Practice Problems

Projectile Motion

Problems based on trajectory

▶ *Basic level*

1. At the top of the trajectory of a projectile, the directions of its velocity and acceleration are

(a) Perpendicular to each other (b) Parallel to each other

(c) Inclined to each other at an angle of 45° (d) Antiparallel to each other

2. A man projects a coin upwards from the gate of a uniformly moving train. The path of coin for the man will be **[RPET 1997]**

(a) Parabolic (b) Inclined straight line (c) Vertical straight line (d) Horizontal straight line

3. A stone is projected with an initial velocity at an angle to the horizontal. A small piece separates from the stone before the stone reaches its maximum height. Then this piece will

(a) Fall to the ground vertically

(b) Fly side by side with the parent stone along a parabolic path

(c) Fly horizontally initially and will trace a different parabolic path

(d) Lag behind the parent stone increasing the distance from it

4. A particle moves in the *X-Y* plane according to the law $x = kt$ and $y = kt(1 - \alpha t)$, where k and α are positive constants and t is time. What is the equation of trajectory of the particle

(a) $y = kx$ (b) $y = x - \frac{\alpha x^2}{k}$ (c) $y = \frac{\alpha x^2}{k}$ (d) $y = \alpha x$

5. The equation of motion of a projectile is $y = 12x - \frac{3}{4}x^2$. Given that g =10 ms^{-2}, what is the range of the projectile

(a) 12.4 m (b) 16 m (c) 30.6 m (d) 36.0 m

▶▶ *Advance level*

6. A particle is moving in a plane with velocity given by $\vec{u} = u_0\hat{i} + (a\omega\cos\omega t)\hat{j}$ where $\hat{i}, \hat{j}$ are unit vectors along x and y axes respectively. The trajectory of the particle if the particle starts from origin at t = 0 will be

(a) $y = a\sin\left(\frac{\omega x}{u_0}\right)$ (b) $y = a\cos\left(\frac{\omega x}{u_0}\right)$ (c) $y = \tan x$ (d) $y = \cos tx$

7. An object is projected with a velocity of 20 m/s making an angle of 45° with horizontal. The equation for the trajectory is $h = Ax - Bx^2$ where h is height, x is horizontal distance, A and B are constants. The ratio $A : B$ is (g = 10 m/s^2) **[EAMCET 2001]**

(a) 1 : 5 (b) 5 : 1 (c) 1 : 40 (d) 40 : 1

8. A ball is dropped from the top of a tower in a high speed wind. The wind exerts a steady force on the ball. The path followed by the ball will be

(a) Parabola (b) Circular arc (c) Elliptical arc (d) Straight line

Problems based on velocity

▶ *Basic level*

9. In a projectile motion, the velocity

(a) Is always perpendicular to the acceleration

(b) Is never perpendicular to the acceleration

(c) Is perpendicular to the acceleration for one instant only

(d) Is perpendicular to the acceleration for two instants

10. A body of mass m is thrown upwards at an angle θ with the horizontal with velocity v. While rising up the velocity of the mass after t *seconds* will be

(a) $\sqrt{(v\cos\theta)^2+(v\sin\theta)^2}$ (b) $\sqrt{(v\cos\theta - v\sin\theta)^2 - gt}$ (c) $\sqrt{v^2+g^2t^2-(2v\sin\theta)gt}$ (d) $\sqrt{v^2+g^2t^2-(2v\cos\theta)gt}$

11. A boy throws a ball with a velocity V_0 at an angle α to the horizontal. At the same instant he starts running with uniform velocity to catch the ball before it hits the ground. To achieve this, he should run with a velocity of

(a) $V_0\cos\alpha$ (b) $V_0\sin\alpha$ (c) $V_0\tan\alpha$ (d) $\sqrt{V_0^2\tan\alpha}$

12. From the top of a tower 19.6 m high, a ball is thrown horizontally. If the line joining the point of projection to the point where it hits the ground makes an angle of 45° with the horizontal, then the initial velocity of the ball is

(a) 9.8 ms^{-1} (b) 4.9 ms^{-1} (c) 14.7 ms^{-1} (d) 2.8 ms^{-1}

13. When a particle is thrown horizontally, the resultant velocity of the projectile at any time t is given by

(a) gt (b) $\frac{1}{2}gt^2$ (c) $\sqrt{u^2+g^2t^2}$ (d) $\sqrt{u^2-g^2t^2}$

14. A body is thrown horizontally from the top of a tower of height 5 m. It touches the ground at a distance of 10 m from the foot of the tower. The initial velocity of the body is (g = 10 ms^{-2})

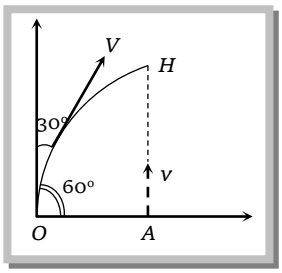
(a) 2.5 ms^{-1} (b) 5 ms^{-1} (c) 10 ms^{-1} (d) 20 ms^{-1}

15. An aeroplane is moving with a horizontal velocity u at a height h above the ground. If a packet is dropped from it the speed of the packet when it reaches the ground will be

(a) $(u^2+2gh)^{1/2}$ (b) $(2gh)^{1/2}$ (c) $(u^2-2gh)^{1/2}$ (d) $2gh$

▶▶ *Advance level*

16. A particle is projected with a speed V from a point O making an angle of 30° with the vertical. At the same instant, a second particle is thrown vertically upwards from a point A. The two particle reach H, the highest point on the parabolic path of particle simultaneously. Then ratio $\frac{V}{v}$ is



(a) $3\sqrt{2}$

(b) $2\sqrt{3}$

(c) $\frac{2}{\sqrt{3}}$

(d) $\frac{\sqrt{3}}{2}$

17. Two paper screens (A) and (B) are separated by a distance of 100 m. A bullet pierces (A) and (B) the hole in (B) is 10 cm below the hole is (A). If the bullet is travelling horizontally at the time of hitting (A). Then velocity of the bullet at (A) is

(a) 100 m/sec (b) 200 m/sec (c) 600 m/sec (d) 700 m/sec

18. A particle is thrown upward with a speed u at an angle θ with the horizontal. When the particle makes an angle ϕ with the horizontal, its speed changes to v, then

(a) $v = u\cos\theta\cos\phi$ (b) $v = u\cos\theta\sec\phi$ (c) $v = u\cos\theta$ (d) $v = u\sec\theta\cos\phi$

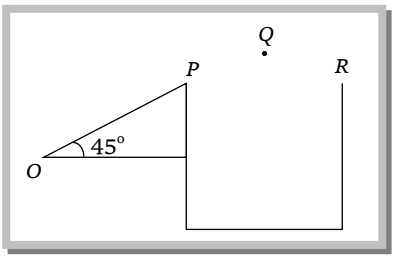
19. Mr. Naveen kicked off a football with an initial speed 19.6 m/s at a projection angle 45°. A receiver on the goal line 67.4 m away in the direction of the kick starts running to meet the ball at that instant. What must be his speed so that he could catch the ball before hitting the ground

(a) 2.82 m/s (b) $2/\sqrt{2}\, m/s$ (c) 39.2 m/s (d) 10 m/s

20. Two balls of same mass are thrown horizontally from the top of a tower in the opposite direction with velocities 3 m/s and 4 m/s. The distance between the balls, when their velocities are mutually perpendicular will be nearest to

(a) 10 m (b) 7 m (c) 5 m (d) 2.5 m

21. A motorcyclist starts from the bottom of a slope of angle 45° to cross the valley PR as shown in the figure. The width of the valley is 90 m and length of the slope is $80\sqrt{2}m$. The minimum velocity at point O required to clear the valley will be



(a) 70 m/s

(b) 30 m/s

(c) 50 m/s

(d) 100 m/s

22. From the top of a tower of height h a body of a mass m is projected in the horizontal direction with a velocity v. It falls on the ground at a distance x from the tower. If a body of mass 2 m is projected from the top of another tower of height 2 h in the horizontal direction so that it falls on the ground at a distance 2x from the tower, the horizontal velocity of the second body is

(a) 2 v (b) $\sqrt{2v}$ (c) $\frac{v}{2}$ (d) $\frac{v}{\sqrt{2}}$

Problems based on time of flight

▶ *Basic level*

23. A cricket ball is thrown with a velocity of 15 m/s at an angle of 30° with the horizontal. The time of flight of the ball will be (g = 10 m/s^2)

(a) 1.5 s (b) 2.5 s (c) 3.5 s (d) 4.5 s

24. If t_1 be the time taken by a body to clear the top of a building and t_2 be the time spent in air, then $t_2 : t_1$ will be

(a) 1 : 2 (b) 2 : 1 (c) 1 : 1 (d) 1 : 4

25. A stone is thrown at an angle θ to the horizontal reaches a maximum height h. The time of flight of the stone is

[EAMCET (Med.) 1998]

(a) $\sqrt{(2h\sin\theta)/g}$ (b) $2\sqrt{(2h\sin\theta)/g}$ (c) $2\sqrt{(2h)/g}$ (d) $\sqrt{(2h)/g}$

26. A bomb is fired from a cannon with a velocity of 1000 m/s making an angle of 30° with the horizontal. What is the time taken by the bomb to reach the highest point

(a) 11 *sec* (b) 23 *sec* (c) 38 *sec* (d) 51 *sec*

27. Two bullets are fired with horizontal velocities of 50 *m/s* and 100 *m/s* from two guns at a height of 19.6 *m*. Which bullet will strike first

(a) First (b) Second (c) Simultaneously (d) None of these

28. A hiker stands on the edge of a cliff 490 *m* above the ground and throws a stone horizontally with a speed of 15 ms^{-1}. The time taken by the stone to reach the ground is

(a) 10 *s* (b) 5 *s* (c) 12 *s* (d) 15 *s*

29. Galileo's experiment showed that if two bodies of unequal masses are dropped from the same height, the time required by them to reach the ground are equal. But if they are thrown vertically upwards with the same initial velocity, the ratio of the time required to reach the ground is equal to

(a) The ratio of their masses (b) The inverse of the ratio of their masses

(c) One (d) The product of their masses

▶▶ *Advance level*

30. A particle is projected with a speed $2\sqrt{gh}$ so that it clears two walls of equal height *h* which are at a distance 2*h* from each other. The time taken by the particle to pass between the two walls is

(a) $\sqrt{\frac{2h}{g}}$ (b) $\frac{2h}{g}$ (c) $\sqrt{2}\frac{h}{g}$ (d) $2\sqrt{\frac{h}{g}}$

31. A projectile is thrown in the upward direction making an angle of 60° with the horizontal direction with a velocity of 147 ms^{-1}. Then the time after which its inclination with the horizontal is 45° is

(a) 15 *s* (b) 10.98 *s* (c) 5.49 *s* (d) 2.745 *s*

32. A cannon ball is fired with a velocity *v* in a direction making an angle θ with the horizontal. At the highest point of its path it breaks into two parts of equal masses. One of the parts retraces the initial path of the ball. The speed of the second part immediately after explosion in *m/s* will be

(a) $\frac{3}{2}v\cos\theta$ (b) $\sqrt{\frac{3}{2}}v\cos\theta$ (c) $2v\cos\theta$ (d) $3v\cos\theta$

33. 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°. Then 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 $g = 10\ ms^2$)

(a) 2 : 1 (b) 3 : 1 (c) 3 : 2 (d) 4 : 1

Problems based on horizontal range

▶ *Basic level*

34. A projectile fired with initial velocity *u* at some angle θ, has a range *R*. If the initial velocity be doubled at the same angle of projection, then the range will be

(a) 2*R* (b) *R*/2 (c) *R* (d) 4*R*

35. The range of a particle when launched at an angle of 15° with the horizontal is 1.5 *km*. What is the range of the projectile when launched at an angle of 45° to the horizontal

(a) 1.5 *km* (b) 3.0 *km* (c) 6.0 *km* (d) 0.75 *km*

36. Three identical balls are thrown with same speed at angles of 15°, 45° and 75° with the horizontal respectively. The ratio of their distances from the point of projection to the where they hit the ground will be

(a) $1:\sqrt{2}:1$ (b) $1:2:1$ (c) $2:4:3$ (d) $1:2:\sqrt{3}$

37. Five balls A, B, C, D and E are projected with the same speed making angles of $10°, 30°, 45°, 60°, 80°$ respectively with the horizontal. Which ball will strike the ground at the farthest point

(a) B (b) A (c) E (d) C

38. An object is thrown along a direction inclined at an angle of 45^o with the horizontal direction. The horizontal range of the particle is equal to

(a) Vertical height (b) Twice the vertical height

(c) Thrice the vertical height (d) Four times the vertical height

39. A projectile is thrown at an angle of 40^o with the horizontal and its range is R_1. Another projectile is thrown at an angle 40^o with the vertical and its range is R_2. What is the relation between R_1 and R_2

(a) $R_1 = R_2$ (b) $R_1 = 2R_2$ (c) $R_2 = 2R_1$ (d) $R_1 = 4R_2/5$

40. It was calculated that a shell when fired from a gun with a certain velocity and at an angle of elevation of $\frac{5\pi}{36}$ radians should strike a given target. In actual practice it was found that a hill just intervened in the trajectory. At what angle of elevation should the gun be fired to hit the target

(a) $\frac{5\pi}{36}$ *rad* (b) $\frac{11\pi}{36}$ *rad* (c) $\frac{7\pi}{36}$ *rad* **(d)** $\frac{13\pi}{36}$ ***rad***

41. Two particles are projected from the same point with the same speed at different angle θ_1 and θ_2 to the horizontal. They have the same horizontal range. Their times of flight are t_1 and t_2 respectively. Then

(a) $\theta_1 + \theta_2 = 90^o$ (b) $\frac{t_1}{t_2} = \frac{\tan\theta_1}{\tan\theta_2}$ (c) $\frac{t_1}{t_2} = \tan\theta_2$ (d) $\frac{t_1}{t_2} = \tan\theta_1$

42. A projectile thrown from a height of 10 m with velocity of $\sqrt{2}\,m/s$, the projectile will fall, from the foot of projection, at distance (g = 10 m/s^2)

(a) 1 m (b) 2 m (c) 3 m (d) $\sqrt{2}$ m

43. On throwing a ball from the top of a vertical tower with a horizontal velocity of 20 m/s, it hits the earth at a distance of 50 m from the foot of the tower. If the ball is thrown with the same horizontal velocity from the top of another tower of height four times the height of first tower, the ball will hit the earth at a distance of

(a) 50 m (b) 100 m (c) 200 m (d) $50\sqrt{2}$ m

44. An aeroplane is flying horizontally with a velocity of 600 km/h and at a height of 1960m. When it is vertically at a point A on the ground, a bomb is released from it. The bomb strikes the ground at point B. The distance AB is **[CPMT 1996; JIPMER 2001, 02]**

(a) 1200 m (b) 0.33 m (c) 3.33 km (d) 33 km

▶▶ *Advance level*

45. A shell is fired vertically upwards with a velocity v_1 from the deck of a ship travelling at a speed of v_2. A person on the shore observes the motion of the shell as parabola whose horizontal range is given by

(a) $\frac{2v_1^2v_2}{g}$ (b) $\frac{2v_1v_2^2}{g}$ (c) $\frac{2v_1v_2}{g}$ (d) $\frac{2v_1^2v^2}{g}$

46. A boy standing on a long rail road car throws a ball straight upward. The car is moving on the horizontal road with an acceleration of 1 m/s^2 and the projection velocity in the vertical direction is 9.8 m/s. How far behind the boy will the ball fall on the car

(a) 1 m (b) 2 m (c) 4 m (d) 0.5 m

47. A projectile has a maximum range of 16 km. At the highest point of its motion, it explodes into two equal masses. One mass drops vertically downwards the horizontal distance covered by the other mass from the time of explosion is **[CPMT 1997]**

(a) 8 km (b) 16 km (c) 24 km (d) 32 km

48. Two projectiles A and B thrown with velocities v and $\frac{v}{2}$ have the same range. If B is thrown at an angle of 15° to the horizontal, A must have been thrown at an angle

(a) $\sin^{-1}\left(\frac{1}{16}\right)$ (b) $\sin^{-1}\left(\frac{1}{4}\right)$ (c) $2\sin^{-1}\left(\frac{1}{4}\right)$ (d) $\frac{1}{2}\sin^{-1}\left(\frac{1}{8}\right)$

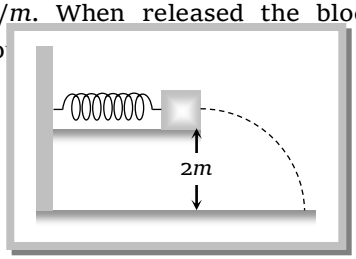
49. A body is projected with a speed u in such a direction that the maximum height obtained is equal to its horizontal range. The horizontal range is

(a) $\frac{8u^2}{17g}$ (b) $\frac{5u^2}{17g}$ (c) $\frac{6u^2}{13g}$ (d) $\frac{u^2}{2g}$

50. A body of mass m thrown horizontally with velocity v, from the top of tower of height h touches the level ground at a distance of 250 m from the foot of the tower. A body of mass $2m$, thrown horizontally with a velocity $v/2$, from the top of tower of height $4h$ will touch the level ground at a distance from the foot of tower

(a) 250 m (b) 500 m (c) 125 m (d) $250\sqrt{2}$ m

51. A small block of mass 0.1 kg is pressed against a horizontal spring fixed at one end to compress the spring through 5.0 cm as shown in figure. The spring constant is 100 N/m. When released the block moves horizontally till it leaves the spring. Where will it hit the ground 2 m belo



(a) Vertically below the edge on which the mass is resting

(b) At a horizontal distance of 1 m from free end of the spring

(c) At a horizontal distance of 2 m from free end of the spring

(d) At a horizontal distance of $\sqrt{2}$ m from free end of the spring

Problems based on maximum height

▶ *Basic level*

52. Which of the following does not affect the maximum height attained by the projectile

(a) Magnitude of initial velocity (b) Acceleration of the projectile

(c) Angle of projection (d) Mass of the projectile

53. A cricketer hits a ball with a velocity 25 m/s at 60° above the horizontal. How far above the ground it passes over a fielder 50 m from the bat (assume the ball is struck very close to the ground)

(a) 8.2 m (b) 9.0 m (c) 11.6 m (d) 12.7 m

54. A person can throw a stone to a maximum distance of 100 m. the greatest height to which he can throw the stone is

(a) 100 m (b) 75 m (c) 50 m (d) 25 m

55. Which of the following is largest, when the height attained by the projectile is the largest

(a) Range (b) Time of flight

(c) Angle of projectile with vertical (d) None of these

56. In broad jumping does it matter how high you jump? What factors determine the span of the jump

(a) Yes, u and θ (b) No, u and θ (c) No, h and θ (d) None of these

▶▶ *Advance level*

57. From a point on the ground at a distance 2 *metres* from the foot of a vertical wall, a ball is thrown at an angle of 45° which just clears the top of the wall and afterward strikes the ground at a distance $4m$ on the other side. The height of the wall is

(a) $\frac{2}{3}m$ (b) $\frac{3}{4}m$ (c) $\frac{1}{3}m$ (d) $\frac{4}{3}m$

58. A ball is thrown from the top of a tower with an initial velocity of 10 m/s at an angle of 30° above the horizontal. It hits the ground at a distance of 17.3 m from the base of the tower. The height of the tower (g = 10 m/s^2) will be

(a) 10 m (b) 12 m (c) 110 m (d) 100 m

59. A ball is projected from the ground at a speed of 10 m/s making angle 30° with the horizontal. Another ball is simultaneously released from a point on the vertical line along the maximum height of the projectile. Both the balls collide at the maximum height of the projectile. What was the initial height of the second ball

(a) 1.0 m (b) 1.25 m (c) 2.0 m (d) 2.5 m

60. A hose shoots a stream of water at an angle of 60° the horizontal with a velocity of 20 m/s. Water will strike a wall at a distance of 10 m at a height

(a) 5.36 m (b) 10.22 m (c) 12.42 m (d) 16.84 m

Problems based on momentum

▶ *Basic level*

61. A particle of mass m is thrown at an angle of 45° with the horizontal with a momentum p. The magnitude of its momentum at the top of its parabolic path will be

(a) p (b) 2 p (c) $p/\sqrt{2}$ (d) $p/2$

62. A bullet of mass m is fired from a point at an angle of 45° with the horizontal with a velocity v. When it reaches the ground, the change in its vertical component of momentum is

(a) Zero (b) $\frac{1}{2}mv$ (c) $mv\sqrt{2}$ (d) 2 mv

63. A ball of mass m and kinetic energy E is thrown at an angle of 45° with the horizontal. The momentum at the highest point of its path will be

(a) $\sqrt{mE}$ (b) $\sqrt{mE/2}$ (c) $\sqrt{2mE}$ (d) Zero

▶▶ *Advance level*

64. A particle having a mass of 0.5 kg is projected under gravity with a speed of 98 m/sec at an angle of 60°. The magnitude of the change in momentum in N-sec of the particle after 10 seconds is

(a) 0.5 (b) 49 (c) 98 (d) 490

65. A projectile is fired at 30° with momentum p. neglecting friction the change in momentum on return to the ground will be

(a) Zero (b) 30% (c) 60% (d) 100%

66. A ball is thrown up with a given angle to the horizontal. Then the total change of momentum by the instant it returns to the ground is equal to

(a) Acceleration due to gravity × total time of flight (b) Weight of the ball × half the time of flight

(c) Weight of the ball × total time of flight (d) None of these

Problems based on energy

▶ *Basic level*

67. The work done to project a body with a certain velocity is W. What extra work is required to be done to double its velocity

(a) W (b) $2W$ (c) $3W$ (d) $4W$

68. A cricket ball is hit at 30^o with the horizontal with kinetic energy K. The kinetic energy at the highest point is

(a) Zero (b) $K/4$ (c) $K/2$ (d) $3K/4$

69. Two balls are projected, one vertically up and the other at an angle of 30^o to the horizontal, with the same initial speed. The potential energy at the highest point will be in the ratio

(a) 3 : 4 (b) 4 : 3 (c) 4 : 1 (d) 1 : 4

70. In the above problem the ratio of kinetic energies of these balls at the highest point is

(a) 4 : 3 (b) 3 : 4 (c) ∞ (d) 0

71. A body is projected such that the K.E. at the topmost position is half of the initial K.E. What is its angle of projection with the horizontal

(a) 30^o (b) 60^o (c) 75^o (d) 45^o

72. A body is thrown with initial kinetic energy $100J$ at an angle θ^o to the horizontal. If its kinetic energy at the top is $25J$, then the angle of projection is

(a) 30^o (b) 45^o (c) 60^o (d) 90^o

Circular Motion

Problems based on angular displacement

▶ *Basic level*

73. Angular velocity of wheel is 2 radian/second. Calculate the number of rotation of the wheel in 5 second **[RPMT 1998]**

(a) $5/\pi$ (b) $10/\pi$ (c) 10π (d) 20π

74. A particle moves along a circular path of radius r with uniform speed v. The angle described by the particle in one second is given by

(a) vr^{-1} (b) $v^{-1}r$ (c) vr^{-2} (d) v^2r

Problems based on angular velocity

▶ *Basic level*

75. The angular velocity of earth about its axis of rotation is

(a) $2\pi/(60\times60\times24)$ rad/sec (b) $2\pi/(60\times60)$ rad/sec

(c) $2\pi/60$ rad/sec (d) $2\pi/(365\times24\times60\times60)$ rad/sec

76. The ratio of the angular velocities of rotational motion of earth round the sun and spinning motion about its own axis is

(a) 1/12 (b) 1/24 (c) 1/365 (d) 1/3600

77. The ratio of an angular speed of hours hand and seconds hand of a clock is

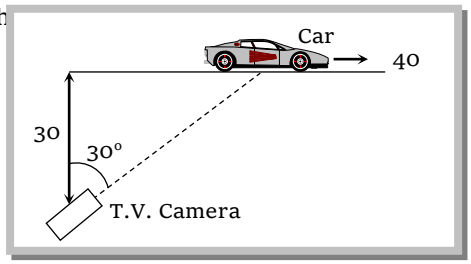
(a) 1 : 1 (b) 1 : 60 (c) 1 : 720 (d) 3600 : 1

78. A point on the rim of a wheel of diameter 400 *cm* has a velocity of 16 *m/sec*. The angular velocity of the wheel is **[Manipal 1998]**

(a) 2 *rad/sec* (b) 4 *rad/sec* (c) 6 *rad/sec* (d) 8 *rad/sec*

▶▶ *Advance level*

79. A racing car is travelling along a track at a constant speed of $40\ m/s$. A T.V. camera men is recording the event from a distance of $30m$ directly away from the track as shown in figure. In order to keep the car under view in the position shown, the angular speed with which the camera sh



(a) $4/3\ rad/\sec$

(b) $3/4\ rad/\sec$

(c) $8/3\sqrt{3}\ rad/\sec$

(d) $1\ rad/\sec$

80. A particle is moving along a circular path with angular speed ω about the axis passing through the centre. What will be its angular speed about a point on the other end of the diameter through the instantaneous position of the particle

(a) 2ω (b) ω (c) $\omega/2$ (d) $\omega/4$

Problems based on velocity

▶ *Basic level*

81. The linear velocity of a point on the equator is nearly (radius of the earth is 6400 *km*)

(a) 800 *km/hr* (b) 1600 *km/hr* (c) 3200 *km/hr* (d) 6400 *km/hr*

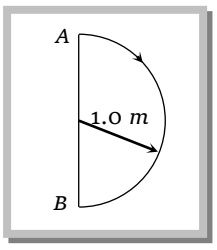
82. The second's hand of a watch has length 6 *cm*. Speed of end point and magnitude of difference of velocities at two perpendicular positions will be

(a) 6.28 and 0 *mm/s* (b) 8.88 and 4.44 *mm/s* (c) 8.88 and 6.28 *mm/s* (d) 6.28 and 8.88 *mm/s*

▶▶ *Advance level*

83. In 1.0 *s* a particle goes from point A to point B, moving in a semicircle of radius 1.0 *m*. The magnitude of the average velocity is

[IIT-JEE 1999]



(a) 3.14 *m/s*

(b) 2.0 *m/s*

(c) 1.0 *m/s*

(d) Zero

84. An aeroplane is moving in a horizontal circle with a uniform speed of 141 *km/hr*. Change in its velocity in one fourth revolution, from its initial direction will be

(a) 100 *km/hr* at an angle of 90° (b) 141 *km/hr* at an angle of 135°

(c) 200 *km/hr* at an angle of 135° (d) Zero

Problems based on angular accelerations

▶ *Basic level*

85. The linear and angular acceleration of a particle are 10 m/sec^2 and 5 rad/sec^2 respectively it will be at a distance from the axis of rotation

(a) 50 m (b) 1/2 m (c) 1 m (d) 2 m

86. On applying brakes the angular velocity of a flywheel reduces from 900 *cycles/min* to 720 *cycles/min* in 6 seconds. Its angular retardation in rad/s^2 will be

(a) $\pi/3$ (b) π (c) $2\pi/3$ (d) 2π

▶▶ *Advance level*

87. A particle is moving in a circular path with velocity varying with time as $v = 1.5\,t^2 + 2t$. If $2cm$ the radius of circular path, the angular acceleration at $t = 2\,\text{sec}$ will be

(a) $4\ rad/\sec^2$ (b) $40\ rad/\sec^2$ (c) $400\ rad/\sec^2$ (d) $0.4\ rad/\sec^2$

Problems based on centripetal acceleration

▶ *Basic level*

88. A stone, tied at the end of a string 80 *cm* long, is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 sec, what is the magnitude of acceleration of the stone

(a) 680 cm/s^2 (b) 720 cm/s^2 (c) 860 cm/s^2 (d) 990 cm/s^2

89. What happens to the centripetal acceleration of a revolving body if you double the orbital speed v and half the angular velocity ω

(a) The centripetal acceleration remains unchanged (b) The centripetal acceleration is halved

(c) The centripetal acceleration is doubled (d) The centripetal acceleration is quadrupled

90. The mean distance of the moon from the earth is 3.84×10^8 m. The moon makes one revolution round the earth in 2.34×10^6 sec. The acceleration of the moon towards the earth is

(a) 2.73×10^{-3} m/s^2 (b) 2.73×10^{-2} m/s^2 (c) 0.273 m/s^2 (d) 2.73×10^{-4} m/s^2

▶▶ *Advance level*

91. An astronaut is rotating in a rotor of radius $4m$. If he can withstand maximum acceleration of $10g$, the maximum permissible frequency of rotor will be

(a) $\frac{\pi}{5}\ Hz$ (b) $\frac{2\pi}{5}\ Hz$ (c) $\frac{5\pi}{5}\ Hz$ (d) $\frac{5}{2\pi}\ Hz$

Problems based on centripetal and centrifugal force

92. Two masses M and m are attached to a vertical axis by weightless threads of combined length L. They are set in rotational motion in a horizontal plane about this axis with constant angular velocity ω. If the tensions in the threads are the same during motion, the distance of M from the axis is

(a) $\frac{Ml}{M+m}$ (b) $\frac{ml}{M+m}$ (c) $\frac{M+m}{M}l$ (d) $\frac{M+m}{m}l$

93. In the Bohr model of a hydrogen atom, the centripetal force is furnished by the coulomb attraction between the proton and the electron. If a_0 is the radius of the ground state orbit, m is the mass, e is the charge on the electron and ε_0 is the vacuum permittivity, then speed of the electron is

(a) $\sqrt{\frac{\varepsilon_0 a_0 m}{e}}$ (b) $\frac{e}{\sqrt{\varepsilon_0 a_0 m}}$ (c) $\frac{\sqrt{4\pi\varepsilon_0 a_0 m}}{e}$ (d) $\frac{e}{\sqrt{4\pi\varepsilon_0 a_0 m}}$

94. A rubber band of length l has a stone of mass m tied to its one end. It is whirled with speed v so that the stone describes a horizontal circular path. The tension T in the rubber band is

(a) Zero (b) mv^2/l (c) $>(mv^2)/l$ (d) $<mv^2/l$

95. A particle of mass m is executing uniform circular motion on a path of radius r. If p is the magnitude of its linear momentum. The radial force acting on the particle is

(a) pmr (b) $\frac{rm}{p}$ (c) $\frac{mp^2}{r}$ (d) $\frac{p^2}{rm}$

96. Two particles of equal masses are revolving in circular paths of radii r_1 and r_2 respectively with the same speed. The ratio of their centripetal forces is

(a) $\frac{r_2}{r_1}$ (b) $\sqrt{\frac{r_2}{r_1}}$ (c) $\left(\frac{r_1}{r_2}\right)^2$ (d) $\left(\frac{r_2}{r_1}\right)^2$

97. A particle of mass m is observed from an inertial frame of reference and is forced to move in a circle of radius r with a uniform speed v. The centrifugal force on it is

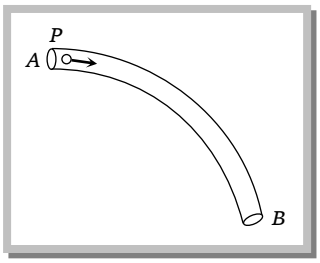
(a) $\frac{mv^2}{r}$ towards the centre (b) $\frac{mv^2}{r}$ away from the centre

(c) $\frac{mv^2}{r}$ along the tangent through the particle (d) Zero

98. A bowl, containing water and mercury, is revolved rapidly about a vertical axis, then the liquid which remains outermost is

(a) Water (b) Mercury (c) Mercury and water both (d) None of the above

99. The tube AB forms a quarter circle in a vertical plane. The particle P can move without friction in the tube. P is placed at A and displaced slightly. It will



(a) Always be in contact with the outer wall

(b) Always be in contact with the inner wall

(c) Initially be in contact with the inner wall and later with the outer wall

(d) Initially be in contact with the outer wall and later with the inner wall

100. A small block of mass $0.1kg$ moves with uniform speed in a horizontal circular groove of radius $1m$. The block takes π sec to complete one round. The normal contact force by the side will be

(a) 0.25 N (b) 0.4 N (c) 0.56 N (d) 0.1 N

▶▶ *Advance level*

101. A particle of mass m_1 is fastened to one end of a string and one of m_2 to the middle point, the other end of the string being fastened to a fixed point on a smooth horizontal table. The particles are then projected, so that the two portions of the string are always in the same straight line and describes horizontal circles. Find the ratio of tensions in the two parts of the string

(a) $\frac{m_1}{m_1+m_2}$ (b) $\frac{m_1+m_2}{m_1}$ (c) $\frac{2m_1+m_2}{2m_1}$ (d) $\frac{2m_1}{m_1+m_2}$

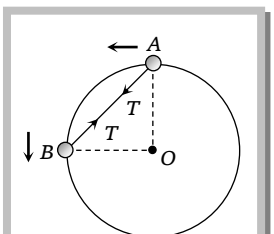
102. A toy cart is tied to the end of an unstretched string of length a. When revolved, thy toy cart moves in a horizontal circle of radius $2a$ with a time period T. Now the toy cart is speeded up until it moves in a horizontal circle of radius $3a$ with a period T'. If Hooke's law holds, then

(a) $T'=T$ (b) $T'=(3/2)T$ (c) $T'=(\sqrt{3}/2)T$ (d) $T'=\sqrt{(3/2)}\,T$

103. A chain of 125 links is $1.25m$ long and has a mass of $2kg$. With the ends fastened together it is set rotating at 3000 *rev/min*. Find the centripetal force on each link

(a) $3.14N$ (b) 314 N (c) $\frac{1}{3.14}N$ (d) $\frac{1}{314}N$

104. Two bodies A and B each of mass m are tied together by a light string. Both bodies are bound to move on a frictionless ring in a vertical plane as shown in figure. Both bodies are released from rest from the positions shown in figure. Just after releasing, the tension in the string will be



(a) $2mg$

(b) $\frac{mg}{2}$

(c) $\frac{mg}{\sqrt{2}}$

(d) $mg\sqrt{2}$

105. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is

[IIT-JEE 1992]

(a) $\frac{ML\omega^2}{2}$ (b) $ML\omega^2$ (c) $\frac{ML\omega^2}{4}$ (d) $\frac{ML^2\omega^2}{2}$

106. A cylindrical tube of length 'l' radius 'r' is filled by liquid of density p is rotated (ω), horizontally about an axis-through one of its edges. The force at the other end by the liquid is,

(a) $\rho\pi r^2\omega^2 l^2$ (b) $\frac{\rho\pi r^2\omega^2 l}{2}$ (c) $\frac{\rho\pi r^2\omega^2 l^2}{2}$ (d) None of these

Problem based on work done

▶ Basic level

107. A body of mass 4 *kg* is being rotated with 120 *rev*. per minute in a horizontal circular path of radius 2*m*. Its kinetic energy is

[CPMT 1994]

(a) 2 J (b) 32 J (c) 80 J (d) 1263 J

Problems based on skidding of vehicle on level road

▶ Basic level

108. A car moves along a horizontal circular road of radius r with velocity v. The coefficient of friction between the wheels and the road is μ. Which of the following statements is not true

(a) The car will slip if $v > \sqrt{\mu rg}$

(b) The car will slip if $\mu < \frac{v^2}{rg}$

(c) The car will slip if $r > \frac{v^2}{\mu g}$

(d) The car will slip at a lower speed, along with some acceleration, than if it moves at constant speed

▶▶ Advance level

109. The driver of a car travelling at velocity v suddenly see a broad wall in front of him at a distance d. He should **[IIT 197**

(a) Brake sharply (b) Turn sharply (c) (a) and (b) both (d) None of the above

Problems based on bending of cyclist

▶ Basic level

110. A cyclist riding the bicycle at a speed of $14\sqrt{3}\,ms^{-1}$ takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. (Given g = 9.8 ms^{-2}), what is his inclination to the vertical

(a) 30° (b) 90° (c) 45° (d) 60°

111. Consider the following statements

Assertion (A) **:** A cyclist always bends inwards while negotiating a curve

Reason (R) **:** By bending he lowers his centre of gravity

Of these statements : **[SCRA 1994]**

(a) Both *A* and *R* are true and *R* is the correct explanation of *A* (b) Both *A* and *R* are true but *R* is not the correct explanation of *A*

(c) *A* is true but *R* is false (d) *A* is false but *R* is true

▶▶ *Advance level*

112. A racing car of $1000\ kg$ moves round a banked track at a constant speed of $108\ km/hr$. Assuming the total reaction at the wheels is normal to the track and the horizontal radius of the track is $100\ m$, calculate the angle of inclination of the track to the horizontal (take $g = 10\ m/s^2$)

(a) 12^o (b) 27^o (c) 42^o (d) 65^o

113. In the above question, what is the reaction at the wheels

(a) 13450 *N* (b) 26900 *N* (c) 6725 *N* (d) 40350 *N*

114. A car is moving with a speed *v* on a road inclined at an angle θ in a circular arc of radius *r*, the minimum coefficient of friction, so that the car does not slip away

(a) $\frac{v^2}{rg} = \mu \tan\theta$ (b) $\mu = v^2/rg$ (c) $\frac{v^2\cos\theta - rg\sin\theta}{rg\cos\theta + v^2\sin\theta}$ (d) $\frac{v^2\cos\theta - rg\sin\theta}{rg\cos\theta - v^2\sin\theta}$

Problems based on vertical looping

▶ *Basic level*

115. A weightless thread can bear tension upto $3.7\ kg\ wt$. A stone of mass $500\ gms$ is tied to it and revolved in a circular path of radius $4m$ in a vertical plane. If g = 10 m/s^2, then the maximum angular velocity of the stone will be **[MP PET/PMT 1998]**

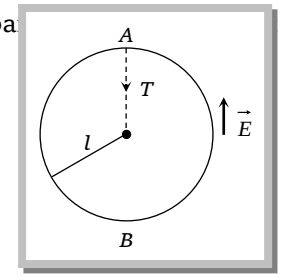
(a) $4\ radians/\sec$ (b) $16\ radians/\sec$ (c) $\sqrt{21}\ radians/\sec$ (d) $2\ radians/\sec$

116. A $2kg$ stone at the end of a string $1m$ long is whirled in a vertical circle at a constant speed. The speed of the stone is $4m/\sec$. The tension in the string will be $52\ N$, when the stone is

(a) At the top of the circle (b) At the bottom of the circle (c) Halfway down (d) None of the above

▶▶ *Advance level*

117. A particle of mass *M* carries a charge +*Q*. It is attached to a string of length *l* and is whirled in a vertical circle in electric field $\vec{E}$ directed upwards; what should be the minimum speed of the pa loops the loop



(a) $[(g + QE/M)\,l]^{1/2}$

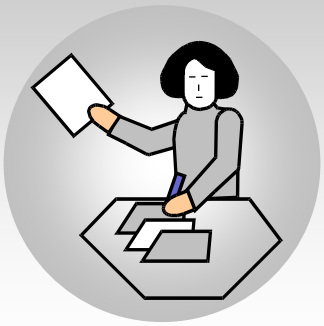
(b) $[(g - QE/M)\,l]^{1/2}$

(c) $[(Mg + QE)\,l]^{1/2}$

(d) $[(Mg - QE)\,l]^{1/2}$

118. A stone tied to a string of length *L* is whirled in a vertical circle with the other end of the string at the centre. At a certain instant of time, the stone is at its lowest position and has a speed *u*. The magnitude of the change in its velocity as it reaches a position where the string is horizontal is

(a) $\sqrt{u^2 - 2\,gL}$ (b) $\sqrt{2\,gL}$ (c) $\sqrt{u^2 - gl}$ (d) $\sqrt{2(u^2 - gL)}$



Answer Sheet (Practice problems)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
a	c	b	b	b	a	d	d	c	c
11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
a	a	c	c	a	c	d	b	d	d
21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
c	b	a	b	c	d	c	a	c	d
31.	32.	33.	34.	35.	36.	37.	38.	39.	40.
c	d	a	d	b	b	d	d	a	d
41.	42.	43.	44.	45.	46.	47.	48.	49.	50.
a	b	b	c	c	b	b	d	a	a
51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
b	d	a	c	b	a	d	a	d	c
61.	62.	63.	64.	65.	66.	67.	68.	69.	70.
c	c	a	b	d	c	c	d	c	d
71.	72.	73.	74.	75.	76.	77.	78.	79.	80.
d	c	a	a	a	c	c	d	d	c
81.	82.	83.	84.	85.	86.	87.	88.	89.	90.
b	d	b	c	d	b	c	d	a	a
91.	92.	93.	94.	95.	96.	97.	98.	99.	100.
d	b	d	d	d	a	d	b	c	b
101.	102.	103.	104.	105.	106.	107.	108.	109.	110.
c	c	b	c	a	c	d	c	a	d

111.	112.	113.	114.	115.	116.	117.	118.
b	c	a	c	a	b	b	d