hat{i}+80\hat{j}-75\hat{k}\right)\text{ms}^{-1}$ (b) $\left(60\hat{i}+80\hat{j}+75\hat{k}\right)\text{ms}^{-1}$ (c) $\left(60\hat{i}+80\hat{j}+70\hat{k}\right)\text{ms}^{-1}$ (d) $\left(60\hat{i}+80\hat{j}-70\hat{k}\right)\text{ms}^{-1}$

8. At what point does the shell hit the target ?

(a) $[900,1200,600]\text{m}$ (b) $[0,1200,600]\text{m}$ (c) $[900,1200,0]\text{m}$ (d) $[900,0,600]\text{m}$

9. After what time does the shell hit the target ?

(a) 10 sec (b) 11 sec (c) 13 sec (d) 15 sec

III. A spying aircraft of mass m is used by the enemy country to gather important information form the neighbouring country and also to help his spies infilterated in that country. At one instance this aircraft flies at a speed of 360kmh^{-1} in the horizontal direction at height of h km from ground. The pilot is aware of the position P of one of his agents on ground. He drops an ammunition bag when it is at a point Q, which is 200 m away from the agent down on the earth. The bag reaches the agent.

At another instant this aircraft was flying horizontally with a speed of 300 ms^{-1} at height of 1500 m from ground A radar locates it and an antiaircraft gun on the ground is aimed at it and a shell of velocity 0.6 kms^{-1} is fired on it. Many aircrafts also start to follow and attack aircraft. The fired shell from ground may or may not hit the spying aircraft. The weather in both the instances was fine so air resistance can be neglected. Value of g may be taken as 9.8 ms^{-2} in the first case and 10 ms^{-2} in the second case. Assume that initial horizontal component of velocity of shell remains uniform throughout the motion.

Now answer the following

10. Time taken by the ammunition box to reach ground is

(a) 2 s (b) 1 s (c) 2.5 s (d) 3 s

11. Height of the aircraft *h* is

(a) 3920 m (b) 2760 m (c) 980 m (d) 1960 m

12. The angle θ from the vertical from which the gun be fired to hit the aircraft.

(a) $\sin^{-1}\frac{1}{\sqrt{2}}$ (b) $\sin^{-1}\frac{1}{3}$ (c) $\sin^{-1}\frac{1}{2}$ (d) $\sin^{-1}\frac{1}{\sqrt{3}}$

13. The minimum altitude at which the aircraft should fly to avoid hitting

(a) 9800 m (b) 1600 m (c) 1600 m (d) 8000 m

14. Non dependence of angle θ from which the gun be fired to hit aircraft is

(a) altitude of plane (b) speed of plane (c) speed of shell (d) (b) and (c)

SECTION - V

PROBLEMS ASKED IN IIT-JEE

1. Two guns situated on the top of a hill of height 10 m fire one shot each with the same speed $5\sqrt{3}$ m/s at some interval of time On gun fires horizontally and other fires upwards at an angle 60° with the horizontal. The shots collide in air at point *P*. Find

   (a) the time interval between the firings and

   (b) the coordinates of the point *P*. Take origion of the coordinate system at the foot of the hill right below the muzzle and trajectories in x-y plane. ($g=10\ m/s^2$)

[IIT 1996]

2. A bullet of mass *M* is fired with a velocity 50 m/s at an angle θ with the horizontal. At the highest point of its trajectory, it collides head on with a bob of mass 3 M suspended by a massless string of length $\frac{10}{3}$ m and gets embedded in the bob. After the collision the string moves through an angle 120°. Find

   (a) the angle θ

   (b) the vertical and horizontal coordinates of the initial position of the bob with respect to the point of firing of the bullet ($g=10\ m/s^2$).

[IIT 1988]