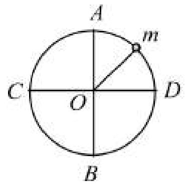
MOTION IN A PLANE

1. A ball rolls of the top of stair-way with a horizontal velocity of magnitude 1.8 ms^{-1}. The steps are 0.20 m high and 0.20 m wide. Which step will the ball hit first?
   a) First b) Second c) Third d) Fourth
2. A body of mass 100 g is rotating in a circular path of radius r with constant velocity. The work done in one complete revolution is
   a) $100\ rJ$ b) $(r/100)J$ c) $(100/r)J$ d) Zero
3. In uniform circular motion of a particle
   a) Velocity is constant but acceleration is variable
   b) Velocity is variable but acceleration in constant
   c) Both speed and acceleration are constant
   d) Speed is constant but acceleration is variable
4. A small sphere is attached to a cord and rotates in a vertical circle about a point O. If the average speed of the sphere is increased, the cord is most likely to break at the orientation when the mass is at



   a) Bottom point B b) Top point A c) The point D d) The point C
5. A stone of mass 1 kg tied to a light inextensible string of length $L = \frac{10}{3}$ is whirling in a circular path of radius L in vertical plane. If the ratio of the maximum tension to the minimum tension in the string is 4. What is the speed of stone at the highest point of the circle? (Taking $g = 10ms^{-2}$)
   a) 10 ms^{-1} b) $5\sqrt{2}$ ms^{-1} c) $10\sqrt{3}$ ms^{-1} d) 20 ms^{-1}
6. A proton in a cyclotron changes its velocity from 30kms^{-1} north to 40kms^{-1} east in 20 s. what is the average acceleration during this time
   a) 2.5 kms^{-2}at 37° E of S b) 2.5 kms^{-2}at 37° N of E
   c) 2.5 kms^{-2}at 37° N of S d) 2.5 kms^{-2}at 37° E of N
7. A man can throw a stone to a maximum distance of 80 m. The maximum height to which it will rise in metre, is
   a) 30 m b) 20 m c) 10 m d) 40 m
8. The bob of a pendulum of mass m and length L is displaced, 90° from the vertical and gently released. In order that the string may not break upon passing through the lowest point, its minimum strength must be
   a) mg b) 2 mg c) 3 mg d) 4 mg
9. An aeroplane is flying horizontally with a constant velocity of 100 kmh^{-1} at a height of 1 km from the ground level. At $t = 0$, it starts dropping packets at constant time intervals of T_0. If R represents the separation between two consecutive points of impact on the ground, then for the first three packets, R_1/R_2 is
   a) 1 b) >1
   c) <1 d) Sufficient data is not given

10. A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in a plane it follows that

a) Its velocity is constant
b) Its acceleration is constant
c) Its kinetic energy is constant
d) It moves in a straight line

11. A stone is just released from the window of a train moving along a horizontal straight track. The stone will hit the ground following

a) Straight path
b) Circular path
c) Parabolic path
d) Hyperbolic path

12. 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^o
b) 90^o
c) 45^o
d) 60^o

13. When a projectile is projected at a certain angle with the horizontal, its horizontal range is R and time of flight is T_1. When the same projectile is throwing with the same speed at some other angle with the horizontal, its horizontal range is R and time of flight is T_2. The product of T_1 and T_2 is

a) $\frac{R}{g}$
b) $\frac{2R}{g}$
c) $\frac{3R}{g}$
d) $\frac{4R}{g}$

14. The equation of a projectile is $y = \sqrt{3}x - \frac{gx^2}{2}$. The angle of projection is given by

a) $\tan\theta = \frac{1}{\sqrt{3}}$
b) $\tan\theta = \sqrt{3}$
c) $\frac{\pi}{2}$
d) Zero

15. A cyclist is moving on a circular track of radius 80 m with a velocity$v = 36\text{kmh}^{-1}$. He has to lean from the vertical approximately through an angle
(take $g = 10\ \text{ms}^{-2}$

a) $\tan^{-1}(4)$
b) $\tan^{-1}\left(\frac{1}{3}\right)$
c) $\tan^{-1}\left(\frac{1}{4}\right)$
d) $\tan^{-1}\left(\frac{1}{8}\right)$

16. A particle of mass m is fixed to one end of a light spring of force constant k and unstretched length l. The system is rotated about the other end of the spring with an angular velocity ω, in gravity free space. As shown in figure the increase in length of the spring will be

a) $\frac{m\,\omega^2 l}{k}$
b) $\frac{m\,\omega^2 l}{k - m\,\omega^2}$
c) $\frac{m\,\omega^2 l}{k + m\,\omega^2}$
d) None of these

17. If a person can throw a stone to maximum height of h metre vertically, then the maximum distance through which it can be thrown horizontally by the same person is

a) $\frac{h}{2}$
b) h
c) $2h$
d) $3h$

18. A particle is tied to $20cm$ long string. It performs circular motion in vertical plane. What is the angular velocity of the string when the tension in the string at the top is zero

a) $5\ rad/sec$
b) $2\ rad/sec$
c) $7.5\ rad/sec$
d) $7\ rad/sec$

19. The maximum and minimum tensions in the string whirling in a circle of radius 2.5 m are in the ratio 5:3, then its velocity is

a) $\sqrt{98}\ \text{ms}^{-1}$
b) $7\ \text{ms}^{-1}$
c) $\sqrt{490}\ \text{ms}^{-1}$
d) $\sqrt{4.9}\ \text{ms}^{-1}$

20. Two bodies are projected from the same point with equal speeds in such directions that they both strike the same point on a plane whose inclination is β. If α be the angle of projection of the first body with the horizontal the ratio of their times of flight is

a) $\frac{\cos\alpha}{\sin(\alpha+\beta)}$
b) $\frac{\sin(\alpha+\beta)}{\cos\alpha}$
c) $\frac{\cos\alpha}{\sin(\alpha-\beta)}$
d) $\frac{\sin(\alpha-\beta)}{\cos\alpha}$

21. The angle of projection at which the horizontal range and maximum height of projectile are equal is

a) 45°
b) $\theta = \tan^{-1}(0.25)$
c) $\theta = \tan^{-1} 4$ or $(\theta = 76°)$
d) 60°

22. A body slides down a frictionless track which ends in a circular loop of diameter D. Then the minimum height h of the body in terms of D so that it may just complete the loop, is

a) $h = \frac{5}{2}D$ b) $h = \frac{3}{2}D$ c) $h = \frac{5}{4}D$ d) $h = 2D$

23. A force $\vec{F} = 2\hat{i} + 2\hat{j}$ N displaces a particle through $\vec{S} = 2\hat{i} + 2\hat{k}$ m in 16 s. The power developed by $\vec{F}$ is

a) 0.25 J s^{-1} b) 25 J s^{-1} c) 225 J s^{-1} d) 450 J s^{-1}

24. A sphere of mass m is tied to end of a string of length l and rotated through the other end along a horizontal circular path with speed v. The work done in full horizontal circle is

a) 0 b) $\left(\frac{mv^2}{l}\right).2\pi l$ c) $mg.2\pi$ d) $\left(\frac{mv^2}{l}\right).(l)$

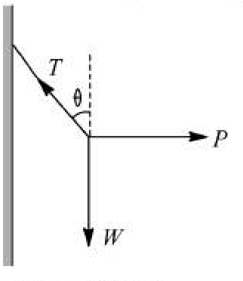
25. Two projectile are thrown with the same initial velocity at angles α and $(90° - \alpha)$ with the horizontal. The maximum heights attained by them are h_1 and h_2 respectively. Then $\frac{h_1}{h_2}$ is equal to

a) $\sin^2\alpha$ b) $\cos^2\alpha$ c) $\tan^2\alpha$ d) 1

26. A particle P is at the origin starts with velocity $\vec{\mathbf{v}} = (2\hat{\mathbf{i}} - 4\hat{\mathbf{j}})\text{ms}^{-1}$ with constant acceleration $(3\hat{\mathbf{i}} - 5\hat{\mathbf{j}})\text{ms}^{-2}$. After travelling for 2 s, its distance from the origin is

a) 10 m b) 10.2 m c) 9.8 m d) 11.7 m

27. A small sphere is hung by a string fixed to a wall. The sphere is pushed away from the wall by a stick. The force acting on the sphere are shown in figure. Which of the following statements is wrong?

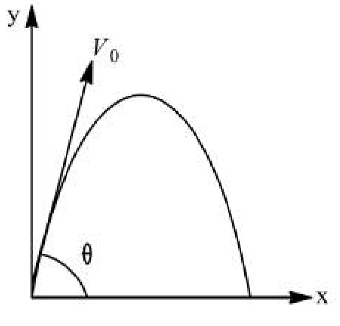


a) $P = W\tan\theta$ b) $\vec{T} + \vec{P} + \vec{W} = 0$ c) $T^2 = P^2 + W^2$ d) $T = P + W$

28. A particle moves in a circle of radius 30cm. Its liner speed is given by $v = 2t$, where t is in second and v in ms^{-1}. Find out its, radial and tangential acceleration at $t = 3$s, respectively,

a) $220 \text{ ms}^{-2}, 50 \text{ ms}^{-2}$ b) $100 \text{ ms}^{-2}, 5 \text{ ms}^{-2}$ c) $120 \text{ ms}^{-2}, 2 \text{ ms}^{-2}$ d) $110 \text{ ms}^{-2}, 10 \text{ ms}^{-2}$

29. A small particle of mass m is projected at an angle θ with the x-axis with an initial velocity v_0 in the x-y plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is



a) $-mgv_0t^2\cos\theta\,\hat{\mathbf{j}}$ b) $mgv_0t\cos\theta\,\hat{\mathbf{k}}$ c) $-\frac{1}{2}mgv_0t^2\cos\theta\,\hat{\mathbf{k}}$ d) $\frac{1}{2}mgv_0t^2\cos\theta\,\hat{\mathbf{i}}$

30. A body is thrown upward from the earth surface with velocity 5 m/s and from a planet surface with velocity 3 m/s. Both follow the same path. What is the projectile acceleration due to gravity on the planet

a) $2\ m/s^2$ b) $3.5\ m/s^2$ c) $4\ m/s^2$ d) $5\ m/s^2$

31. An unbanked curve has a radius of 60 m. The maximum speed at which the car make a turn is (Take $\mu = 0.75$)

a) 7 ms^{-1} b) 14 ms^{-1} c) 21 ms^{-1} d) 2.1 ms^{-1}

32. A fly wheel rotates about a fixed axis and slows down from 300 rpm to 100 rpm in 2 min. Then its angular retardation in rad/min^2 is

a) $\frac{100}{\pi}$ b) 100 c) $100\,\pi$ d) $200\,\pi$

33. A particle is projected with a velocity 200 ms^{-1} at an angle of 60°. At the highest point, it explodes into three particles of equal masses. One goes vertically upwards with a velocity 100 ms^{-1}, the second particle goes vertically downwards. What is the velocity of third particle?

a) 120 ms^{-1} making 60° angle with horizontal b) 200 ms^{-1} making 60° angle with horizontal

c) 300 ms^{-1} d) 200 ms^{-1}

34. A car is moving on a circular path and takes a turn. If R_1 and R_2 be the reactions on the inner and outer wheels respectively, then

a) $R_1 = R_2$ b) $R_1 < R_2$ c) $R_1 > R_2$ d) $R_1 \geq R_2$

35. If the vector $\vec{A} = 2\hat{\imath} + 4\hat{\jmath}$ and $\vec{B} = 5\hat{\imath} + p\hat{\jmath}$ are parallel to each other, the magnitude of $\vec{B}$ is

a) $5\sqrt{5}$ b) 10 c) 15 d) $2\sqrt{5}$

36. A body is revolving with a uniform speed v in a circle of radius r. The tangential acceleration is

a) $\frac{v}{r}$ b) $\frac{v^2}{r}$ c) Zero d) $\frac{v}{r^2}$

37. A bridge is in the form of a semi-circle of radius 40 m. The greatest speed with which a motor cycle can cross the bridge without leaving the ground at the highest point is ($g = 10\text{ms}^{-2}$) (frictional force is negligibly small)

a) 40 ms^{-1} b) 20 ms^{-1} c) 30 ms^{-1} d) 15 ms^{-1}

38. A car is moving with high velocity when it has a turn. A force acts on it outwardly because of

a) Centripetal force b) Centrifugal force c) Gravitational force d) All the above

39. If time of flight of a projectile is 10 seconds. Range is 500 *meters*. The maximum height attained by it will be

a) 125 m b) 50 m c) 100 m d) 150 m

40. A stone is projected with a velocity $20\sqrt{2}\text{ms}^{-1}$ at an angle of 45° to the horizontal. The average velocity of stone during its motion from starting point to its maximum height is ($g = 10\text{ms}^{-2}$)

a) $5\sqrt{5}$ ms^{-1} b) $10\sqrt{5}$ ms^{-1} c) 20 ms^{-1} d) $20\sqrt{5}$ ms^{-1}

41. A stone is thrown at an angle θ to the horizontal reaches a maximum heights H. then the time of flight of stone will be

a) $\sqrt{\frac{2H}{g}}$ b) $2\sqrt{\frac{2H}{g}}$ c) $\frac{2\sqrt{2H\sin\theta}}{g}$ d) $\frac{\sqrt{2H\sin\theta}}{g}$

42. A particle does uniform circular motion in a horizontal plane. The radius of the circle is 20 cm. The centripetal force acting on the particle is 10 N. It's kinetic energy is

a) 0.1 J b) 0.2 J c) 2.0 J d) 1.0 J

43. When a simple pendulum is rotated in a vertical plane with constant angular velocity, centripetal force is

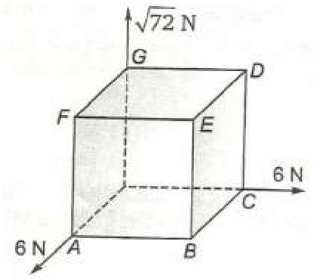
a) Maximum at highest point b) Maximum at lowest point

c) Same at all lower point d) Zero

44. The magnitude of the vectors product o two vectors is $\sqrt{3}$ times their scalar product. The angle between the two vectors is

a) 90° b) 60° c) 45° d) 30°

45. Three forces of magnitudes 6N, 6N and $\sqrt{72}$ N at a corner of a cube along three sides as shown in figure. Resultant of these forces is



a) 12 N along OB b) 18 N along OA c) 18 N along OC d) 12 N along OE

46. The angle which the bicycle and its rider must make with the vertical when going round a curve of 7 m radius at 5 ms^{-1} is
a) 20° b) 15° c) 10° d) 5°

47. A projectile is thrown at angle β with vertical. It reaches a maximum height H. The time taken to reach the highest point of its path is
a) $\sqrt{\frac{H}{g}}$ b) $\sqrt{\frac{2H}{g}}$ c) $\sqrt{\frac{H}{2g}}$ d) $\sqrt{\frac{2H}{g\cos\beta}}$

48. A cart is moving horizontally along a straight line with constant speed 30 m/s. A projectile is to be fired from the moving cart in such a way that it will return to the cart after the cart has moved 80 m. At what speed (relative to the cart) must the projectile be fired (Take $g = 10\ m/s^2$)
a) 10 m/s b) $10\sqrt{8}\ m/s$ c) $\frac{40}{3}\ m/s$ d) None of these

49. A sphere of mass 0.2 kg is attached to an inextensible string of length 0.5 m whose upper end is fixed to the ceiling. The sphere is made to describe a horizontal circle of radius 0.3 m. The speed of the sphere will be
a) 1.5 m s^{-1} b) 2.5 m s^{-1} c) 3.2 m s^{-1} d) 4.7 m s^{-1}

50. The resultant of two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to the vector $\vec{A}$ and its magnitude is equal to half of the magnitude of vector $\vec{B}$. Then the angle between $\vec{A}$ and $\vec{B}$ is
a) 30° b) 45° c) 150° d) 120°

51. What is the smallest radius of a circle at which a cyclist can travel if its speed is 36 kmh^{-1}, angle of inclination 45° and $g = 10ms^{-2}$?
a) 20 m b) 10 m c) 30 m d) 40 m

52. A body of mass m moves in a circular path with uniform angular velocity. The motion of the body has constant
a) Acceleration b) Velocity c) Momentum d) Kinetic energy

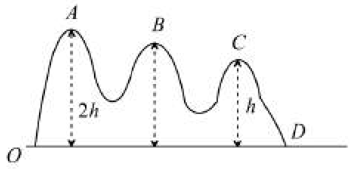
53. A body of mass m is suspended from a string of length l. What is minimum horizontal velocity that should be given to the body in its lowest position so that it may complete one full revolution in the vertical plane with the point of suspension as the centre of the circle
a) $v = \sqrt{2lg}$ b) $v = \sqrt{3lg}$ c) $v = \sqrt{4lg}$ d) $v = \sqrt{5lg}$

54. A car is travelling with linear velocity v on a circular road of radius r. If it is increasing its speed at the rate of $'a' m/s^2$, then the resultant acceleration will be
a) $\sqrt{\left\{\frac{v^2}{r^2} - a^2\right\}}$ b) $\sqrt{\left\{\frac{v^4}{r^2} + a^2\right\}}$ c) $\sqrt{\left\{\frac{v^4}{r^2} - a^2\right\}}$ d) $\sqrt{\left\{\frac{v^2}{r^2} + a^2\right\}}$

55. $(\vec{P} + \vec{Q})$ is a unit vector along X-axis. If $\vec{P} = \hat{i} - \hat{j} + \hat{k}$, then what value is $\vec{Q}$?
a) $\hat{i} + \hat{j} - \hat{k}$ b) $\hat{j} - \hat{k}$ c) $\hat{i} + \hat{j} + \hat{k}$ d) $\hat{j} + \hat{k}$

56. For a projection, $(\text{range})^2$ is 48 times of $(\text{maximum height})^2$ obtained. Find angle projection.
a) 60° b) 30° c) 45° d) 75°

57. A small roller coaster starts at point A with a speed u on a curved track as shown in figure



The friction between the roller coaster and the track is negligible and it always remains in contact with the track. The speed of the roller coaster at point D on the track will be

a) $(u^2+gh)^{\frac{1}{2}}$ b) $(u^2+2gh)^{\frac{1}{2}}$ c) $(u^2+4gh)^{\frac{1}{2}}$ d) u

58. A particle rests on the top of a hemisphere of radius R. Find the smallest horizontal velocity that must be imparted to the particle if it is to leave the hemisphere without sliding down it

a) $\sqrt{gR}$ b) $\sqrt{2gR}$ c) $\sqrt{3gR}$ d) $\sqrt{5gR}$

59. A 2 kg stone tied at the end of a string 1 m long is whirled along a vertical circle at a constant speed of 4 ms^{-1}. The tension in the string has a value of 52 N when the stone is

a) At the top of the circle b) Half way down

c) At the bottom of the circle d) None of the above

60. A stone thrown at an angle θ to the horizontal a projectile makes an angle $\pi/4$ with the horizontal, then its initial velocity and angle of projection are, respectively

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

61. Given that centripetal force$F=-k/r^2$. The total energy is

a) $-k/r^2$ b) k/r c) $-k/2r^2$ d) $-k/2r$

62. The area of parallelogram formed from the vectors $\vec{A}=\hat{\imath}-2\hat{\jmath}+3\hat{k}$ and $\vec{B}=3\hat{\imath}-2\hat{\jmath}+\hat{k}$ as adjacent sides is

a) $8\sqrt{3}$ units b) 64 units c) 32 units d) $4\sqrt{6}$ units

63. Two vectors $\vec{A}$ and $\vec{B}$ are inclined to each other at an angle θ. Which of the following is the unit vector perpendicular to both $\vec{A}$ and $\vec{B}$?

a) $\frac{\vec{A}\times\vec{B}}{\vec{A}\cdot\vec{B}}$ b) $\frac{\hat{A}\cdot\hat{B}}{\sin\theta}$ c) $\frac{\vec{A}\times\vec{B}}{AB\sin\theta}$ d) $\frac{\hat{A}\times\hat{B}}{AB\cos\theta}$

64. A coastguard ship locates a pirate ship at a distance 560 m. It fires a cannon ball with an initial speed 82 m/s. At what angle from horizontal the ball must be fired so that it hits the pirate ship

a) 54° b) 125° c) 27° d) 18°

65. What happens to the centripetal acceleration of a particle, when its speed is doubled and angular velocity is halved?

a) Doubled b) Halved

c) Remains unchanged d) Becomes 4 times

66. A particle moves in a circular path with decreasing speed. Choose the correct statement

a) Angular momentum remains constant

b) Acceleration ($\vec{a}$) is towards the centre

c) Particle moves in a spiral path with decreasing radius

d) The direction of angular momentum remains constant

67. An object is projected so that its horizontal range R is maximum. If the maximum height attained by the object is H, then the ratio of R/H is

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

68. A cricketer can throw a ball to a maximum horizontal distance of 100 m. The speed with which he throws the ball is (to the nearest integer)

a) 30 ms^{-1} b) 42 ms^{-1} c) 32 ms^{-1} d) 35 ms^{-1}

69. The maximum height attained by a projectile when thrown at an angle θ with the horizontal is found to be half the horizontal range. Then θ is equal to

a) $\tan^{-2}(2)$ b) $\frac{\pi}{6}$ c) $\frac{\pi}{4}$ d) $\tan^{-1}\left(\frac{1}{2}\right)$

70. The angular velocity of a wheel is 70 rad/sec. If the radius of the wheel is 0.5 m, then linear velocity of the wheel is

a) 70 m/s b) 35 m/s c) 30 m/s d) 20 m/s

71. A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved?

a) center of the circle
b) on the circumference of the circle
c) inside the circle
d) outside the circle

72. An aeroplane is flying horizontally with a velocity of 216 kmh^{-1} and at a height of 1960 m. When it is vertically above a point A on the ground, a bomb is released from it. The bomb strikes the ground at point B. The distance AB is (ignoring air resistance)

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

73. If the magnitude of the sum of the two vectors is equal to the difference of their magnitudes, then the angle between vectors is

a) 0° b) 45° c) 90° d) 180°

74. Which of the following sets of factors will affect the horizontal distance covered by an athlete in a long-jump event

a) Speed before he jumps and his weight
b) The direction in which he leaps and the initial speed
c) The force with which he pushes the ground and his speed
d) None of these

75. A point of application of a force $\vec{F} = 5\hat{i} - 4\hat{j} + 2\hat{k}$ is moved from $\vec{r_1} = 2\hat{i} + 7\hat{j} + 4\hat{k}$ to $\vec{r_2} = 5\hat{i} + 2\hat{j} + 3\hat{k}$ the work done is

a) 22 units b) −22 units c) 33 units d) −33 units

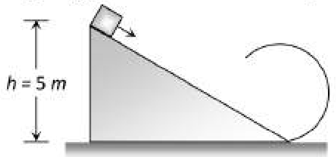
76. If a particle of mass m is moving in a horizontal circle of radius r with a centripetal force $(-K/r^2)$ the total energy is

a) $-\frac{K}{2r}$ b) $-\frac{K}{r}$ c) $-\frac{2K}{r}$ d) $-\frac{4K}{r}$

77. The x and y components of a force are 2 N and −3N. The force is

a) $2\hat{i} - 3\hat{j}$ b) $2\hat{i} + 3\hat{j}$ c) $-2\hat{i} - 3\hat{j}$ d) $3\hat{i} + 2\hat{j}$

78. As per given future to complete the circular loop what should be the radius if initial height is 5 m



a) 4 m b) 3 m c) 2.5 m d) 2 m

79. A particle is projected from the ground at an angle of 60° with horizontal with speed $u = 20\ ms^{-1}$. The radius of curvature of the path of the particle, when its velocity makes an angle of 30° with horizontal is $(g = 10\ ms^{-2})$

a) 10.6 m b) 12.8 m c) 15.4 m d) 24.2 m

80. A body of mass 1 kg thrown with a velocity of 10 ms^{-1} at an angle of 60° with the horizontal. Its momentum at the highest point is

a) 2 kg ms^{-1} b) 3 kg ms^{-1} c) 4 kg ms^{-1} d) 5 kg ms^{-1}

81. A body is tied to one end of the string and whirled in a vertical circle, the physical quantity which remains constant is

a) Momentum b) Speed c) Kinetic energy d) Total energy

82. A mass of 100 gm is tied to one end of a string 2 m long. The body is revolving in a horizontal circle making a maximum of 200 revolutions per min. The other end of the string is fixed at the centre of the circle of revolution. The maximum tension that the string can bear is (approximately)

a) 8.76 N b) 8.94 N c) 89.42 N d) 87.64 N

83. A ball is projected with velocity u at an angle α with horizontal plane. Its speed when it makes an angle β with the horizontal is

a) $u\cos\alpha$ b) $\frac{u}{\cos\beta}$ c) $u\cos\alpha\cos\beta$ d) $\frac{u\cos\alpha}{\cos\beta}$

84. The angular speed of a car increases from 600 rpm to 1200 rpm in 10 s. What is the angular acceleration of the car?

a) 600 rad s^{-1} b) 60 rad s^{-1} c) 60 π rad m s^{-1} d) 2 π rad s^{-1}

85. A glass marble projected horizontally from the top of a table falls at a distance x from the edge of the table. If h is the height of the table, then the velocity of projection is

a) $h\sqrt{\frac{g}{2x}}$ b) $x\sqrt{\frac{g}{2h}}$ c) gxh d) $gx + h$

86. A curved road of 50 m radius is banked at correct angle for a given speed. If the speed is to be doubled keeping the same banking angle, the radius of curvature of the road should be changed to

a) 25 m b) 100 m c) 150 m d) 200 m

87. With what minimum speed a particle be projected from the origin so that it is able to pass through a given point (30 m, 40 m)?

a) 30 ms^{-1} b) 40 ms^{-1} c) 50 ms^{-1} d) 60 ms^{-1}

88. A wheel rotates with a constant angular velocity of 300 rpm. The angle through which the wheel rotates in one second is

a) π rad b) 5 π rad c) 10 π rad d) 20 π rad

89. 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 th the ground)

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

90. A bucket filled with water is tied to a rope of length 0.5 m and is rotated in a circular path in vertical pane. The least velocity it should have at the lowest point of circle so that water dose not spill is, ($g = 10$ ms^{-2})

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

91. An object of mass 5 kg is whirled round in a vertical circle of radius 2 m with a constant speed of 6 ms^{-1}. The maximum tension in the string is

a) 152 N b) 139 N c) 121 N d) 103 N

92. A body just being revolved in a vertical circle of radius R with a uniform speed. The string breaks when the body is at the highest point. The horizontal distance covered by the body after the string breaks is

a) 2 R b) R c) $R\sqrt{2}$ d) 4 R

93. The coefficient of friction between the tyres and the road is 0.25. The maximum speed with which a car can be driven round a curve a radius 40 m without skidding is (assume $g = 10$ ms^{-2})

a) 40 ms^{-1} b) 20 ms^{-1} c) 15 ms^{-1} d) 10 ms^{-1}

94. A car wheel is rotated to uniform angular acceleration about its axis. Initially its angular velocity is zero. It rotates through an angle θ_1 in the first 2 s , in the next 2 s, it rotates through an additional angle θ_2, the ratio of $\frac{\theta_2}{\theta_1}$ is

a) 1 b) 2 c) 3 d) 5

95. If a particle covers half the circle of radius R with constant speed then

a) Change in momentum is mvr
b) Change in $K.E.$ is $1/2\ mv^2$
c) Change in $K.E.$ is mv^2
d) Change in $K.E.$ is zero

96. A cylinder full. Of water, is rotating about its own axis with uniform angular velocity ω. The shape of free surface of water will be

a) Parabola b) Elliptical c) Circular d) Spherical

97. What is the angle between $\hat{i} + \hat{j} + \hat{k}$ and $\hat{i}$

a) 0° b) $\pi/6$ c) $\pi/3$ d) None of these

98. A body moves along a circular path of radius 10 m and the coefficient of friction is 0.5. What should be its angular speed in rad s^{-1}, if it is not to slip from the surface? ($g = 9.8\ ms^{-2}$)

a) 5 b) 10 c) 0.1 d) 0.7

99. An object is projected at an angle of 45° with the horizontal. The horizontal range and maximum height reached will be in the ratio

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

100. A car sometimes overturns while taking a turn. When it overturns, it is

a) The inner wheel which leaves the ground first
b) The outer wheel which leaves the ground first
c) Both the wheels leave the ground simultaneously
d) Either wheel leaves the ground first

101. A projectile is fired with a velocity v at an angle θ with the horizontal. The speed of the projectile when its direction of motion makes an angle β with the horizontal is

a) $v \cos\theta$ b) $v \cos\theta \cos\beta$ c) $v \cos\theta \sec\beta$ d) $v \cos\theta \tan\beta$

102. A body is projected with speed $v\ ms^{-1}$ at angle θ. The kinetic energy at the highest point is half of the initial kinetic energy. The value of θ is

a) 30° b) 45° c) 60° d) 90°

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

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

104. In a vertical circle of radius r, at what point in its path a particle has tension equal to zero if it is just able to complete the vertical circle

a) Highest point b) Lowest point
c) Any point d) At a point horizontally from the centre of circle of radius r

105. A particle comes round a circle of radius 1 m once. The time taken by it is 10 sec. The average velocity of motion is

a) $0.2\ \pi m/s$ b) $2\ \pi m/s$ c) $2\ m/s$ d) Zero

106. A car of mass 1000 kg negotiates a banked curve of radius 90 m on a frictionless road. If the banking angle is 45°, the speed of the car is

a) $20ms^{-1}$ b) $30ms^{-1}$ c) $5ms^{-1}$ d) $10ms^{-1}$

107. What is the unit vector along $\hat{\imath} + \hat{\jmath}$?

a) $\frac{\hat{\imath} + \hat{\jmath}}{\sqrt{2}}$ b) $\sqrt{2}(\hat{\imath} + \hat{\jmath})$ c) $\hat{\imath} + \hat{\jmath}$ d) $\hat{k}$

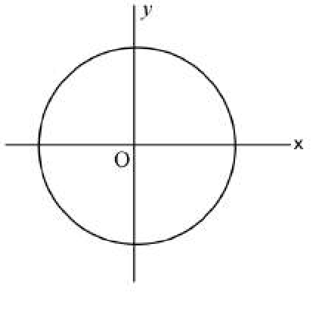
108. The speed limit of a car over a roadways bridge in the form of a vertical arc is $9.8\ ms^{-1}$. The diameter of the are is

a) 19.6 m b) 9.8 m c) 39.2 m d) 4.9 m

109. A body is acted upon by a constant force directed towards a fixed point. The magnitude of the force varies inversely as the square of the distance from the fixed point. What is the nature of the path?

a) Straight line b) Parabola c) Circle d) Hyperbola

110. The figure shows a circular path of a moving particle. If the velocity of the particle at same instant is $\mathbf{v} = -3\hat{\mathbf{i}} - 4\hat{\mathbf{j}}$, through which quadrant is the particle moving when clockwise and anti-clockwise respectively



a) 1st and 4 th b) 2nd and 4th c) 2 nd and 3rd d) 3 rd and 4 th

111. A car is moving along a straight horizontal road with a speed v_0. If the coefficient of friction between tyres and the road is μ, the shortest distance in which the car can be stopped is

a) $\frac{v_0^2}{2\mu g}$ b) $\frac{v_0}{\mu g}$ c) $\left(\frac{v_0}{\mu g}\right)^2$ d) $\frac{v_0}{\mu}$

112. A particle moves in a circle of radius 5 cm with constant speed and time period 0.2 πs. The acceleration of the particle is

a) 5 m/s^2 b) 15 m/s^2 c) 25 m/s^2 d) 36 m/s^2

113. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/hr. The centripetal force is

a) 250 N b) 750 N c) 1000 N d) 1200 N

114. A road of 10 m width has radius of curvature 50 m. Its outer edge is raised above the inner edge by a distance of 1.5 m. The road is most suited for vehicles moving with velocity of

a) 8.5 ms^{-1} b) 6.5 ms^{-1} c) 5.5 ms^{-1} d) None of these

115. A plane surface is inclined making an angle θ with the horizontal. Form the bottom of this inclined plane, a bullet is fired with velocity v. The maximum possible range of the bullet on the inclined plane is

a) $\frac{v^2}{g}$ b) $\frac{v^2}{g(1+\sin\theta)}$ c) $\frac{v^2}{g(1-\sin\theta)}$ d) $\frac{v^2}{g(1+\sin\theta)^2}$

116. The maximum range of a gun on horizontal terrain is 16 km. If $g = 10\ m/s^2$. What must be the muzzle velocity of the shell

a) 200 m/s b) 400 m/s c) 100 m/s d) 50 m/s

117. A man projects a coin upwards from the gate of a uniformly moving train. The path of coin for the man will be

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

118. Three vectors $\vec{A}, \vec{B}$ and $\vec{C}$ satisfy the relation $\vec{A}\cdot\vec{B} = 0$ and $\vec{A}\cdot\vec{C} = 0$. If $\vec{B}$ and $\vec{C}$ are not lying in the same plane then $\vec{A}$ is parallel to

a) $\vec{B}$ b) $\vec{C}$ c) $\vec{B}\times\vec{C}$ d) $\vec{B}\cdot\vec{C}$

119. The equation of motion of a projectile is $y = 12x - \frac{3}{4}x^2$. The horizontal component of velocity is $3ms^{-1}$. What is the range of the projectile?

a) 18 m b) 16 m c) 12 m d) 21.6 m

120. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that they make complete circles in the same time t. The ratio of their centripetal acceleration is

a) $m_1r_1 : m_2r_2$ b) $m_1 : m_2$ c) $r_1 : r_2$ d) 1 : 1

121. A particle moves in a circle of radius 30 cm. Its linear speed is given by $v = 2t$ where t in second and v in m/s. Find out its radial and tangential acceleration at $t = 3\ sec$ respectively

a) 220 m/sec^2 , 50 m/sec^2 b) 100 m/sec^2 , 5 m/sec^2
c) 120 m/sec^2 , 2 m/sec^2 d) 110 m/sec^2 , 10 m/sec^2

122. Two particles are projected simultaneously in the same vertical plane, from the same point, both with different speeds and at different angles with horizontal. The path followed by one, as seed by the other, is

a) A vertical line
b) A parabola
c) A hyperbola
d) A straight line making a constant angle ($\neq 90°$) with the horizontal

123. Find the maximum speed at which a car can turn round a curve of 30 m radius on a level road if the coefficient of friction between the tyres and the road is 0.4
(Acceleration due to gravity = 10 ms^{-2})

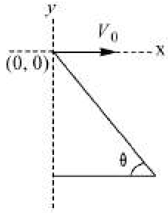
a) 12 ms^{-2} b) 10 ms^{-2} c) 11 ms^{-2} d) 15 ms^{-2}

124. The simple sum of two co-initial vectors is 10 units. Their vector sum is 8 units. The resultant of the vectors is perpendicular to the smaller vector. The magnitudes of the two vectors are

a) 2 units and 14 units
b) 4 units and 12 units
c) 6 units and 10 units
d) 8 units and 8 units

125. The resultant of two forces at right angle is 5N. When the angle between them is 120°, the resultant is $\sqrt{13}$. Then the force are
a) $\sqrt{12}$N, $\sqrt{13}$N b) $\sqrt{20}$N, $\sqrt{5}$N c) 3 N, 4 N d) $\sqrt{40}$N, $\sqrt{15}$N

126. A man standing on a hill top projects a stone horizontally with speed v_0 as shown in figure. Taking the coordinate system as given in the figure. The coordinates of the point where the stone will hit the hill surface



a) $\left(\frac{2v_0^2\tan\theta}{g}, \frac{-2v_0^2\tan^2\theta}{g}\right)$ b) $\left(\frac{2v_0^2}{g}, \frac{2v_0^2\tan^2\theta}{g}\right)$
c) $\left(\frac{2v_0^2\tan\theta}{g}, \frac{2v_0^2}{g}\right)$ d) $\left(\frac{2v_0^2\tan^2\theta}{g}, \frac{2v_0^2\tan\theta}{g}\right)$

127. Given $\vec{c} = \vec{a} \times \vec{b}$. The angle which $\vec{a}$ makes with $\vec{c}$ is
a) 0° b) 45° c) 90° d) 180°

128. Two bodies are projected from ground with equal speed 20 ms^{-1} from the same position in the same vertical plane to have equal range but at different angles above the horizontal. If one of the angle is 30° the sum of their maximum heights is (assume $g = 10\ ms^{-2}$)
a) 400 m b) 20 m c) 30 m d) 40 m

129. Two bodies of mass 10 kg and 5 kg moving in concentric orbits of radii R and r such that their periods are the same. Then the ratio between their centripetal acceleration is
a) R/r b) r/R c) R^2/r^2 d) r^2/R^2

130. A body is whirled in a horizontal circle of radius 20 cm. It has angular velocity of 10 rad/s. What is its linear velocity at any point on circular path
a) 10 m/s b) 2 m/s c) 20 m/s d) $\sqrt{2}\ m/s$

131. A body of mass 0.4 kg is whirled in a vertical circle making 2rev/s. If the radius of the circle is 2m, then tension in the string when the body is at the top of the circle is
a) 41.56 N b) 89.86 N c) 109.86 N d) 115.86 N

132. A body is projected horizontally with speed 20 ms^{-1}. The approximate displacement of the body after 5 s is
a) 80 m b) 120 m c) 160 m d) 320 m

133. A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant tangential acceleration. If the velocity of the particle is 80 ms^{-1}, at the end of seconds revolution after motion has begun, the tangential acceleration is
a) 40 ms^{-2} b) 640 π ms^{-2} c) 1609 π ms^{-2} d) 40 π ms^{-2}

134. A projectile is thrown at angle β with vertical. It reaches a maximum height H. The time taken to reach the highest point of its path is
a) $\sqrt{\frac{H}{g}}$ b) $\sqrt{\frac{2H}{g}}$ c) $\sqrt{\frac{H}{2g}}$ d) $\sqrt{\frac{H}{g\cos\beta}}$

135. An object of mass 10 kg is whirled round a horizontal circle of radius 4 m by a revolving string inclined 30° to the vertical. If the uniform speed of the object is 5 ms^{-1}, the tension in the string (approximately) is
a) 720 N b) 960 N c) 114 N d) 125 N

136. The angle between $\vec{A}$ and $\vec{B}$ is θ, the value of the triple product $\vec{A} \cdot \vec{B} \times \vec{A}$ is

a) A^2B b) Zero c) $A^2B \sin\theta$ d) $A^2B\cos\theta$

137. A body crosses the topmost point of a vertical circle with critical speed. What will be its acceleration when the string is horizontal?

a) g b) 2 g c) 3 g d) 6 g

138. A car of mass 2000 kg is moving with a speed of 10 ms^{-1} on a circular path of radius 20 m on a level road. What must be the frictional force between the car and the road so that the car does not slip?

a) 10^4 N b) 10^3 N c) 10^5 N d) 10^2 N

139. The magnitude of the X and Y components of $\vec{A}$ are 7 and 6. Also the magnitudes of X and Y components of $\vec{A}+\vec{B}$ are 11 and 9 respectively. What is the magnitude of $\vec{B}$?

a) 5 b) 6 c) 8 d) 9

140. 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) $\sqrt{v^2+g^2t^2-(2v\cos\theta)gt}$

141. A car is moving with speed 30 m/sec on a circular path of radius 500 m. Its speed is increasing at the rate of $2m/\sec^2$, What is the acceleration of the car

a) $2m/\sec^2$ b) $2.7m/\sec^2$ c) $1.8m/\sec^2$ d) $9.8m/\sec^2$

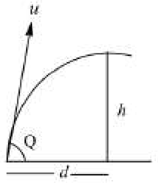
142. The co-ordinates of a moving particle at time t are given by $x = ct^2$ and $y = bt^2$. The instantaneous speed of the particle is

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

143. A simple pendulum oscillates in a vertical plane. When it passes through the mean position, the tension in the string is 3 times the weight of the pendulum bob. What is the maximum displacement of the pendulum with respect to the vertical

a) 30° b) 45° c) 60° d) 90°

144. If a stone s to hit at a point which is at a distance d away and at a height h above the point from where the stone starts, then what is the value of initial sped u, if the stone is launched at an angle Q?



a) $\frac{g}{\cos\theta}\sqrt{\frac{d}{2(d\tan\theta - h)}}$ b) $\frac{d}{\cos\theta}\sqrt{\frac{g}{2(d\tan\theta - h)}}$ c) $\sqrt{\frac{gd^2}{h\cos^2\theta}}$ d) $\sqrt{\frac{gd^2}{(d-h)}}$

145. A car is circulating on the path of radius r and at any time its velocity is v and rate of increases of velocity is a. The resultant acceleration of the car will be

a) $\sqrt{\frac{v^2}{a^2}+r^2}$ b) $\sqrt{\frac{v^2}{r}+a}$ c) $\sqrt{\frac{v^4}{r^2}+a^2}$ d) $\left(\frac{v^2}{r}+a\right)$

146. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time as $a_c = k^2rt^4$, where k is a constant. The power delivered to the particle by the forces acting on its is

a) Zero b) $mk^2r^2t^2$ c) $\frac{1}{3}mk^2r^2t^2$ d) $2mk^2r^2t^3$

147. A particle is moving in a vertical circle. The tensions in the string when passing through two positions at angles 30° and 60° from vertical (lowest position) are T_1 and T_2 respectively. then

a) $T_1 = T_2$ b) $T_2 > T_1$

c) $T_1 > T_2$ d) Tension in the string always remains the same

148. A car is moving on a circular level road of radius of curvature 300 m. If the coefficient of friction is 0.3 and acceleration due to gravity 10 ms^{-2}, the maximum speed the car can have is (in km h^{-1})

a) 30 b) 81 c) 108 d) 162

149. A body is projected at an angle θ to the horizontal with kinetic energy E_k. The potential energy at the highest point of the trajectory is

a) E_k b) $E_k \cos^2\theta$ c) $E_k \sin^2\theta$ d) $E_k \tan^2\theta$

150. There are two forces each of magnitude 10 units. One inclined at an angle of 30° and the other at an angle of 135° to the positive direction of x −axis. The x and y components of the resultant are respectively.

a) $1.59\hat{\imath}$ and $12.07\hat{\jmath}$ b) $10\hat{\imath}$ and $10\hat{\jmath}$ c) $1.59\hat{\imath}$ d) $15.9\hat{\imath}$ and $12.07\hat{\jmath}$

151. An aircraft executes a horizontal loop with a speed of 150 m/s with its wings banked at an angle of 12°. The radius of the loop is ($g = 10\ m/s^2$, $\tan 12° = 0.2126$)

a) 10.6 km b) 9.6 km c) 7.4 km d) 5.8 km

152. If $\vec{A} + \vec{B} = \vec{C}$ and $A = \sqrt{3}, B = \sqrt{3}$ and $C = 3$, then the angle between $\vec{A}$ *and* $\vec{B}$ is

a) 0° b) 30° c) 60° d) 90°

153. The velocity of projection of an oblique projectile is $\vec{v} = 3\hat{\imath} + 2\hat{\jmath}$ (in ms^{-1}). The speed of the projectile at the highest point of the trajectory is

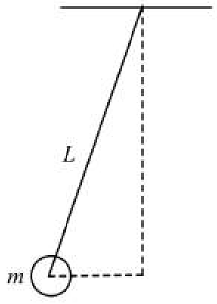
a) 3 ms^{-1} b) 2 ms^{-1} c) 1 ms^{-1} d) Zero

154. If $\vec{A} \cdot \vec{B} = 0$ and $\vec{A} \times \vec{B} = 1$, then $\vec{A}$ and $\vec{B}$ are

a) Perpendicular unit vectors b) Parallel unit vectors

c) Parallel d) Perpendicular.

155. A ball of mass(m)0.5 kg is attached to the end of a string having length (L) 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324 N. The maximum possible value of angular velocity of ball (in rad/s) is



a) 9 b) 18 c) 27 d) 36

156. The maximum speed with which a car is driven round a curve of radius 18 m without skidding (where, g = 10ms^{-2} and the coefficient of friction between rubber tyres and the roadway is 0.2) is

a) 36.0 km h^{-1} b) 18.0 km h^{-1} c) 21.6 km h^{-1} d) 14.4 km h^{-1}

157. The minimum speed for a particle at the lowest point of a vertical circle of radius r, to describe the circle is v. If the radius of the circle is reduced to one-fourth its value, the corresponding minimum speed will be

a) $v/4$ b) $v/2$ c) $2v$ d) $4v$

158. The angle of projection of a projectile for which the horizontal range and maximum height are equal is

a) $\tan^{-1}(2)$ b) $\tan^{-1}(4)$ c) $\cot^{-1}(2)$ d) 60°

159. A string of length l is fixed at one end and caries a mass m at the other end. The string makes $2/\pi$ rps around a vertical axis through the fixed end. What is the tension in string?

a) $m\,l$ b) 16 $m\,l$ c) 4 $m\,l$ d) 2 $m\,l$

160. At what point of a projectile motion acceleration and velocity and velocity are perpendicular to each other

a) At the point of projection b) At the point of drop

c) At the topmost point d) Any where in between the point of projection and topmost point

161. A motorcycle is going on an overbridge of radius R. The driver maintains a constant speed. As the motorcycle is ascending on the overbridge, the normal force on it

a) Increases b) Decreases c) Remains the same d) Fluctuates

162. If $\vec{A}$ and $\vec{B}$ denote the sides of a parallelogram and its area is $\frac{1}{2}AB$(A and B are the magnitude of $\vec{A}$ and $\vec{B}$ respectively), the angle between $\vec{A}$ and $\vec{B}$ is

a) 30° b) 60° c) 45° d) 120°

163. Given $\vec{r} = 4\hat{j}$ and $\vec{p} = 2\hat{i} + 3\hat{j} + \hat{k}$. The angular momentum is

a) $4\hat{i} - 8\hat{k}$ b) $8\hat{i} - 4\hat{k}$ c) $8\hat{j}$ d) $9\hat{k}$

164. The maximum and minimum tension in the string whirling in a circle of radius 2.5 m with constant velocity are in the ratio 5: 3 the the velocity is

a) $\sqrt{98}\ m/s$ b) 7 m/s c) $\sqrt{490}\ m/s$ d) $\sqrt{4.9}$

165. Two forces $\vec{F_1}$ and $\vec{F_2}$ are acting at right angles to each other. Then their resultant is

a) $F_1 + F_2$ b) $\sqrt{F_1^2 + F_2^2}$ c) $\sqrt{F_1^2 - F_2^2}$ d) $\frac{F_1 + F_2}{2}$

166. If a_r and a_t represent radial and tangential accelerations, the motion of a particle will be uniformly circular if

a) $a_r = 0, a_t = 0$ b) $a_r \neq 0, a_t \neq 0$ c) $a_r \neq 0, a_t = 0$ d) $a_r = 0, a_t \neq 0$

167. In the above question, if the angular velocity is kept same but the radius of the path is halved, the new force will be

a) $2F$ b) F^2 c) $F/2$ d) $F/4$

168. If $\vec{A}, \vec{B}$ and $\vec{C}$ are the unit vectors along the incident ray, reflected ray and outward normal to the reflecting surface, then

a) $\vec{B} = \vec{A} - \vec{C}$ b) $\vec{B} = \vec{A} + (\vec{A} \cdot \vec{C})\vec{C}$ c) $\vec{B} = 2\vec{A} - \vec{C}$ d) $\vec{B} = \vec{A} - 2(\vec{A} \cdot \vec{C})\vec{C}$

169. A stone of mass m is tied to a string of length l and rotated in a circle with a constant speed v. If the string is released, the stone flies

a) Radially outwards b) Radially inwards

c) Tangentially outwards d) With an acceleration mv^2/l

170. A particle is thrown with a speed u at an angle θ with the horizontal. When the particle makes an angle α with the horizontal, its speed becomes v, whose values is

a) $u \cos \theta$ b) $u \cos \theta \cos \alpha$ c) $u \cos \theta \sec \alpha$ d) $u \sec \theta \cos \alpha$

171. A bullet is fired horizontally with a velocity of 80 ms^{-1}. During the first second,

a) It falls 9.8 m b) It falls $\frac{80}{9.8}$ m c) It does not fall at all d) It falls 4.9 m

172. In a circus stuntman rides a motorbike in a circular track of radius R in the vertical plane. The minimum speed at highest point of track will be

a) $\sqrt{2gR}$ b) $2gR$ c) $\sqrt{3gR}$ d) $\sqrt{gR}$

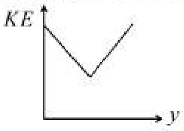
173. A particle is moving in a circular path with a constant speed v. If θ is the angular displacement, then starting from θ = 0°, the maximum and maximum changes in the momentum will occur, when value of θ is respectively

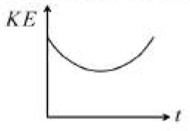
a) 45° and 90° b) 90° and 180° c) 180° and 360° d) 90° and 270°

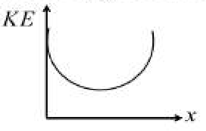
174. An object is projected at an angle of 45° with the horizontal. The horizontal range and the maximum height reached will be in the ratio

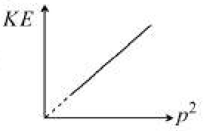
a) 1 : 2 b) 2 : 1 c) 1 : 4 d) 4 : 1

175. A particle is projected up from a point at an angle θ with the horizontal direction. At any time t'. If p is the linear momentum, y is the vertical displacement, x is horizontal displacement, the graph among the following which does not represent the variation of kinetic energy KE of the particle

a) 

b) 

c) 

d) 

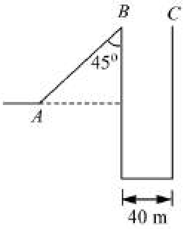
176. A weightless thread can bear tension upto 37 N. A. stone of mass 500 g is tied to it and revolved in a circular path of radius 4 m in a vertical plane. If $g = 10\ ms^{-2}$, then the maximum angular velocity of the stone will be

a) $2\ rad\ s^{-1}$
b) $4\ rad\ s^{-1}$
c) $8\ rad\ s^{-1}$
d) $16\ rad\ s^{-1}$

177. A1 kg stone at the end of 1 m long string is whirled in a vertical circle at constant speed of 4 m/sec. The tension in the string is 6 N, when the stone is at $(g = 10\ m/\sec^2\ )$

a) Top of the circle
b) Bottom of the circle
c) Half way down
d) None of the above

178. A body is projected up a smooth inclined plane with a velocity v_0 from the point A as shown in figure. The angle of inclination is 45° and top B of the plane is connected to a well of diameter 40 m. If the body just manages to cross the well, what is the value of v_0? Length of the inclined plane is $20\sqrt{2}$m, and $g = 10ms^{-2}$



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

179. A body moving along a circular path of radius R with velocity v, has centripetal acceleration$a$. If its velocity is made equal to $2v$, then its centripetal acceleration is

a) $4a$
b) $2a$
c) $\frac{a}{4}$
d) $\frac{a}{2}$

180. In uniform circular motion

a) Both the angular velocity and the angular momentum vary
b) The angular velocity varies but the angular momentum remains constant
c) Both the angular velocity and the angular momentum stay constant
d) The angular momentum varies but the angular velocity remains constant

181. A toy cyclist completes one round of a square track of side 2 m in 40 s. What will be the displacement at the end of 3 min?

a) 52 m
b) Zero
c) 16 m
d) $2\sqrt{2}$ m

182. The X and Y components of vector $\vec{A}$ have numerical values 6 and 6 respectively and that of $(\vec{A} + \vec{B})$ have numerical values 10 and 9. What is the numerical value of $\vec{B}$?

a) 2
b) 3
c) 4
d) 5

183. If $\vec{P} = 2\hat{i} - 3\hat{j} + \hat{k}$ and $\vec{Q} = 3\hat{i} - 2\hat{j}$, then $\vec{P} \cdot \vec{Q}$ is

a) Zero
b) 6
c) 12
d) 15

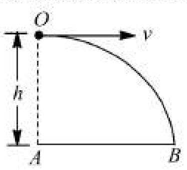
184. If the equation for the displacement of a particle moving on a circular path is given by $(\theta) = 2t^3 + 0.5$, where θ is in radians and t in seconds, then the angular velocity of the particle after 2 sec from its start is

a) 8 rad/sec
b) 12 rad/sec
c) 24 rad/sec
d) 36 rad/sec

185. Four persons K, L, M and N are initially at the corners of a square of side of length d. If every person starts moving, such that K is always headed towards L, L towards M, M is headed directly towards N and N towards K, then the four persons will meet after

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

186. An aeroplane is flying in a horizontal direction with a velocity $600kmh^{-1}$ at a height of 1960 m. when it is vertically above the point A on the ground, a body is dropped from it. The body strikes the ground at point B. Calculate the distance AB.



a) 3.33 km b) 333 km c) 33.3 km d) 3330 km

187. A car round an unbanked curve of radius 92 m without skidding at a speed of 26 ms^{-1}. The smallest possible coefficient of static friction between the tyres and the road is

a) 0.75 b) 0.60 c) 0.45 d) 0.30

188. A projectile is fired at an angle of 30° to the horizontal such that the vertical component of its initial velocity is 80 ms^{-1}. Its time of flight is T. Its velocity at $t = \frac{T}{4}$ has a magnitude of nearly

a) 200 ms^{-1} b) 300 ms^{-1} c) 140 ms^{-1} d) 100 ms^{-1}

189. A bomb is dropped from an aeroplane moving horizontally at constant speed. When air resistance is taken into consideration, the bomb

a) Falls to earth exactly below the aeroplane b) Fall to earth behind the aeroplane

c) Falls to earth ahead of the aeroplane d) Flies with the aeroplane

190. A body is thrown with a velocity of 10 ms^{-1} at an angle of 60° with the horizontal. Its velocity at the highest point is

a) 7 ms^{-1} b) 9 ms^{-1} c) 18.7 ms^{-1} d) 5 ms^{-1}

191. A bend in a level road has a radius of 80 m. Find the maximum speed which a car turning the bend may have without skidding, if $\mu = 0.25$

a) 24 ms^{-1} b) 4 ms^{-1} c) 14 ms^{-1} d) 9.8 ms^{-1}

192. Two vectors $\vec{a}$ and $\vec{b}$ are at an angle of 60° with each other. Their resultant makes an angle of 45° with $\vec{a}$. If $|\vec{b}| = 2$ units, then $|\vec{a}|$ is

a) $\sqrt{3}$ b) $\sqrt{3} - 1$ c) $\sqrt{3} + 1$ d) $\sqrt{3}/2$

193.

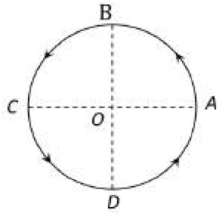


Figure shows a body of mass m moving with a uniform speed v along a circle of radius r. The change in velocity in going from A to B is

a) $v\sqrt{2}$ b) $v/\sqrt{2}$ c) v d) zero

194. A stone of mass 1 kg is tied to a string 4 m long and is rotated at constant speed of 40 ms^{-1} in a vertical circle. The ratio of the tension at the top and the bottom is

a) 11 : 12 b) 39 : 41 c) 41 : 39 d) 12 : 11

195. If the sum of the two unit vectors is also a unit vector, then magnitude of their difference is

a) $\sqrt{2}$ b) $\sqrt{3}$ c) $\sqrt{4}$ d) $\sqrt{7}$

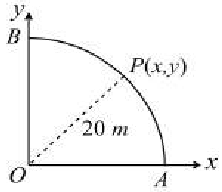
196. Two stones are projected from the same speed but making different angels with the horizontal. Their horizontal ranges are equal. The angle of projection of one is $\pi/3$ and the maximum height reached by it is 102 m. Then maximum height reached by the other in metre is

a) 336 b) 224 c) 56 d) 34

197. A particle of a mass m is projected with velocity v making an angle of 45° with the horizontal. The magnitude of the angular momentum of the particle about the point of projection when the particle is at its maximum height is (where g = acceleration due to gravity)

a) Zero b) $mv^3/(4\sqrt{2}g)$ c) $mv^3/(\sqrt{2}g)$ d) $mv^2/2g$

198. A point P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of "P" is such that it sweeps out a length $s = t^3 + 5$, where s is in metres and t is in seconds. The radius of the path is 20 m. The acceleration of "P" when $t = 2s$ is nearly



a) 14 m/s^2 b) 13 m/s^2 c) 12 m/s^2 d) 7.2 m/s^2

199. A man can thrown a stone 100 m away. The maximum height to which he can throw vertically is
a) 200 m b) 100 m c) 50 m d) 25 m

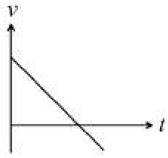
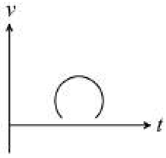
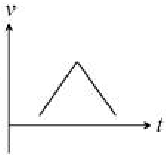
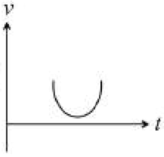
200. In a loop-the-loop, a body starts at a height $h = 2R$. The minimum speed with which the body must be pushed down initially in order that it may be able to complete the vertical circle is
a) $\sqrt{2gR}$ b) $\sqrt{gR}$ c) $\sqrt{3gR}$ d) $2\sqrt{gR}$

201. A wheel making 20 revolution per second is in a horizontal circle with a uniform angular velocity. Let T be the tension in the string. If the length of the string is halved and its angular velocity is doubled, tension in the string will be
a) π rad s^{-2} b) 2 π rad s^{-2} c) 4 π rad s^{-2} d) 8 π rad s^{-2}

202. For a particle in non-uniform accelerated circular motion
a) Velocity is radial and acceleration is transverse only
b) Velocity is transverse and acceleration is radial only
c) Velocity is radial and acceleration has both radial and transverse components
d) Velocity is transverse and acceleration has both radial and transverse components

203. A cricketer can throw a ball to a maximum horizontal distance of 100 m. With the same effort, he throws the ball vertically upwards. The maximum height attained by the ball is
a) 100 m b) 80 m c) 60 m d) 50 m

204. A particle is thrown above, the correct $v - t$ graph will be

a) 
b) 
c) 
d) 

205. A can filled with water is revolved in a vertical of radius 4 m and the water does not fall down. The time period for a revaluation is about
a) 2 s b) 4 s c) 8 s d) 10 s

206. After one second the velocity of a projectile makes an angle of 45° with the horizontal. After another one second it is travelling horizontally. The magnitude of its initial velocity and angle of projection are ($g = 10\ ms^{-2}$)
a) 14.02 ms^{-1}, $\tan^{-1}(2)$ b) 22.36 ms^{-1}, $\tan^{-1}(2)$ c) 14.62 ms^{-1}, 60° d) 22.36 ms^{-1}, 60°

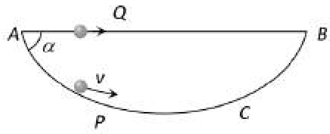
207. A bob of mass 10 kg is attached to wire 0.3 m long. Its breaking stress is $4.8 \times 10^7 N/m^2$. The area of cross section of the wire is $10^{-6}m^2$. The maximum angular velocity with which it can be rotated in a horizontal circle
a) 8 rad/sec b) 4 rad/sec c) 2 rad/sec d) 1 rad/sec

208. When a ceiling fan is switched on, it makes 10 rotations in the first 4 s. How many rotations will it make in the next 4 s? (Assuming uniform angular acceleration)
a) 10 b) 20 c) 40 d) 30

209. 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 speed u. The magnitude of the change in its velocity as it reaches a position where the string is horizontal is
a) $\sqrt{u^2 - 2gL}$ b) $\sqrt{2gL}$ c) $\sqrt{u^2 - gl}$ d) $\sqrt{2(u^2 - gL)}$

210. A particle P is sliding down a frictionless hemispherical bowl. It passes the point A at $t = 0$. At this instant of time, the horizontal component of its velocity v. A bead Q of the same mass as P is ejected from A to $t =$

0 along the horizontal string AB (see figure) with the speed v. Friction between the bead and the string may be neglected. Let t_p and t_Q be the respective time taken by P and Q to reach the point B. Then



a) $t_p < t_Q$ b) $t_p = t_Q$ c) $t_p > t_Q$ d) All of these

211. The equation of trajectory of a projectile is $y = 10x - \left(\frac{5}{9}\right)x^2$. if we assume $g = 10\text{ms}^{-2}$, the range of projectile (in metre) is
a) 36 b) 24 c) 18 d) 9

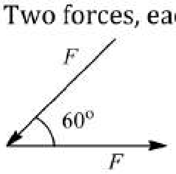
212. A stone tied to the end of a string $1m$ long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolution in 44 seconds, what is the magnitude and direction of acceleration of the stone
a) $\pi^2/4\ ms^{-2}$ and direction along the radius towards the centre
b) $\pi^2 ms^{-2}$ and direction along the radius away from the centre
c) $\pi^2 ms^{-2}$ and direction along the radius towards the centre
d) $\pi^2 ms^{-2}$ and direction along the tangent to the circle

213. A shell is fired from a cannon with a velocity v at angle θ with horizontal. At the highest point, it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon. The speed of the other piece just after explosion is
a) $3\ v\cos\theta$ b) $2\ v\cos\theta$ c) $\frac{3}{2}v\cos\theta$ d) $\frac{\sqrt{3}}{2}v\cos\theta$

214. A car runs at a constant speed on a circular track of radius 100 m, taking 62.8 s for every circular lap. The average velocity and average speed for each circular lap respectively is
a) 0,0 b) 0, 10 ms^{-1} c) 10 ms^{-1}, 10 ms^{-1} d) 10 ms^{-1}, 0

215. An object moves along a straight line path from P to Q under the action of a force $(4\hat{\imath} - 3\hat{\jmath} + 3\hat{k})$N. If the coordinates of P and Q, in metres, are (3,3,−1) and (2,−1,4) respectively, then the work done by the force is
a) +23 J b) −23 J c) 1015 J d) $\sqrt{35}(4\hat{\imath} - 3\hat{\jmath} + 2\hat{k})$ J

216. Two forces, each equal to F, act as shown in figure. Their resultant is



a) $\frac{F}{2}$ b) F c) $\sqrt{3}\ F$ d) $\sqrt{5}\ F$

217. A ball is projected from a certain point on the surface of a planet at a certain angel with the horizontal surface. The horizontal and vertical displacement x and y vary with time t in second as
$x = 10\sqrt{3}t$ and $y = 10t - t^2$
The maximum height attained by the ball is
a) 100 m b) 75 m c) 50 m d) 25 m

218. The wheel of toy car rotates about axis. It slows down from 400 rps to 200 rps in 2s. Then its angular retardation in rads^{-2} is
a) 200 π b) 100 c) 400 π d) None of these

219. If a_r and a_t represent radial and tangential accelerations, the motion of a particle will be uniformly circular if
a) $a_r = 0$ and $a_t = 0$ b) $a_r = 0$ but $a_t \neq 0$ c) $a_r \neq 0$ but $a_t = 0$ d) $a_r \neq 0$ and $a_t \neq 0$

220. Two bodies are projected from ground with equal speeds 20 m/sec from the same position in same vertical plane to have equal range but at different angle above the horizontal. If one of the angle is 30° the sum of their maximum heights is (assume $g = 10m/s^2$)

a) 400 m b) 20 m c) 30 m d) 40 m

221. The horizontal range and the maximum height of a projectile are equal. The angle of projection of the projectile is

a) $\theta = \tan^{-1}\left(\frac{1}{4}\right)$ b) $\theta = \tan^{-1}(4)$ c) $\theta = \tan^{-1}(2)$ d) $\theta = 45°$

222. A cane filled with water is revolved in a vertical circle of radius 4 m and the water just does not fall down. The time period of revolution will be

a) 1 sec b) 10 sec c) 8 sec d) 4 sec

223. A body constrained to move in Y direction, is subjected to a force given by $\vec{F} = (-2\hat{i} + 15\hat{j} + 6\hat{k})$N done by this force in moving the body through a distance of 10m along Y axis?

a) 190 J b) 160 J c) 150 J d) 20 J

224. A particle starts from the origin of coordinates at time $t = 0$ and moves in the $x - y$ plane with a constant acceleration α in the y-diretion. Its equation of motion is $y = \beta x^2$. Its velocity component in the x-direction is

a) Variable b) $\sqrt{\frac{2\alpha}{\beta}}$ c) $\frac{\alpha}{2\beta}$ d) $\sqrt{\frac{\alpha}{2\beta}}$

225. An aircraft is flying at a height of 3400 m above the ground. If the angle subtended at a ground observation point by the aircraft position 10 s apart is 30°, then the speed of the aircraft is

a) 19.63 ms^{-1} b) 1963 ms^{-1} c) 108 ms^{-1} d) 196.3 ms^{-1}

226. Find the maximum velocity for skidding for a car moved on a circular track of radius 100 m. The coefficient of friction between the road and tyre is 0.2

a) 0.14 m/s b) 140 m/s c) 1.4 km/s d) 14 m/s

227. A particle moves along the parabolic path $y = ax^2$ in such a way that the x-component of the velocity remains constant, say c. The acceleration of the particle is

a) $ac\hat{\mathbf{k}}$ b) $2ac^2\hat{\mathbf{j}}$ c) $ac^2\hat{\mathbf{k}}$ d) $a^2c\hat{\mathbf{j}}$

228. A tennis ball rolls off the top of a stair case way with a horizontal velocity u ms^{-1}. If the steps are b metre wide and h metre high, the ball will hit the edge of the nth step, if

a) $n = \frac{2hu}{gb^2}$ b) $n = \frac{2hu^2}{gb^2}$ c) $n = \frac{2hu^2}{gb}$ d) $n = \frac{hu^2}{gb^2}$

229. The minimum velocity at the lowest point, so that the string just slack at the highest point in a vertical circle of radius l

a) $\sqrt{gl}$ b) $\sqrt{3gl}$ c) $\sqrt{5gl}$ d) $\sqrt{7gl}$

230. A particle is moving in a circle of radius R with constant speed v, if radius is double then its centripetal force to keep the same speed should be

a) Doubled b) Halved c) Quadrupled d) Unchanged

231. Radius of the curved road on national highway is R. Width of the road is b. The outer edge of the road is raised by h with respect to inner edge so that a car with velocity v can pass safe over it. The value of h is

a) $\frac{v^2b}{Rg}$ b) $\frac{v}{Rgb}$ c) $\frac{v^2R}{g}$ d) $\frac{v^2b}{R}$

232. In case of uniform circular motion which of the following physical quantity do not remain constant

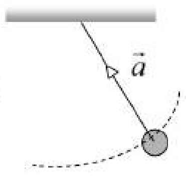
a) Speed b) Momentum c) Kinetic energy d) Mass

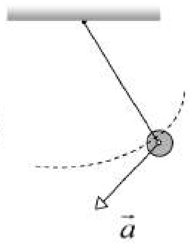
233. A projectile shot into air at some angle with the horizontal has a range of 200 m. If the time of flight is 5 s, then the horizontal component of the velocity of the projectile at the highest point of trajectory is

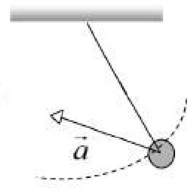
a) 40 ms^{-1} b) 0 ms^{-1}

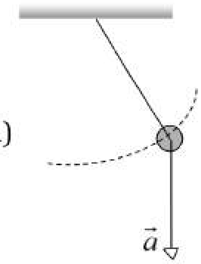
c) 9.8 ms^{-1} d) Equal to the velocity of projection of the projectile

234. A simple pendulum is oscillating without damping. When the displacement of the bob is less than maximum, its acceleration vector $\vec{a}$ is correctly shown in

a) 

b) 

c) 

d) 

235. An artillery piece which consistently shoots its shells with the same muzzle speed has a maximum range R. To hit a target which is $\frac{R}{2}$ from the gun and on the same level, the elevation angle of the gun should be

a) 15° b) 45° c) 30° d) 60°

236. The string of a pendulum of length l is displaced through 90° from the vertical and released. Then the minimum strength of the string in order to withstand the tension as the pendulum passes through the mean position is

a) mg b) 6 mg c) 3 mg d) 5 mg

237. A particle is moving with velocity $\vec{v} = K(y\hat{\imath} + x\hat{\jmath})$, where K is a constant. The general equation for its path is

a) $y^2 = x^2 +$ constant b) $y = x^2 +$ constant c) $y^2 = x +$ constant d) $xy =$ constant

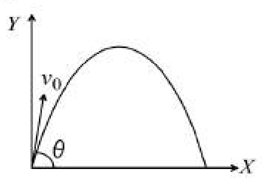
238. A man is supported on a frictionless horizontal surface. It is attached to a string and rotates about a fixed centre at an angular velocity ω. The tension in the string if F. If the length of string and angular velocity are doubled, the tension is string is now

a) F b) $F/2$ c) 4 F d) 8 F

239. A particle is projected from horizontal making an angle 60° with initial velocity 40ms^{-1}. The time taken by the particle to make angel 45° from horizontal, is

a) 15 s b) 2.0 s c) 20 s d) 1.5 s

240. A small particle of mass m is projected at an angle θ with the x-axis with an initial velocity v_0 in the x-y plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is



Where $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$ are unit vectors along x, y and z-axis respectively.

a) $\frac{1}{2}mgv_0t^2\cos\theta\,\hat{\imath}$ b) $-mgv_0t^2\cos\theta\,\hat{\jmath}$ c) $mgv_0t\cos\quad\hat{k}$ d) $-\frac{1}{2}mgv_0t^2\cos\theta\,\hat{k}$

241. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km h^{-1}. The centripetal force, is

a) 250 N b) 750 N c) 1000 N d) 1200 N

242. A 500 kg crane takes a turn of radius 50 m with velocity of 36 km/hr. The centripetal force is

a) 1200 N b) 1000 N c) 750 N d) 250 N

243. In the case of an oblique projectile, the velocity is perpendicular to acceleration

a) Once only b) Twice c) Thrice d) Four times

244. What is the angular velocity of earth

a) $\frac{2\pi}{86400}\,rad/sec$ b) $\frac{2\pi}{3600}\,rad/sec$ c) $\frac{2\pi}{24}\,rad/sec$ d) $\frac{2\pi}{6400}\,rad/sec$

245. A stone projected with a velocity u at an angle θ with the horizontal reaches maximum height H_1. When it is projected with velocity u at an angle $\left(\frac{\pi}{2} - \theta\right)$ with the horizontal, it reaches maximum height H_2. The relation between the horizontal range R of the projectile, H_1 and H_2 is

a) $R = 4\sqrt{H_1H_2}$ b) $R = 4(H_1 - H_2)$ c) $R = 4(H_1 + H_2)$ d) $R = \frac{H_1^2}{H_2^2}$

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

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

247. The relation between the time of flight of a projectile T_f and the time to reach the maximum height t_m is

a) $T_f = 2t_m$ b) $T_f = t_m$ c) $T_f = \frac{t_m}{2}$ d) $T_f = \sqrt{2}(t_m)$

248. A long horizontal rod has a bead which can slide along its length, and initially placed at a distance L from one end A of the rod. The rod is set in angular motion about A with constant angular acceleration α. If the coefficient of friction between the rod and the bead is μ, and gravity is neglected, then the time after which the bead starts slipping is

a) $\sqrt{\frac{\mu}{\alpha}}$ b) $\frac{\mu}{\sqrt{\alpha}}$ c) $\frac{1}{\sqrt{\mu\alpha}}$ d) Infinitesimal

249. A body of mass m thrown horizontally with velocity v, from the top of tower of height h touches the level ground at distance of 250 m from the foot of the tower. A body of mass $2m$ thrown horizontally with velocity $\frac{v}{2}$, from the top of tower of height $4h$ will touch the level ground at a distance x from the foot of tower. The value of x is

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

250. If the magnitudes of scalar and vector products of two vectors and are 6 and $6\sqrt{3}$ respectively, then the angle between two vectors is

a) 15° b) 30° c) 60° d) 75°

251. A wheel is subjected to uniform angular acceleration about its axis. Initially its angular velocity is zero. In the first 2 *sec*, it rotates through an angle θ_1. In the next 2 *sec*, it rotates through an additional angle θ_2. The ratio of θ_2 / θ_1 is

a) 1 b) 2 c) 3 d) 5

252. A force of $(10\hat{i} - 3\hat{j} + 6\hat{k})$ N acts on a body of mass 100 g and displaces it from $(6\hat{i} + 5\hat{j} - 3\hat{k})$ m to $(10\hat{i} - 2\hat{j} + 7\hat{k})$ m. The work done is

a) 21 J b) 121 J c) 361 J d) 1000 J

253. A stone is swinging in a horizontal circle 0.8 m in diameter, at 30rev/min. A distant light causes a shadow of the stone to be formed on a nearby wall. What is the amplitude of the motion of the shadow? What is the frequency?

a) 0.4 m, 1.5 Hz b) 0.4 m, 0.5 Hz c) 0.8 m, 0.5 Hz d) 0.2 m, 0.5 Hz

254. A body starts from rest from the origin with an acceleration of 6 m/s^2 along the x-axis and 8 m/s^2 along the y-axis. Its distance from the origin after 4 seconds will be

a) 56 m b) 64 m c) 80 m d) 128 m

255. A car rounds an unbanked curve of radius 92 m without skidding at a speed of 26 ms^{-1}. The smallest possible coefficient of static friction between the tyres and the road is

a) 0.75 b) 0.60 c) 0.45 d) 0.30

256. A particle reaches its highest point when it has covered exactly one half of its horizontal range. The corresponding point on the displacement time graph is characterised by

a) Negative slope and zero curvature
b) Zero slope and negative curvature
c) Zero slope and positive curvature
d) positive slope and zero curvature

257. Given $\vec{P} = 3\hat{j} + 4\hat{k}$ and $\vec{Q} = 2\hat{i} + 5\hat{k}$. The magnitude of the scalar product of these vectors is

a) 20 b) 23 c) 26 d) $5\sqrt{33}$

258. A ball is moving to and fro about the lowest point A of a smooth hemispherical bowl. If it is able to rise up to a height of 20 cm on either side of A, its speed at A must be ($Take\ g = 10\ m/s^2$, massof the body 5 g)

a) 0.2 m/s b) 2 m/s c) 4 m/s d) 4.5 ms^{-1}

259. The radio of angular speeds of minute hand and hour hand of a watch is

a) 1 : 12 b) 12 : 1 c) 6 : 1 d) 1 : 6

260. Two projectiles A and B thrown with speed in the ratio $1:\sqrt{2}$ acquired the same heights. If A is thrown at an angle of $45°$ with the horizontal, the angle of projection of B will be

a) $0°$ b) $60°$ c) $30°$ d) $45°$

261. A particle of mass m is projected with a velocity v making an angle of $45°$ with the horizontal. The magnitude of the angular momentum of the particle about the point of projection when the particle is at its maximum height, is

a) $m\sqrt{2gh^3}$ b) $\frac{mv^3}{\sqrt{2}g}$ c) $\frac{mv^3}{4\sqrt{2}g}$ d) Zero

262. A ball is projected with kinetic energy E at an angle of $45°$ to the horizontal. At the highest point during its flight, its kinetic energy will be

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

263. A ball is projected from the ground at a speed of $10 ms^{-1}$ making an angle of $30°$ 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 first ball. The initial height of the second ball is $(g = 10 ms^{-2})$

a) $6.25m$ b) $2.5m$ c) $3.75m$ d) $5m$

264. One end of a string of length l is connected to a particle of mass m and the other to a small peg on a smooth horizontal table. If the particle moves in a circle with speed v, the net force on the particle (directed towards the centre) is

a) T b) $T - \frac{mv^2}{l}$ c) $T + \frac{mv^2}{l}$ d) Zero

265. The trajectory of a projectile in vertical plane in $y = ax - bx^2$, where a and b are constant and x and y are respectively horizontal and vertical distances of the projectile from the point of projection. The maximum height attained by the particle and the angle of projection from the horizontal are

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

266. A force $\vec{F} = -K(y\hat{i} + x\hat{j})$ (where K is a positive constant) acts on a particle moving in the $x - y$ plane. Starting from the origin, the particle is taken along the positive x-axis to the point $(a, 0)$ and then parallel to the y-axis to the (a, a). The total work done by the force $\vec{F}$ on the particle is

a) $-2Ka^2$ b) $2Ka^2$ c) $-Ka^2$ d) Ka^2

267. 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) $2.745\ s$

268. The angle between the z-axis and the vector $\hat{i} + \hat{j} + \sqrt{2}\hat{k}$ is

a) $30°$ b) $45°$ c) $60°$ d) $90°$

269. If the length of the second's hand in a stop clock is $3\ cm$ the angular velocity and linear velocity of the tip is

a) $0.2047\ rad/sec., 0.0314\ m/sec$ b) $0.2547\ rad/sec., 0.314\ m/sec$

c) $0.1472\ rad/sec., 0.06314\ m/sec$ d) $0.1047\ rad/sec., 0.00314\ m/sec$

270. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as, $a_c = k^2rt^2$, The power delivered to the particle by the forces acting on it is

a) $2\pi mk^2r^2t$ b) mk^2r^2t c) $\frac{mk^4r^2t^5}{3}$ d) Zero

271. A missile is fired for maximum range with an initial velocity of $20\ m/s$. If $g = 10\ m/s^2$, the range of the missile is

a) $20\ m$ b) $40\ m$ c) $50\ m$ d) $60\ m$

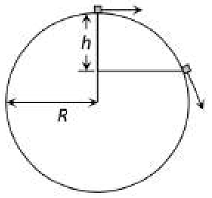
272. A body of mass m tied to a string is moved in a vertical circle of radius r. The difference in tensions at the lowest point and the highest point is

a) $2\ mg$ b) $6\ mg$ c) $4\ mg$ d) $8\ mg$

273. A car runs at a constant speed on a circular track of radius 100 m, taking 62.8 *seconds* for every circular loop. The average velocity and average speed for each circular loop respectively is

a) $10 m/s, 10 m/s$ b) $10\ m/s, 0$ c) 0, 0 d) $0, 10\ m/s$

274. A particle originally at rest at the highest point of a smooth vertical circle is slightly displaced. It will leave the circle at a vertical distance h below the highest point such that



a) $h = R$ b) $h = \frac{R}{3}$ c) $h = \frac{R}{2}$ d) $h = \frac{2R}{3}$

275. A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. The magnitude of angular momentum of projectile about the point of projection when the particle is at its maximum height h is

a) Zero b) $\frac{mvh}{\sqrt{2}}$ c) $\frac{mvh^2}{\sqrt{2}}$ d) None of these

276. A projectile is projected with velocity kv_e in vertically upward direction from the ground into the space (v_e is the escape velocity and$k < 1$). If air resistance is considered to be negligible then the maximum height from the center of earth to which it can go will be (R = radus of earth)

a) $\frac{R}{k^2+1}$ b) $\frac{R}{k^2-1}$ c) $\frac{R}{1-k^2}$ d) $\frac{R}{k+1}$

277. The tension in the string revolving in a vertical circle with a mass m at the end which is the lowest position

a) $\frac{mv^2}{r}$ b) $\frac{mv^2}{r} - mg$ c) $\frac{mv^2}{r} + mg$ d) mg

278. A particle is projected with a velocity v such that its range on the horizontal plane is twice the greatest height attained by it. The range of the projectile is (where g is acceleration due to gravity)

a) $\frac{4v^2}{5g}$ b) $\frac{4g}{5v^2}$ c) $\frac{v^2}{g}$ d) $\frac{4v^2}{\sqrt{5}g}$

279. The time period of the second's hand of a watch is

a) 1 h b) 1 s c) 12 h d) 1 min

280. If the resultant of two forces $(A + B)$ and $(A - B)$ is $\sqrt{A^2 + B^2}$, then the angle between these forces is

a) $\cos^{-1}\left[-\frac{(A^2 - B^2)}{A^2 + B^2}\right]$ b) $\cos^{-1}\left[-\frac{(A^2 + B^2)}{(A^2 - B^2)}\right]$

c) $\cos^{-1}\left[-\frac{A^2 + B^2}{2(A^2 - B^2)}\right]$ d) $\cos^{-1}\left[-\frac{2(A^2 + B^2)}{A^2 - B^2}\right]$

281. A pendulum bob on a 2 m string is displaced 60° from the vertical and then released. What is the speed of the bob as it passes through the lowest point in its path

a) $\sqrt{2}\ m/s$ b) $\sqrt{9.8}\ m/s$ c) $4.43\ m/s$ d) $1/\sqrt{2}\ m/s$

282. The angular velocity of a particle rotating in a circular orbit 100 times per minute is

a) 1.66 rad s^{-1} b) 10.47 rad s^{-1} c) 10.47 deg s^{-1} d) 60 rad s^{-1}

283. An object is moving in a circle of radius 100 m with a constant speed of 31.4 m/s. What is its average speed for one complete revolution

a) Zero b) $31.4\ m/s$ c) $3.14\ m/s$ d) $\sqrt{2} \times 31.4\ m/s$

284. A stone is thrown at an angle θ to the horizontal reaches a maximum height H. Then the time of flight of stone will be

a) $\sqrt{\frac{2H}{g}}$ b) $2\sqrt{\frac{2H}{g}}$ c) $\frac{2\sqrt{2H \sin\theta}}{g}$ d) $\frac{\sqrt{2H \sin\theta}}{g}$

285. A particle (A) is dropped from a height and another particle (B) is thrown in horizontal direction with speed of 5 m/sec from the same height. The correct statement is
a) Both particles will reach at ground simultaneously
b) Both particles will reach at ground with same speed
c) Particle (A) will reach at ground first with respect to particle (B)
d) Particle (B) will reach at ground first with respect to particle (A)

286. A car moving with the speed of 10 m/s takes a circular turn of radius 20 m. The magnitude of the acceleration of the car is
a) 5.0 ms $^{-2}$ b) 50.0 ms $^{-2}$ c) 0.25 ms $^{-2}$ d) 0.5 ms $^{-2}$

287. Ratio between maximum range and square of time of flight in projectile motion is
a) 10 : 49 b) 49 : 10 c) 98 : 10 d) 10 : 98

288. A ball is projected upwards from the top of tower with a velocity 50 ms^{-1} making an angle 30° with the horizontal. The height of tower is 70m. After how many seconds from the instant of throwing will the ball reach the ground?
a) 2 s b) 5 s c) 7 s d) 9 s

289. The horizontal range of an oblique projectile is equal to the distance through which a projectile has to fall freely from rest to acquire a velocity equal to the velocity of projection in magnitude. The angle of projection is
a) 75° b) 60° c) 45° d) 30°

290. Which one of the following statements is not correct in uniform circular motion
a) The speed of the particle remains constant
b) The acceleration always points towards the centre
c) The angular speed remains constant
d) The velocity remains constant

291. A cyclist moves in such a way that he track 60° turn after 100 m. What is the displacement when to takes seventh turn?
a) 100 m b) 200 m c) $100\sqrt{3}$ m d) $100\sqrt{3}$ m

292. When a body moves with a constant speed along a circle
a) No work is done on it
b) No acceleration is produced in the body
c) No force acts on the body
d) Its velocity remains constant

293. A particle of mass m moves with constant speed along a circular path of radius r under the action of force F. Its speed is
a) $\sqrt{Fr/m}$ b) $\sqrt{F/r}$ c) $\sqrt{F\,m\,r}$ d) $\sqrt{F/mr}$

294. A body of mass 0.5 kg is projected under gravity with a speed of 98 m/s at an angle of 30° with the horizontal. The change in momentum (in magnitude) of the body is
a) 24.5 $N-s$ b) 49.0 $N-s$ c) 98.0 $N-s$ d) 50.0 $N-s$

295. A block of mass m at the end of a string is whirled round in a vertical circle of radius R. The critical speed of the block at the top of its swing below which the string would slacken before the block reaches the top is
a) Rg b) $(Rg)^2$ c) R/g d) $\sqrt{Rg}$

296. A body of mass 1 kg is rotating in a vertical circle of radius 1m. What will be the difference in its kinetic energy at the top and bottom of the circle? (Take g = 10 ms^{-2})
a) 10 J b) 20 J c) 30 J d) 50 J

297. Which of the following statements is false for a particle moving in a circle with a constant angular speed
a) The velocity vector is tangent to the circle
b) The acceleration vector is tangent to the circle
c) The acceleration vector points to the centre of the circle
d) The velocity and acceleration vectors are perpendicular to each other

298. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10ms^{-1} at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground? [$g = 10ms^{-2}, \sin 30° = 1/2, \cos 60° = \sqrt{3}/2$]
a) 5.20 m b) 4.33 m c) 2.60 m d) 8.66 m

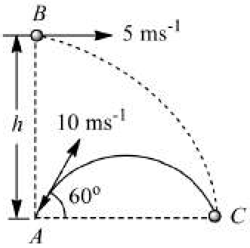
299. A particle is projected with a speed v at 45° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height h is

a) Zero b) $\frac{mvh^2}{\sqrt{2}}$ c) $\frac{mvh}{\sqrt{2}}$ d) $\frac{mvh^3}{\sqrt{2}}$

300. A motor cyclist moving with a velocity of 72 $km/hour$ on a flat road takes a turn on the road at a point where the radius of curvature of the road is 20 m. The acceleration due to gravity is 10 $m/\sec^2$. In order to avoid skidding, he must not bend with respect to the vertical plane by an angle greater than

a) $\theta = \tan^{-1} 6$ b) $\theta = \tan^{-1} 2$ c) $\theta = \tan^{-1} 25.92$ d) $\theta = \tan^{-1} 4$

301. A particle A is projected from the ground with an initial velocity of 10 ms^{-1} at an angle of 60° with horizontal. From what height h should an another particle B be projected horizontally with velocity 5ms^{-1} so that both the particles collide in ground at point C if both are projected simultaneously? ($g = 10 \ ms^{-2}$)



a) 10 m b) 30 m c) 15 m d) 25 m

302. A cannon on a level plane is aimed at an angle θ above the horizontal and a shell is fired with a muzzle velocity v_0 towards a vertical cliff a distance D away. Then the height from the bottom at which the shell strikes the side walls of the cliff is

a) $D\sin\theta - \frac{gD^2}{2v_0^2\sin^2\theta}$ b) $D\cos\theta - \frac{gD^2}{2v_0^2\cos^2\theta}$ c) $D\tan\theta - \frac{gD^2}{2v_0^2\cos^2\theta}$ d) $D\tan\theta - \frac{gD^2}{2v_0^2\sin^2\theta}$

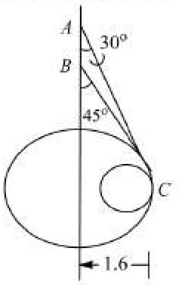
303. Two stones are projected with the same velocity in magnitude but making different angles with the horizontal. Their ranges are equal. If the angel of projection of one is $\pi/3$ and its maximum height is y_1, the maximum height of the other will be

a) $3y_1$ b) $2y_1$ c) $\frac{y_1}{2}$ d) $\frac{y_1}{3}$

304. Two stones thrown at different angles have same initial velocity and same range. If H is the maximum height attained by one stone thrown at an angle of 30°, then the maximum height attained by the other stone is

a) $\frac{H}{2}$ b) H c) $2H$ d) $3H$

305. Two wires AC and BC are tied at C of small sphere of mass 5 kg, which revolves at a constant speed v in the horizontal circle of radius 1.6 m. The minimum value of v is



a) 3.01 ms^{-1} b) 4.01 ms^{-1} c) 8.2 ms^{-1} d) 3.96 ms^{-1}

306. If the resultant of the vectors $(\hat{\imath} + 2\hat{\jmath} - \hat{k})$, $(\hat{\imath} - \hat{\jmath} + 2\hat{k})$ and $\vec{C}$ is a unit vector along the y-direction, then $\vec{C}$ is

a) $-2\hat{\imath} - \hat{k}$ b) $-2\hat{\imath} + \hat{k}$ c) $2\hat{\imath} - \hat{k}$ d) $2\hat{\imath} + \hat{k}$

307. Which of the following statements is false for a particle moving in a circle with a constant angular speed?

a) The velocity vector is tangent to the circle

b) The acceleration vector is tangent to the circle

c) The acceleration vector point to the center of the circle
d) The velocity and acceleration vectors are perpendicular to each other

308. The horizontal range of a projectile $4\sqrt{3}$ times the maximum height achieved by it, then the angle of projection is
a) 30° b) 45° c) 60° d) 90°

309. An object is moving in a circle of radius 100 m with a constant speed of 31.4 ms^{-1}. What is its average speed for one complete revolution?
a) Zero b) 31.4 ms^{-1} c) 3.14 ms^{-1} d) $\sqrt{2} \times 31.4\ ms^{-1}$

310. A particle of mass m moves with constant speed along a circular path of radius r under the action of a force F. Its speed is
a) $\sqrt{\frac{rF}{m}}$ b) $\sqrt{\frac{F}{r}}$ c) $\sqrt{Fmr}$ d) $\sqrt{\frac{F}{mr}}$

311. A projectile is thrown in the upward direction making an angle of 60° with the horizontal direction with a velocity of147ms^{-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

312. The position of a particle moving in the xy- plane at any time t is given by $x = (3t^2 - 6t)\ metres, y = (t^2 - 2t)\ metres$. Select the correct statement about the moving particle from the following
a) The acceleration of the particle is zero at $t = 0$ second
b) The velocity of the particle is zero at $t = 0$ second
c) The velocity of the particle is zero at $t = 1$ second
d) The velocity and acceleration of the particle are never zero

313. A circular road of radius 1000 m has banking angle 45°. The maximum safe speed of a car having mass 2000 kg will be, if the coefficient of friction between tyre and road is 0.5
a) 172 m/s b) 124 m/s c) 99 m/s d) 86 m/s

314. A particle of mass m is moving in a horizontal circle of radius r, under a centripetal force $= \frac{k}{r^2}$, where k is a constant.
a) The potential energy of the particle is zero
b) The potential energy of the particle is $\frac{k}{r}$
c) The total energy of the particle is $-\frac{k}{2r}$
d) The Kinetic energy of the particle is $-\frac{k}{r}$

315. A ball is thrown up at an angle with the horizontal. Then the total change of momentum by the instant it returns to ground is
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) Weight of the ball × horizontal range

316. 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) $\frac{M+m}{m}l$

317. The length of second's hand in a watch is 1 cm. The change in velocity of its tip in 15 seconds is
a) Zero b) $\frac{\pi}{30\sqrt{2}}\ cm/sec$ c) $\frac{\pi}{30}\ cm/sec$ d) $\frac{\pi\sqrt{2}}{30}\ cm/sec$

318. A mass of 2 kg is whirle'd in a horizontal circle by means of a string at an initial speed of 5 revolutions per minute. Keeping the radius constant, the tension in the string is double. The new speed is nearly

a) 2.25 rpm b) 7 rpm c) 10 rpm d) 14 rpm

319. Consider a vector $\vec{F} = 4\hat{i} - 3\hat{j}$. Another vector that is perpendicular to $\vec{F}$ is

a) $4\hat{i} + 3\hat{j}$ b) $6\hat{i}$ c) $7\hat{j}$ d) $3\hat{i} - 4\hat{j}$

320. What should be the coefficient of friction between the tyres and the road, when a car travelling at 60 km h^{-1} makes a level turn of radius 40 m?

a) 0.5 b) 0.66 c) 0.71 d) 0.80

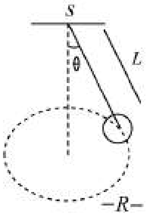
321. In above question, if the centripetal force F is kept constant but the angular velocity is doubled, the new radius of the path (original radius R) will be

a) $2R$ b) $R/2$ c) $R/4$ d) $4R$

322. A heavy mass is attached to a thin wire and is whirled in a vertical circle. The wire is most likely to break

a) When the mass is at the highest point of the circle
b) When the mass is the lowest point of the circle
c) When the wire is horizontal
d) At an angle of $\cos^{-1}$ (1/3) from the upward vertical

323. A string of length L is fixed at one end and the string makes $\frac{2}{\pi}$ rev/s around the vertical axis through, the fixed and as shown in the figure, then tension in the string is



a) ML b) $2\,ML$ c) $4\,ML$ d) $16\,ML$

324. A projectile is thrown with velocity v making an angle θ with the horizontal. It just crosses the tops of two poles, each of height h, after 1s and 3s respectively. The time of flight of the projectile is

a) 1 s b) 3 s c) 4 s d) 7.8 s

325. An unbanked curve has a radius of $60m$. The maximum speed at which car can make a turn if the coefficient of static friction is 0.75, is

a) 2.1 m/s b) 14 m/s c) 21 m/s d) 7 m/s

326. A particle is moving along a circular path with a uniform speed. How does its angular velocity change when it completes half of the circular path?

a) No change b) Increases c) Decreases d) Cannot say

327. Roads are banked on curves so that

a) The speeding vehicles may not fall outwards
b) The frictional force between the road and vehicle may be decreased
c) The wear and tear of tyres may be avoided
d) The weight of the vehicle may be decreased

328. A bullet is to be fired with a speed of 2000 ms^{-1} to hit a target 200 m away on a level ground. If $g =$ 10 ms^{-2}, the gun should be aimed

a) Directly at the target
b) 5 cm below the target
c) 5 cm above the target
d) 2 cm above the target

329. A particle is projected up an inclined plane with initial speed $v = 20\text{ms}^{-1}$ at an angle $\theta = 30°$ with plane. The component of its velocity perpendicular to plane when it strikes the plane is

a) $10\sqrt{3}\ \text{ms}^{-1}$
b) $10\ \text{ms}^{-1}$
c) $5\sqrt{3}\ \text{ms}^{-1}$
d) Data is insufficient

330. A stone is projected from the ground with velocity 50 m/s at an angle of 30°. It crosses a wall after 3 sec. How far beyond the wall the stone will strike the ground ($g = 10\ m/\sec^2$)

a) 90.2 m b) 89.6 m c) 86.6 m d) 70.2 m

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

a) force and displacement are perpendicular other
b) the force is always away from the center

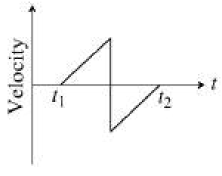
c) there is no displacement
d) there is no net force

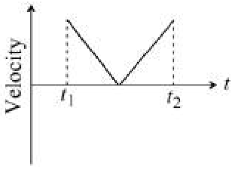
332. The angle of banking is independent of
a) speed of vehicle
b) radius of curvature of road
c) height of inclination
d) None of the above

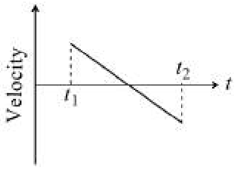
333. A ball of mass 0.1 kg. Is whirled in a horizontal circle of radius 1 m. By means of a string at an initial speed of 10 $R.P.M.$ Keeping the radius constant, the tension in the string is reduced to one quarter of its initial value. The new speed is
a) 5 $r.p.m.$
b) 10 $r.p.m.$
c) 20 $r.p.m.$
d) 14 $r.p.m.$

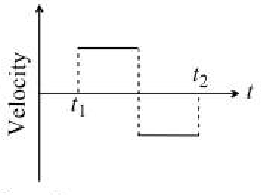
334. A gun is aimed at a target in a line of its barrel. The target is released and allowed to fall under gravity at the same instant the gun is fired. The bullet will
a) Pass above the target
b) Pass below the target
c) Hit the target
d) Certainly miss the target

335. A batsman hits a sixer and the ball touches the ground outside the cricket ground. Which of the following graph describes the variation of the cricket ball's vertical velocity v with time between the time t_1 as it hits the bat and time t_2 when it touches the ground

a) 

b) 

c) 

d) 

336. A body moves with constant angular velocity on a circle. Magnitude of angular acceleration
a) $r\omega^2$
b) Constant
c) Zero
d) None of the above

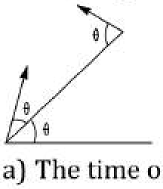
337. For a particle in uniform circular motion the acceleration **a** at a point $P(R, \theta)$ on the circle of the radius R is (here θ is measured from the x –axis)
a) $-\frac{v^2}{R}\cos\theta\,\hat{\mathbf{i}}+\frac{v^2}{R}\sin\theta\,\hat{\mathbf{j}}$
b) $-\frac{v^2}{R}\sin\theta\,\hat{\mathbf{i}}+\frac{v^2}{R}\cos\theta\,\hat{\mathbf{j}}$
c) $-\frac{v^2}{R}\cos\theta\,\hat{\mathbf{i}}-\frac{v^2}{R}\sin\theta\,\hat{\mathbf{j}}$
d) $-\frac{v^2}{R}\,\hat{\mathbf{i}}+\frac{v^2}{R}\,\hat{\mathbf{j}}$

338. A body is projected at an angle θ with respect to horizontal direction with velocity u. The maximum range of the body is
a) $R=\frac{u^2\sin 2\theta}{g}$
b) $R=\frac{u^2\sin^2\theta}{2g}$
c) $R=\frac{u^2}{g}$
d) $R=u^2\sin\theta$

339. A particle is projected with certain velocity at two different angels of projections with respect to horizontal plane so as to have same range R on a horizontal plane. If t_1 and t_2 are the time taken for the two paths, the which one of the following relations is correct?
a) $t_1t_2=\frac{2R}{g}$
b) $t_1t_2=\frac{R}{g}$
c) $t_1t_2=\frac{R}{2g}$
d) $t_1t_2=\frac{4R}{g}$

340. A particle is moving on a circular path with constant speed, then its acceleration will be
a) Zero
b) External radial acceleration
c) Internal radial acceleration
d) Constant acceleration

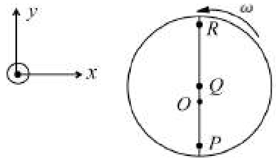
341. From an inclined plane two particles are projected with same speed at same angle θ, one up and other down the plane as shown in figure. Which of the following statements (s) is/are correct?



a) The time of flight of each particle is the same.
b) The particles will collide the plane with same speed
c) Both the particles strike the plane perpendicularly

d) The particles will collide in mid air if projected simultaneously and time of flight of each particle is less than the time of collision

342. Consider a disc rotating in the horizontal plane with a constant angular speed ω about its centre O. The disc has a shaded region on one side of the diameter and an unshanded region on the other side as shown in the figure. When the disc is in the orientation as shown, two pebbles P and Q are simultaneously projected at an angle towards R. The velocity of projection is in the $y-z$ plane and is same for both pebbles with respect to the disc. Assume that (i) they land back on the disc before the disc has completed $\frac{1}{8}$ rotation. (ii) their range is less than half the disc radius, and (iii) ω remains constant throughout. Then



a) P lands in the shaded region and Q in the unshaded region

b) P lands in the unshaded region and Q in the shaded region

c) Both P and Q land in the unshaded region

d) Both P and Q land in the shaded region

343. An airplane, diving at an angle of 53.0° with the vertical releases a projectile at an altitude of 730 m. The projectile hits the ground 5.00 s after being released. What is the speed of the aircraft?

a) 282 ms^{-1} b) 202 ms^{-1} c) 182 ms^{-1} d) 102 ms^{-1}

344. In a projectile motion, velocity at maximum height is

a) $\frac{u\cos\theta}{2}$ b) $u\cos\theta$ c) $\frac{u\sin\theta}{2}$ d) None of these

345. A small cone filled with water is revolved in a vertical circle of radius 4 m and the water does not fall down. What must be the maximum period of revolution?

a) 4 s b) 2 s c) 1 s d) 6 s

346. If $0.5\hat{i} + 0.8\hat{j} + c\hat{k}$ is a unit vector, then the value of c is

a) $\sqrt{0.11}$ b) $\sqrt{0.22}$ c) $\sqrt{0.33}$ d) $\sqrt{0.89}$

347. If a cyclist moving with a speed of 4.9 m/s on a level road can take a sharp circular turn of radius 4 m, then coefficient of friction between the cycle tyres and road is

a) 0.41 b) 0.51 c) 0.61 d) 0.71

348. Given that $\vec{A} + \vec{B} + \vec{C} = 0$. Out of three vectors, two are equal in magnitude and the magnitude of third vector is $\sqrt{2}$ times that of either of the two having equal magnitude. Then the angles between vectors are given by

a) 45°, 45°, 90° b) 90°, 135°, 135° c) 30°, 60°, 90° d) 45°, 60°, 90°

349. A mass of 2 kg is whirled in a horizontal circle by means of a string at an initial speed of 5 *revolutions per minute*. Keeping the radius constant the tension in the string is doubled. The new speed is nearly

a) 14 rpm b) 10 rpm c) 2.25 rpm d) 7 rpm

350. For a given velocity, a projectile has the same range R for two angles of projection if t_1 and t_2 are the times of flight in the two cases then

a) $t_1t_2 \propto R^2$ b) $t_1t_2 \propto R$ c) $t_1t_2 \propto \frac{1}{R}$ d) $t_1t_2 \propto \frac{1}{R^2}$

351. 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) $\frac{p^2}{rm}$

352. 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 change in its velocity as it reaches a position, where the string is horizontal is

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

353. What is the angular velocity of earth?

a) $\frac{2\pi}{86400}$ rad s^{-1} b) $\frac{2\pi}{3600}$ rad s^{-1} c) $\frac{2\pi}{24}$ rad s^{-1}l d) $\frac{2\pi}{6400}$ rad s^{-1}

354. A body of mass m hangs at one end of a string of length l, the other end of which is fixed. It is given a horizontal velocity so that the string would just reach where it makes an angle of 60° with the vertical. The tension in the string at mean position is

a) $2\,mg$ b) mg c) $3mg$ d) $\sqrt{3}mg$

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

a) There is no displacement

b) There is no net force

c) Force and displacement are perpendicular to each other

d) The force is always away from the centre

356. Two bodies are projected from the same point with equal speeds in such directions that they both strike the same point on a plane whose inclination isβ. If $\propto$ be the angle of projection of the first body with the horizontal the ratio of their times of flight is

a) $\frac{\cos\propto}{\sin(\propto+\beta)}$ b) $\frac{\sin(\propto+\beta)}{\cos\propto}$ c) $\frac{\cos\propto}{\sin(\propto-\beta)}$ d) $\frac{\sin(\propto-\beta)}{\cos\propto}$

357. Given $\vec{A} = \hat{\imath} + 2\hat{\jmath} - 3\hat{k}$. When a vector $\vec{B}$ is added to $\vec{A}$, We get a unit vector along X=axis. Then, $\vec{B}$ is

a) $-2\hat{\jmath} + 3\hat{k}$ b) $-\hat{\imath} - 2\hat{\jmath}$ c) $-\hat{\imath} + 3\hat{k}$ d) $2\hat{\jmath} - 3\hat{k}$

358. What is the angle between $(\hat{\imath} + 2\hat{\jmath} + 2\hat{k})$ and $\hat{\imath}$

a) 0° b) $\pi/6$ c) $\pi/3$ d) None of these

359. A bucket tied at the end a 1.6 m long string is whirled in a vertical circle with constant speed. What should be the minimum speed so that the water from the bucket does not spill, when the bucket is at the highest position (Take $g = 10m/\sec^2$)

a) 4 m/sec b) 6.25 m/sec c) 16 m/sec d) None of the above

360. If α is angular acceleration, ω is angular velocity and a is the centripetal acceleration then, which of the following is true?

a) $\alpha = \frac{\omega a}{v}$ b) $\alpha = \frac{v}{\omega a}$ c) $\alpha = \frac{va}{\omega}$ d) $\alpha = \frac{a}{\omega v}$

361. A particle leaves the origin with an initial velocity $\vec{\mathbf{v}} = (3.00\hat{\mathbf{\imath}})\text{ms}^{-1}$ and a constant acceleration $\vec{\mathbf{a}} = (-1.00\hat{\mathbf{\imath}} - 0.50\hat{\mathbf{\jmath}})\text{ ms}^{-2}$. When the particle reaches it maximum x-coordinate, what is its y-component a velocity?

a) -2.0 ms^{-1} b) -1.0 ms^{-1} c) -1.5 ms^{-1} d) 1.0 ms^{-1}

362. What vector must be added to the sum of two vectors $2\hat{\imath} - \hat{\jmath} + 3\hat{k}$ and $3\hat{\imath} - 2\hat{\jmath} - 2\hat{k}$ so that the resultant is a unit vector along Z-axis.

a) $5\hat{\imath} + \hat{k}$ b) $-5\hat{\imath} + 3\hat{\jmath}$ c) $3\hat{\jmath} + 5\hat{k}$ d) $-3\hat{\jmath} + 2\hat{k}$

363. A long horizontal rod has a bead, which can slide along its length and initially placed at a distance L from one end A of the rod. The rod is set in angular acceleration α. If the coefficient of friction, between the rod and the bead is μ and gravity is neglected, then the time after which the bead starts slipping is

a) $\sqrt{\mu/\alpha}$ b) $\mu/\sqrt{\alpha}$ c) $1/\sqrt{\mu\alpha}$ d) Infinitesimal

364. A particle moves in a circular orbit under the action of a central attractive force inversely proportional to the distance 'r'. The speed of the particle is

a) Proportional to r^2 b) Independent of r c) Proportional to r d) Proportional to $1/r$

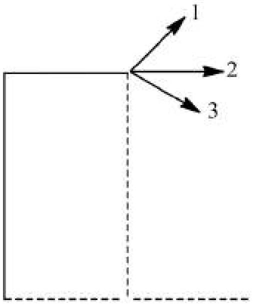
365. A cricket ball is hit at 30° with the horizontal with kinetic energy E_k. What is the kinetic energy at the highest point?

a) $E_k/2$ b) $3E_k/4$ c) $E_k/4$ d) Zero

366. The speed of a projectile at its maximum height is half of its initial speed. The angle of projection is

a) 60° b) 15° c) 30° d) 45°

367. Three balls are dropped from the top of a building with equal speed at different angles. When the balls strike ground their velocities are v_1, v_2 and v_3 respectively, then



a) $v_1 > v_2 > v_3$ b) $v_3 > v_2 > v_1$ c) $v_1 = v_2 = v_3$ d) $v_1 < v_2 < v_3$

368. The angular amplitude of a simple pendulum is θ_0. The maximum tension in its string will be

a) $mg(1-\theta_0)$ b) $mg(1+\theta_0)$ c) $mg(1-\theta_0^2)$ d) $mg(1+\theta_0^2)$

369. The resultant of two forces, each P, acting at an angle θ is

a) $2P\sin\frac{\theta}{2}$ b) $2P\cos\frac{\theta}{2}$ c) $2P\cos\theta$ d) $P\sqrt{2}$

370. A bomber plane moves horizontally with a speed of 500 m/s and a bomb released from it, strikes the ground in 10 sec. Angle at which it strikes the ground will be ($g = 10\ m/s^2$)

a) $\tan^{-1}\left(\frac{1}{5}\right)$ b) $\tan^{-1}\left(\frac{1}{2}\right)$ c) $\tan^{-1}(1)$ d) $\tan^{-1}(5)$

371. A stone of mass 2kg is tied to a string of length 0.5 m. If the breaking tension of the string is 900 N, then the maximum angular velocity, the stone can have in uniform circular motion is

a) 30 rad s^{-1} b) 20 rad s^{-1} c) 10 rad s^{-1} d) 25 rad s^{-1}

372. A particle has velocity $\sqrt{3rg}$ at the highest pint in vertical circle. Find the ratio of tensions at the highest and lowest point

a) 1 : 6 b) 1 : 4 c) 1 : 3 d) 1 : 2

373. If $\vec{A}\cdot\vec{B} = AB$, then the angle between $\vec{A}$ and $\vec{B}$ is

a) 0° b) 45° c) 90° d) 180°

374. A car of mass 800 kg moves on a circular track of radius 40 m. If the coefficient of friction is 0.5, then maximum velocity with which the car can move is

a) 7 m/s b) 14 m/s c) 8 m/s d) 12 m/s

375. Two projectiles A and B thrown with speeds in the ratio $1:\sqrt{2}$ acquired the same heights. If A is thrown at an angle of 45° with the horizontal, the angle of projection of B will be

a) 0° b) 60° c) 30° d) 45°

376. Toy cart tied to the end of an unstretched string of length a, when revolved 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 Hook's law holds then

a) $T' = \sqrt{\frac{3}{2}}T$ b) $T' = \left(\frac{\sqrt{3}}{2}\right)T$ c) $T' = \left(\frac{3}{2}\right)T$ d) $T' = T$

377. If a cycle wheel of radius 4 m completes one revolution in two seconds. Then acceleration of a point on the cycle wheel will be

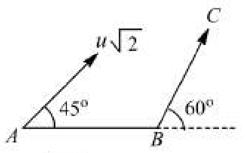
a) $\pi^2 m/s^2$ b) $2\pi^2 m/s^2$ c) $4\pi^2 m/s^2$ d) $8\pi m/s^2$

378. Following forces start acting on a particle at rest at the origin of the co-ordinate system simultaneously

$\vec{F}_1 = 5\hat{i} - 5\hat{j} + 5\hat{k}$, $F_2 = 2\hat{i} + 8\hat{j} + 6\hat{k}$, $F_3 = -6\hat{i} + 4\hat{j} - 7\hat{k}$,
$F_4 = -\hat{i} - 3\hat{j} - 2\hat{k}$. The particle will move

a) in $x-y$ plane b) in $y-z$ plane c) in $x-z$ plane d) along x-axis

379. A particle is projected from a point A with velocity $u\sqrt{2}$ at an angle of 45° with horizontal as shown in figure. It strikes the plane BC at right angles. The velocity of the particle at the time of collision is



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

380. The magnitude of the centripetal force acting on a body of *mass* m executing uniform motion in a circle of radius r with speed v is
a) mvr b) mv^2/r c) v/r^2m d) v/rm

381. A particle moves along a circle of radius $\left[\frac{20}{\pi}\right]$ m with constant tangential acceleration. If the velocity of the particle is 80 m/s at the end of the second revolution after motion has begun, the tangential acceleration is
a) 40 ms^{-2} b) 640 πms^{-2} c) 160 πms^{-2} d) 40 πms^{-2}

382. A bullet is fired from a cannon with velocity 500 m/s . If the angle of projection is 15° and $g = 10\ m/s^2$. Then the range is
a) $25 \times 10^3\ m$ b) $12.5 \times 10^3\ m$ c) $50 \times 10^2\ m$ d) $25 \times 10^2\ m$

383. If the length of the second's hand in a stop-clock is 3 cm, the angular velocity and linear velocity of the tip is
a) 0.2047 $rads^{-1}$, 0.0314 ms^{-1} b) 0.2547 $rads^{-1}$, 0.0314 ms^{-1}
c) 0.1472 $rads^{-1}$, 0.06314 ms^{-1} d) 0.1047 $rads^{-1}$, 0.00314 ms^{-1}

384. If a car is to travel with a speed v along the frictionless, banked circular track of radius r, the required angle of banking so that the car does skid is
a) $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$ b) $\theta = \tan^{-1}\left(\frac{v}{rg}\right)$ c) $\theta = \tan^{-1}\left(\frac{r^2}{vg}\right)$ d) $\theta < \tan^{-1}\left(\frac{v^2}{rg}\right)$

385. A body moves along a circular path of radius 5 m. The coefficient of friction between the surface of path and the body is 0.5. The angular velocity, in radians/sec, with which the body should move so that it does not leave the path is ($g = 10ms^{-2}$)
a) 4 b) 3 c) 2 d) 1

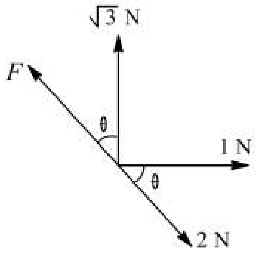
386. A sphere is suspended by a thread of length l. What minimum horizontal velocity has to be imparted the ball for it to reach the height of the suspension
a) gl b) $2gl$ c) $\sqrt{gl}$ d) $\sqrt{2gl}$

387. A body of mass 5 kg is moving in a circle of radius 1 m with an angular velocity of 2 rad s^{-1}. The centripetal force, is
a) 10 N b) 20 N c) 30 N d) 40 N

388. A body is thrown with a velocity of 9.8 m/s making an angle of 30° with the horizontal. It will hit the ground after a time
a) 1.5 s b) 1 s c) 3 s d) 2 s

389. A particle performing uniform circular motion has
a) Radial velocity and radial acceleration
b) A radial velocity and transverse acceleration
c) Transverse velocity and radial acceleration
d) Transverse velocity and transverse acceleration

390. Four concurrent coplanar forces in newton are acting at a point and keep it in equilibrium figure. Then values of F and θ are



a) 1 N, 60° b) 2 N, 60° c) $\sqrt{2}$ N,90° d) 2 N, 90°

391. On an unbanked road, a cyclist negotiating a bend of radius r at velocity v leans inwards by an angle

a) $\tan^{-1}\left(\frac{v^2}{2gr}\right)$ b) $\tan^{-1}\left(\frac{v^2}{gr}\right)$ c) $\tan^{-1}\left(\frac{rg}{v^2}\right)$ d) $\tan^{-1}\left(\frac{v}{gr}\right)$

392. If a particle of mass m is moving in a horizontal circle of radius r with a centripetal force $(-k/r^2)$, the total energy is

a) $-\frac{k}{2r}$ b) $-\frac{k}{r}$ c) $-\frac{2k}{r}$ d) $-\frac{4k}{r}$

393. Four bodies P, Q, R and S are projected with equal velocities having angles of projection 15°, 30°, 45° and 60° with the horizontal respectively. The body having shortest range is

a) P b) Q c) R d) S

394. A body of mass m kg is rotating in a vertical circle at the end of a string of length r metre. The difference in the kinetic energy at the top and bottom of the circle is

a) $\frac{mg}{r}$ b) $\frac{2mg}{r}$ c) $2mgr$ d) mgr

395. A car of mass 1000 kg moves on a circular track of radius 20 m. If the coefficient of friction is 0.64, then the maximum velocity with which the car can move is

a) 22.4 ms^{-1} b) 5.6 ms^{-1} c) 11.2 ms^{-1} d) None of these

396. A cyclist is travelling on a circular section of highway of radius 2500 ft at the speed of 60 mile h^{-1}. The cyclist suddenly applies the brakes causing the bicycle to slown sown at constant rate. Knowing that after 8 s the speed has been reduced to 45 mileh^{-1}. The acceleration of the bicycle immediately after the brakes have been applied is

a) 2 ft/s^2 b) 4.14 ft/s^2 c) 3.10 ft/s^2 d) 2.75 ft/s^2

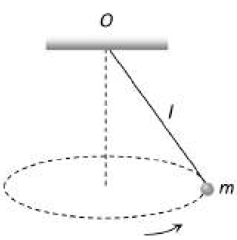
397. Angle between $\vec{A}$ and $\vec{B}$ is θ. What is the value of $\vec{A}.(\vec{B}\times\vec{A})$?

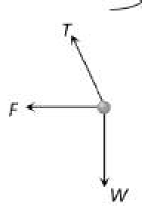
a) A^2B cosθ b) A^2B sinθcosθ c) A^2B sinθ d) zero

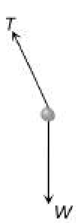
398. For an object thrown at 45° to horizontal, the maximum height (H) and horizontal range (R) are related as

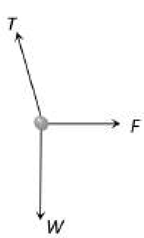
a) $R = 16H$ b) $R = 8H$ c) $R = 4H$ d) $R = 2H$

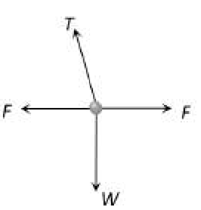
399. A point mass m is suspended from a light thread of length l, fixed at$O$, is whirled in a horizontal circle at constant speed as shown. From your point of view, stationary with respect to the mass, the forces on the mass are



a) 

b) 

c) 

d) 

400. The speed of revolution of a particle going around a circle is doubled and its angular speed is halved. What happens to the centripetal acceleration?

a) Becomes four times b) Double c) Halved d) Remains unchanged

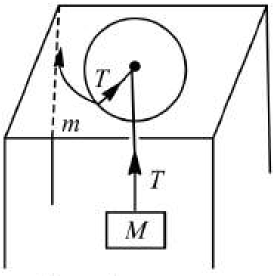
401. The magnitudes of the two vectors $\vec{a}$ and $\vec{b}$ are a and b respectively. The vector product of $\vec{a}$ and $\vec{b}$ cannot be

a) equal to zero b) less than ab c) equal to ab d) greater than ab

402. The angle turned by a body undergoing circular motion depends on time as $\theta = \theta_0 + \theta_1 t + \theta_2 t^2$. Then the angular acceleration of the body is

a) θ_1 b) θ_2 c) $2\theta_1$ d) $2\theta_2$

403. A particle of mass m is rotating in a horizontal circle of radius R and is attached to a hanging mass M as shown in the figure. The speed of rotation required by the mass m keep M steady is



a) $\sqrt{\frac{mgR}{M}}$ b) $\sqrt{\frac{mgR}{m}}$ c) $\sqrt{\frac{mg}{MR}}$ d) $\sqrt{\frac{mR}{Mg}}$

404. A projectile is projected with kinetic energy K. If it has the maximum possible horizontal range, then its kinetic energy at the highest point will be

a) 0.25 K b) 0.5 K c) 0.75 K d) 1.0 K

405. In hydrogen atom, the electron is moving round the nucleus with velocity 2.18×10^6 ms^{-1} in an orbit of radius 0.528 Å. The acceleration of the electron is

a) 9×10^{18} ms^{-2} b) 9×10^{22} ms^{-2} c) 9×10^{-22} ms^{-2} d) 9×10^{12} ms^{-2}

406. A particle moves along a parabolic path $y = 9x^2$ in such a way that the x-componentes of velocity remains constant and has a value$\frac{1}{3}$ ms^{-1}. The acceleration of the projectile is

a) $\frac{1}{2}\hat{\mathbf{j}}$ ms^{-2} b) $3\hat{\mathbf{j}}$ ms^{-2} c) $\frac{2}{3}\hat{\mathbf{j}}$ ms^{-2} d) $2\hat{\mathbf{j}}$ ms^{-2}

407. In uniform circular motion, the velocity vector and acceleration vector are

a) Perpendicular to each other b) Same direction
c) Opposite direction d) Not related to each other

408. A body is projected at such angle that the horizontal range is three times the greatest height. The angel of projection is

a) 42°8′ b) 53°7′ c) 33°7′ d) 25°8′

409. A stone of mass 1 kg is tied at one end of string of length 1 m. It is whirled in a vertical circle at constant speed of 4 ms^{-1}. The tension in the string is 6 N when the stone is at (g = 10ms^{-2})

a) Top of the circle b) Bottom of the circle c) Half way down d) None of these

410. A body is projected from the earth at angle 30° with the horizontal with some initial velocity. If its range is 20 m, the maximum height reached by its is (in metre)

a) $5\sqrt{3}$ b) $\frac{5}{\sqrt{3}}$ c) $\frac{10}{\sqrt{3}}$ d) $10\sqrt{3}$

411. A small disc is on the top of a hemisphere of radius R. What is the smallest horizontal velocity v that should be given to the disc for it to leave the hemisphere and not slide down it? [There is no friction]

a) $v = \sqrt{2gR}$ b) $v = \sqrt{gR}$ c) $v = \frac{g}{R}$ d) $v = \sqrt{g^2 R}$

412. A body is fired vertically upward. At half the maximum height, the velocity of the body is 10 m/s. The maximum height raised by the body is

a) 0 m b) 10 m c) 15 m d) 20 m

413. Two bullets are fired simultaneously, horizontally and with different speeds from the same place. Which bullet will hit the ground first?

a) The faster bullet b) The slower bullet
c) Both will hit simultaneously d) Depends on the masses

414. The speed of projection of a projectile is increased by 10%, without changing the angel of projection. The percentage increase in the range will be

a) 10% b) 20% c) 15% d) 5%

415. A particle is projected with velocity $\sqrt{2gh}$, such that it just crosses two walls of height h and separated by h Find the angle of projection.

a) 15° b) 75° c) 60° d) 30°

416. The kinetic energy k of a particle moving along a circle of radius R depends on the distance covered s as $k = as^2$ where a is a constant

a) $2a\frac{s^2}{R}$ b) $2as\left(1+\frac{s^2}{R^2}\right)^{1/2}$ c) $2as$ d) $2a\frac{R^2}{s}$

417. 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) $\left(\frac{r_2}{r_1}\right)^2$

418. A ball rolls off the top of a stairway with horizontal velocity $v_0 ms^{-1}$. If the steps are h metre high and w metre wide, the ball will hit the edge of nth step if

a) $n = \frac{2hv_0}{gw^2}$ b) $n = \frac{2hv_0^2}{gw}$ c) $n = \frac{hv_0^2}{gw^2}$ d) $n = \frac{2hv_0^2}{gw^2}$

419. A grass hopper finds that he can jump a maximum horizontal distance of 1 m. With what speed can be travel along the path if he speeds a negligible time on the ground

a) 9.8 ms^{-1} b) 4.42 ms^{-1} c) 2.21 ms^{-1} d) 3.13 ms^{-1}

420. A particle is kept at rest at the top of a sphere of diameter 42 m. When disturbed slightly, it slides down. At what height $'h'$ from the bottom, the particle will leave the sphere

a) 14 m b) 28 m c) 35 m d) 7 m

421. In a bicycle the radius of rear wheel is twice the radius of front wheel. If r_f and r_r are the radius, v_f and v_r are the speed of top most points of wheel, then

a) $v_r = 2v_f$ b) $v_f = 2v_r$ c) $v_f = v_r$ d) $v_f > v_r$

422. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/sec. A plumb bob is suspended from the roof of the car by a light rigid rod of length 1.00 m. The angle made by the rod with track is

a) Zero b) 30° c) 45° d) 60°

423. The horizontal range of a projectile is $4\sqrt{3}$ times its maximum height. Its angle of projection will be

a) 45° b) 60° c) 90° d) 30°

424. An athlete completes one round of a circular track of radius 10 m in 40 sec. The distance covered by him in 2 min 20 sec is

a) 70 m b) 140 m c) 110 m d) 220 m

425. At the height 80 m, an aeroplane is moving with 150 m/s. A bomb is dropped from it so as to hit a target. At what distance from the target should be bomb be dropped (Given $g = 10\ m/s^2$)

a) 605.3 m b) 600 m c) 80 m d) 230 m

426. When a ceiling fan is switched off its angular velocity reduces to 50% while it makes 36 rotations. How many more rotation will it make before coming to rest (Assume uniform angular retardation)

a) 18 b) 12 c) 36 d) 48

427. In resultant of which of the following sets of forces can not be zero

a) 10,20 and 40 b) 10,10 and 20 c) 10,20 and 20 d) 10,10 and 10

428. A particle moves with constant angular velocity in circular path of certain radius and is acted upon by a certain centripetal force F. If the angular velocity is doubled keeping radius the same, the new force will be

a) $2F$ b) F^2 c) $4F$ d) $F/2$

429. A body of mass 5 kg is whirled in a vertical circle by a string 1 m long. Calculate velocity at the top of the circle for just looping the vertical loop

a) 3.1 ms^{-1} b) 7 ms^{-1} c) 9 ms^{-1} d) 7.3 ms^{-1}

430. A projectile is thrown with a speed u at an angle θ to the horizontal. The radius of curvature of its trajectory when the velocity vector of the projectile makes an angle α with the horizontal is

a) $\frac{u^2 \cos^2 \alpha}{g\cos^2 \theta}$ b) $\frac{2u^2 \cos^2 \alpha}{g\cos^2 \theta}$ c) $\frac{u^2 \cos^2 \theta}{g\cos^3 \alpha}$ d) $\frac{u^2 \cos^2 \theta}{g\cos^2 \alpha}$

431. The sum of two vectors $\vec{A}$ and $\vec{B}$ is at right angles to their difference. Then

a) $A = B$

b) $A = 2B$

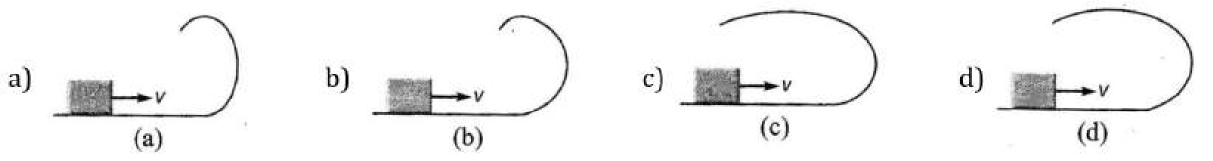
c) $B = 2A$

d) $\vec{A}$ and $\vec{B}$ have the same direction

432. The radius vector and linear momentum are respectively given by vector $2\hat{i} + 2\hat{j} + \hat{k}$ and $2\hat{i} - 2\hat{j} + \hat{k}$. Their angular momentum is

a) $2\hat{i} - 4\hat{j}$ b) $4\hat{i} - 8\hat{k}$ c) $2\hat{i} - 4\hat{j} + 2\hat{k}$ d) $4\hat{i} - 8\hat{j}$

433. A small block is shot into each of the four tracks as shown below. Each of the frictionless track rises to the same height. The speed, which the block enters the tracks, is same in all cases. At the highest point of the track, normal reaction is maximum in



434. A body moving along a circular path of radius R with velocity v, has centripetal acceleration a. If its velocity is made equal to $2v$, then its centripetal acceleration is

a) $4a$ b) $2a$ c) $\frac{a}{4}$ d) $\frac{a}{2}$

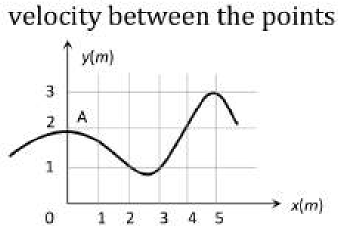
435. The minimum velocity (in ms^{-1}) with which a car driver must traverse a flat curve of radius of 150 m and coefficient of friction 0.6 to avoid skidding is

a) 60 b) 30 c) 15 d) 25

436. A cart is moving horizontally along a straight line with constant speed30 ms^{-1}. A projectile is to be fired from the moving cart in such a way that it will return to the cart has moved 80 m. At what speed (relative to the cart) must the projectile be fired? (Take $g = 10\ ms^{-2}$)

a) 10 ms^{-1} b) $10\sqrt{8}ms^{-1}$ c) $\frac{40}{3}ms^{-1}$ d) None of the above

437. The trajectory of a particle moving in vast maidan is as shown in the figure. The coordinates of a position A are (0,2). The coordinates of another point at which the instantaneous velocity is same as the average velocity between the points are



a) (1, 4) b) (5, 3) c) (3, 4) d) (4, 1)

438. A ball thrown by a boy is caught by another after 2 *sec* some distance away in the same level. If the angle of projection is 30°, the velocity of projection is

a) 19.6 m/s b) 9.8 m/s c) 14.7 m/s d) None of these

439. At the top of the trajectory of a projectile, the direction of its velocity and acceleration are

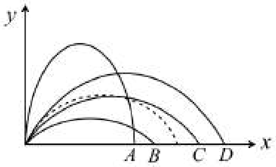
a) perpendicular to each other b) parallel to each other

c) inclined to each other at angle of 45° d) antiparallel to each other

440. A tachometer is a device to measure

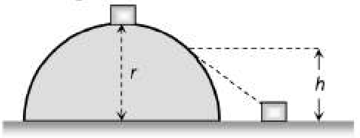
a) Gravitational pull b) Speed of rotation c) Surface tension d) Tension in a spring

441. The path of a projectile in the absence of air drag is shown in the figure by dotted line. If the air resistance is not ignored then which one of the path is shown in the figure is appropriate for the projectile



a) B b) A c) D d) C

442. A small body of mass m slides down from the top of a hemisphere of radius r. The surface of block and hemisphere are frictionless. The height at which the body lose contact with the surface of the sphere is

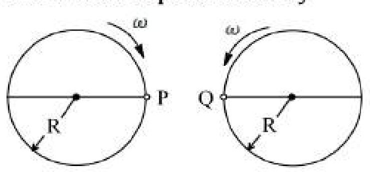


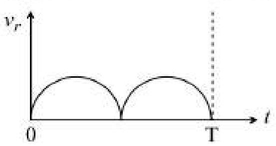
a) $\frac{3}{2}r$ b) $\frac{2}{3}r$ c) $\frac{1}{2}gt^2$ d) $\frac{v^2}{2g}$

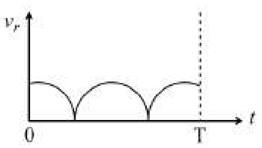
443. The maximum velocity (in ms^{-1}) with which a car driver must traverse a flat curve of radius 150 m and coefficient of friction 0.6 to avoid skidding is

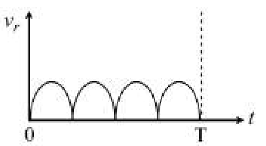
a) 60 b) 30 c) 15 d) 25

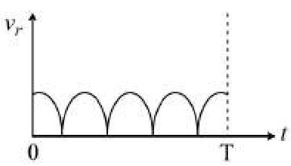
444. Two identical discs of same radius R are rotating about their axes in opposite directions with the same constant angular speed ω. The discs are in the same horizontal plane. At time $t = 0$, the points P and Q are facing each other as shown in figure. The relative speed between the two points P and Q is V_r as function of times best represented by



a)


b)


c)


d)


445. A car is moving in a circular horizontal track of radius 10m with a constant speed of 10 ms^{-1}. The angle made by the rod with track is

a) Zero b) 30° c) 45° d) 60°

446. An object of mass 2 m is projected with a speed of 100 ms^{-1} at angle $\theta = \sin^{-1}\left(\frac{3}{5}\right)$ to the horizontal. At the highest point, the object breaks into pieces of same mass m and the first one comes to rest. The distance between the point of projection and the point of landing of the bigger piece (in metre) is (given, $g = 10\ ms^{-2}$)

a) 3840　　b) 1280　　c) 1440　　d) 960

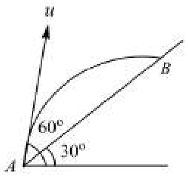
447. A child travelling in a train throws a ball outside with a speed V. According to a child who is standing on the ground, the speed of the ball is

a) Same as V　　b) Greater than V　　c) Less than V　　d) None of these

448. On the centre of a frictionless table a small hole is made, through which a weightless string of length $2l$ is inserted. On the two ends of the string two balls of the same mass m are attached. Arrangement is made in such a way that half of the string is on the table top and half is hanging below. The ball on the table top is made to move in a circular path with a constant speed v. What is the centripetal acceleration of the moving ball

a) mvl　　b) g　　c) Zero　　d) $2mvl$

449. The time taken by the projectile to reach from A to B is t, then the distance AB is equal to



a) $2\ ut$　　b) $\sqrt{3}\ ut$　　c) $\frac{\sqrt{3}}{2}ut$　　d) $\frac{ut}{\sqrt{3}}$

450. A 2 kg stone at the end of a string 1 m long is whirled in a vertical circle at a constant speed. The speed of the stone is 4 m/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

451. A body of mass $\sqrt{3}$ kg is suspended by a string from a rigid support. The body is pulled horizontally by a force F until the string makes an angle of 30° with the vertical. The value o F and tension in the string are

a) 19.6 N; 19.6 N　　b) 9.8 N; 9.8 N　　c) 9.8 N, 19.6 N　　d) 19.6 N, 9.8 N

452. One end of a string of length l is connected to a particle of mass m and other to a small peg on a smooth horizontal table. If the particle moves in a circle with speed v, the net force on the particle (directed towards the centre) is

a) T　　b) $T - \frac{mv^2}{l}$　　c) $T + \frac{mv^2}{l}$　　d) zero

453. A particle moves in a plane with constant acceleration in a direction different from the initial velocity. The path of the particle will be

a) A straight line　　b) An arc of a circle　　c) A parabola　　d) An ellipse

454. If the resultant of $\vec{A}$ and $\vec{B}$ makes angle α with $\vec{A}$ and β with $\vec{B}$ then

a) $\alpha < \beta$ always　　b) $\alpha < \beta$, if $A < B$　　c) $\alpha < \beta$, if $A > B$　　d) $\alpha < \beta$, if $A = B$

455. A cylindrical vessel partially filled with water is rotated about its vertical central axis. It's surface will

a) Rise equally　　b) Rise from the sides　　c) Rise from the middle　　d) Lowered quality

456. A projectile is thrown in the upward direction making an angle of 60° with the horizontal direction with velocity of147 ms^{-1}. Then the time after which its inclination with the horizontal is 45°, is

a) 25 s　　b) 10.98 s　　c) 5.49 s　　d) 2.745 s

457. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of 0.5 m/s. What is the height of the plane of circle from vertex of the funnel

a) 0.25 cm　　b) 2 cm　　c) 4 cm　　d) 2.5 cm

458. At the point of a projectile motion, acceleration and velocity are perpendicular to each other?

a) At the point of projection

b) At the point of drop
c) At the top most point
d) Anywhere in between the point of projection and two most point

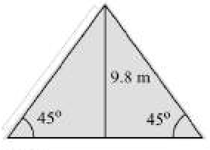
459. A fighter plane is moving in a vertical circle of radius $'r'$. Its minimum velocity at the highest point of the circle will be
a) $\sqrt{3\,g\,r}$ b) $\sqrt{2\,g\,r}$ c) $\sqrt{g\,r}$ d) $\sqrt{g\,r/2}$

460. A projectile is projected with a speed u making an angle 2θ with the horizontal. What is the speed when its direction of motion makes an angle θ with the horizontal
a) $(u\cos 2\theta)/2$ b) $u\cos\theta$ c) $u(2\cos\theta - \sec\theta)$ d) $u(\cos\theta - \sec\theta)$

461. For motion in a plane with constant acceleration $\vec{a}$, initial velocity $\vec{v}_0$ and final velocity $\vec{v}$ after time t, we have
a) $\vec{v}.(\vec{v} - \vec{a}t) = \vec{v}_0.(\vec{v}_0 + \vec{a}t)$ b) $\vec{v}.\vec{v}_0 = at^2$
c) $\vec{v}.\vec{v}_0 = \vec{v}.\vec{v}_0 t$ d) $\vec{v}_0.\vec{v}_0 = \vec{a}.\vec{v}_0 t$

462. The average acceleration vector for a particle having a uniform circular motion is
a) A constant vector of magnitude v^2/r
b) A vector of magnitude v^2/r directed normal to the plane of the given uniform circular motion
c) Equal to the instantaneous acceleration vector at the start of the motion
d) A null vector

463. Two inclined planes are located as shown in figure. A particle is projected from the foot of one frictionless plane along its line with a velocity just sufficient to carry it to top after which the particle slides down the other frictionless inclined plane. The total time it will take to reach the point C is



a) 2 s b) 3 s c) $2\sqrt{2}$ s d) 4 s

464. When a body is thrown with a velocity u making an angle θ with the horizontal plane, the maximum distance covered by it in horizontal direction is
a) $\frac{u^2\sin\theta}{g}$ b) $\frac{u^2\sin 2\theta}{2g}$ c) $\frac{u^2\sin 2\theta}{g}$ d) $\frac{u^2\cos 2\theta}{g}$

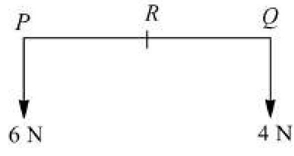
465. An aeroplane is flying with a uniform speed of 100 m/s along a circular path of radius 100 m. the angular speed of the aeroplane will be
a) 1 rad/sec b) 2 rad/sec c) 3 rad/sec d) 4 rad/sec

466. An arrow is shot into air. Its range is 200 m and its time of flight is $5s$. If $g = 10m/s^2$, then the horizontal component of velocity of the arrow is
a) 12.5 m/s b) 25 m/s c) 31.25 m/s d) 40 m/s

467. Given θ is the angle between $\vec{A}$ and $\vec{B}$. Then $|\hat{A} \times \hat{B}|$ is equal to
a) Sin θ b) Cos θ c) Tan θ d) Cot θ

468. A body moving with constant speed in a circular path has
a) angular momentum b) constant acceleration c) constant velocity d) no work done

469. The resultant of a system of forces shown in figure is a force of 10 N parallel to given forces through R, where PR equals



a) $(2/5)R\ Q$ b) $(3/5)R\ Q$ c) $(2/3)R\ Q$ d) $(1/2)R\ Q$

470. A body of mass 5 kg is moving in a circle of radius 1 m with an angular velocity of 2 $radian$/sec. The centripetal force is

a) 10 N b) 20 N c) 30 N d) 40 N

471. Two particles A and B are projected with same speed so that ratio of their maximum heights reached is 3:1. If the speed of A is doubled without altering other parameters, the ratio of horizontal ranges attained by A and B is

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

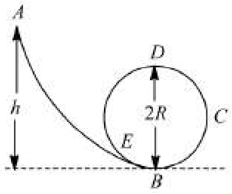
472. A monkey can jump a maximum horizontal distance of 20 m. Then the velocity of the monkey is

a) 10 ms^{-1} b) 14 ms^{-1} c) 20 ms^{-1} d) 24 ms^{-1}

473. A body can throw a stone up to a maximum height of $10m$. The maximum horizontal distance that the boy can throw the same stone up to will be

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

474. A frictionless track $ABCDE$ ends in a circular loop of radius R, figure. A body slides down the track from point A which is at a height $h = 5$ cm. Maximum value of R for the body to successfully complete the loop is



a) 5 cm b) 15/4 cm c) 10/3 cm d) 2 cm

475. Given $\vec{P} \cdot \vec{Q} = 0$, then $|\vec{P} \times \vec{Q}|$ is

a) $|\vec{P}||\vec{Q}|$ b) Zero c) 1 d) $\sqrt{PQ}$

476. An object is being weighed on a spring balance moving around a curve of radius 100 m at a speed 7 ms^{-1}. The object has a weight of 60 kg-wt. The reading registered on the spring balance would be

a) 60.075 kg-wt b) 60.125 kg-wt c) 60.175 kg-wt d) 60.225 kg-wt

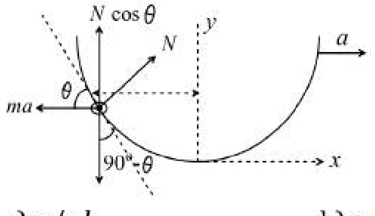
477. Two projectiles A and B are thrown with velocities v and $\frac{v}{2}$ respectively. They have the same range. If B is thrown at an angle of 15° to the horizontal, a must have been thrown at an angle

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) $\frac{1}{2}\sin^{-1}\left(\frac{1}{8}\right)$

478. An electric fan has blades of length 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 $r.p.m.$ The acceleration of a point on the tip of the blade is about

a) 1600 $m/\sec^2$ b) 4740 $m/\sec^2$ c) 2370 $m/\sec^2$ d) 5055 $m/\sec^2$

479. A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can side on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is



a) a/gk b) $a/2gk$ c) $2a/gk$ d) $a/4gk$

480. If the angle of projection of a projectile is 30°, then how many times the horizontal range is larger than the maximum height?

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

481. A scooter is going round a circular road of radius 100 m at a speed of 10 m/s. The angular speed of the scooter will be

a) 0.01 rad/s b) 0.1 rad/s c) 1 rad/s d) 10 rad/s

482. An aeroplane is flying horizontally with a velocity of 600 km/h and at a height of 1960 m. When it is vertically above a point A on the ground a bomb is released from it. The bomb strikes the ground at point B. The distance AB is

a) 1200 m b) 0.33 km c) 333.3 km d) 3.33 km

483. The vector which can give unit vector along x-axis with $\vec{A} = 2\hat{i} - 4\hat{j} + 7\hat{k}$, $\vec{B} = 7\hat{i} + 2\hat{j} - 5\hat{k}$ and $\vec{C} = -4\hat{i} + 7\hat{j} + 3\hat{k}$ is

a) $4\hat{i} + 5\hat{j} + 5\hat{k}$ b) $-5\hat{i} - 5\hat{j} + 5\hat{k}$ c) $-4\hat{i} - 5\hat{j} - 5\hat{k}$ d) $4\hat{i} - 5\hat{j} + 5\hat{k}$

484. A wheel completes 2000 revolutions to cover the 9.5 km. distance. Then the diameter of the wheel is

a) 1.5 m b) 1.5 cm c) 7.5 cm d) 7.5 m

485. Given that A and B are greater than 1. The magnitude of $(\vec{A} \times \vec{B})$ can not be

a) equal to AB b) less than AB c) more than AB d) equal to A/B

486. Given $\vec{R} = \vec{A} + \vec{B}$ and $R = A = B$. The angle between $\vec{A}$ and $\vec{B}$ is

a) 60° b) 90° c) 120° d) 180°

487. A body of mass 1 kg tied to one end of string is revolved in a horizontal circle of radius 0.1 m with a speed of 3 $revolution/sec$, assuming the effect of gravity is negligible, then linear velocity, acceleration and tension in the string will be

a) 1.88 m/s, 35.5m/s^2, 35.5 N b) 2.88 m/s, 45.5m/s^2, 45.5 N

c) 3.88 m/s, 55.5m/s^2, 55.5 N d) None of these

488. A body of mass m is moving in a circle of radius r with a constant speed v. The force on the body is $\frac{mv^2}{r}$ and is directed towards the centre. What is the work done by this force in moving the body over half the circumference of the circle

a) $\frac{mv^2}{r} \times \pi r$ b) Zero c) $\frac{mv^2}{r^2}$ d) $\frac{\pi r^2}{mv^2}$

489. A particle describes a horizontal circle in a conical funnel whose inner surface is smooth with speed of 0.5 ms^{-1}. What is the height of the plane of circle from vertex of the funnel?

a) 0.25 cm b) 2 cm c) 4 cm d) 2.5 cm

490. A projectile is given an initial velocity of $\hat{\mathbf{i}} + 2\hat{\mathbf{j}}$. The cartesian equation of its path is ($g = 10$ ms^{-2})

a) $y = x - 5x^2$ b) $y = 2x - 5x^2$ c) $y = 2x - 15x^2$ d) $y = 2x - 25\,x^2$

491. A stone of mass m is tied to a string and is moved in a vertical circle of radius r making n revolutions per $minute$. The total tension in the string when the stone is at its lowest point is

a) mg b) $m(g + \pi n r^2)$

c) $m(g + \pi n r)$ d) $m\{g + (\pi^2\, n^2\, r)/900\}$

492. The kinetic energy K of a particle moving along a circle or radius R depends on the distance covered s as $K = a\,s^2$. The force acting on the particle is

a) $2\,a\,s\,R$ b) $2\,a\,s[1 + s^2/R^2]^{1/2}$ c) $2\,a\,s$ d) $2\,as^2/R$

493. Two vectors $\vec{A}$ and $\vec{B}$ are inclined at an angle θ. Now if the vectors are interchanged then the resultant turns through an angle β. Which of the following relation is true

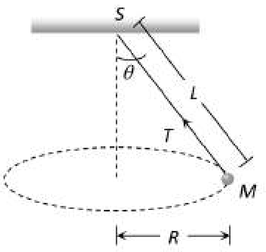
a) $\tan\frac{\alpha}{2} = \left(\frac{A - B}{A + B}\right)^2 \tan\frac{\theta}{2}$ b) $\tan\frac{\alpha}{2} = \left(\frac{A - B}{A + B}\right) \tan\frac{\theta}{2}$

c) $\tan\frac{\alpha}{2} = \left(\frac{A - B}{A + B}\right)^2 \cot\frac{\theta}{2}$ d) $\tan\frac{\alpha}{2} = \left(\frac{A - B}{A + B}\right) \cot\frac{\theta}{2}$

494. The resultant of two vectors of magnitudes $2A$ and $\sqrt{2}A$ acting at an angle θ is $\sqrt{10}A$. The correct value of θ is

a) 30° b) 45° c) 60° d) 90°

495. A string of length L is fixed at one end and carries a mass M at the other end. The string makes $2/\pi$ revolutions per $second$ around the vertical axis through the fixed end as shown in figure , then tension in the string is



a) ML b) $2\ ML$ c) $4\ ML$ d) $16\ ML$

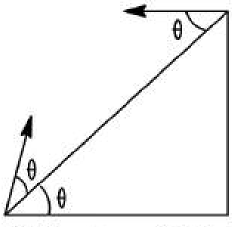
496. A projectile fired with initial velocity u at some angle θ has a range R. If the initial velocity be doubled at the same angle off projection, then the range will be

a) $2R$ b) $R/2$ c) R d) $4R$

497. A helicopter is flying horizontally at an altitude of 2 km with a speed of 100 ms^{-1}. A packet is dropped from it. The horizontal distance between the point where the packet is dropped and the point where it hits the ground is ($g = 10\ ms^{-2}$)

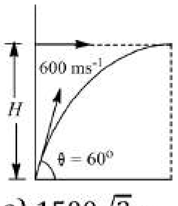
a) 2 km b) 0.2 km c) 20 km d) 4 km

498. From an inclined plane two particles are projected with same speed at same angle θ, one up and other down the plane as shown in figure, which of the following statements is/are correct?



a) The time of flight of each particle is the same
b) The particles will collide the plane with same speed
c) Both the particles strike the plane perpendicularly
d) The particles will collide in mid air if projected simultaneously and time of flight of each particle is less than of collision

499. A fighter plane enters inside the enemy territory, at time $t = 0$ with velocity $v_0 = 250\ ms^{-1}$ and moves horizontally with constant acceleration $a = 20 ms^{-2}$ (see figure). An enemy tank at the border, spot the plane and fire shots at an angle $\theta = 60°$ with the horizontal and with velocity $u = 600\ ms^{-1}$. At what altitude H of the plane it can be hit by the shot?



a) $1500\sqrt{3}$m b) 125 m c) 1400 m d) 2473 m

500. The vectors $\vec{a}$ and $\vec{b}$ are such that $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$. What is the angle between $\vec{a}$ and $\vec{b}$?

a) 0° b) 90° c) 60° d) 180°

501. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10 ms^{-1} at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground?
($g = 10\ ms^{-2}, \sin 30° = 1/2, \cos 30° = \sqrt{3}/2$

a) 5.20 m b) 4.33 m c) 2.60 m d) 8.66 m

502. What is the value of linear velocity, if $\vec{\omega} = 3\hat{\imath} - 4\hat{\jmath} + \hat{k}$ and $\vec{r} = 5\hat{\imath} - 6\hat{\jmath} + 6\hat{k}$

a) $6\hat{\imath} + 2\hat{\jmath} - 3\hat{k}$ b) $-18\hat{\imath} - 13\hat{\jmath} + 2\hat{k}$ c) $4\hat{\imath} - 13\hat{\jmath} + 6\hat{k}$ d) $6\hat{\imath} - 2\hat{\jmath} + 2\hat{k}$

503. A vector $\vec{A}$ when added to the vector $\vec{B} = 3\hat{\imath} + 4\hat{\jmath}$ yields a resultant vector that is in the positive y direction and has a magnitude equal to that of $\vec{B}$. Find the magnitude of $\vec{A}$

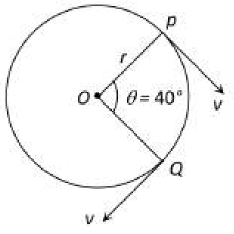
a) $\sqrt{10}$ b) 10 c) 5 d) $\sqrt{15}$

504. Neglecting the air resistance, the time of flight of a projectile is determined by

a) $U_{vertical}$ b) $U_{horizontal}$

c) $U = U^2_{vertical} + U^2_{horizontal}$ d) $U = U\left(U^2_{vertical} + U^2_{horizontal}\right)^{1/2}$

505. A particle is moving on a circular path of radius r with uniform velocity v. The change in velocity when the particle moves from P to Q is $(\angle POQ = 40°)$



a) $2v\cos 40°$ b) $2v\sin 40°$ c) $2v\sin 20°$ d) $2v\cos 20°$

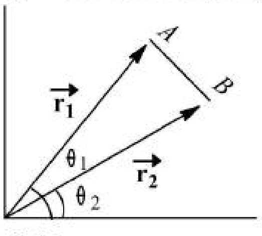
506. A bullet is fired with a velocity u making an angle of $60°$ with the horizontal plane. The horizontal component of the velocity of the bullet when it reaches the maximum height is

a) u b) 0 c) $\frac{\sqrt{3}u}{2}$ d) $u/2$

507. A body of mass 0.4 kg is whirled in a vertical circle making 2 rev/sec. If the radius of the circle is 2 m, then tension in the string when the body is at the top of the circle, is

a) 41.56 N b) 89.86 N c) 109.86 N d) 115.86 N

508. In a two dimensional motion of a particle, the particle moves from point A, position vector $\vec{r}_1$. If the magnitudes of these vectors are respectively, r_1=3 and $r_2 = 4$ and the angles they make with the x-axis are $\theta_1 = 75°$ and $15°$, respectively, then find the magnitude of the displacement vector



a) 15 b) $\sqrt{13}$ c) 17 d) $\sqrt{15}$

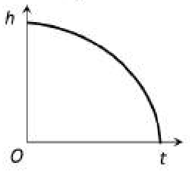
509. A ball rolls of the top of a stair way with a horizontal velocity u ms^{-1}. If the steps are h metre and b metre wide, the ball hits the edge of nth step, the time taken by the ball is

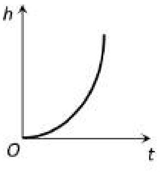
a) $\frac{hu}{gb}$ b) $\frac{2hu}{gb}$ c) $\frac{2hu^2}{gb}$ d) $\frac{hu^2}{2gb}$

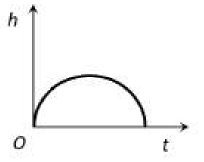
510. A coin placed on a rotating turn table just slips if it is placed at a distance of 8 cm from the centre. If angular velocity of the turn table is doubled, it will just slip at a distance of

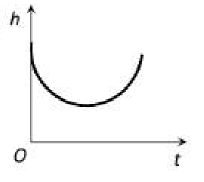
a) 1 cm b) 2 cm c) 4 cm d) 8 cm

511. Which of the following is the graph between the height (h) of a projectile and time (t), when it is projected from the ground

a) 

b) 

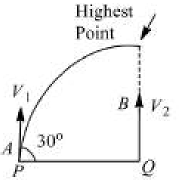
c) 

d) 

512. A ball is projected horizontally with a velocity of 5 m/s from the top of a building 19.6 m high. How long will the ball take to hit the ground

a) $\sqrt{2}$ s b) 2 s c) $\sqrt{3}$ s d) 3 s

513. A projectile A is thrown at an angle of $30°$ to the horizontal from point P. At the same time, another projectile B is thrown with velocity v^2 upwards from the point Q vertically below the highest point. For B to collide with A, $\frac{v_2}{v_1}$ should be



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

514. A pallet of mass 1 g is moving with an angular velocity of 1 rads $^{-1}$ along a circle of radius 1 m the centrifugal force is

a) 0.1 dyne b) 12 dyne c) 10 dyne d) 100 dyne

515. A stone is tied to one end of a string 50 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 10 revolutions in 20 s, what is the magnitude of acceleration of the stone

a) 493 cm/s^2 b) 720 cm/s^2 c) 860 cm/s^2 d) 990 cm/s^2

516. An object moves at a constant speed along a circular path in a horizontal XY plane, with the centre at the origin. When the object is at $x = -2m$, its velocity is $-(4m/s)\hat{j}$. What is the object's acceleration when it is $y = 2m$

a) $-(8m/s^2)\hat{j}$ b) $-(8m/s^2)\hat{i}$ c) $-(4m/s^2)\hat{j}$ d) $(4m/s^2)\hat{i}$

517. A ball is projected from the ground at a speed of $10ms^{-1}$ making an angle of $30°$ with the horizontal. Another ball is simultaneously released from a point on the vertical line along the maximum height of the projectile. The initial height of the second ball is ($g = 10ms^{-2}$)

a) 6.25 m b) 2.5 m c) 3.75 m d) 5 m

518. A particle is moving in a circle with uniform speed$v$. In moving from a point to another diametrically opposite point

a) the momentum changes by mv
b) the momentum changes by 2 mv
c) the kinetic energy changes by (1/2) mv^2
d) the kinetic energy changes by mv^2

519. A particle is projected with velocity v_0 along x-axis. The deceleration on the particle is proportional to the square of the distance from the origin ie $a = \propto x^2$ the distance at which the particle stops is

a) $\sqrt{\frac{3v_0}{2\propto}}$ b) $\left(\frac{3v_0}{2\propto}\right)^{\frac{1}{3}}$ c) $\sqrt{\frac{2v_0^2}{3\propto}}$ d) $\left(\frac{3v_0^2}{2\propto}\right)^{\frac{1}{3}}$

520. For a projectile, the ratio of maximum height reached to the square of flight time is ($g = 10\ ms^{-2}$)

a) 5 : 4 b) 5 : 2 c) 5 : 1 d) 10 : 1

521. A weightless thread can support tension upto 30 N. A stone of mass 0.5 kg is tied to it and is revolved in a circular path of radius 2 m in a vertical plane. If $g = 10\ m/s^2$, then the maximum angular velocity of the stone will be

a) 5 rad/s b) $\sqrt{30}$ rad/s c) $\sqrt{60}$ rad/s d) 10 rad/s

522. A mass is supported on a frictionless horizontal surface. It is attached to a string and rotates about a fixed centre at an angular velocity ω_0. If the length of the string and angular velocity both are doubled, the tension in the string which was initially T_0 is now

a) T_0 b) $T_0/2$ c) $4T_0$ d) $8T_0$

523. A small object placed on a rotating horizontal turn table just slips when it is placed at a distance of 4 cm from the axis of rotation, if the angular velocity of the turn table is doubled the object slips when its distance from the axis of rotation is

a) 1 cm b) 2 cm c) 4 cm d) 8 cm

524. A ball is projected with kinetic energy K at an angle of $45°$ to the horizontal. At the highest point during its flight, its kinetic energy will be

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

525. Two forces, each of magnitude F, have a resultant of the same magnitude F. The angle between the two forces is

a) 45° b) 120° c) 150° d) 180°

526. For a body moving in a circular path, a condition for no skidding if μ is the coefficient of friction, is

a) $\frac{mv^2}{r} \leq \mu mg$ b) $\frac{mv^2}{r} \geq \mu mg$ c) $\frac{v}{r} = \mu g$ d) $\frac{mv^2}{r} = \mu mg$

527. If the radius of curvature of the path of two particles of same masses are in the ratio 1 : 2, then in order to have constant centripetal force, their velocity, should be in the ratio of

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

528. A car runs at a constant speed on a circular track of radius 100 m, taking 62.8 s for every circular lap. The average velocity and average speed for each circular lap is

a) 0, 0 b) 0,10 ms^{-1} c) 10 ms^{-1}, 10ms^{-1} d) 10 ms^{-1}, 0

529. A particle of mass M is moving in a horizontal circle of radius R with uniform speed V. When it moves from one point to a diametrically opposite point, its

a) Kinetic energy changes by $MV^2/4$
b) Momentum does not change
c) Momentum changes by $2MV$
d) Kinetic energy changes by MV^2

530. A ball is projected up an incline of 30° with a velocity of 30 ms^{-1} at an angle of 30° with reference to the inclined plane from the bottom of the inclined plane. If $g = 10ms^{-2}$, then the range on the inclined plane is

a) 12 m b) 60 m c) 120 m d) 600 m

531. A particle is moving with a constant speed v in a circle. What is the magnitude of average after half rotation?

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

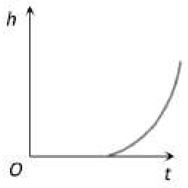
532. A particle is moving in a circle of radius R in such a way that at any instant the normal and tangential components of its acceleration are equal. If its speed at $t = 0$ is v_0, the time taken to complete the first revolution is

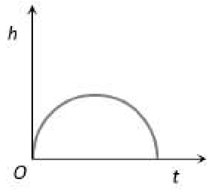
a) $\frac{R}{v_0}$ b) $\frac{R}{v_0}(1 - e^{-2\pi})$ c) $\frac{R}{v_0}e^{-2\pi}$ d) $\frac{2\pi R}{v_0}$

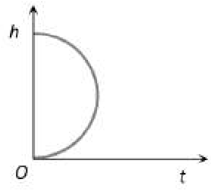
533. A particle is projected from the ground with an initial speed of v at an angle θ with horizontal. The average velocity of the particle between its point of projection and highest point of trajectory is

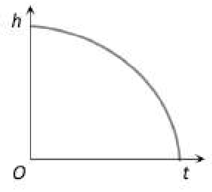
a) $\frac{v}{2}\sqrt{1 + 2\cos^2\theta}$ b) $\frac{v}{2}\sqrt{1 + \cos^2\theta}$ c) $\frac{v}{2}\sqrt{1 + 3\cos^2\theta}$ d) $v\cos\theta$

534. Which of the following is the altitude-time graph for a projectile thrown horizontally from the top of the tower

a) 

b) 

c) 

d) 

535. A plumb line is suspended from a ceiling of a car moving with horizontal acceleration of$a$. What will be the angle of inclination with vertical?

a) $\tan^{-1}\left(\frac{a}{g}\right)$ b) $\tan^{-1}\left(\frac{g}{a}\right)$ c) $cas^{-1}\left(\frac{a}{g}\right)$ d) $cas^{-1}\left(\frac{g}{a}\right)$

536. Centripetal acceleration is

a) A constant vector
b) A constant scalar
c) A magnitude changing vector
d) Not a constant vector

537. $\vec{A} = 3\hat{i} - \hat{j} + 7\hat{k}$ and $\vec{B} = 5\hat{i} - \hat{j} + 9\hat{k}$ the direction cosine m of the vector $\vec{A} + \vec{B}$ is

a) Zero b) $\frac{3}{\sqrt{31}}$ c) $\frac{9}{\sqrt{107}}$ d) 5

538. A particle is projected with velocity $2\sqrt{gh}$ so that it just clears two walls of equal height h, which are at a distance of $2h$ from each other. What is the time interval of passing between the two walls?

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

539. For what value of a, $\vec{A} = 2\hat{i} + a\hat{j} + \hat{k}$ will be perpendicular to $\vec{B} = 4\hat{i} - 2\hat{j} - \hat{k}$

a) 4 b) zero c) 3 d) 1

540. If the body is moving in a circle of radius r with a constant speed v, its angular velocity is

a) v^2/r b) vr c) v/r d) r/v

541. A body is moving in a circular path with acceleration a. If its velocity gets doubled, find the ratio of acceleration after and before the change

a) 1 : 4 b) $\frac{1}{4}:2$ c) 2 : 1 d) 4 : 1

542. A man throws a ball vertically upwards and it rises through 20 m and returns to his hands. What was the initial velocity (u) of the ball and for how much time (T) it remained in the air? ($g = 10\ ms^{-2}$)

a) $u = 10\ ms^{-1}; T = 2\ s$ b) $u = 10\ ms^{-1}; T = 4\ s$ c) $u = 20\ ms^{-1}; T = 2\ s$ d) $u = 20\ ms^{-1}; T = 4\ s$

543. A stone tied to one end of rope and rotated in a circular motion. If the string suddenly breaks, then the stone travels

a) in perpendicular direction
b) in direction of centrifugal force
c) towards centripetal force
d) in tangential direction

544. Neglecting the air resistance, the time of flight of a projectile is determined by

a) U_{vertical} b) $U_{\text{horizontal}}$
c) $U = U^2_{\text{vertical}} + U^2_{\text{horizontal}}$ d) $U = (U^2_{\text{vertical}} + U^2_{\text{horizontal}})^{1/2}$

545. A particle is projected at an angle of 60° above the horizontal with a speed of $10\ ms^{-1}$. After some time the direction of its velocity makes an angle of 30° above the horizontal. The speed of the particle at this instant is

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

546. A ball of mass 0.25 kg attached to the end of string of length 1.96 m moving in a horizontal circle. The string will break if the tension is more than 25 N. What is the maximum speed with which the ball can be moved

a) 14 m/s b) 3 m/s c) 3.92 m/s d) 5 m/s

547. What will be the maximum speed of a car on a road-turn of radius 30m if the coefficient of friction between the tyres and the road is 0.4?

a) $10.84\ ms^{-1}$ b) $9.84\ ms^{-1}$ c) $8.84\ ms^{-1}$ d) $6.84\ ms^{-1}$

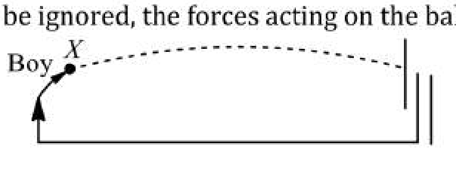
548. Two particles of equal mass are connected to a rope AB of negligible mass such that one is at end A and other dividing the length of rope in the ratio 1 : 2 from B. The rope is rotated about end B in a horizontal plane. Ratio of tensions in the smaller part to the other is (ignore effect of gravity)

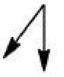
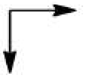
a) 4 : 3 b) 1 : 4 c) 1 : 2 d) 1 : 3

549. A stone of mass 1 kg tied to the end of a string of length 1 m, is whirled in a horizontal circle with a uniform angular velocity 2 rads^{-1}. The tension of the string is (in newton)

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

550. A boy throws a cricket ball from the boundary to the wicket-keeper. If the frictional force due to air cannot be ignored, the forces acting on the ball at the position X are respected by



a)    b)    c)    d) 

551. A stone tied with string, is rotated in a vertical circle. The minimum speed with which the string has to be rotated

a) Is independent of the mass of the stone
b) Is independent of the length of the string
c) Decreases with increasing mass of the stone
d) Decreases with increasing length of the string

552. A body executing uniform circular motion has at any instant its velocity vector and acceleration vector

a) along the same direction
b) in opposite direction
c) normal to each other
d) not related to each other

553. A body is tided with a string and is given a circular motion with velocity v in radius r. The magnitude of the acceleration

a) $\frac{v}{r}$
b) $\frac{v^2}{r}$
c) $\frac{v}{r^2}$
d) $\frac{v^2}{r^2}$

554. Two paper screens A and B are separated by a distance of 200 m. A bullet pierces A and then B. The hole in B is 40 cm below the hole in A. If the bullet is travelling horizontally at the time of hitting A, then the velocity of the bullet at A is

a) 200 ms^{-1}
b) 400 ms^{-1}
c) 600 ms^{-1}
d) 700 ms^{-1}

555. A 100 kg car is moving with a maximum velocity of 9 m/s across a circular track of radius 30 m. The maximum force of friction between the road and the car is

a) 1000 N
b) 706 N
c) 270 N
d) 200 N

556. 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

557. A force of $(7\hat{\imath} + 6\hat{k})$ N makes a body move on a rough plane with a velocity of $(3\hat{\jmath} + 4\hat{k})\text{ms}^{-1}$. Calculate the power in watt

a) 24
b) 34
c) 21
d) 45

558. A body is moving with a certain velocity in a circular path. Now, the body reverses its direction, then

a) the magnitude of centripetal force remains same
b) the direction of centripetal force remains same
c) the direction of centripetal acceleration remains same
d) the of centripetal force does not change

559. 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

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

560. A 500 kg car takes a round of radius 50 m with a velocity of 36 kmh^{-1}. The centripetal force is

a) 250 N
b) 750 N
c) 1000 N
d) 1200 N

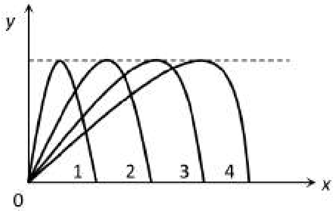
561. A man, using a 70 kg garden roller on a level surface exerts a force of 200 N at 45° to the ground. What is the vertical force of the roller on the ground, if he pushed the roller? $(g = 10\text{ms}^{-2})$

a) 70 N
b) 200 N
c) 560 N
d) 840 N

562. A particle is projected with speed v at an angle θ $\left(0 < \theta < \frac{\pi}{2}\right)$ above the horizontal from a height H above the ground. If v = speed with which particle hits the ground and t =time taken by particle to reach ground, then

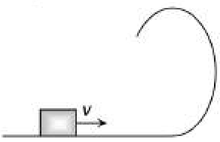
a) As θ increases, v decreases and t increases
b) As θ increases, v increases and t increases
c) As θ increases, v remains same and t increases
d) As θ increases, v remains same and t decreases

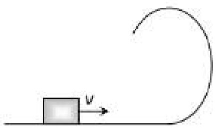
563. Figure shows four paths for a kicked football. Ignoring the effects of air on the flight, rank the paths according to initial horizontal velocity component, highest first

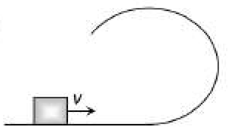


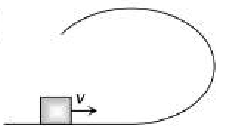
a) 1, 2, 3, 4 b) 2, 3, 4, 1 c) 3, 4, 1, 2 d) 4, 3, 2, 1

564. A small block is shot into each of the four tracks as shown below. Each of the tracks rises to the same height. The speed with which the block enters the track is the same in all cases. At the highest point of the track, the normal reaction is maximum in

a) 

b) 

c) 

d) 

565. A sphere is suspended by a thread of length l. The minimum horizontal velocity which has to be imparted to the sphere for it to reach the height of suspension is

a) $2\sqrt{gR}$ b) $\sqrt{2gl}$ c) $2\,g\,l$ d) $g\,l$

566. The torque of a force $\vec{F} = -3\hat{i} + \hat{j} + 5\hat{k}$ acting at a point is $\vec{\tau}$. If the position vector of the point is $7\hat{i} + \hat{j} + \hat{k}$, then $\vec{\tau}$ is

a) $7\hat{i} - 8\hat{j} + 9\hat{k}$ b) $14\hat{i} - \hat{j} + 3\hat{k}$ c) $2\hat{i} - 3\hat{j} + 8\hat{k}$ d) $14\hat{i} - 38\hat{j} + 16\hat{k}$

567. The coordinates of a moving particle at any time 't' are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time 't' is given by

a) $\sqrt{\alpha^2 + \beta^2}$ b) $3t\sqrt{\alpha^2 + \beta^2}$ c) $3t^2\sqrt{\alpha^2 + \beta^2}$ d) $t^2\sqrt{\alpha^2 + \beta^2}$

568. A car when passes through a convex bridge exerts a force on it which is equal to

a) $Mg + \frac{Mv^2}{r}$ b) $\frac{Mv^2}{r}$ c) Mg d) None of these

569. The acceleration of a vehicle travelling with speed of $400 ms^{-1}$ as it goes round a curve of radius 160 m, is

a) $1\ kms^{-2}$ b) $100\ ms^{-2}$ c) $10\ ms^{-2}$ d) $1\ ms^{-2}$

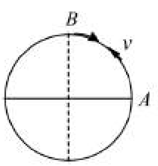
570. A cyclist turns around a curve at 15 miles/hour. If the turns at double the speed, the tendency to overturn is

a) Doubled b) Quadrupled c) Halved d) Unchanged

571. A force is inclined at 60° to the horizontal. If its rectangular component in the horizontal direction is 50 N, then magnitude of the force in the vertical direction is

a) 25 N b) 75 N c) 87 N d) 100 N

572. A body of mass m is moving with a uniform speed v along a circle of radius r, what is the average acceleration in going from A to B?



a) $2v^2/\pi r$ b) $2\sqrt{2}v^2/\pi r$ c) $v^2/\pi r$ d) None of these

573. Two particles A and B are projected with same speed so that the ratio of their maximum heights reached is 3 : 1. If the speed of A is doubled without altering other parameters, the ratio of the horizontal ranges attained by A and B is

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

574. What should be the angular velocity of earth so that a body on its equator is weightless?

a) $\frac{1}{8000}$ rad s^{-1} b) $\frac{1}{8}$ rad s^{-1} c) $\frac{1}{800}$ rad s^{-1} d) $\frac{1}{80}$ rad s^{-1}

575. An object is tied to a string and rotated in a vertical circle of radius r. Constant speed is maintained along the trajectory. If $T_{max}/T_{min} = 2$, then v^2/rg is

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

576. A chain of 125 links is 1.25 m long and has mass of 2 kg with the ends fastened together. It is set for rotating at 50 $revs^{-1}$, centripetal force on each links is

a) 3.14 N b) 0.314 N c) 314 N d) None of these

577. At the height 80 m, an aeroplane is moving with 150 ms^{-1}. A bomb is dropped from it, so as to hit a target. At what distance from the target should bomb be dropped? ($g = 10\ ms^{-2}$)

a) 605.3 m b) 600m c) 80 m d) 230m

578. Given $\vec{A} = 4\hat{i} + 6\hat{j}$ and $\vec{B} = 2\hat{i} + 3\hat{j}$. Which of the following is correct?

a) $\vec{A} \times \vec{B} = \vec{0}$

b) $\vec{A} \cdot \vec{B} = 24$

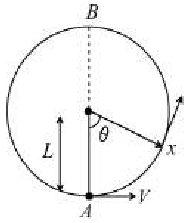
c) $\frac{|\vec{A}|}{|\vec{B}|} = \frac{1}{2}$

d) $\vec{A}$ and $\vec{B}$ are anti-parallel

579. If $\vec{A} = 2\hat{i} + 3\hat{j} + 6\hat{k}$ and $\vec{B} = 3\hat{i} - 6\hat{j} + 2\hat{k}$, then vector perpendicular to both $\vec{A}$ and $\vec{B}$ has magnitude k times that $(6\hat{i} + 2\hat{j} - 3\hat{k})$. That k is equal to

a) 1 b) 4 c) 7 d) 9

580. A bob of mass M is suspended by a massless string of length L. The horizontal velocity V at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies

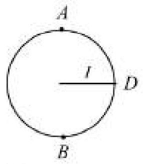


a) $\theta = \frac{\pi}{4}$ b) $\frac{\pi}{4} < \theta < \frac{\pi}{4}$ c) $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$ d) $\frac{3\pi}{4} < \theta < \pi$

581. A body is projected with initial velocity of $(8\hat{\mathbf{i}} + 6\hat{\mathbf{j}})ms^{-1}$. The horizontal range is

a) 9.6 m b) 14 m c) 50 m d) None of these

582. A particle of mass m attracted with a string of length l is just revolving on the vertical circle without slacking of the string. If v_A, v_B and v_D are speed at position A, B and D then



a) $v_B > v_D > v_A$

b) Tension in string at $D = 3\ mg$

c) $v_D = \sqrt{3gl}$

d) All of the above

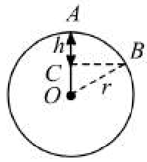
583. An aeroplane flying horizontally with a speed of 360 kmh^{-1} releases a bomb at a height of 490 m from the ground. When will the bomb strike the ground?

a) 8 s b) 6 s c) 7 s d) 10 s

584. An aeroplane flying at a velocity of 900 kmh^{-1} loops the loop. If the maximum force pressing the pilot against the seat is five times its weight, the loop radius should be

a) 1594 m b) 1402 m c) 1315 m d) 1167 m

585. In figure, a particle is placed at the highest point A of a smooth sphere of radius r. It is given slight push, and it leaves the sphere at B, at a depth h vertically below A such that h is equal to



a) $\frac{r}{6}$ b) $\frac{1}{4}r$ c) $\frac{1}{3}r$ d) $\frac{1}{2}r$

586. A string breaks if its tension exceeds 10 *newtons*. A stone of mass 250 *gm* tied to this string of length 10 *cm* is rotated in a horizontal circle. The maximum angular velocity of rotation can be

a) 20 rad/s b) 40 rad/s c) 100 rad/s d) 200 rad/s

587. A cannon of a level plane is aimed at an angle θ above the horizontal and a shell is fired muzzle velocity v_0 towards a cliff D distance away. The height at which the canon strikes the cliff is given by

a) $D\sin\theta-\frac{1}{2}\frac{gD^2}{v_0^2\sin^2\theta}$ b) $D\cos\theta-\frac{1}{2}\frac{gD^2}{v_0^2\sin^2\theta}$

c) $D\tan\theta-\frac{1}{2}\frac{gD^2}{v_0^2\cos^2\theta}$ d) $D\tan\theta-\frac{1}{2}\frac{gD^2}{v_0^2\sin^2\theta}$

588. A body of mass 1 kg is moving in a vertical circular path of radius 1 m. The difference between the kinetic energies at its highest and lowest point is

a) 20 J b) 10 J c) $4\sqrt{5}$ J d) $10\sqrt{5}$ J

589. The $x-y$ plane is the boundary between two transparent media. A medium I has a refractive index $\mu_1=\sqrt{2}$ and medium II has a refractive index $\mu_2=\sqrt{3}$. A ray of light in medium I, given by vector, $\vec{A}=\sqrt{3}\hat{\imath}-\hat{k}$ is incident on the plane of separation. The unit vector in the direction of the refracted ray in medium II is

a) $\frac{1}{\sqrt{2}}(\hat{\imath}+\hat{k})$ b) $\frac{1}{\sqrt{2}}(\hat{\imath}+\hat{\jmath})$ c) $\frac{1}{\sqrt{2}}(\hat{k}-\hat{\imath})$ d) $\frac{1}{\sqrt{2}}(\hat{\imath}-\hat{k})$

590. What is the angle between $\vec{P}$ and $\vec{Q}$. The resultant of $(\vec{P}+\vec{Q})$ and $(\vec{P}-\vec{Q})$?

a) Zero b) $\tan^{-1}(P/Q)$

c) $\tan^{-1}(Q/P)$ d) $\tan^{-1}(P-Q)/(P+Q)$

591. Given, $\vec{P}=\vec{A}+\vec{B}$ and $P=A+B$. The angle between $\vec{A}$ and $\vec{B}$ is

a) 0° b) $\frac{\pi}{4}$ c) $\frac{\pi}{2}$ d) π

592. A cyclist moves in such a way that he track 60° turn after 100 m. What is the displacement when to takes seventh turn?

a) 100 m b) 200 m c) $100\sqrt{3}$ m d) $100\sqrt{3}$ m

593. A roller coaster is designed such that riders experience "weightlessness" as they go round the top of a hill whose radius of curvature is 20 m. The speed of the car at the top of the hill is between

a) 16 m/s and 17 m/s b) 13 m/s and 14 m/s c) 14 m/s and 15 m/s d) 15 m/s and 16 m/s

594. A particle of mass m is circulating on a circle of radius r having angular momentum L, then the centripetal force will be

a) L^2/mr b) L^2m/r c) L^2/mr^3 d) L^2/mr^2

595. The ratio of the angular speed of minutes hand and hour hand of a watch is

a) 6 : 1 b) 12 : 1 c) 1 : 6 d) 1 : 12

596. The string of pendulum of length l is displaced through 90° from the vertical and released. Then the minimum strength of the string in order to withstand the tension, as the pendulum passes through the mean position is

a) mg b) $3mg$ c) 5 mg d) 6 mg

597. A coin is placed on a gramophone record rotating at a speed of 45 rpm. It flies away when the rotational speed is 50 rpm. If two such coins are placed over the other on the same record, both of them will fly away when rotational speed is

a) 100 rpm b) 25 rpm c) 12.5 rpm d) 50 rpm

598. A mass of 100 g is tied to one end of string 2 m long. The body is revolving in a horizontal circle making a maximum of 200 revolutions/min. The other end of the string is fixed at the centre of the circle of revolution. The maximum tension that the string can bear is approximately

a) 8.76 N b) 8.94 N c) 89.42 N d) 87.64 N

599. A cyclist goes round a circular path of circumference 34.3 m in $\sqrt{22}$ sec. the angle made by him, with the vertical, will be

a) 45° b) 40° c) 42° d) 48°

600. A boy throws a ball upwards with velocity $u = 15\text{ms}^{-1}$. The wind imparts a horizontal acceleration of $3\text{ms}^{-1}$to the left. The angel θ at which the ball must be thrown so that the ball returns to the boy's hand is (use $\text{g} = 10\text{ ms}^{-2}$)

a) $\tan^{-1}(0.4)$ b) $\tan^{-1}(0.2)$ c) $\tan^{-1}(0.3)$ d) $\tan^{-1}(0.15)$

601. The velocity of projection of an oblique projectile is $(6\hat{\imath} + 8\hat{\jmath})\text{ms}^{-1}$. The horizontal range of the projectile is

a) 4.9 m b) 9.6 m c) 19.6 m d) 14 m

602. If a body A of mass M is thrown with velocity V at an angle of 30° to the horizontal and another body B of the same mass is thrown with the same speed at an angle of 60° to the horizontal. The ratio of horizontal range of A to B will be

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

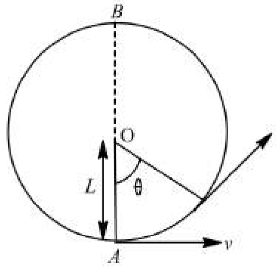
603. Two projectiles thrown from the same point at angles 60° and 30° with the horizontal attain the same height. The ratio of their initial velocities is

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

604. A car is moving on a circular road of diameter 50 m with a speed of 5 ms^{-1}. It is suddenly accelerated at rate 1 ms^{-2}. If the mass is 500 kg, find the net force acting on the car

a) 5 N b) 1000 N c) $500\sqrt{2}$ N d) $500/\sqrt{2}$ N

605. A bob of mass M is suspended by a massless string of length L. The horizontal velocity v at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies



a) $\theta = \frac{\pi}{4}$ b) $\frac{\pi}{4} < \theta < \frac{\pi}{2}$ c) $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$ d) $\frac{3\pi}{4} < \theta < \pi$

606. A stone is thrown with a velocity v making an angle θ with the horizontal. At some instant, its velocity V is perpendicular to the initial velocity v. Then V is

a) $v \sin\theta$ b) $v \cos\theta$ c) $v \tan\theta$ d) $v \cot\theta$

607. A cycle wheel of radius 0.4 m completes one revolution in one *second* then the acceleration of a point on the cycle wheel will be

a) 0.8 m/s^2 b) 0.4 m/s^2 c) 1.6 $\pi^2 m/s^2$ d) 0.4 $\pi^2 m/s^2$

608. If $\vec{A}_1$ and $\vec{A}_2$ are two non-collinear unit vectors and if $|\vec{A}_1 + \vec{A}_2| = \sqrt{3}$, then the value of $(\vec{A}_1 - \vec{A}_2)\cdot(2\vec{A}_1 + \vec{A}_2)$ is

a) 1 b) 1/2 c) 3/2 d) 2

609. A body of mass m is projected with a speed u making an angle α with the horizontal. The change in momentum suffered by the body along he y-axis between the starting point and the highest point of its path will be

a) $mu \cos\alpha$ b) $mu \sin\alpha$ c) 3 $mu \sin\alpha$ d) mu

610. For a particle in uniform circular motion, thee acceleration $\vec{a}$ at a point $P(R,\theta)$ on the circle of radius R is (Here θ is measured from the x-axis)

a) $\frac{v^2}{R}\hat{\imath}+\frac{v^2}{R}\hat{\jmath}$
b) $-\frac{v^2}{R}\cos\theta\,\hat{\imath}+\frac{v^2}{R}\sin\theta\,\hat{\jmath}$
c) $-\frac{v^2}{R}\sin\theta\,\hat{\imath}+\frac{v^2}{R}\cos\theta\,\hat{\jmath}$
d) $-\frac{v^2}{R}\cos\theta\,\hat{\imath}-\frac{v^2}{R}\sin\theta\,\hat{\jmath}$

611. A particle moves in a circular path with decreasing speed. Choose the correct statement.

a) Angular momentum remains constant
b) Acceleration (**a**) is towards the center
c) Particle moves in a spiral path with decreasing radius
d) The direction of angular momentum remains constant

612. The string of a pendulum of length l is displaced through 90° from the vertical and released. Then the minimum strength of the string in order to withstand the tension as the pendulum passes through the mean position is

a) mg b) 6 mg c) 3 mg d) 5 mg

613. The maximum speed of a car on a road-turn of radius 30 m, if the coefficient of friction between the tyres and the road is 0.4, will be

a) 10.84 m/sec b) 9.84 m/sec c) 8.84 m/sec d) 6.84 m/sec

614. A particle moves in the $x-y$ plane with velocity $v_x=8t-2$ and $v_y=2$. If it passes through the pointy $x=14$ and $y=4$ at $t=2s$, find the equation ($x-y$ relation) of the path

a) $x=y^2-y+2$
b) $x=2y^2+2y-3$
c) $x=3y^2+5$
d) Can not be found from above data

615. A particle of mass m is tied to one end of a string of length l and rotated through the other end along a horizontal circular path with speed v. The work done in half horizontal circle is

a) Zero b) $\left(\frac{mv^2}{l}\right)2\pi l$ c) $\left(\frac{mv^2}{l}\right)\pi l$ d) $\left(\frac{mv^2}{l}\right)l$

616. A body is projected with a speed u m/s at an angle β with the horizontal. The kinetic energy at the highest point is $\frac{3}{4}$ th of the initial energy. The values of β is

a) 30° b) 45° c) 60° d) 120°

617. A car takes a turn around a circular curve. If it turns at double the speed, the tendency to overturn is

a) Halved b) Doubled c) Quadrupled d) Unchanged

618. Galileo writes that for angles of projection of a projectile at angles $(45+\theta)$ and $(45-\theta)$, the horizontal ranges described by the projectile are in the ratio of (if $\theta\leq 45$)

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

619. A particle revolves around a circular path. The acceleration of the particle is

a) Along the circumference of the circle
b) Along the tangent
c) Along the radius
d) Zero

620. A fan is making 600 revolutions per $minute$. If after some time it makes 1200 revolutions per $minute$, then increase in its angular velocity is

a) 10 π rad/sec b) 20 π rad/sec c) 40 π rad/sec d) 60 π rad/sec

621. A stone of mass 16 kg is attached to a string 144 m long and is whirled in a horizontal circle. The maximum tension the string can withstand is 16 $Newton$. The maximum velocity of revolution that can be given to the stone without breaking it, will be

a) 20 ms^{-1} b) 16 ms^{-1} c) 14 ms^{-1} d) 12 ms^{-1}

622. A wheel completes 2000 revolutions to cover the 9.5 km distance, then the diameter of the wheel is

a) 1.5 m b) 1.5 cm c) 7.5 cm d) 7.5 m

623. Two tall buildings are 40 m apart. With what speed must a ball be thrown horizontally from a window 145 m above the ground in one building, so that it will enter a window 22.5 m from the ground in the other?

a) 5 ms^{-1} b) 8 ms^{-1} c) 10 ms^{-1} d) 16 ms^{-1}

624. Two stones are projected with same velocity v at an angle θ and $(90° - θ)$. If H and H_1 are greatest heights in the two paths, what is the relation between R, H and H_1?

a) $R = 4\sqrt{HH_1}$ b) $R = \sqrt{HH_1}$ c) $R = 4HH_1$ d) None of these

625. The angular speed of a fly wheel making 120 $revolutions/minute$ is

a) $2\pi\ rad/s$ b) $4\pi^2\ rad/s$ c) $\pi\ rad/s$ d) $4\pi\ rad/s$

626. The horizontal range is four times the maximum height attained by a projectile. The angle of projection is

a) 90° b) 60° c) 45° d) 30°

627. A vector $\vec{F_1}$ is along the positive Y-axis. If its vector product with another vector $\vec{F_1}$ is zero, then $\vec{F_2}$ could be

a) $4\hat{j}$ b) $\hat{j} + \hat{k}$ c) $\hat{j} - \hat{k}$ d) $-4\hat{i}$

628. For a projectile the ratio of maximum height reached to the square of time of flight is ($g = 10\ ms^{-1}$)

a) 5 : 1 b) 5 : 2 c) 5 : 4 d) 1 : 1

629. The sum of the magnitudes of two forces acting at a point is 16 N. the resultant of these forces is perpendicular to the smaller force has a magnitude of 8 N. If the smaller force is magnitude x, then the value of x is

a) 2 N b) 4 N c) 6 N d) 7 N

630. For an object thrown at 45° to horizontal, the maximum height (H) and horizontal range (R) are related as

a) $R = 16H$ b) $R = 8H$ c) $R = 4H$ d) $R = 2H$

631. A gramophone disc is set revolving in a horizontal plane and reaches a steady state of motion of two revolutions per second. It is found that a small coin placed on the disc will remain there if its centre is not more than 5 cm from the axis of rotation; the coefficient of friction between the coin and the disc is

a) 0.2 b) 0.4 c) 0.6 d) 0.8

632. A hollow sphere has radius 6.4 m. Minimum velocity required by a motor cyclist at bottom to complete the circle will be

a) 17.7 m/s b) 10.2 m/s c) 12.4 m/s d) 16.0 m/s

633. If $\vec{A} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ and $\vec{B} = 4\hat{i} + 3\hat{j} + 2\hat{k}$, then angle between $\vec{A}$ and $\vec{B}$ is

a) $\sin^{-1}(25/29)$ b) $\sin^{-1}(29/25)$ c) $\cos^{-1}(25/29)$ d) $\cos^{-1}(29/25)$

634. A curved road of diameter 1.8 km is banked so that no friction is required at a speed of 30 ms^{-1}. What is the banking angle?

a) 6° b) 16° c) 26° d) 0.6°

635. An aeroplane moving horizontally with a speed of 720 km/h drops a food pocket, while flying at a height of 396.9 m. The time taken by a food pocket to reach the ground and its horizontal range is (Take $g = 9.8\ m/sec^2$)

a) 3 sec and 2000 m b) 5 sec and 500 m c) 8 sec and 1500 m d) 9 sec and 1800 m

636. If retardation produced by air resistance of projectile is one-tenth of acceleration due to gravity, the time to reach maximum height

a) Decreases by 11 percent b) Increases by 11 percent

c) Decreases by 9 percent d) Increases by 9 percent

637. A body crosses the topmost point of a vertical circle with critical speed. Its centripetal acceleration, when the string is horizontal will be

a) 6 g b) 3 g c) 2 g d) g

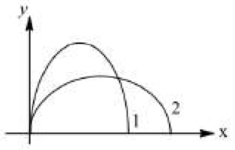
638. In the above question, the percentage increase in the time of flight of the projectile will be

a) 5% b) 10% c) 15% d) 20%

639. An aeroplane moving horizontally at a speed of 200 ms^{-1} and at a height of 8×10^3 m is to drop a bomb on a target. At what horizontal distance from the target should the bomb be released? (Take $g = 10\ ms^{-2}$)

a) 9124 m b) 8714 m c) 8000 m d) 7234 m

640. Trajectories of two projectiles are shown in figure. Let T_1 and T_2 be the time periods and u_1 and u_2 their speeds of projection. Then



a) $T_2 > T_1$ b) $T_1 = T_2$ c) $u_1 > u_2$ d) $u_1 < u_2$

641. A particle of mass 100 g tied to a string is rotated along circle of radius 0.5 m. The breaking tension of string is 10 N. The maximum speed with which particle can rotated without breaking the string is

a) 10 ms^{-2} b) 9.8 ms^{-2} c) 7.7 ms^{-2} d) 7.07 ms^{-2}

642. When the road is dry and coefficient of friction is μ, the maximum speed of a car in a circular path is 10 ms^{-1}. If the road becomes wet and $\mu' = \mu/2$, what is the maximum speed permitted?

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

643. A vector $\vec{A}$ points vertically upwards and $\vec{B}$ points upwards North. The vector product $\vec{A} \times \vec{B}$ is

a) Zero b) along East

c) along West d) vertically downwards

644. A very broad elevator is going up vertically with a constant acceleration of 2 ms^{-2}. At the instant when its velocity is 4 ms^{-1} a ball is projected from the floor of the list with a speed of 4 ms^{-1} relative to the floor at an elevation of 30°. The time taken by the ball to return the floor is ($g = 10$ ms^{-2})

a) 1/2 s b) 1/3 s c) 1/4 s d) 1 s

645. An aeroplane is flying horizontally with a velocity of 600 km/h at a height of 1960 m.
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

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

646. A particle P is moving in a circle of radius r with a uniform speed v. C is the centre of the circle and AB is the diameter. The angular velocity of P about A and C is in ratio

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

647. A bridge is in the form of a semi-circle of radius 40m. The greatest speed with which a motor cycle can cross the bridge without leaving the ground at the highest point is ($g = 10$ ms^{-2})
(frictional force is negligibly small)

a) 40 ms^{-1} b) 20 ms^{-1} c) 30 ms^{-1} d) 15 ms^{-1}

648. In an atom for the electron to revolve around the nucleus, the necessary centripetal force is obtained from the following force exerted by the nucleus on the electron

a) Nuclear force b) Gravitational force c) Magnetic force d) Electrostatics force

649. If KE of the particle of mass m performing UCM in a circle of radius r is E. Find the acceleration of the particale

a) $\frac{2E}{mr}$ b) $\left(\frac{2E}{mr}\right)^2$ c) $2\,Emr$ d) $\frac{4E}{mr}$

650. A particle moves with constant speed v along a circular path of radius r and completes the circle in time T. The acceleration of the particle is

a) $2\pi v/T$ b) $2\pi r/T$ c) $2\pi r^2/T$ d) $2\pi v^2/T$

651. A bomb is dropped on an enemy post by an aeroplane flying horizontally with a velocity of 60 kmh^{-1} and at a height of 490 m. At the time of dropping the bomb, how far the aeroplane should be from the enemy post so that the bomb may directly hit the target?

a) $\frac{400}{3}$ m b) $\frac{500}{3}$ m c) $\frac{1700}{3}$ m d) 498 m

652. A projectile of mass m is thrown with a velocity v making an angle of 45° with the horizontal. The change in momentum from departure to arrival along vertical direction, is

a) $2mv$ b) $\sqrt{2}\,mv$ c) mv d) $\frac{mv}{2}$

653. A car is moving rectilinearly on a horizontal path with acceleration a_0. A person sitting inside the car observes that an insect S is crawling up the screen with an acceleration a. If θ is the inclination of the screen with the horizontal the acceleration of the insect

a) Parallel to screen is $a + a_0 \cos\theta$
b) Along the horizontal is $a_0 - a\cos\theta$
c) Perpendicular to screen is $a_0 \sin\theta$
d) Perpendicular to screen is $a_0 \tan\theta$

654. A projectile can have the same range R for two angles of projection. If T_1 and T_2 be the times of flights in the two cases, then the product of the two times of flights is directly proportional to

a) $\frac{1}{R^2}$
b) $\frac{1}{R}$
c) R
d) R^2

655. Three particles A, B and C are projected from the same point with the same initial speeds making angles30°, 45° and 60° respectively with the horizontally. Which of the following statements is correct?

a) A,B and C have unequal ranges
b) Range of A and C are less than that of B
c) Range of A and C are equal and greater than that of B
d) A,B and C have equal ranges

656. A projectile moves from the ground such that its horizontal displacement is $x = Kt$ and vertical displacement is $y = Kt(1 - \alpha t)$, where K and α are constants and t is time. Find out total time of flight (T) and maximum height attained (Y_{max}) its

a) $T = \alpha, Y_{max} = \frac{K}{2\alpha}$
b) $T = \frac{1}{\alpha}, Y_{max} = \frac{2K}{\alpha}$
c) $T = \frac{1}{\alpha}, Y_{max} = \frac{K}{6\alpha}$
d) $T = \frac{1}{\alpha}, Y_{max} = \frac{K}{4\alpha}$

657. A man standing on the roof of a house of height h throws one particle vertically downwards and another particle horizontally with the same velocity u. The ratio of their velocities when they reach the earth's surface will be

a) $\sqrt{2gh + u^2} : u$
b) 1: 2
c) 1: 1
d) $\sqrt{2gh + u^2} : \sqrt{2gh}$

658. The force required to keep a body in uniform circular motion is

a) Centripetal force
b) Centrifugal force
c) Resistance
d) None of the above

659. A projectile is fired with a velocity v at right angle to the slope which is inclined at an angle θ with the horizontal. What is the time of flight?

a) $\frac{2v^2}{g}\tan\theta$
b) $\frac{v^2}{g}\tan\theta$
c) $\frac{2v^2}{g}\sec\theta$
d) $\frac{2v^2}{g}\tan\theta\sec\theta$

660. One o the rectangular components of a velocity of 60kmh^{-1} is 30 kmh^{-1}. The other rectangular component is

a) 30 kmh^{-1}
b) 30 $\sqrt{3}$ kmh^{-1}
c) 30 $\sqrt{2}$ kmh^{-1}
d) Zero

661. A ball of mass 0.1 kg is suspended by a string. It is displaced through an angle of 60° and left. When the ball passes through the mean position, the tension in the string is

a) 19.6 N
b) 1.96 N
c) 9.8 N
d) Zero

662. The vectors $2\hat{i} + 3\hat{j} - 2\hat{k}, 5\hat{i} + a\hat{j} + \hat{k}$ and $-\hat{i} + 2\hat{j} + 3\hat{k}$ are coplanar when a is

a) −9
b) 9
c) −18
d) 18

663. The centripetal acceleration of a body moving in a circle of radius 100 m with a time period of 2 s will be

a) 98.5 ms^{-2}
b) 198.5 ms^{-2}
c) 49.29 ms^{-2}
d) 985.9 ms^{-2}

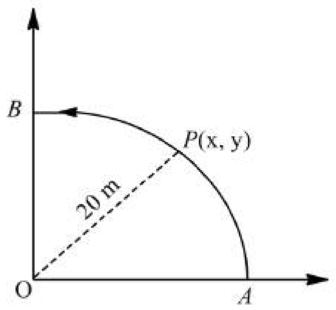
664. An electric fan has blades of length 30 cm measured from the axis of rotation. If the fan is rotating at 120 rpm, the acceleration of a point on the tip of the blade is

a) 1600 ms^{-2}
b) 47.4 ms^{-2}
c) 23.7 ms^{-2}
d) 50.55 ms^{-2}

665. A bucket full of water is revolved in vertical circle of radius 2m. What should be the maximum time-period of revolution so that the water doesn't fall of the bucket

a) 1 sec
b) 2 sec
c) 3 sec
d) 4 sec

666. A point P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of P is such that it sweeps out length $s = t^3 + 5$, where s is in metre and t is in second. The radius of the path is 20 m. The acceleration of P when t=2s is nearly



a) 13 ms $^{-2}$ b) 12 ms $^{-2}$ c) 7.2 ms $^{-2}$ d) 14 ms $^{-2}$

667. A boy is hanging from a horizontal branch of a tree. The tension in the arms will be maximum when the angle between the arms is

a) 0° b) 60° c) 90° d) 120°

668. An aeroplane is flying at a constant horizontal velocity of 600 km/hr at an elevation of 6 km towards a point directly above the target on the earth's surface. At an appropriate time, the pilot releases a ball so that it strikes the target at the earth. The ball will appear to be falling

a) On a parabolic path as seen by pilot in the plane

b) Vertically along a straight path as seen by an observer on the ground near the target

c) On a parabolic path as seen by an observer on the ground near the target

d) On a zig-zag path as seen by pilot in the plane

669. A coin, placed on a rotating turn-table slips, when it is placed at a distance of 9 cm from the centre. If the angular velocity of the turn-table is tripled, it will just slip, if its distance from the centre is

a) 27 cm b) 9 cm c) 3 cm d) 1 cm

670. A ball is projected with kinetic energy E at an angle of 45° to the horizontal. At the highest point during its flight, its kinetic energy will be

a) Zero b) $^{E}/_{2}$ c) $^{E}/_{\sqrt{2}}$ d) E

671. A boy on a cycle pedals around a circle of 20 *metres* radius at a speed of 20 *metres/sec*. The combined mass of the boy and the cycle is 90 kg.The angle that the cycle makes with the vertical so that it may not fall is ($g = 9.8\ m/sec^2$)

a) 60.25° b) 63.90° c) 26.12° d) 30.00°

672. A stone of mass 1 kg tied to a light inextensible string of length $L = \frac{10}{3} m$ is whirling in a circular path of radius L in a vertical plane. If the ratio of the maximum tension in the string to the minimum tension in the string is 4 and if g is taken to be $10 m/\sec^2$, the speed of the stone at the highest point of the circle is

a) $20m/sec$ b) $10\sqrt{3}m/sec$ c) $5\sqrt{2}m/sec$ d) $10m/sec$

673. A stone is tied at one end of a 5m long string and whirled in a vertical circle. The minimum speed required to just cross the topmost position is

a) 5 ms^{-1} b) 7 ms^{-1} c) 57 ms^{-1} d) 75 ms^{-1}

674. If $\vec{P} = 4\hat{i} - 2\hat{j} + 6\hat{k}$ and $\vec{Q} = \hat{i} - 2\hat{j} - 3\hat{k}$, then the angle which $\vec{P} + \vec{Q}$ makes with x-axis is

a) $\cos^{-1}\left(\frac{3}{\sqrt{50}}\right)$ b) $\cos^{-1}\left(\frac{4}{\sqrt{50}}\right)$ c) $\cos^{-1}\left(\frac{5}{\sqrt{50}}\right)$ d) $\cos^{-1}\left(\frac{12}{\sqrt{50}}\right)$

675. A particle is moving in a circle of radius R with constant speed$v$. If radius is doubled, then its centripetal force to keep the same speed gets

a) twice as great as before b) half

c) one-fourth d) remains constant

676. 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) 5% b) 10% c) 15% d) 20%

677. A proton of mass $1.6 \times 10^{-27} kg$ goes round in a circular orbit of radius 0.10 m under a centripetal force of 4×10^{-13} N. then the frequency of revolution of the proton is about

a) 0.08×10^8 *cycles per sec*
b) 4×10^8 *cycles per sec*
c) 8×10^8 *cycles per sec*
d) 12×10^8 *cycles per sec*

678. Two bodies are thrown up at angles of $45°$ and $60°$, respectively with the horizontal. If both bodies attain same vertical height , then the ratio of velocities with which these are thrown is

a) $\sqrt{\frac{2}{3}}$
b) $\frac{2}{\sqrt{3}}$
c) $\sqrt{\frac{3}{2}}$
d) $\frac{\sqrt{3}}{2}$

679. A particle is projected with velocity V_0 along x-axis. The deceleration on the particle is proportional to the square of the distance from the origin i.e. $a = \alpha x^2$, the distance at which the particle stops is

a) $\sqrt{\frac{3V_0}{2\alpha}}$
b) $\left(\frac{3V_0}{2\alpha}\right)^{\frac{1}{3}}$
c) $\sqrt{\frac{2V_0^2}{3\alpha}}$
d) $\left(\frac{3V_0^2}{2\alpha}\right)^{\frac{1}{3}}$

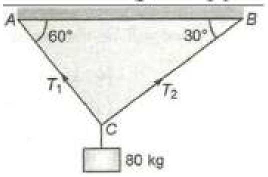
680. A proton of velocity $(3\hat{\imath} + 2\hat{\jmath}) \times 10^5 \mathrm{ms}^{-1}$ enters a magnetic field $(2\hat{\imath} + 3\hat{k})$T. If the specific charge is $9.6 \times 10^7 \mathrm{C\,kg}^{-1}$. The acceleration of the proton in ms^{-2} is

a) $(6\hat{\imath} - 9\hat{\jmath} + 4\hat{k}) \times 9.6 \times 10^{12}$
b) $(6\hat{\imath} + 9\hat{\jmath} + 4\hat{k}) \times 9.6 \times 10^{12}$
c) $(6\hat{\imath} - 9\hat{\jmath} - 4\hat{k}) \times 9.6 \times 10^{12}$
d) $(6\hat{\imath} + 9\hat{\jmath} - 4\hat{k}) \times 9.6 \times 10^{12}$

681. A project 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 ($g = 10\ ms^{-2}$)

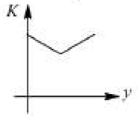
a) 1 : 5
b) 5 : 1
c) 1 : 40
d) 40 : 1

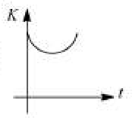
682. A man 80 kg is supported by two cables as shown in the figure. Then the ratio of tensions T_1 and T_2 is

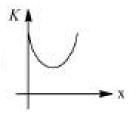


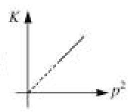
a) 1:1
b) 1:$\sqrt{3}$
c) $\sqrt{3}$: 1
d) 1:3

683. A particle is projected up from a point at an angle with the horizontal. At any time t if p =linear momentum, y =vertical displacement, x =horizontal displacement, then the kinetic energy (K) of the particle plotted against these parameters can be

a) 

b) 

c) 

d) 

684. A wheel of radius 1m rolls forward half a revolution on a horizontal ground. The magnitude to the displacement of the point of the wheel initially in contact with the ground is

a) 2π
b) $\sqrt{2\pi}$
c) $\sqrt{\pi^2 + 4}$
d) π

685. 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 4 m in a vertical plane. If $g = 10\ ms^{-2}$, then the maximum angular velocity of the stone will be

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

686. Two forces, each equal to $\frac{P}{2}$, act at right angles. Their effect may be neutralized by a third force acting along their bisector in the opposite direction with a magnitude of

a) P
b) $\frac{P}{2}$
c) $\frac{P}{\sqrt{2}}$
d) $\sqrt{2}\,P$

687. A roller coaster is designed such that riders experience 'weightlessness' as they go round the top of a hill whose radius of curvature is 20 m. The speed of the car at the top the hill is between

a) 14 ms^{-1} and 15 ms^{-1}
b) 15 ms^{-1} and 16 ms^{-1}
c) 16 ms^{-1} and 17 ms^{-1}
d) 13 ms^{-1} and 14 ms^{-1}

688. What is the numerical value of the vector $3\hat{\imath} + 4\hat{\jmath} + 5\hat{k}$?

a) $3\sqrt{2}$
b) $5\sqrt{2}$
c) $7\sqrt{2}$
d) $9\sqrt{2}$

689. A stone is tied to one end of a string and rotated in a horizontal circle with a uniform angular velocity. Let T be the tension in the string. If the length of the string is halved and its angular velocity is doubled, tension in the string will be

a) $T/4$ b) $T/2$ c) $2T$ d) $4T$

690. 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

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

691. A particle of mass $= 5$ is moving with a uniform speed $v = 3\sqrt{2}$ in the XOY plane along the line $Y = X + 4$. The magnitude of the angular momentum of the particle about the origin is

a) 60 units b) $40\sqrt{2}$ units c) 7.5 units d) zero

692. A particle crossing the origin of co-ordinates at time $t = 0$, moves in the xy-plane with a constant acceleration a in the y-direction. If its equation of motion is $y = bx^2$ (b is a constant), its velocity component in the x-direction is

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

693. The area o the parallelogram represented by the vectors. $\vec{A} = 4\hat{i} + 3\hat{j}$ and $\vec{B} = 2\hat{i} + 4\hat{j}$ is

a) 14 units b) 7.5 units c) 10 units d) 5 units

694. Two bodies are projected with the same velocity. If one is projected at an angle of $30°$ and the other at an angle of $60°$ to the horizontal, the ratio of the maximum heights reached is

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

695. Tom and Dick are running forward with the same speed. They are throwing a rubber ball to each other at a constant speed v as seen by the thrower. According to Sam who is standing on the ground the speed of the ball is

a) Same as v b) Greater than v c) Less than v d) None of these

696. A ball of mass m is thrown vertically upwards. Another ball of mass $2m$ is thrown at an angle θ with the vertical. Both of them stay in air for same period of time. The heights attained by the two balls are in the ratio of

a) 2: 1 b) $1: \cos\theta$ c) 1: 1 d) $\cos\theta : 1$

697. An arrow is projected into air. Its time of flight is 8 s and range 200 m. What is the maximum height reached by it? (Take g $=$ 10 ms^{-2})

a) 31.25 m b) 24.5 m c) 18.25 m d) 46.75 m

698. A bullet fired at an angle of $30°$ with the horizontal hits the ground 3 km away. By adjusting its angle of projection, one can hope to hit a target 5 km away. Assume the muzzle speed to be same and the air resistance is negligible

a) possible to hit a target 5 km away b) not possible to hit a target 5 km away

c) prediction is not possible d) None of the above

699. The angular speed of seconds needle in a mechanical watch is

a) $\frac{\pi}{30}\ rad/s$ b) $2\pi\ rad/s$ c) $\pi\ rad/s$ d) $\frac{60}{\pi}\ rad/s$

700. Two racing cars of masses $m_1$and $m_2$are moving in circles of radii $r_1$and r_2 respectively. Their speeds are such that each makes a complete circle in the same duration of time t.The ratio of the angular speed of the first to the second car is

a) $m_1 : m_2$ b) $r_1 : r_2$ c) 1 : 1 d) $m_1 : r_1 : m_2 r_2$

701. The equation of motion of a projectile are given by $x = 36\ t\ metre$ and $2y = 96\ t - 9.8\ t^2\ metre$. The angle of projection is

a) $\sin^{-1}\left(\frac{4}{5}\right)$ b) $\sin^{-1}\left(\frac{3}{5}\right)$ c) $\sin^{-1}\left(\frac{4}{3}\right)$ d) $\sin^{-1}\left(\frac{3}{4}\right)$

702. A ball is projected upwards from the top of a tower with a velocity of 50 ms^{-1} making an angle of 60° with the vertical. If the height of the tower is 70 m, then the ball will reach the ground in (Take $g = 10\ ms^{-2}$)

a) 2 s b) 3 s c) 5 s d) 7 s

703. A particle A is projected from the ground with an initial velocity of 10 ms^{-1} at an angle 60° with horizontal. From what height should an another particle B be projected horizontally with velocity 5 ms^{-1} so that both the particles collide in ground at point C if both are projected simultaneously $g = 10 ms^{-2}$

a) 10 m b) 15 m c) 20 m d) 30 m

704. A railway carriage has its centre of gravity at a height of 1 m above the rails, which are 1.5 m apart. The maximum safe speed at which it could travel round an unbanked curve of radius 100 m is

a) 12 ms^{-1} b) 18 ms^{-1} c) 22 ms^{-1} d) 27 ms^{-1}

705. The maximum horizontal range of a projectile is 400 m. The maximum value of the height attained by it will be

a) 100 m b) 200 m c) 400 m d) 800 m

706. The earth moves round the sun in a near circular orbit of radius 1.5×10^{11} m. Its centripetal acceleration is

a) $1.5 \times 10^{-3}\ m/s^2$ b) $3 \times 10^{-3}\ m/s^2$ c) $6 \times 10^{-3}\ m/s^2$ d) $12 \times 10^{-3}\ m/s^2$

707. A particle is moving in a horizontal circle with constant speed. It has constant

a) Velocity b) Acceleration c) Kinetic energy d) Displacement

708. Projection of $\vec{P}$ on $\vec{Q}$ is

a) $\vec{P} \cdot \hat{Q}$ b) $\hat{p} \cdot \vec{Q}$ c) $\vec{P} \times \hat{Q}$ d) $\vec{P} \times \vec{Q}$

709. A projectile is fired at an angle of 45° with the horizontal. Elevation angle of the projectile at its highest point as seen from the point of projection, is:

a) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ b) 45° c) 60° d) $\tan^{-1}\frac{1}{2}$

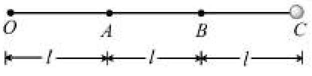
710. A particle covers 50 m distance when projected with an initial speed. On the same surface it will cover a distance, when projected with double the initial speed

a) 100 m b) 150 m c) 200 m d) 250 m

711. A heavy small sized sphere is suspended by a string of length l. The sphere is rotated uniformly in a horizontal circle with the string making an angle θ with the vertical. The time period of this conical pendulum is

a) $2\pi\sqrt{\frac{l \tan\theta}{g}}$ b) $2\pi\sqrt{l \sin\theta / g}$ c) $2\pi\sqrt{\frac{l}{g}}$ d) $2\pi\sqrt{\frac{l \cos\theta}{g}}$

712. Three identical particles are joined together by a thread as shown in figure. All the three particles are moving in a horizontal plane. If the velocity of the outermost particle is v_0, then the ratio of tensions in the three sections of the string is



a) 3 : 5 : 7 b) 3 : 4 : 5 c) 7 : 11 : 6 d) 3 : 5 : 6

713. If $\vec{A} = \vec{B}$, then which of the following is not correct

a) $\hat{A} = \hat{B}$ b) $\hat{A} \cdot \hat{B} = AB$ c) $|\vec{A}| = |\vec{B}|$ d) $A\hat{B} \,||\, B\hat{A}$

714. 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}

715. A particle of mass m is projected with a velocity v making an angle of 30° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height h is

a) $\frac{\sqrt{3}}{2}\frac{mv^2}{g}$ b) Zero c) $\frac{mv^3}{\sqrt{2g}}$ d) $\frac{\sqrt{3}}{16}\frac{mv^3}{g}$

716. For a projectile thrown into space with a speed v, the horizontal range is $\frac{\sqrt{3}v^2}{2g}$. The vertical range is $\frac{v^2}{8g}$. The angle which the projectile makes with the horizontal initially is

a) 15° b) 30° c) 45° d) 60°

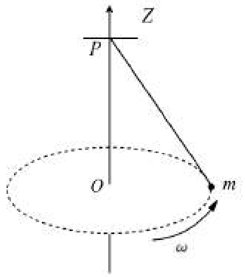
717. A car is travelling at a velocity of 10 kmh^{-1} on a straight road. The driver of the car throws a parcel with a velocity of $10\sqrt{2}$ kmh^{-1} when the car is passing by a man standing on the side of the road. If the parcel is to reach the man, the direction of throw makes the following angle with direction of the car

a) 135° b) 45° c) $\tan^{-1}(\sqrt{2})60°$ d) $\tan\left(\frac{1}{\sqrt{2}}\right)$

718. Velocity vector and acceleration vector in a uniform circular motion are related as

a) Both in the same direction
b) Perpendicular to each other
c) Both in opposite direction
d) No related to each other

719. A small mass m is attached to a massless string whose other end is fixed at P as shown in the figure. The mass is undergoing circular motion in the $x-y$ plane with centre at O and constant angular speed ω. If the angular momentum of the system, calculated about O and P are denoted by $\vec{L}_O$ and $\vec{L}_P$ respectively, then



a) $\vec{L}_O$ and $\vec{L}_P$ do not vary with time
b) $\vec{L}_O$ varies with time while $\vec{L}_P$ remains constant
c) $\vec{L}_O$ remains constant while $\vec{L}_P$ varies with time
d) $\vec{L}_O$ and $\vec{L}_P$ both vary with time

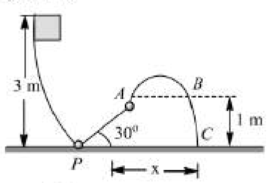
720. A mass m is attached to the end of a rod of length l. The mass goes along a vertical circular path with the other end hinged at its centre. What should be the minimum velocity of the mass at the bottom of the circle so that the mass completes the circle?

a) $\sqrt{5gl}$ b) $\sqrt{2gl}$ c) $\sqrt{3gl}$ d) $\sqrt{4gl}$

721. The adjacent sides of a parallelogram are represented by co-initial vectors $2\hat{i} + 3\hat{j}$ and $\hat{i} + 4\hat{j}$. The area of the parallelogram is

a) 5 units along z-axis
b) 5 units in $x-y$ plane
c) 3 units in $x-z$ plane
d) 3 units in $y-z$ plane

722. A 0.098 kg block slides down a frictionless track as shown. The vertical component of the velocity of block at A is



a) $\sqrt{g}$ b) $2\sqrt{g}$ c) $3\sqrt{g}$ d) $4\sqrt{g}$

723. The height y and the distance x along the horizontal plane of a projectile on a certain planet (with no surrounding atmosphere) are given by $y = 8t - 5t^2$ metre and $x = 6t$ metre, where t is in second. The velocity with which the projectile is projected, is

a) 14 ms^{-1} b) 10 ms^{-1} c) 8 ms^{-1} d) 6 ms^{-1}

724. A particle moves in circle of radius 25 cm at the rate of two revolutions per second. The acceleration of particle is

a) $2\pi^2 ms^{-2}$ b) $4\pi^2 ms^{-2}$ c) $8\pi^2 ms^{-2}$ d) $\pi^2 ms^{-2}$

725. A bucket tied at the end of 11.6 m long string is whirled in a vertical circle with a constant speed. The minimum speed at which water from the bucket does not spill when it is a the highest position is

a) 4 ms^{-1} b) 6.25 ms^{-1} c) 2 ms^{-1} d) 16 ms^{-1}

726. The centripetal acceleration of a particle of mass m moving with a velocity v in a circular orbit of radius r is

a) v^2/r along the radius, towards the center
b) v^2/r along the radius, away from the center
c) mv^2/r along the redius, away from the center
d) mv^2/r along the radius, towards the center

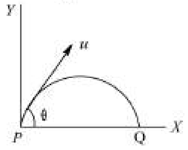
727. A particle moves in a circle with a uniform speed. When it goes from a point A to a diametrically opposite point B, the momentum of the particle changes by $\vec{\mathbf{p}}_A - \vec{\mathbf{p}}_B = 2$ kg $ms^{-1}(\hat{\mathbf{j}})$ and the centripetal fore acting on it changes by $\vec{\mathbf{F}}_A - \vec{\mathbf{F}}_B = 8$ N$(\hat{\mathbf{i}})$ where $\hat{\mathbf{i}}$ and $\hat{\mathbf{j}}$ are unit vectors along X and Y axes respectively. The angular velocity of the particle is

a) Dependent of its mass b) 4 rad s^{-1} c) $\frac{2}{\pi}$ rad s^{-1} d) 16 μ rad s^{-1}

728. A bomber plane moves horizontally with a speed of 500ms^{-1} and a bomb released from it, strikes the ground in 10 s. Angel at which it strikes the ground will be (g = 10ms^{-2})

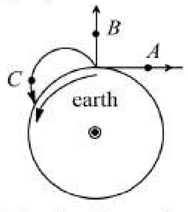
a) $\tan^{-1}\left(\frac{1}{5}\right)$ b) $\tan\left(\frac{1}{5}\right)$ c) $\tan^{-1}(1)$ d) $\tan^{-1}(5)$

729. Average torque on a projectile of mass m, initial speed u and angles of projection θ, between initial and final position P and Q as shown in figure about the point of projection is



a) $mu^2 \sin\theta$ b) $mu^2 \cos\theta$ c) $\frac{1}{2}mu^2 \sin 2\theta$ d) $\frac{1}{2}mu^2 \cos 2\theta$

730. A body 'A' moves with constant velocity on a straight line path tangential to the earth's surface. Another body 'B' is thrown vertically upwards, it goes to a height and falls back on earth. A third body 'C' is projected to an angle and follows a parabolic path as shown in figure



The bodies whose angular momentum relative to the center of the earth is conserved are

a) B only b) B and C c) A, B, C d) None of the above

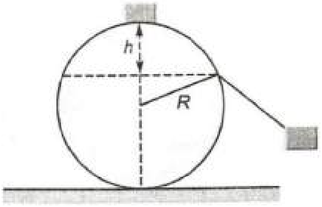
731. A particle is moving with velocity $\mathbf{v} = k(y\hat{\mathbf{i}} + x\,\hat{\mathbf{j}})$, where k is a constant. The general equation for its path is

a) $y = x^2 +$ constant b) $y^2 = x +$ constant
c) $xy =$ constant d) $y^2 = x^2$constant

732. The maximum and minimum tension in the string whirling in a circle of radius 2.5 m with constant velocity are in the ratio 5 : 3 then its velocity is

a) $\sqrt{98}$ ms^{-1} b) 7 ms^{-1} c) $\sqrt{490}$ ms^{-1} d) $\sqrt{4.9}$ ms^{-1}

733. A particle originally at a rest at the highest point of a smooth circle in a vertical plane, is gently pushed and starts sliding along the circle. It will leave the circle at a vertical distance h below the highest point such that



a) $h = 2R$ b) $h = \frac{R}{2}$ c) $h = R$ d) $h = \frac{R}{3}$

734. A particle moves in a circle of radius 25 cm at two revolutions per second. The acceleration of the particle in m/s^2 is

a) π^2 b) $8\pi^2$ c) $4\pi^2$ d) $2\pi^2$

735. A cyclist goes round a circular path of circumference 34.3 m in $\sqrt{22}$ s, the angle made by him with the vertical will be

a) 45° b) 40° c) 42° d) 48°

736. A bomb is dropped from an aeroplane flying horizontally with a velocity 469 ms^{-1} at an altitude of 980 m. The bomb will hit the ground after a time

a) 2 s b) $\sqrt{2}$ s c) $5\sqrt{2}$ s d) $10\sqrt{2}$ s

737. The horizontal range of a projectile is $4\sqrt{3}$ times its maximum height. Its angle of projection will be

a) 45° b) 60° c) 90° d) 30°

738. Which one is Angular resolution fundamental quantity

a) Length b) Time c) Radian d) Angle

739. A ball thrown by one player reaches the other in 2 s. The maximum height attained by the ball above the point of projection will be ($g = 10$ ms^{-2})

a) 2.5 m b) 5 m c) 7.5 m d) 10 m

740. The acceleration of a train travelling with speed of 400 m/s as it goes round a curve of radius 160 m, is

a) 1 km/s^2 b) 100 m/s^2 c) 10 m/s^2 d) 1 m/s^2

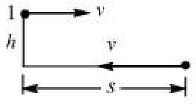
741. A ball of mass 0.25 kg attached to the end of a string of length 1.96 m is moving in a horizontal circle. The string will break if the tension is more than 25N. What is the maximum speed with which the ball can be moved?

a) 14 ms^{-1} b) 3 ms^{-1} c) 3.92 ms^{-1} d) 5 ms^{-1}

742. An electric fan has blades of length 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 rpm, the acceleration of a point on the tip of the blade is about

a) 1600 ms^{-2} b) 4740 ms^{-2} c) 2370 ms^{-2} d) 5055 ms^{-2}

743. Two particles 1 and 2 are projected with same speed v as shown in figure. Particle 2 is on the ground and particle 1 is at a height h from the ground and at a horizontal distance s from particle 2. If a graph is plotted between v and s for the condition of collision of the two then (v on y-axis and s on x-axis)



a) It will be a parabola passing through the origin

b) It will be straight line passing through the origin and having a slope of $\sqrt{\frac{g}{8h}}$

c) It will be a straight line passing through the origin and having a slope of $\sqrt{\frac{g}{4h}}$

d) It will be a straight line not passing through the origin

744. If a body is projected with an angle θ to the horizontal then

a) its velocity is always perpendicular to its acceleration

b) its velocity becomes zero as its maximum height

c) its velocity makes zero angle with the horizontal at its maximum height

d) the body just before hitting the ground, the direction of velocity coincides with the acceleration

745. A bullet is to be fired with a speed of 20 ms^{-1} to hit a target 200m away on a level ground. If $g = 10\ ms^{-2}$, the gun should be aimed
a) directly at the target
b) 5 cm below the target
c) 5 cm above the target
d) 2 cm above the target

746. The magnitude of resultant of three vectors of magnitude 1, 2 and 3 whose directions are those of the sides of an equilateral triangle taken in order is
a) zero
b) $2\sqrt{2}$ unit
c) $4\sqrt{3}$ unit
d) $\sqrt{3}$ unit

747. A boy whirl is a stone in a horizontal circle of radius 1.5 m and at height 2.0 m above level ground. The string breaks and the stone flies off tangentially and strikes the ground after traveling a horizontal distance of 10 m. What is the magnitude of the centripetal acceleration of the stone while in circular motion?
a) 163 ms^{-2}
b) 64 ms^{-2}
c) 15.63 ms^{-2}
d) 125 ms^{-2}

748. If the range of a gun which fires a shell with muzzle speed V is R, then the angle of elevation of the gun is
a) $\cos^{-1}\left(\frac{V^2}{Rg}\right)$
b) $\cos^{-1}\left(\frac{gR}{V^2}\right)$
c) $\frac{1}{2}\left(\frac{V^2}{Rg}\right)$
d) $\frac{1}{2}\sin^{-1}\left(\frac{gR}{V^2}\right)$

749. The condition of apparent weightlessness can be created momentarily when a plane flies over the top of a vertical circle. At a speed of 900 kmh^{-1}, the radius of the vertical circle that the pilot must use is
a) 10.6 km
b) 8.5 kg
c) 6.4 km
d) 4.0 km

750. A stone is projected from the ground with velocity 50 ms^{-1} and angle of 30°. It crosses a wall after 3 s. How far beyond the wall the stone will strike the ground?
a) 80.5 m
b) 85.6 m
c) 86.6 m
d) 75.2 m

751. The momentum of a particle is $\vec{P}=2\cos t\hat{\imath} + 2\sin t\hat{\jmath}$. What is the angle between the force $\vec{F}$ acting on the particle and the momentum $\vec{P}$
a) 65°
b) 90°
c) 150°
d) 180°

752. A body of mass m is projected at an angle of 45° with the horizontal. If air resistance is negligible, then total change in momentum when it strikes the ground is
a) $2mv$
b) $\sqrt{2}\,mv$
c) mv
d) $mv/\sqrt{2}$

753. The distance r from the origin of a particle moving in $x-y$ plane varies with time as $r = 2t$ and the angle made by the radius vector with positive x-axis is $\theta = 4t$. Here, t is in second, r in metre and θ in radian. The speed of the particle at $t = 1$ s is
a) 10 ms^{-1}
b) 16 ms^{-1}
c) 10 ms^{-1}
d) 12 ms^{-1}

754. A ball is projected upwards from the top of tower with a velocity 50 ms^{-1} making an angle 30° with the horizontal. The height of tower is 70 m. After how many seconds from the instant of throwing will the ball reach the ground
a) 2 s
b) 5 s
c) 7 s
d) 9 s

755. A piece of marble is projected from earth's surface with velocity of 50ms^{-1}. 2 s later, it just clears a wall 5 m high. What is the angle of projection?
a) 45°
b) 30°
c) 60°
d) None of these

756. The kinetic energy of a projectile at the highest point is half of the initial kinetic energy. What is the angle of projection with the horizontal?
a) 30°
b) 45°
c) 60°
d) 90°

757. The horizontal and vertical displacement x and y of a projectile at a given time t are given by $x = 6t$ metre and $y = 8t - 5t^2$ metre. The range of the projectile in metre is
a) 9.6
b) 10.6
c) 19.2
d) 38.4

758. A ball is projected with velocity V_o at an angle of elevation 30° . Mark the correct statement
a) Kinetic energy will be zero at the highest point of the trajectory
b) Vertical component of momentum will be conserved
c) Horizontal component of momentum will be conserved
d) Gravitational potential energy will be minimum at the highest point of the trajectory

759. An aeroplane moving horizontally at a speed of 200 m/s and at a height of 8.0×10^3 m is to drop a bomb on a target. At what horizontal distance from the target should the bomb be released

a) 7.234 km b) 8.081 km c) 8.714 km d) 9.124 km

760. A body is projected vertically upwards at time $t = 0$ and it is seen at a height H at instants t_1 and t_2 seconds during its flight. The maximum height attained is (g is acceleration due to gravity)

a) $\frac{g(t_2 - t_1)^2}{8}$ b) $\frac{g(t_1 + t_2)^2}{4}$ c) $\frac{g(t_1 + t_2)^2}{8}$ d) $\frac{g(t_2 - t_1)^2}{4}$

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

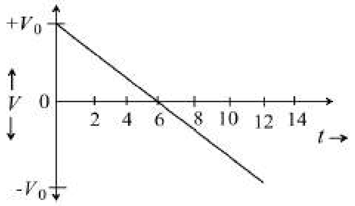
762. Work done when a force, $\vec{F} = (\hat{i} + 2\hat{j} + 3\hat{k})$N acting on a particle takes it from the point $\vec{r}_1 = (\hat{i} + \hat{j} + \hat{k})$m to the point $\vec{r}_2 = (\hat{i} + \hat{j} + 2\hat{k})$

a) -3 J b) -1 J c) zero d) 2 J

763. A body of mass 2 kg attached to a string is whirled in a vertical circle of radius 5 m. The minimum speed of the body at lowest point so that the cord does not slacken even at the highest point is

a) 15.65 ms^{-1} b) 6.75 ms^{-1} c) 20.87 ms^{-1} d) 45.83 ms^{-1}

764. Consider the given velocity-time graph



It represents the motion of

a) A projectile projected vertically upward, from a point

b) An electron in the hydrogen atom

c) A car with constant acceleration along a straight road

d) A bullet fired horizontally from the top of a tower

765. A cyclist is travelling with velocity v on a banked curved road of radius R. The angle θ through which the cyclist leans inwards is given by

a) $\tan\theta = \frac{Rg}{v^2}$ b) $\tan\theta = v^2 Rg$ c) $\tan\theta = \frac{v^2 g}{R}$ d) $\tan\theta = \frac{v^2}{Rg}$

MOTION IN A PLANE

: ANSWER KEY :

1)	d	2)	d	3)	d	4)	a	177)	a	178)	b	179)	a	180)	c
5)	a	6)	a	7)	b	8)	c	181)	d	182)	d	183)	a	184)	c
9)	a	10)	c	11)	c	12)	d	185)	a	186)	a	187)	a	188)	c
13)	b	14)	b	15)	d	16)	b	189)	b	190)	d	191)	c	192)	b
17)	c	18)	d	19)	a	20)	d	193)	a	194)	b	195)	b	196)	d
21)	c	22)	c	23)	a	24)	a	197)	b	198)	a	199)	c	200)	b
25)	c	26)	b	27)	d	28)	c	201)	b	202)	d	203)	d	204)	a
29)	c	30)	b	31)	c	32)	d	205)	b	206)	b	207)	b	208)	d
33)	c	34)	b	35)	a	36)	c	209)	d	210)	a	211)	c	212)	c
37)	b	38)	b	39)	a	40)	b	213)	a	214)	b	215)	a	216)	b
41)	b	42)	d	43)	c	44)	b	217)	d	218)	a	219)	c	220)	b
45)	d	46)	a	47)	b	48)	c	221)	b	222)	d	223)	c	224)	d
49)	a	50)	c	51)	b	52)	d	225)	d	226)	d	227)	b	228)	b
53)	d	54)	b	55)	b	56)	b	229)	c	230)	b	231)	a	232)	b
57)	d	58)	a	59)	c	60)	c	233)	a	234)	c	235)	a	236)	c
61)	d	62)	d	63)	b	64)	c	237)	a	238)	d	239)	d	240)	d
65)	c	66)	d	67)	a	68)	c	241)	c	242)	b	243)	a	244)	a
69)	a	70)	b	71)	a	72)	a	245)	a	246)	b	247)	a	248)	a
73)	d	74)	b	75)	a	76)	a	249)	a	250)	c	251)	c	252)	b
77)	a	78)	d	79)	c	80)	d	253)	b	254)	c	255)	a	256)	b
81)	d	82)	d	83)	d	84)	d	257)	c	258)	b	259)	b	260)	c
85)	b	86)	d	87)	a	88)	c	261)	c	262)	b	263)	b	264)	a
89)	a	90)	c	91)	b	92)	a	265)	c	266)	c	267)	c	268)	b
93)	d	94)	c	95)	d	96)	a	269)	d	270)	b	271)	b	272)	b
97)	d	98)	d	99)	d	100)	a	273)	d	274)	b	275)	b	276)	c
101)	c	102)	b	103)	a	104)	a	277)	c	278)	a	279)	d	280)	c
105)	d	106)	b	107)	a	108)	a	281)	c	282)	b	283)	b	284)	b
109)	c	110)	b	111)	a	112)	a	285)	a	286)	a	287)	b	288)	c
113)	c	114)	a	115)	b	116)	b	289)	a	290)	d	291)	a	292)	a
117)	c	118)	c	119)	b	120)	c	293)	a	294)	b	295)	d	296)	b
121)	c	122)	d	123)	c	124)	c	297)	b	298)	d	299)	c	300)	b
125)	c	126)	a	127)	c	128)	d	301)	c	302)	c	303)	d	304)	d
129)	a	130)	b	131)	d	132)	c	305)	d	306)	a	307)	b	308)	a
133)	a	134)	b	135)	d	136)	b	309)	b	310)	a	311)	d	312)	c
137)	c	138)	a	139)	a	140)	c	313)	a	314)	a	315)	c	316)	b
141)	b	142)	d	143)	d	144)	b	317)	d	318)	b	319)	b	320)	c
145)	c	146)	d	147)	c	148)	c	321)	c	322)	b	323)	d	324)	c
149)	c	150)	a	151)	a	152)	c	325)	c	326)	a	327)	a	328)	c
153)	a	154)	a	155)	d	156)	c	329)	b	330)	c	331)	a	332)	d
157)	b	158)	b	159)	b	160)	c	333)	a	334)	c	335)	c	336)	c
161)	a	162)	a	163)	a	164)	a	337)	c	338)	c	339)	a	340)	c
165)	b	166)	c	167)	c	168)	d	341)	a	342)	a	343)	b	344)	b
169)	c	170)	c	171)	d	172)	d	345)	a	346)	a	347)	c	348)	b
173)	c	174)	d	175)	a	176)	b	349)	d	350)	b	351)	d	352)	d

353)	a	354)	a	355)	c	356)	b	553)	b	554)	d	555)	c	556)	d
357)	a	358)	d	359)	a	360)	a	557)	a	558)	a	559)	a	560)	c
361)	c	362)	b	363)	a	364)	b	561)	d	562)	c	563)	d	564)	a
365)	b	366)	a	367)	c	368)	d	565)	b	566)	d	567)	c	568)	d
369)	b	370)	a	371)	a	372)	b	569)	a	570)	b	571)	c	572)	b
373)	a	374)	b	375)	c	376)	a	573)	c	574)	c	575)	c	576)	c
377)	c	378)	b	379)	c	380)	b	577)	b	578)	a	579)	c	580)	d
381)	a	382)	b	383)	d	384)	d	581)	a	582)	d	583)	d	584)	a
385)	d	386)	d	387)	b	388)	b	585)	c	586)	a	587)	c	588)	a
389)	c	390)	d	391)	b	392)	a	589)	d	590)	a	591)	a	592)	a
393)	a	394)	c	395)	c	396)	b	593)	c	594)	c	595)	b	596)	b
397)	d	398)	c	399)	c	400)	d	597)	d	598)	d	599)	a	600)	c
401)	d	402)	d	403)	b	404)	b	601)	b	602)	b	603)	d	604)	c
405)	b	406)	d	407)	a	408)	b	605)	d	606)	d	607)	c	608)	b
409)	d	410)	b	411)	b	412)	b	609)	b	610)	d	611)	d	612)	c
413)	c	414)	b	415)	d	416)	b	613)	a	614)	a	615)	a	616)	a
417)	a	418)	d	419)	d	420)	c	617)	c	618)	c	619)	c	620)	b
421)	c	422)	c	423)	d	424)	d	621)	d	622)	a	623)	b	624)	a
425)	a	426)	b	427)	a	428)	c	625)	d	626)	c	627)	a	628)	c
429)	a	430)	c	431)	a	432)	b	629)	c	630)	c	631)	d	632)	a
433)	a	434)	a	435)	b	436)	c	633)	c	634)	a	635)	d	636)	c
437)	b	438)	a	439)	a	440)	b	637)	b	638)	a	639)	c	640)	d
441)	a	442)	b	443)	b	444)	a	641)	d	642)	d	643)	c	644)	b
445)	c	446)	c	447)	d	448)	b	645)	c	646)	b	647)	b	648)	d
449)	d	450)	b	451)	d	452)	a	649)	a	650)	a	651)	b	652)	b
453)	c	454)	c	455)	b	456)	c	653)	c	654)	c	655)	b	656)	d
457)	d	458)	c	459)	c	460)	c	657)	c	658)	a	659)	a	660)	b
461)	a	462)	d	463)	d	464)	c	661)	b	662)	d	663)	d	664)	b
465)	a	466)	d	467)	a	468)	d	665)	c	666)	d	667)	d	668)	c
469)	c	470)	b	471)	c	472)	b	669)	d	670)	b	671)	b	672)	d
473)	d	474)	d	475)	a	476)	a	673)	b	674)	c	675)	b	676)	b
477)	d	478)	b	479)	b	480)	d	677)	a	678)	c	679)	d	680)	c
481)	b	482)	d	483)	c	484)	a	681)	d	682)	c	683)	b	684)	c
485)	c	486)	c	487)	a	488)	b	685)	a	686)	c	687)	a	688)	b
489)	d	490)	b	491)	d	492)	d	689)	c	690)	a	691)	a	692)	b
493)	b	494)	b	495)	d	496)	d	693)	c	694)	b	695)	b	696)	c
497)	a	498)	a	499)	a	500)	b	697)	a	698)	b	699)	a	700)	c
501)	d	502)	b	503)	a	504)	a	701)	a	702)	d	703)	b	704)	d
505)	c	506)	d	507)	d	508)	c	705)	a	706)	c	707)	c	708)	b
509)	b	510)	b	511)	c	512)	b	709)	d	710)	c	711)	d	712)	d
513)	c	514)	d	515)	a	516)	a	713)	b	714)	c	715)	d	716)	b
517)	b	518)	b	519)	d	520)	a	717)	b	718)	b	719)	c	720)	d
521)	a	522)	d	523)	a	524)	c	721)	a	722)	a	723)	b	724)	b
525)	b	526)	a	527)	d	528)	b	725)	a	726)	a	727)	b	728)	a
529)	c	530)	b	531)	b	532)	b	729)	c	730)	d	731)	d	732)	a
533)	c	534)	d	535)	a	536)	d	733)	d	734)	c	735)	a	736)	d
537)	a	538)	d	539)	c	540)	c	737)	d	738)	d	739)	b	740)	a
541)	d	542)	d	543)	d	544)	a	741)	a	742)	b	743)	b	744)	c
545)	d	546)	a	547)	a	548)	a	745)	c	746)	d	747)	a	748)	d
549)	c	550)	c	551)	a	552)	c	749)	c	750)	c	751)	b	752)	b

753)	b	754)	c	755)	c	756)	b	765)	d
757)	a	758)	c	759)	b	760)	c		
761)	d	762)	b	763)	a	764)	a		

MOTION IN A PLANE

: HINTS AND SOLUTIONS :

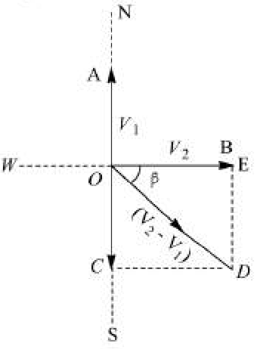
1 **(d)**
Given, $x = 0.20$ m, $y = 0.20$ m, $u = 1.8\text{ms}^{-1}$
Let the ball strike the nth step of stairs,
Vertical distance travelled
$= ny = n \times 0.20 = \frac{1}{2}gt^2$
Horizontal distance travelled, $nx = ut$
or $t = \frac{nx}{u}$
$\therefore ny = \frac{1}{2}g \times \frac{n^2x^2}{u^2}$
or $n = \frac{2u^2}{g}\frac{y}{x^2} = \frac{2 \times (1.8)^2 \times 0.20}{9.8 \times (0.20)^2}$
$= 3.3 = 4$

2 **(d)**
Work done in circular motion is always zero

4 **(a)**
The cord is most likely to break at the orientation, when mass is at B as tension in the string at this point is maximum

5 **(a)**
$\frac{T_{\max}}{T_{\min}} = \frac{\frac{mv^2}{L}+mg}{\frac{mv^2}{L}-mg} = 2$ ...(i)
Simplifying Eq. (i), we get,
$v_H = \sqrt{3gL} = \sqrt{\frac{3 \times 10 \times 10}{3}} = 10\text{ ms}^{-1}$

6 **(a)**
Here, $\vec{v_1}$=30km h^{-1} due north = $\overrightarrow{OA}$
$\vec{v_2} = 40\text{kmh}^{-1}$ due east = $\overrightarrow{OB}$
Change in velocity in 20 s
$\Delta\vec{v} = \vec{v_2} - \vec{v_1} = \vec{v_2} + (-\vec{v_1})$
$= \overrightarrow{OB} + \overrightarrow{OC} = \overrightarrow{OD}$
$|\Delta\vec{v}| = \sqrt{v_2^2 + v_1^2} = \sqrt{40^2 + 30^2}$
$= 50\text{ kmh}^{-1}$
Acceleration , $\vec{a} = \frac{|\Delta\vec{v}|}{\Delta t}$
$= \frac{50}{20} = 2.5\text{ kmh}^{-2}$
$\text{Tan}\,\beta = \frac{v_1}{v_2} = \frac{30}{40}$
$= 0.75 = \tan 37°$
$\therefore \beta = 37°$ north of east



7 **(b)**
Maximum horizontal range = 80 m
$\because\ \theta = 45°$ m
$\therefore\ \frac{u^2}{g} = 80$ m
Maximum height, $h = \frac{u^2\sin^2\theta}{2g}$
$= \frac{80}{2}(\sin^2 45°) = 20$ m

8 **(c)**
If v is velocity of the bob on reaching the lowest point, then $\frac{1}{2}mv^2 = mgL$
To void breaking, strength of the string
$T_L = \frac{mv^2}{L} + mg = \frac{2mg\,L}{L} + mg = 3\,mg$

10 **(c)**
When a force of constant magnitude acts on velocity of particle perpendicularly, then there is no change in the kinetic energy of particle.
Hence, kinetic energy remains constant.

11 **(c)**
Due to constant velocity along horizontal and vertical downward force of gravity stone will hit the ground following parabolic path

12 **(d)**

$$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$

$$= \tan^{-1}\left[\frac{(14\sqrt{3})^2}{20\sqrt{3} \times 9.8}\right] = \tan^{-1}[\sqrt{3}]$$

$$= 60^{\circ}$$

13 **(b)**

The two angles of projection are clearly θ and $(90^\circ - \theta)$

$$T_1 = \frac{2v\sin\theta}{g} \text{ and } T_2 = \frac{2v\sin(90^\circ - \theta)}{g}$$

$$T_1T_2 = \frac{2(v)^2(2\sin\theta\cos\theta)}{g \times g} = \frac{2R}{g}$$

14 **(b)**

Computing the given equation with

$y = x\tan\theta - \frac{gx^2}{2v^2\cos^2\theta}$, we get

$\tan\theta = \sqrt{3}$

15 **(d)**

Angle made by the cyclist with vertical is given by

$$\tan\theta = \frac{v^2}{rg}$$

$$\therefore \theta = \tan^{-1}\left(\frac{10 \times 10}{80 \times 10}\right) \left(\therefore v = 36 \times \frac{5}{18} = 10 \text{ ms}^{-1}\right)$$

$$= \tan^{-1}\left(\frac{1}{8}\right)$$

16 **(b)**

Let x be increase in length of the spring. The particle would move in a circular path of radius $(l + x)$. Centripetal force = force due to the spring

$$m(l + x)\omega^2 = kx$$

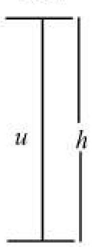
$$\therefore x = \frac{m\omega^2 l}{k - m\omega^2}$$

17 **(c)**

$$h = \frac{u^2}{2g} \Rightarrow u^2 = 2gh$$

Maximum horizontal distance

$$R_{\text{max}} = \frac{u^2}{g}$$



$$R_{\text{max}} = 2h$$

18 **(d)**

$$\omega = \sqrt{\frac{g}{r}} = \sqrt{\frac{9.8}{0.2}} = 7rad/s$$

19 **(a)**

Minimum tension $T_1 = \frac{mv^2}{r} - mg$

Maximum tension $T_2 = \frac{mv^2}{r} + mg$

Let $\frac{mv^2}{r} = x$

So, $T_1 = x - mg$ ...(i)

$T_2 = x + mg$ ...(ii)

Diving Eq. (i) by Eq. (ii)

$$\frac{T_1}{T_2} = \frac{x - mg}{x + mg} \quad \left(\because \text{Given} \frac{T_1}{T_2} = \frac{3}{5}\right)$$

$$\therefore \frac{3}{5} = \frac{x - mg}{x + mg}$$

or $3x + 3mg = 5x - 5mg$

or $x = 4\,mg$

$ie, \frac{mv^2}{r} = 4mg$

$\therefore \quad v^2 = 4\,rg$

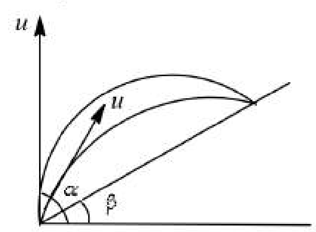
or $\quad v = \sqrt{4rg}$

or $v = \sqrt{4 \times 2.5 \times 9.8}$

$v = \sqrt{98}\text{ ms}^{-1}$

20 **(d)**

Let α″ be the angle of projection of the second body



$$R = \frac{u^2}{g\cos\beta}[\sin(2\alpha - \beta)]$$

Range of both the bodies is same. Therefore,

$\sin(2\alpha - \beta) = \sin(2\alpha'' - \beta)$

or $2\alpha'' - \beta = \pi - (2\alpha - \beta)$

$$\alpha'' = \frac{\pi}{2} - (\alpha - \beta)$$

Now, $T = \frac{2u\sin(\alpha - \beta)}{g\cos\beta}$ and $T'' = \frac{2u\sin(\alpha'' - \beta)}{g\cos\beta}$

$$\therefore \frac{T}{T''} = \frac{\sin(\alpha - \beta)}{\sin(\alpha'' - \beta)} = \frac{\sin(\alpha - \beta)}{\sin\left\{\frac{\pi}{2} - (\alpha - \beta) - \beta\right\}}$$

$$= \frac{\sin(\alpha - \beta)}{\sin\left(\frac{\pi}{2} - \alpha\right)} = \frac{\sin(\alpha - \beta)}{\cos\alpha}$$

21 **(c)**

$R = 4H\cot\theta$

When $R = H$ then $\cot\theta = 1/4 \Rightarrow \theta = \tan^{-1}(4)$

22 **(c)**

For looping the loop, the velocity at the lowest point of loop should be

$v=\sqrt{5gr}=\sqrt{5gD/2}=\sqrt{2gh}$ or $h=5\,D/4$

23 **(a)**

$$\vec{P}=\frac{\vec{F}\cdot\vec{S}}{t}$$

$$=\frac{(2\hat{\imath}+2\hat{\jmath})\cdot(2\hat{\imath}+2\hat{k})}{16}\text{Js}^{-1}=\frac{4}{16}\text{Js}^{-1}=0.25\text{Js}^{-1}$$

24 **(a)**

Work done by centripetal force in uniform circular motion is always equal to zero

25 **(c)**

$$h_1=\frac{v^2\sin^2\alpha}{2g},h_2=\frac{v^2\cos^2\alpha}{2g},\frac{h_1}{h_2}=\tan^2\alpha$$

26 **(b)**

Since, acceleration is constant

$$\therefore\ \vec{s}=\vec{u}+\frac{1}{2}\vec{a}t^2$$

$$=(2\hat{\imath}-4\hat{\jmath})t+\frac{1}{2}(3\hat{\imath}+5\hat{\jmath})t^2$$

$$=(2\hat{\imath}-4\hat{\jmath})2+\frac{1}{2}(3\hat{\imath}+5\hat{\jmath})2^2$$

$$=10\hat{\imath}+2\hat{\jmath}$$

$$|\vec{s}|=\sqrt{10^2+2^2}=\sqrt{104}=10.2\text{m}$$

27 **(d)**

Here $W=T(\cos\theta+\sin\theta)<T$

so $P+Q=T(\cos\theta+\sin\theta)<T$

Where as (a), (b) and (c) are correct and (d) is wrong.

28 **(c)**

Given that, radius of circle, $r=30\text{cm}=0.3\text{m}$

linear speed $v=2t$

Now, radial acceleration $a_R=\frac{v^2}{r}=\frac{(2t)^2}{0.3}$

at $t=3s$

$$a_R=\frac{(2\times3)^2}{0.3}$$

$$\frac{36}{0.3}=120\text{ms}^{-2}$$

or $a_R=120\text{ms}^{-2}$

and tangential acceleration $a_T=\frac{dv}{dt}=\frac{d}{dt}(2t)$

$$=2\text{ms}^{-2}$$

29 **(c)**

$$\mathbf{L}=m(\mathbf{r}\times\mathbf{v})$$

$$\mathbf{L}=m\left[v_0\cos\theta\,t\hat{\imath}+\left(v_0\sin\theta\,t-\frac{1}{2}gt^2\right)\hat{\jmath}\right]$$

$$\times\left[v_0\cos\theta\,\hat{\imath}+(v_0\sin\theta-gt)\hat{\jmath}\right]$$

$$=mv_0\cos\theta\,t\left[-\frac{1}{2}gt\right]\hat{\mathbf{k}}$$

$$=-\frac{1}{2}mgv_0t^2\cos\theta\,\hat{\mathbf{k}}$$

30 **(b)**

$$v^2=u^2+2as$$

At max. height $v=0$ and for upward direction

$$a=-g$$

$$\therefore u^2=2gs\Rightarrow s=\frac{u^2}{2g};\ \because s_e=s_p$$

$$\left(\frac{u_e}{u_p}\right)^2=\left(\frac{g_e}{g_p}\right)\Rightarrow\left(\frac{5}{3}\right)^2=\frac{9.8}{g_p}\Rightarrow g_p=3.5\,m/s^2$$

31 **(c)**

From $\frac{mv^2}{r}=F=\mu\,mg$

$$\therefore v=\sqrt{\mu rg}=\sqrt{0.75\times60\times10}=\sqrt{450}$$

$$=21\text{ms}^{-1}$$

32 **(d)**

$$\omega_1=2\pi\times300\text{ rad/min}$$

$$\omega_2=2\pi\times100\text{ rad/min}$$

Angular retardation

$$\alpha=\frac{\omega_1-\omega_2}{2}$$

$$=\frac{2\pi\times300-2\pi\times100}{2}$$

$$=2\pi\times100\text{ rad/min}^2$$

$$=200\pi\text{ rad/min}^2$$

33 **(c)**

If a particle is projected with velocity u at an angle θ with the horizontal, the velocity of the particle at the highest point is

$$v=u\cos\theta=200\cos60^\circ=100\text{ ms}^{-1}$$

If m is the mass of the particle, then its initial momentum at highest point in the horizontal direction $=mv=m\times100$. It means at the highest point, initially the particle has no momentum vertically upwards or downwards. Therefore, after explosion, the final momentum of the particles going upwards and downwards must be zero. Hence, the final momentum after explosion is the momentum of the third particle, in the horizontal direction. If the third particle moves with velocity v', then its momentum $=\frac{mv'}{3}$,

According to law of conservation of linear momentum,

We have $\frac{mv'}{3}=m\times100$ or $v'=300\text{ ms}^{-1}$

34 **(b)**

Reaction on inner wheel $R_1=\frac{1}{2}M\left[g-\frac{v^2h}{ra}\right]$

Reaction on outer wheel $R_2=M\left[g+\frac{v^2h}{ra}\right]$

where, r = radius of circular path, $2a$ =distance between two wheels and h = height of centre of gravity of car

35 **(a)**

$\vec{A} = 2\hat{i} + 4\hat{j}, \vec{B} = 5\hat{i} + p\,\hat{j}$

$A = \sqrt{2^2 + 4^2} = \sqrt{20}$

$B = \sqrt{5^2 + p^2}$

$\vec{A} \cdot \vec{B} = 10 - 4p$

If $\vec{A} \parallel \vec{B}$ then

$\vec{A} \cdot \vec{B} = AB\cos 0° = AB$

$10 - 4p = \sqrt{20}\sqrt{25 + p^2}$

Square $100 + 16p^2 - 80p$

$= 20(25 + p^2) = 500 = 20p^2$

or $20p^2 - 16p^2 + 80p + 400 = 0$

or $p^2 + 20p + 100 = 0$

or $(p + 10)^2 = 0$

$\therefore \quad p = -10$

$\therefore \quad \vec{B} = 5\hat{i} + 10\hat{j}$

$B = \sqrt{5^2 + (10)^2} = \sqrt{125} = 5\sqrt{5}$

36 **(c)**

In uniform circular motion only centripetal acceleration works

37 **(b)**

Given, $r = 40$ m and $g = 10\text{m/s}^2$

we have $v = \sqrt{gr}$

$= 10 \times 40 = \sqrt{400}$

$= 20$ m/s

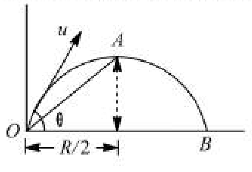
39 **(a)**

$T = \dfrac{2u\sin\theta}{g} = 10 \text{ Sec} \Rightarrow u\sin\theta = 50\, m/s$

$\therefore H = \dfrac{u^2\sin^2\theta}{2g} = \dfrac{(u\sin\theta)^2}{2g} = \dfrac{50 \times 50}{2 \times 10} = 125\, m$

40 **(b)**

Refer figure are when projectile is at A, then



$OC = \dfrac{R}{2} = \dfrac{1}{2}\dfrac{u^2}{g}\sin 2\theta = \dfrac{1}{2} \times \dfrac{(20\sqrt{2})^2}{10}\sin 2 \times 45°$

$= 40$ m

$AC = H = \dfrac{u^2\sin^2\theta}{2g} = \dfrac{(20\sqrt{2})^2}{2 \times 10}\sin^2 45°$

$\therefore$ Displacement, $OA = \sqrt{OC^2 + CA^2} =$

$\sqrt{40^2 + 20^2}$

Time of projectile from O to A

$= \dfrac{1}{2}\left(\dfrac{2u\sin\theta}{g}\right) = \dfrac{u\sin\theta}{2g} = \dfrac{(20\sqrt{2})\sin 45°}{10} = 2\text{s}$

$\therefore$ Average velocity $= \dfrac{\text{displacement}}{\text{time}}$

$= \dfrac{\sqrt{40^2 + 20^2}}{2} = 10\sqrt{5}\text{ ms}^{-1}$

41 **(b)**

Maximum height $H = \dfrac{u^2\sin^2\theta}{2g}$

and times of flight $T = \dfrac{2u\sin\theta}{g}$

or $T^2 = \dfrac{4u^2\sin^2\theta}{g^2}$

$\therefore \dfrac{T^2}{H} = \dfrac{8}{g}$

or $T = \sqrt{\dfrac{8H}{g}} = 2\sqrt{\dfrac{2H}{g}}$

42 **(d)**

$\dfrac{mv^2}{r} = 10 \Rightarrow \dfrac{1}{2}mv^2 = 10 \times \dfrac{r}{2} = 1\,J$

43 **(c)**

In a vertical circular motion, centripetal force remains same at all points on circular path and always directed towards the centre of circular path

44 **(b)**

Given , $|\vec{A} \times \vec{B}| = \sqrt{3}\vec{A} \cdot \vec{B}$

$AB\sin\theta = \sqrt{3}\;\; AB\cos\theta$

or $\tan\theta = \sqrt{3}$

$\theta = 60°$

45 **(d)**

The resultant of 5 N along OC and 5 N along OA is

$R = \sqrt{6^2 + 6^2}$

$= \sqrt{72}$ N along OB

The resultant of $\sqrt{72}$ N along OB and $\sqrt{72}$ N along OG is

$R' = \sqrt{72 + 72} = 12\text{N}$ along OE.

46 **(a)**

Here, $r = 7$ m, $v = 5\text{ ms}^{-1}, \theta = ?$

$\tan\theta = \dfrac{v^2}{rg} = \dfrac{5 \times 5}{7 \times 9.8} = 0.364$

$\theta = \tan^{-1}(0.364) = 20°$

47 **(b)**

$H = \dfrac{v^2\cos^2\beta}{2g}$ or $v\cos\beta = \sqrt{2gH}$

$t = \dfrac{v\cos\beta}{g} = \dfrac{\sqrt{2gH}}{g}$ or $t = \sqrt{\dfrac{2H}{g}}$

48 **(c)**

As seen from the cart, the projectile moves vertically upward and comes back

The time taken by cart to cover 80 m

$\frac{s}{v} = \frac{80}{30} = \frac{8}{3}\ s$

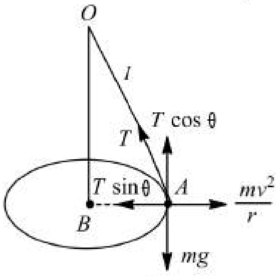
For a projectile going upward , $a = -g = -10\ m/s^2, v = 0$

And $t = \frac{8/3}{2} = \frac{4}{3}\ s$

$\therefore v = u + a\,t \Rightarrow 0 = u - 10 \times \frac{4}{3} \Rightarrow u = \frac{40}{3}\ ms^{-1}$

49 **(a)**

In figure, $T\sin\theta = \frac{mv^2}{r}; T\cos\theta = mg;$



So, $\tan\theta = \frac{v^2}{rg} = \frac{r}{\sqrt{l^2-r^2}}$

$v = \left[\frac{r^2 g}{(l^2-r^2)^{1/2}}\right]^{1/2} = \left[\frac{0.09 \times 10}{(0.25-0.09)^{1/2}}\right]^{1/2}$

$= 1.5\ ms^{-1}$

50 **(c)**

$\tan 90° = \frac{B\sin\theta}{A+B\cos\theta}$ or $A + B\cos\theta = 0$

or $\cos\theta = -A/B$ ....(i)

$R = \frac{B}{2} = [A^2 + B^2 + 2AB\cos\theta]^{1/2}$

or $\frac{B^2}{4} = A^2 + B^2 + 2AB(-A/B) = B^2 - A^2$

or $\frac{A^2}{B^2} = \frac{3}{4}$ or $\frac{A}{B} = \frac{\sqrt{3}}{2}$

From (i), $\cos\theta = -\frac{\sqrt{3}}{2} = \cos 150°$

51 **(b)**

From, $\tan\theta = \frac{v^2}{rg}$

$r = \frac{v^2}{g\tan\theta} = \frac{10 \times 10}{10 \times \tan 45°} = 10\ \text{m}$

53 **(d)**

For looping the loop minimum velocity at the lowest point should be $\sqrt{5gl}$

54 **(b)**

$a_{resultant} = \sqrt{a_{radial}^2 + a_{tangential}^2} = \sqrt{\frac{v^4}{r^2} + a^2}$

55 **(b)**

$\vec{P} + \vec{Q} = \hat{i}$

$\vec{Q} = \hat{i} - \hat{i} + \hat{j} - \hat{k}$

$= \hat{j} - \hat{k}$

56 **(b)**

Let the angle of projection be α.

$\therefore$ Range, $R = \frac{u^2 \sin 2\alpha}{g}$

and maximum height $H = \frac{u^2 \sin^2\alpha}{2g}$

Now, it is given that,

$(\text{Range})^2 = 48(\text{maximum height})^2$

$\therefore \left(\frac{u^2 \sin 2\alpha}{g}\right)^2 = 48\left(\frac{u^2\sin^2\alpha}{2g}\right)^2$

or $\frac{u^2 \sin 2\alpha}{g} = 4\sqrt{3}\left(\frac{u^2\sin^2\alpha}{2g}\right)$

or $\frac{2\sin\alpha\cos\alpha}{4\sqrt{3}} = \frac{\sin^2\alpha}{2}$

or $\tan\alpha = \frac{4}{4\sqrt{3}} = \frac{1}{\sqrt{3}}$

$\therefore \alpha = 30°$

57 **(d)**

There is no loss of energy. Therefore the final velocity is the same as the initial velocity

58 **(a)**

The velocity should be such that the centripetal acceleration is equal to the acceleration due to gravity *ie*, $v^2/R = g$ or $v = \sqrt{gR}$

59 **(c)**

Here, $m = 2\ \text{kg}, r = 1\ \text{m}, v = 4\ \text{ms}^{-1}$

Tension at the bottom of the circle,

$T_L = mg + \frac{mv^2}{r}$

$= 2 \times 10 + \frac{2 \times 4^2}{1} = 52\text{N}$

60 **(c)**

Here, $h = \frac{u^2\sin^2\theta}{2g}$ or $\sqrt{\frac{2h}{g}} = \frac{u\sin\theta}{g}$

Time of flight, $T = \frac{2u\sin\theta}{g} = 2\sqrt{\frac{2h}{g}}$

61 **(d)**

Centripetal force $F = -\frac{k}{r^2}$

$\frac{mv^2}{r} = \frac{k}{r^2} \Rightarrow mv^2 = \frac{k}{r}$

Kinetic energy $= \frac{1}{2}mv^2 = \frac{k}{2r}$

Since the centripetal force is a conservative force, and for a conservative force,

$F = \frac{dU}{dr} \Rightarrow U = -\int F \cdot dr$

$$U = \int \frac{k}{r^2} dr = -\frac{k}{r}$$

Toatal energy $= K + U = \frac{k}{2r} - \frac{k}{r} = -\frac{k}{2r}$

62 **(d)**

$\vec{A} \times \vec{B} = (\hat{\imath} - 2\hat{\jmath} + 3\hat{k}) \times (3\hat{\imath} - 2\hat{\jmath} + \hat{k})$

$= -2\hat{k} - \hat{\jmath} - 6(-\hat{k}) - 2\hat{\imath} + 9\hat{\jmath} - 6(-\hat{\imath})$

$= 4\hat{\imath} + 8\hat{\jmath} + 4\hat{k}$

Modulus is $\sqrt{4^2 + 8^2 + 4^2} = \sqrt{32 + 64}$

$= \sqrt{96} = 4\sqrt{6}$ units.

63 **(b)**

$$\hat{n} = \frac{\vec{A} \times \vec{B}}{AB\sin\theta} = \frac{A\hat{A} \times B\hat{B}}{AB\sin\theta} = \frac{\hat{A} \times \hat{B}}{\sin\theta}$$

64 **(c)**

Horizontal range $R = \frac{u^2 \sin 2\theta}{g}$

Substituting the given values we get

$$560 = \frac{82 \times 82 \times \sin 2\theta}{9.8}$$

$$\Rightarrow \sin 2\theta = \frac{560 \times 9.8}{82 \times 82} = \frac{5488}{6724}$$

$\Rightarrow \sin 2\theta = 0.82 \Rightarrow 2\theta = \sin^{-1}(0.82)$

$\Rightarrow 2\theta = 55.1° \Rightarrow \theta \approx 27°$

65 **(c)**

From $v = r\omega$, when v is doubled and ω halved, r must be 4 times. Therefore, centripetal acceleration

$= \frac{v^2}{r} = r\omega^2$ will remain unchanged

66 **(d)**

Angular momentum is an axial vector. It is directed always in a fix direction (perpendicular to the plane of rotation either outward or inward), if the sense of rotation remain same

68 **(c)**

$$R_{\max} = \frac{u^2}{g} = 100 \Rightarrow u = 10\sqrt{10} = 32\ m/s$$

69 **(a)**

Maximum height, $H = \frac{u^2\sin^2\theta}{2g}$

Range, $R = \frac{u^2\sin 2\theta}{g}$

Given, $H = \frac{R}{2}$

$$\therefore \frac{u^2\sin^2\theta}{2g} = \frac{u^2 2\sin\theta\cos\theta}{2g}$$

or $\sin\theta = 2\cos\theta$

or $\tan\theta = 2$

or $\theta = \tan^{-1}(2)$

70 **(b)**

$v = r\omega = 0.5 \times 70 = 35 m/s$

71 **(a)**

In uniform circular motion the only force acting on the particle is centripetal (towards centre). Torque of this force about the centre is zero. Hence angular momentum about centre remains conserved.

72 **(a)**

Horizontal velocity of aeroplane,

$$u = \frac{216 \times 1000}{60 \times 100} = 60\ \text{ms}^{-1}$$

Time of flight, $T = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2 \times 1960}{9.8}} = 20\text{s}$

Horizontal range, $AB = uT$

$= 60 \times 20 = 1200\text{m}$

73 **(d)**

$\sqrt{P^2 + Q^2 + 2PQ\cos\theta} = (P - Q)$

$\Rightarrow P^2 + Q^2 + 2PQ\cos\theta = P^2 + Q^2 - 2PQ$

$\Rightarrow 2PQ(1+\cos\theta)=0$

but $2PQ \neq 0$

$\therefore 1 + \cos\theta = 0$ or $\cos\theta = -1$

or $\theta = 180°$

74 **(b)**

Range $= \frac{u^2 \sin 2\theta}{g}$. It is clear that range is proportional to the direction (angle) and the initial speed.

75 **(a)**

Displacement, $\vec{r} = (\vec{r}_2 - \vec{r}_1)$ and workdone $= \vec{F}.\vec{r}$

76 **(a)**

From $F = -\frac{dU}{dr}$, $dU = -F\,dr$

$$U = \int -F\,dr = \int \frac{K}{r^2} dr = -\frac{K}{r}$$

$$\text{KE} = \frac{1}{2}\text{PE} = \frac{K}{2r}$$

Total energy = KE + PE

$$= \frac{K}{2r} - \frac{K}{r} = -\frac{K}{2r}$$

77 **(a)**

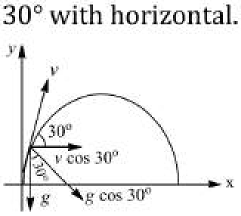
$\vec{F} = F_x\hat{\imath} + F_y\hat{\jmath}$ or $\vec{F} = 2\hat{\imath} - 3\hat{\jmath}$.

78 **(d)**

$$h = \frac{5}{2}r \Rightarrow r = \frac{2}{5} \times h = \frac{2}{5} \times 5 = 2\ metre$$

79 **(c)**

Let v be the velocity of particle when it makes 30° with horizontal. Then



$v \cos 30° = u \cos 60°$

or $v = \frac{u \cos 60°}{\cos 30°} = \frac{20\left(\frac{1}{2}\right)}{\left(\frac{\sqrt{3}}{2}\right)} = \frac{20}{\sqrt{3}} \text{ms}^{-1}$

Now, $g \cos 30° = \frac{v^2}{R}$

or $R = \frac{v^2}{g \cos 30°} = \frac{\left(\frac{20}{\sqrt{3}}\right)^2}{(10)\frac{\sqrt{3}}{2}}$

$= 15.4$ m

80 **(d)**

$p = mv \cos \theta$

$= 1 \times 10 \times \cos 60° = 10\left(\frac{1}{2}\right) \text{kg ms}^{-1}$

$= 5 \text{ kg ms}^{-1}$

81 **(d)**

Momentum, speed and kinetic energy change continuously in a vertical circular motion. The physical quantity which remains constant is the total energy.

82 **(d)**

Maximum tension $= m\omega^2 r = m \times 4\pi^2 \times n^2 \times r$

By substituting the values we get $T_{\max} = 87.64\ N$

83 **(d)**

$v \cos \beta = u \cos \alpha$

$v = \frac{u \cos \alpha}{\cos \beta}$

84 **(d)**

$\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{2\pi v_2 - 2\pi v_1}{t}$

$= \frac{2\pi\left(\frac{1200}{60} - \frac{600}{60}\right)}{10} = 2\pi \text{ rads}^{-2}$

85 **(b)**

$t = \sqrt{\frac{2h}{g}}, x = v\sqrt{\frac{2h}{g}}$ or $v = x\sqrt{\frac{g}{2h}}$

86 **(d)**

Here, $r = 50$ m

As $\tan \theta = \frac{v^2}{rg}$, therefore, when speed v is doubled; r must be made 4 times, if θ remains the same

$\therefore$ New radius of curvature,

$r' = 4r = 4 \times 50 \text{ m} = 200$ m

87 **(a)**

Using the equation for projectile motion,

$y = x \tan \theta - \frac{gx^2}{2u^2}(1 + \tan^2 \theta)$, we have

$40 = 30 \tan \theta - \frac{g(30)^2}{2u}(1 + \tan^2 \theta)$

or $900 \tan^2 \theta - 6u^2 \tan \theta + (900 + 8u^2) = 0$

For real value of θ

$(6u^2)^2 \geq 4 \times 900(900 + 8u^2)$

or $(u^4 - 800u^2) \geq 90000$

or $(u^2 - 400)^2 \geq 200000$

or $u^2 \geq 900$ or $u \geq 30 \text{ms}^{-1}$

88 **(c)**

Frequency of wheel, $v = \frac{300}{60} = 5$ rps. Angle described by wheel in one rotation $= 2\pi$ rad. Therefore, angle described by wheel in 1 s $= 2\pi \times 5$ rad $= 10\pi$ rad

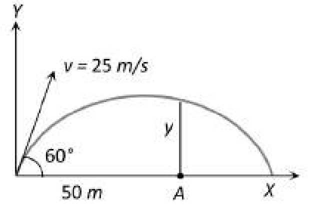
89 **(a)**

Horizontal component of velocity

$v_x = 25 \cos 60° = 12.5\ m/s$

Vertical component of velocity

$v_y = 25 \sin 60° = 12.5\sqrt{3}\ m/s$



Tim to over 50 m distance $t = \frac{50}{12.5} = 4\ sec$

The vertical height y is given by

$y = v_y t - \frac{1}{2}gt^2 = 12.5\sqrt{3} \times 4 - \frac{1}{2} \times 9.8 \times 16$

$= 8.2\ m$

90 **(c)**

For water not to spill out of the bucket,

$v_{\min} = \sqrt{5gR}$ (at the lowest point)

$= \sqrt{5 \times 10 \times 0.5 = 5 \text{ ms}^{-1}}$

91 **(b)**

Here, $m = 5$ kg, $r = 2$m, $v = 6 \text{ ms}^{-1}$

The tension is maximum at the lowest point

$T_{\max} = mg + \frac{mv^2}{r}$

$= 5 \times 9.8 + \frac{5 \times 6 \times 6}{2}$

$= 139$N

92 **(a)**

As the body just completes the circular path, hence critical speed at the highest point.

$v_H = \sqrt{gR}$

which is totally horizontal.

As the string breaks at the highest point, hence form here onwards the body will follow parabolic path. Time taken by the body to reach the ground

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 2R}{g}}$

Hence, horizontal distance covered by the body

$= v_H \times t$

$= \sqrt{gR} \times \sqrt{\frac{4R}{g}} = 2R$

93 **(d)**

$v = \sqrt{\mu r g} = \sqrt{0.25 \times 40 \times 10} = 10\ m/s$

94 **(c)**

$\alpha = \frac{\omega}{t}$ and $\omega = \frac{\theta}{t}$

$\therefore\ \alpha = \frac{\theta}{t^2}$

But α =constant

So, $\frac{\theta_1}{\theta_1+\theta_2} = \frac{(2)^2}{(2+2)^2}$

or $\frac{\theta_1}{\theta_1+\theta_2} = \frac{1}{4}$

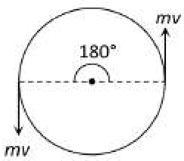
or $\frac{\theta_1+\theta_2}{\theta_1} = \frac{4}{1}$

or $1 + \frac{\theta_2}{\theta_1} = \frac{4}{1}$

$\therefore\ \frac{\theta_2}{\theta_1} = 3$

95 **(d)**

As momentum is vector quantity



$\therefore$ change in momentum

$\Delta P = 2mv \sin(\theta/2)$

$= 2mv \sin(90) = 2mv$

But kinetic energy remains always constant so change in kinetic energy is zero

96 **(a)**

The shape of free surface of water is parabolic, because of difference in centrifugal force ($F = mr\omega^2$, which is proportional to r)

97 **(d)**

$\vec{A} = \hat{i} + \hat{j} + \hat{k}; A = \sqrt{1^2 + 1^2 + 1^2} = \sqrt{3}$

$\cos\theta = \frac{\vec{A}.\hat{i}}{\sqrt{3}} = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}$

$= \frac{1.732}{3} = 0.5773 = \cos 54°44'$

$\theta = 54°44'$

98 **(d)**

For body to move on circular path. Frictional force provides the necessary centripetal force, *ie*, frictional force = centripetal force

or $\mu mg = \frac{mv_0^2}{r} = mr\omega^2$

or $\mu g = r\omega^2$

$\therefore\ 0.5 \times 9.8 = 10\ \omega^2$

or $\omega = 0.7$ rad s^{-1}

99 **(d)**

Horizontal range, $R = \frac{u^2 \sin^2 45°}{2g} = \frac{u^2}{g}$

Maximum height, $H = \frac{u^2 \sin^2 45°}{g} = \frac{u^2}{4g}$

$\therefore\ \frac{R}{H} = \frac{4}{1}$

100 **(a)**

Because the reaction on inner wheel decreases and becomes zero. So it leaves the ground first

101 **(c)**

$V \cos\beta = v \cos\theta$

or $V = v \cos\theta \sec\beta$

102 **(b)**

Given $(KE)_{\text{highest}} = \frac{1}{2}(\text{KE})$

$\frac{1}{2}mv^2 \cos^2\theta = \frac{1}{2}.\frac{1}{2}mv^2$

$\cos^2\theta = \frac{1}{2} \Rightarrow \cos\theta = \sqrt{\frac{1}{2}}$

$\Rightarrow\ \theta = 45°$

103 **(a)**

The horizontal range $R_x = \frac{u^2 \sin 2\theta}{g}$

When projected at angle of 15°

$R_{x1} = \frac{u^2}{g}\sin(2 \times 15) = \frac{u^2}{2g} = 1.5\text{km}$

When projected at angle of 45°

$R_{x1} = \frac{u^2}{g}\sin(2 \times 45°)\frac{u^2}{g}$

$= \frac{2u^2}{2g} = 2 \times 1.5 = 3.0$ km

105 **(d)**

In complete revolution total displacement is zero so average velocity is zero

106 **(b)**

For banking $\tan\theta = \frac{V^2}{Rg}$

$\tan 45 = \frac{V^2}{90 \times 10} = 1$

$V = 30\ m/s$

107 **(a)**

$\vec{A} = A\vec{A}$ or $\vec{A} = \frac{\vec{A}}{A}$

$\therefore$ required unit vector is $\frac{\hat{i}+\hat{j}}{|\hat{i}+\hat{j}|} = \frac{\hat{i}+\hat{j}}{\sqrt{2}}$

108 **(a)**

$v = \sqrt{rg}$

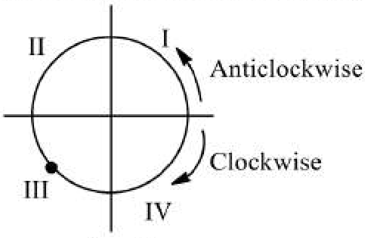
$2r = \frac{2v^2}{g} = \frac{2\times9.8\times9.8}{9.8} = 19.6$ m

109 **(c)**

When the force acting on a body is directed towards a fixed point, then it changes only the direction of motion of the body without changing its speed. So, the particle will describe a circular motion

110 **(b)**

The figure shows a circular path of moving particle. At any instant velocity of particle.



$v = -3\hat{i} - 4\hat{j} = (-3, -4)$ (in coordinate from).

The coordinates of velocity show that particle is in 3rd quadrant at that instant. While moving clockwise particle will enter into 4th quadrant and these into 3rd and while moving anticlockwise particle will enter into 2nd quadrant and then into 3rd quadrant.

∴ 4th and 2nd quadrants.

111 **(a)**

Retarding force $F = ma = \mu R = \mu mg$

$a = \mu g$

Now, from equation of motion, $v^2 = u^2 - 2as$

$\therefore\ 0 = u^2 - 2as$

$$\therefore\ s = \frac{u^2}{2a} = \frac{u^2}{2\mu g} = \frac{v_0^2}{2\mu g}$$

112 **(a)**

$$a = \omega^2 R = \left(\frac{2\pi}{0.2\pi}\right)^2 (5 \times 10^{-2}) = 5\, m/s^2$$

113 **(c)**

$$v = 36\frac{km}{h} = 10\frac{m}{s}\ \therefore F = \frac{mv^2}{r} = \frac{500 \times 100}{50}$$
$$= 1000\, N$$

114 **(a)**

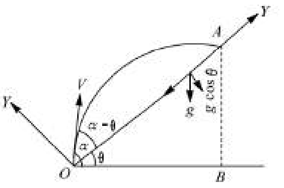
$$\tan\theta = \frac{h}{b} = \frac{v^2}{rg},$$

$$v = \sqrt{\frac{hrh}{b}} = \sqrt{\frac{1.5 \times 50 \times 10}{10}} = 8.5\ \text{ms}^{-1}$$

115 **(b)**

$v_x = v\cos(\alpha - \theta)\,;\, v_y = v\sin(\alpha - \theta)$

$a_x = -g\sin\theta\,;\, a_y = -g\cos\theta$



If T is the time of flight, then

$$0 = v\sin(\alpha - \theta).T - \frac{1}{2}g\cos\theta\,.T^2$$

or $T = \frac{2v\sin(\alpha-\theta)}{g\cos\theta}$

$OB = v\cos\alpha \times T$

Now, $\cos\theta = \frac{OB}{OA}$ or $OA = \frac{OB}{\cos\theta}$

or $OA = \frac{v\sin\alpha T}{\cos\theta}$

or $OA = v\cos\alpha \times \frac{2v\sin(\alpha-\theta)}{g\cos\theta} \times \frac{1}{\cos\theta}$

or $OA = \frac{v^2}{g\cos^2\theta}[\sin(2\alpha - \theta)\cos\alpha]$

or $OA = \frac{v^2}{g\cos^2\theta}[\sin(2\alpha - \theta) + \sin(-\theta)]$

or $OA = \frac{v^2}{g\cos^2\theta}[\sin(2\alpha - \theta) - \sin\theta]$

Clearly, the range $R(= OA)$ will be maximum when $\sin(2a - \theta)$ is maximum, *ie*, 1.

This would mean

$2\alpha - \theta = \frac{\pi}{2}$ or $\alpha\ \frac{\theta}{2} + \frac{\pi}{4}$

Maximum range up the inclined plane,

$$R_{\max} = \frac{v^2}{g\cos^2\theta}(1 - \sin\theta) = \frac{v^2(1 - \sin\theta)}{g(1 - \sin^2\theta)}$$
$$= \frac{v^2(1 - \sin\theta)}{g(1 - \sin\theta)(1 + 1 - \sin\theta)} = \frac{v^2}{g(1 + \sin\theta)}$$

116 **(b)**

$$R_{\max} = \frac{u^2}{g} = 16 \times 10^3$$

$\Rightarrow u = 400 m/s$

117 **(c)**

Because horizontal velocity is same for coin and the observer. So relative horizontal displacement will be zero

118 **(c)**

As, $\vec{A}\cdot\vec{B} = 0$ so $\vec{A}$ is perpendicular to $\vec{B}$. Also $\vec{A}.\vec{C} = 0$ means $\vec{A}$ is perpendicular to $\vec{C}$. Since $\vec{B} \times \vec{C}$ is perpendicular to $\vec{B}$ and $\vec{C}$, so $\vec{A}$ parallel to $\vec{B} \times \vec{C}$.

119 **(b)**

Given, $y = 12x - \frac{3}{4}x^2$

$u_x = 3\ \text{ms}^{-1}$

$$v_y = \frac{dy}{dt} = 12\frac{dx}{dt} - \frac{3}{2}x\frac{dx}{dt}$$

At $x = 0, v_y = u_y = 12\frac{dx}{dt} = 12u_x = 12 \times 3 = 36\ ms^{-1}$

$a_y = \frac{d}{dt}\left(\frac{dy}{dt}\right) = 12\frac{d^2x}{dt^2} - \frac{3}{2}\left(\frac{dx}{dt} + x\frac{d^2x}{dt^2}\right)$

But $\frac{d^2x}{dt^2} = a_x = 0$, hence

$a_y = -\frac{3}{2}\frac{dx}{dt} = -\frac{3}{2}u_x = -\frac{3}{2} \times 3 - \frac{9}{2}ms^{-2}$

Range $R = \frac{2u_xu_y}{a_y} = \frac{2\times3\times12}{9/2} = 16m$

120 **(c)**

They have same ω

Centripetal acceleration $= \omega^2 r$

$\frac{a_1}{a_2} = \frac{\omega^2 r_1}{\omega^2 r_2} = \frac{r_1}{r_2}$

121 **(c)**

$a_T = \frac{dv}{dt} = \frac{d}{dt}(2t) = 2m/s^2$

$a_c = \frac{V^2}{r} = \frac{(2 \times 3)^2}{30 \times 10^{-2}} = 120\ m/s^2$

122 **(d)**

Let $\vec{\mathbf{u}}_1$ and $\vec{\mathbf{u}}_2$ be the initial velocities of the two particles and θ_1 and θ_2 be their angles of projection with the horizontal

The velocities of the two particles after time t are,

$\vec{\mathbf{v}}_1 = (u_1 \cos\theta_1)\hat{\mathbf{i}} + (u_1 \sin\theta_1 - gt)\hat{\mathbf{j}}$ and

$\vec{\mathbf{v}}_1 = (u_1 \cos\theta_1)\hat{\mathbf{i}} + (u_2 \sin\theta_2 - gt)\hat{\mathbf{j}}$

Their relative velocity is $\vec{\mathbf{v}}_{12} = \vec{\mathbf{v}}_1 - \vec{\mathbf{v}}_2$

$= (u_1 \cos\theta_1 - u_2 \cos\theta_1)\,\hat{\mathbf{i}} + (u_1 \sin\theta_1 - u_2 \sin\theta_2)\hat{\mathbf{j}}$

Which is a constant. So the path followed by one, as seen by the other is a straight line, making a constant angle with the horizontal

123 **(c)**

Centripetal force is provided by friction, so

$\frac{mv^2}{r} < f_L\ ie, \frac{mv^2}{r} < \mu mg$

$i.e,\ \ v < \sqrt{\mu gr}$ so that, $v_{max} = \sqrt{\mu gr}$

Here, $\mu = 0.4, r = 30m$ and $g = 10ms^{-2}$

$\therefore\ v_{max} = \sqrt{0.4 \times 30 \times 10} = 11m/s$

124 **(c)**

$P + Q = 16$ (i)

$P^2 + Q^2 + 2PQ\cos\theta = 64$ (ii)

$\tan 90° = \frac{Q\sin\theta}{P+Q\cos\theta}$

$\infty = \frac{Q\sin\theta}{P + Q\cos\theta}$

$\Rightarrow\ \ P + Q\cos\theta = 0$ or $Q\cos\theta = -P$

From Eq. (ii)

$P^2 + Q^2 + 2P(-P) = 64$ or $Q^2 - P^2 = 64$

or $(Q - P)(Q + P) = 64$

or $Q - P = \frac{64}{16} = 4$ (iii)

Adding Eq. (i) and (iii), we get

$2Q = 20$ or $Q = 10$ units

From (i), $P + 10 = 16$ or $P = 6$ units

125 **(c)**

Let A and B be the two forces. As per question

$\sqrt{A^2 + B^2} = 5$

or $A^2 + B^2 = 25$ (i)

and $A^2 + B^2 + 2AB\cos 120° = 13$

or $25 + 2AB \times (-1/2) = 13$

or $AB = 25 - 13 = 12$

or $2AB = 24$ (ii)

Solving (i) and (ii), we get

$A = 3N$

and $B = 4$ N

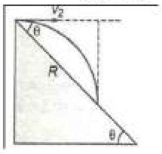
126 **(a)**

Range of the projectile on an inclined plane (down the plane) is,

$R = \frac{u^2}{g\cos^2\beta}[\sin(2\alpha + \beta) + \sin\beta]$

Here, $u = v_0, \alpha = 0$ and $\beta = \theta$

$\therefore R = \frac{2v_0^2 \sin\theta}{g\cos^2\theta}$



Now $x = R\cos\theta = \frac{2v_0^2 \tan\theta}{g}$

and $y = -R\sin\theta = -\frac{2v_0^2 \tan^2\theta}{g}$

127 **(c)**

The result follows from the definition of cross product.

128 **(d)**

Maximum height attained is given by

$h_{max} = \frac{u^2}{2g}$

Given, $u = 20ms^{-1}$

$h_{max} = \frac{(20)^2}{2 \times 10} = 20m$

For the second body also $h_{max} = 20m$

$\therefore$ Sum of maximum height = 20m+20m=40m

129 **(a)**

$\frac{a_R}{a_r} = \frac{\omega_{R\times R}^2}{\omega_r^2 \times r} = \frac{T_r^2}{T_R^2} \times \frac{R}{r} = \frac{R}{r}[As\ T_r = T_R]$

130 **(b)**

$v = r\omega = 20 \times 10 cm/s = 2m/s$

131 **(d)**

Tension at the top of the circle

$T = m\omega^2 r - mg$

$T = 0.4 \times 4\pi^2 n^2 \times 2 - 0.4 \times 9.8$

$= 115.86$ N

132 **(c)**

$x = 20 \times 5 = 100\text{m}$

$y = \frac{1}{2} \times 10 \times 5 \times 5 = 125\text{m}$

$r = \sqrt{100^2 + 125^2} = 160\text{m}$

133 **(a)**

Initial angular velocity $\omega_0 = 0$. Final angular velocity $\omega = \frac{v}{r} = \frac{80}{(20/\pi)} = 4\pi$ rad s^{-1}

angle described, $\theta = 4\pi$ rad

$\therefore$ Angular acceleration, $\alpha = \frac{\omega^2 - \omega_0^2}{2\theta}$

$= \frac{(4\pi)^2 - 0}{2 \times 4\pi} = 2\pi$ rad s^{-2}

Linear acceleration, $a = \alpha r$

$= 2\pi \times \frac{20}{\pi} = 40$ ms^{-2}

134 **(b)**

Maximum height $H = \frac{v^2 \cos^2 \beta}{2g}$

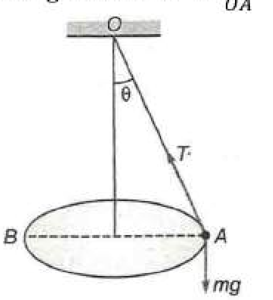
or $v\cos\beta = \sqrt{2gH}$

$t = \frac{v\cos\beta}{g} = \frac{\sqrt{2gH}}{g}$

$t = \sqrt{\frac{2H}{g}}$

135 **(d)**

In figure, $\sin 30° = \frac{AB}{OA}$



or $OA = \frac{AB}{\sin 30°} = \frac{4}{1/2} = 8\text{m}$

$\frac{T}{AO} = \frac{F}{AB} = \frac{mg}{OB}$

$F = \frac{AO}{AB} \times F = \frac{AO}{AB} \frac{mv^2}{r} = \frac{8}{4} \times 10 \times \frac{5^2}{4} \approx 125$ N

136 **(b)**

If any two vectors are parallel or equal, then the scalar triple product is zero.

137 **(c)**

The body crosses the top most position of a vertical circle with critical velocity, so the velocity at the lowest point of vertical circle $u = \sqrt{5gr}$

Velocity of the body when string is horizontal is

$v^2 = u^2 - 2gr = 5gr - 2gr = 3gr$

$\therefore$ Centripetal acceleration $= \frac{v^2}{r} = \frac{3gr}{r} = 3g$

138 **(a)**

To avoid slipping friction force

$F = \frac{mv^2}{r}$

$F = \frac{2000 \times 10 \times 10}{20} = 10^4$ N

139 **(a)**

Let $\vec{A} + \vec{B} = \vec{R}$. Given $A_x = 7$ and $A_y = 6$

Also $R_x = 11$ and $R_y = 9$. Therefore,

$B_x = R_x - A_x = 11 - 7 = 4$

and $B_y = R_y - A_y = 9 - 6 = 3$

Hence, $B = \sqrt{B_x^2 + B_y^2} = \sqrt{4^2 + 3^2} = 5$

140 **(c)**

Instantaneous velocity of rising mass after t sec will be

$v_t = \sqrt{v_x^2 + v_y^2}$

Where $v_x = v\cos\theta$ = Horizontal component of velocity

$v_y = v\sin\theta - gt$

= Vertical component of velocity

$v_t = \sqrt{(v\cos\theta)^2 + (v\sin\theta - gt)^2}$

$v_t = \sqrt{v^2 + g^2t^2 - 2v\sin\theta\ gt}$

141 **(b)**

Net acceleration in nonuniform circular motion,

$a = \sqrt{a_t^2 + a_c^2} = \sqrt{(2)^2 + \left(\frac{900}{500}\right)^2} = 2.7\ m/s^2$

a_t = tangential acceleration

a_c = centripetal acceleration $= \frac{v^2}{r}$

142 **(d)**

$v_x = \frac{dx}{dt} = 2ct$ and $v_y = \frac{dy}{dt} = 2bt$

$\therefore v = \sqrt{v_x^2 + v_y^2} = 2t(c^2 + b^2)^{1/2}$

143 **(d)**

Tension at mean position, $mg + \frac{mv^2}{l} = 3mg$

$v = \sqrt{2gl}$

And if the body displaces by angle θ with the vertical

Then $v = \sqrt{2gl(1 - \cos\theta)}$

Comparing (i) and (ii), $\cos\theta = 0 \Rightarrow \theta = 90°$

144 **(b)**

$$h = (u\sin\theta)t - \frac{1}{2}gt^2$$

$$d = (u\cos\theta)t \text{ or } t = \frac{d}{u\cos\theta}$$

$$h = u\sin\theta . \frac{d}{u\cos\theta} - \frac{1}{2}g . \frac{d^2}{u^2\cos^2\theta}$$

$$u = \frac{d}{\cos\theta}\sqrt{\frac{g}{2(d\tan\theta - h)}}$$

145 **(c)**

Resultant acceleration

$$= \sqrt{\left(\begin{matrix}\text{tangential}\\ \text{acceleration}\end{matrix}\right)^2 + \left(\begin{matrix}\text{centripetal}\\ \text{acceleration}\end{matrix}\right)^2}$$

$$= \sqrt{a^2 + \left(\frac{v^2}{r}\right)^2} = \sqrt{\frac{v^4}{r^2} + a^2}$$

146 **(d)**

$a_c = k^2rt^4 = \frac{v^2}{r}$ or $v = krt^2$

The tangential acceleration is $a_T = \frac{dv}{dt} = 2krt$

The tangential force on the particle, $F_T = ma_T = 2mkrt$

Power delivered to the particle

$= F_T = ma_T = 2mkrt = F_Tv = (2mkrt)(krt)^2$
$= 2mk^2r^2t^3$

147 **(c)**

Tension, $T = \frac{mv^2}{r} + mg\cos\theta$

For, $\theta = 30°, T_1 = \frac{mv^2}{r} + mg\cos 30°$

$\theta = 60°, T_2 = \frac{mv^2}{r} + mg\cos 60° \therefore T_1 > T_2$

148 **(c)**

Here, $r = 300$ m, $\mu = 0.3$, $g = 10\ \text{ms}^{-2}$

$v_{max} = \sqrt{\mu rg} = \sqrt{0.3 \times 300 \times 10} = 30\ \text{ms}^{-1}$

$= 30 \times \frac{18}{5}\text{km h}^{-1} = 108\text{ km h}^{-1}$

149 **(c)**

Let v be the velocity of projection and θ the angle of projection

Kinetic energy at highest point

$= \frac{1}{2}mv^2\cos^2\theta$ or $E_k\cos^2\theta$

Potential energy at highest point

$= E_k - E_k\cos^2\theta = E_k(1-\cos^2\theta) = E_k\sin^2\theta$

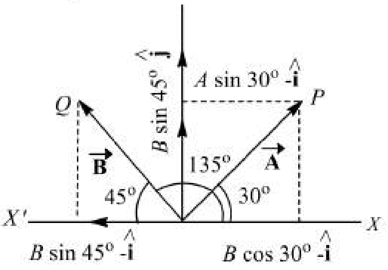
150 **(a)**

Here $\vec{A} - \overrightarrow{OP} = 10$ units along OP

$\vec{B} - (\overrightarrow{OQ}) = 10$ units along OQ

$\therefore\ \angle XOP = 30°$ and $\angle XOQ = 135°$

$\therefore\ \angle QOX' = 180° - 135° = 45°$



Resolving $\vec{A}$ and $\vec{B}$ into two rectangular components we have $A\cos 30°$ along OX and $A\sin 30°$ along OY. $B\cos 45°$ along OX' and $B\sin 45°$ along OY'.

Resultant component force along X-axis.

$(A\cos 30° - B\sin 45)\hat{i}$

$= (10 \times \sqrt{3}/2 - 10 \times 1/\sqrt{2})\hat{i} = 1.59\hat{i}$

Resultant component force along Y-axis

$= (A\sin 30° + B\sin 45°)\hat{j}$

$= (10 \times 1/2 + 10 \times 1/\sqrt{2})\hat{j} = 12.07\hat{j}$

151 **(a)**

The angle of banking, $\tan\theta = \frac{v^2}{rg}$

$\Rightarrow \tan 12° = \frac{(150)^2}{r \times 10} \Rightarrow r = 10.6 \times 10^3 m$
$= 10.6\ km$

152 **(c)**

$\vec{A} + \vec{B} = \vec{C}$ (given)

So, it is given that $\vec{C}$ is the resultant of $\vec{A}$ and $\vec{B}$

$\therefore\ C^2 = A^2 + B^2 + 2AB\cos\theta$

$3^2 = 3 + 3 + 2 \times 3 \times \cos\theta$

$3 = 6\cos\theta$ or $\cos\theta = \frac{1}{2}$ $\Rightarrow \theta\ 60°$

153 **(a)**

At the highest point, velocity is horizontal

154 **(a)**

$\vec{A} \cdot \vec{B} = 0 \Rightarrow \vec{A} \perp \vec{B}$

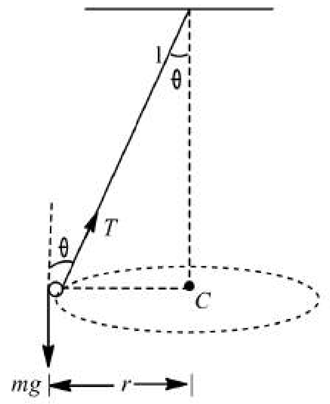
Now, $\vec{A} \times \vec{B} = \vec{1}$ or $AB\sin\theta = 1$

$AB\sin 90° = 1$ or $AB = 1 \Rightarrow A = 1$ and $B = 1$

So, $\vec{A}$ and $\vec{B}$ are perpendicular unit vectors.

155 **(d)**

$T\cos\theta$ component will cancel mg.



$T \sin\theta$ Component will provide necessary centripetal force the ball towards center C.

$\therefore T\sin\theta = mr\omega^2 = m(l\sin\theta)\omega^2$

or $T = ml\omega^2 \Rightarrow \omega = \sqrt{\frac{T}{ml}}$ rad/s

or $\omega_{max} = \sqrt{\frac{T_{max}}{ml}} = \sqrt{\frac{324}{0.5\times 0.5}} = 36$ rad/s

156 **(c)**

Here, $v_{max} = ?, r = 18$ m, $g = 10\ ms^{-2}$

$\mu = 0.2$

$\frac{mv_{max}^2}{r} = F = \mu R = \mu mg$

$v_{max} = \sqrt{\mu rg} = \sqrt{0.2\times 18\times 10} = 6\ ms^{-1}$

$= 6\times\frac{18}{5}$ km h^{-1} = 21.6 km h^{-1}

157 **(b)**

$v = \sqrt{5gR}$

When $R' = \frac{R}{4}$

$v' = \sqrt{5gR'} = \sqrt{5gR/4} = \frac{1}{2}\sqrt{5gR} = \frac{1}{2}v$

158 **(b)**

Given, $R = H$

$\frac{u^2\sin 2\alpha}{g} = \frac{u^2\sin^2\alpha}{2g}$

or $2\sin\alpha\cos\alpha = \frac{\sin^2\alpha}{2}$

or $\frac{\sin\alpha}{\cos\alpha} = 4$ or $\tan\alpha = 4$

$\therefore\ a = \tan^{-1}(4)$

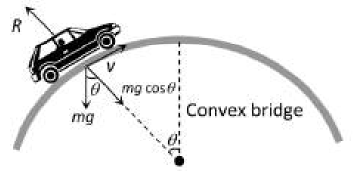
159 **(b)**

$T\sin\theta = mr\omega^2 = m(l\sin\theta)\omega^2$

or $T = ml\omega^2 = ml\left(2\pi\times\frac{2}{\pi}\right)^2 = 16ml$

161 **(a)**

$R = mg\cos\theta - \frac{mv^2}{r}$



When θ decreases $\cos\theta$ increases *i.e.*, R increases

162 **(a)**

Area of parallelogram = $|A\times B|$

$AB\sin\theta = \frac{1}{2}AB$

$\therefore \sin\theta = \frac{1}{2}, \theta = 30°$

163 **(a)**

$\vec{L} = \vec{r}\times\vec{p} = \begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 0 & 4 & 0\\ 2 & 3 & 1\end{vmatrix}$

$= \hat{i}[4-0] + \hat{j}[0-0] + \hat{k}[0-8] = 4\hat{i} - 8\hat{k}$

164 **(a)**

In this problem it is assumed that particle although moving in a vertical loop but its speed remain constant

Tension at lowest point $T_{max} = \frac{mv^2}{r} + mg$

Tension at highest point $T_{min} = \frac{mv^2}{r} - mg$

$\frac{T_{max}}{T_{min}} = \frac{\frac{mv^2}{r}+mg}{\frac{mv^2}{r}-mg} = \frac{5}{3}$

By solving we get, $v = \sqrt{4gr} = \sqrt{4\times 9.8\times 2.5} = \sqrt{98}\ m/s$

165 **(b)**

$F^2 = F_1^2 + F_2^2 + 2F_1F_2\cos 90°$

or $F^2 = F_1^2 + F_2^2 \Rightarrow F = \sqrt{F_1^2 + F_2^2}$

166 **(c)**

For uniform circular motion $a_t = 0$

$a_r = \frac{v^2}{r} \neq 0$

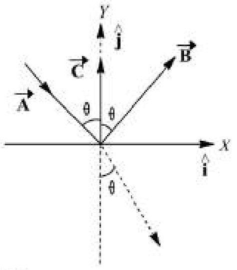
167 **(c)**

$F = m\omega^2 R\ \therefore F \propto R$ (m and ω are constant)

If radius of the path is halved, then force will also become half

168 **(d)**

Let $\vec{A}, \vec{B}$ and $\vec{C}$ be as shown in figure. Let θ be the angle of incidence, which is also equal to the angle of reflection. Resolving these vectors in rectangular components, we have



$\vec{A} = \sin\theta\hat{i} - \cos\theta\hat{j}$

$\vec{B} = \sin\theta\hat{i} + \cos\theta\hat{j}$

$\vec{B} - \vec{A} = 2\cos\theta\,\hat{j}$

or $\vec{B} = \vec{A} + 2\cos\theta\,\hat{j}$

Now $\vec{A}.\vec{C} = 2\cos\theta\hat{j}$ or $\vec{B} = \vec{A}\cos\theta\,\hat{j}$

$\therefore\ \vec{B} = \vec{A} - 2(\vec{A}.\vec{C})\hat{j}$ or $\vec{B} = \vec{A} - 2(\vec{A}.\vec{C})\vec{C}$

(as $\hat{j} = \vec{C}$)

169 **(c)**

When a stone tied at the end of string is rotated in a circle, the velocity of the stone at an instant acts tangentially outwards the circle. When the string is released, the stone files off tangentially outwards *ie*, in the direction of velocity

170 **(c)**

In projectile motion given angular projection, the horizontal component velocity remains unchanged. Hence

$v\cos\alpha = u\cos\theta$ or $v = u\cos\theta\sec\alpha$

171 **(d)**

$$s = 0\times1 + \frac{1}{2}\times9.8\times1\times1 = 4.9\text{ m}$$

172 **(d)**

Minimum speed at the highest point of vertical circular path $v = \sqrt{gR}$

173 **(c)**

When $\theta = 180°$, the particle will be at diametrically opposite point, where its velocity is opposite to the initial directions of motion. The change in momentum $= mv - (-mv) = 2mv$ (maximum). When $\theta = 360°$, the particle is at the initial position with momentum m. Change in momentum $mv - mv = 0$ (minimum)

174 **(d)**

$R = 4H\cot\theta$, if $\theta = 45°$ then $R = 4H \Rightarrow \frac{R}{H} = \frac{4}{1}$

176 **(b)**

Maximum tension in the thread is given by

$$T_{max} = mg + \frac{mv^2}{r}$$

or $T_{max} = mg + mrw^2 \qquad (\because v = r\omega)$

or $\omega^2 = \dfrac{T_{max} - mg}{mr}$

Given, $T_{max} = 37$ N, m = 500g = 0.5 kg, $g = \text{mg}^{-2}$,

$r = 4$m

$$\therefore\ \omega^2 = \frac{37 - 0.5\times10}{0.5\times4} = \frac{37-5}{2}$$

or $\omega^2 = 16$

or $\omega = 4$ rad s^{-1}

177 **(a)**

$$mg = 1\times10 = 10N, \frac{mv^2}{r} = \frac{1\times(4)^2}{1} = 16$$

Tension at the top of circle $= \frac{mv^2}{r} - mg = 6N$

Tension at the bottom of circle $= \frac{mv^2}{r} + mg = 26N$

178 **(b)**

Let v be the velocity acquired by the body at B which will be moving making an angle 45° with the horizontal direction. As the body just crosses the well so $\frac{v^2}{g} = 40$

or $v^2 = 40g = 40\times10 = 400$

or $v = 20\text{ ms}^{-1}$

Taking motion of the body from A to B along the inclined plane we have

$$u = v_0, a = -g\sin45° = -\frac{10}{\sqrt{2}}\text{ms}^{-2}$$

$s = 20\text{m}, v = 20\text{ms}^{-1}$

As $v^2 = u^2 + 2as$

$$\therefore\ 400 = v_0^2 + 2\left(-\frac{10}{\sqrt{2}}\right)\times20\sqrt{2}$$

or $v_0^2 = 400 + 400 = 800$ or $v = 20\sqrt{2}\text{ms}^{-1}$

179 **(a)**

Centripetal force

$$\frac{mv^2}{R} = ma$$

or $\quad a = \dfrac{v^2}{R}$

$$\therefore\ \frac{a_1}{a_2} = \frac{v_1^2}{v_2^2}$$

Here, $\quad v_1 = v,\ v_2 = 2v, \qquad a_1 = a$

$$\therefore\ \frac{a}{a_2} = \frac{v^2}{(2v)^2} = \frac{1}{4}$$

or $a_2 = 4a$

180 **(c)**

$L = I\omega$. In U. C. M. ω = constant $\therefore L$ = constant.

181 **(d)**

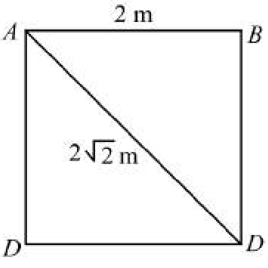
Displacement is distance from initial to final position In 40s cyclist completes =1 round

∴ In 3 min(180 s) cyclist will complete

$= 4\frac{1}{2}$ round Displacement for 4 round is zero.

Displacement for $\frac{l}{2}$ round = length of diagonal

$= 2\sqrt{2}$m.



182 **(d)**

$B_x = 10 - 6 = 4$ and $B_y = 9 - 6 = 3$

so, $B = (B_x^2 + B_y^2)^{1/2} = \sqrt{4^2 + 3^2} = \sqrt{16 + 9}$

$= \sqrt{25} = 5$

183 **(a)**

$(2\hat{\imath} - 3\hat{\jmath} + \hat{k}).(3\hat{\imath} + 3\hat{\jmath}) = 6(\hat{\imath}.\hat{\imath}) - 6(\hat{\jmath}.\hat{\jmath}) = 0$

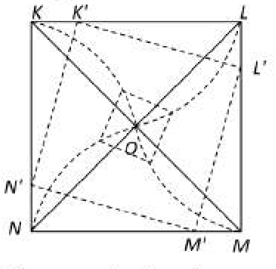
184 **(c)**

$\omega = \frac{d\theta}{dt} = \frac{d}{dt}(2t^3 + 0.5) = 6t^2$

At $t = 2\ s, \omega = 6 \times (2)^2 = 24\ rad/s$

185 **(a)**

It is obvious from considerations of symmetry that at any moment of time all of time all of the persons will be at the corners of square whose side gradually decreases (see fig.) and so they will finally meet at the centre of the square O



The speed of each person along the line joining his initial position and O will be $v \cos 45 = v/\sqrt{2}$

As each person has displacement $d \cos 45 = d/\sqrt{2}$ to reach the centre, the four persons will meet at the centre of the square O after time

$\therefore t = \frac{d/\sqrt{2}}{v/\sqrt{2}} = \frac{d}{v}$

186 **(a)**

From $h = \frac{1}{2}gt^2$

We have $t_{OB} = \sqrt{\frac{2h_{OA}}{g}}$

$= \sqrt{\frac{2 \times 1960}{9.8}} = 20$s

Horizontal distance $AB = vt_{OB}$

$= \left(600 \times \frac{5}{18}\right)(20)$

$= 3333.33$ m $= 3.33$ km

187 **(a)**

Here, $r = 92$ m, $v = 26\ ms^{-1}$, $\mu = ?$

As $\frac{mv^2}{r} = F = \mu R = \mu\, mg$

$\mu = \frac{v^2}{rg} = \frac{26 \times 26}{92 \times 9.8} = 0.75$

188 **(c)**

$\frac{u_x}{u_y} = \cot 30° = \sqrt{3} \therefore u_x = 80\sqrt{3}\ ms^{-1}$

$T = \frac{2u_y}{g} = \frac{2 \times 80}{10} = 16$ s

At $t = \frac{T}{4} = 4\ s, v_x = 80\sqrt{3}\ ms^{-1}$

$v_y = 80 - 10 \times 4 = 40\ ms^{-1}$

$\therefore 0\ v = \sqrt{(80\sqrt{3})^2 + (40)^2} = 140\ ms^{-1}$

189 **(b)**

Due to air resistance, it's horizontal velocity will decrease so it will fall behind the aeroplane

190 **(d)**

$v \cos\theta = 10 \cos 60° = 5\ ms^{-1}$

191 **(c)**

$v = \sqrt{\mu\, rg} = \sqrt{0.25 \times 80 \times 9.8} = 14\ ms^{-1}$

192 **(b)**

$\text{Tan } 45° = \frac{2\sin 60°}{a + 2\cos 60°} = \frac{\sqrt{3}}{a+1}$

$1 = \frac{\sqrt{3}}{a+1}$

or $a + 1 = \sqrt{3}$

$a = \sqrt{3} - 1$

193 **(a)**

$|\overrightarrow{\Delta v}| = 2v \sin(\theta/2) = 2v \sin\left(\frac{90}{2}\right) = 2v \sin 45$

$= v\sqrt{2}$

194 **(b)**

$T_{top} = \frac{mv^2}{r} - mg$ ...(i)

$T_{bottom} = \frac{mv^2}{r} + mg$ ...(ii)

$\frac{T_{top}}{T_{bottom}} = \frac{\frac{v^2}{r} - g}{\frac{v^2}{r} + g} = \frac{\frac{40 \times 40}{4} - 10}{\frac{40 \times 40}{4} + 10}$

$= \frac{400 - 10}{400 + 10} = \frac{390}{410} = \frac{39}{41}$

195 **(b)**

Let $\widehat{A}+\widehat{B}=\widehat{R}$ then using parallelogram law of vectors we have

$1=(1^2+1^2+2.1.1\cos\theta)^{1/2}$

or $\quad 1=2(1+\cos\theta)$

or $\quad \frac{1}{2}-1=\cos\theta$

or $\quad \cos\theta=-\frac{1}{2}=\cos120°$

or $\quad \theta=120°$

$\therefore |\widehat{A}-\widehat{B}|=|\widehat{A}+(-\widehat{B})|$.

Now the angle between $\widehat{A}$ and $-\widehat{B}$ is 60°

The resultant of $|\widehat{A}+(-\widehat{B})|$

$(1^2+1^2+2\times1\times1\times\cos60°)^{1/2}$

$=\sqrt{3}$

196 **(d)**

We know that if two stones have same horizontal range, then this implies that both are projected at θ and $90°-\theta$.

Given, $\theta=\frac{\pi}{3}=60°$

$\therefore\ 90°-\theta=90°-60°=30°$

For first stone,

Maximum height $=102=\frac{u^2\sin^2 60°}{2g}$

For second stone,

Maximum height, $h=\frac{u^2\sin^2 30°}{2g}$

$\therefore \frac{h}{102}=\frac{\sin^2 30°}{\sin^2 60°}=\frac{(1/2)^2}{(\sqrt{3}/2)^2}$

or $h=102\times\frac{1/4}{3/4}=34$ m

197 **(b)**

$$\vec{L}=\vec{r}\times m\vec{v}=H\,mv\cos\theta=\frac{v\sin^2\theta}{2g}mv\cos\theta$$

$$=\frac{mv^3}{4\sqrt{2}g}$$

198 **(a)**

As $S=t^3+5$

$\frac{ds}{dt}=3t^2=v$

$\therefore a_t=\frac{dv}{dt}=6t$

at $t=2\ sec$

$|\vec{a}|=\sqrt{a_c^2+a_t^2}$

$=\sqrt{\left(\frac{v^2}{R}\right)^2+a_t^2}=\sqrt{\left(\frac{4t^4}{R}\right)^2+\left(\frac{dv}{dt}\right)^2}$

$=\sqrt{(7.2)^2+144}$

$|\vec{a}|=14m/s^2$

199 **(c)**

$\frac{v^2}{g}=100$ or $v^2=100$ g

$h_{\text{max.}}=\frac{v^2}{2g}=\frac{100g}{2g}=50$m

200 **(b)**

In going from C to A, potential energy lost = potential energy gained in going from A to B

For looping the loop, minimum velocity required at B is $\sqrt{gR}$. This must be the velocity of push down initially from C

201 **(b)**

$\omega_1=2\pi r=2\pi\times20, \omega_2=0, t=20a, \alpha=?$

As $\omega_2=\omega_1+\alpha t$

$\therefore \alpha=\frac{\omega_2-\omega_1}{t}=\frac{40\pi-0}{20}=2\pi$ rad s^{-2}

202 **(d)**

In non-uniform circular motion particle possess both centripetal as well as tangential acceleration

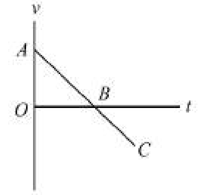
203 **(d)**

Maximum range $=\frac{u^2}{g}=100\ m$

Maximum height $=\frac{u^2}{2g}=\frac{100}{2}=50\ m$

204 **(a)**

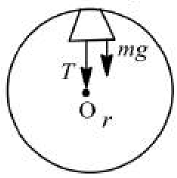
Taking initial position as origin and direction of motion (*i.e.*, vertically up) as positive. As the particle is thrown with initial velocity, at highest point its velocity is zero and then it returns back to its reference position. This situation is best depicted in figure of option (a)



In figure, AB part denotes upward motion and BC part denotes downward motion

205 **(b)**

When a body is revolving in circular motion it is acted upon by a centripetal force directed towards the center. Water will not fall if weight is balanced by centripetal force. Therefore



$mg=\frac{mv^2}{r}$

$\Rightarrow v^2=rg\ \ ...(i)$

Circumference of a circle is $2\pi r$.

Time of revoluation $= \frac{2\pi r}{v}$

Putting the value of v from Eq. (i), we get

$$T = \frac{2\pi r}{\sqrt{gr}} = 2\pi\sqrt{\frac{r}{g}}$$

Given, $r = 4$ m, $g = 9.8\ \frac{\text{m}^2}{\text{s}}$

$$\therefore T = 2\pi\sqrt{\frac{4}{9.8}}$$

$$\Rightarrow T = \frac{4\pi}{\sqrt{9.8}} = 4\text{s}$$

206 **(b)**

Time of flight of this particle, $T = 4$ s. if u is its initial speed and θ is the angle of projection, then

$T = 4 = \frac{2u\sin\theta}{g}$ or $u\sin\theta = 2g$ ...(i)

After 1 s, the velocity vector of particle makes an angle of 45° with horizontal, so

$v_x = v_y$ ie, $u\cos\theta = (u\sin\theta) - gt$

or $u\cos\theta = 2g - g \quad (\therefore t = 1s)$

or $u\cos\theta = g$ ...(ii)

Squaring and adding Eqs. (i) and (ii), we have

$u^2 = 5g^2 = 5(10)^2 = 500$

or $u = \sqrt{500} = 22.36\ \text{ms}^{-1}$

Dividing Eq. (i) by Eq. (ii), we have

$\tan\theta = 2$ or $\theta = \tan^{-1}(2)$

207 **(b)**

Centripetal force = breaking force

$\Rightarrow m\omega^2 r =$ breaking stress × cross sectional area

$$\Rightarrow m\omega^2 r = p \times A \Rightarrow \omega = \sqrt{\frac{p \times A}{mr}}$$

$$= \sqrt{\frac{4.8 \times 10^7 \times 10^{-6}}{10 \times 0.3}}$$

$\therefore \omega = 4\ rad/sec$

208 **(d)**

$$\theta = 2\pi n = \omega_0 t + \frac{1}{2}\alpha t^2$$

$2\pi \times 10 = \frac{1}{2}\alpha 4^2$ or $\alpha = \frac{40\pi}{16}$

Let it make N rotations in the first 8 s

Then, $2\pi N = \frac{1}{2}\alpha\, 8^2$

or $N = \frac{1}{2\pi} \times \frac{64}{2} \times \frac{40\pi}{16} = 40$

∴ The required number of rotations

$= 40 - 10 = 30$

209 **(d)**

$$\frac{1}{2}mu^2 - \frac{1}{2}mv^2 = mgL$$

$$\Rightarrow v = \sqrt{u^2 - 2gL}$$

$$|\vec{v} - \vec{u}| = \sqrt{u^2 + v^2} = \sqrt{u^2 + u^2 - 2gL}$$

$$= \sqrt{2(u^2 - gL)}$$

210 **(a)**

For particle P, motion between A and C will be an accelerated one while between C and B a retarded one. But in any case horizontal component of it's velocity will be greater than or equal to v on the other hand in case of particle Q, it is always equal to v. Horizontal displacement of both the particles are equal, so $t_P < t_Q$

211 **(c)**

Equation of projectile

$$y = x - \left(\frac{5}{9}\right)x^2$$

Standard equation

$$y = x\tan\theta - \frac{g}{2u^2\cos^2\theta} \cdot x^2$$

On comparing, we get

$\tan\theta = 10$

and $\frac{g}{2u^2\cos^2\theta} = \frac{5}{9}$

or $10u^2\cos^2\theta = 9g$

$g = 10\ \text{ms}^{-2}$

$\therefore u^2\cos^2\theta = 9$

range of projecticle $R = \frac{2u^2\tan\theta \cdot \cos\theta}{g}$

$$= \frac{2u^2\tan\theta \cdot \cos\theta}{g}$$

$(\because \sin\theta = \tan\theta \cdot \cos\theta)$

$$\frac{2(u^2\cos^2\theta) \cdot \tan\theta}{g}$$

$$= \frac{2 \times 9 \times 10}{10} = 18\ \text{m}$$

212 **(c)**

$$a = \frac{v^2}{r} = \omega^2 r = 4\pi^2 n^2 r = 4\pi^2\left(\frac{22}{44}\right)^2 \times 1$$

$$= \pi^2 m/s^2$$

and its direction is always along the radius and towards the centre

213 **(a)**

According to law of conservation of linear momentum at the highest point.

$$mv\cos\theta = \frac{m}{2}(-v\cos\theta) + \frac{m}{2}v_1$$

or $v_1 = 3v\cos\theta$

214 **(b)**

On a circular path in completing one turn, the distance traveled is $2\pi r$ while displacement is zero.

Hence, average velocity $= \frac{\text{displacement}}{\text{time interval}} = \frac{0}{t} = 0$

Average speed $= \frac{\text{distance}}{\text{time interval}}$

$= \frac{2\pi r}{t} = \frac{2 \times 3.14 \times 100}{62.8} = 10 \text{ ms}^{-1}$

215 **(a)**

$(\overrightarrow{PO}) = \vec{r} = (2-3)\hat{i} + (-1-3)\hat{j} + (4+1)\hat{k}$

$= -1\hat{i} - 4\hat{j} + 5\hat{k}$

Work done $= \vec{F} \cdot \vec{r}$

$= (4\hat{i} - 3\hat{j} + 3\hat{k}) \cdot (-1\hat{i} - 4\hat{j} + 5\hat{k})$

$= -4 + 12 + 15 = 23 \text{ J}$

216 **(b)**

Note that the angle between two forces is 120° and not 60°.

$R^2 = F^2 + F^2 + 2F^2 \cos 120°$

or $R^2 = 2F^2 + 2F^2\left(-\frac{1}{2}\right) = F^2$

or $R = F$

217 **(d)**

$v_y = \frac{d}{dt}(y) = \frac{d}{dt}(10t) - \frac{d}{dt}(t^2) = 10 - 2t$

At maximum height, $v_y = 0$

$\therefore 10 - 2t = 0$ or $2t = 10$ or $t = 5$ s

$\therefore y = (10 \times 5 - 5 \times 5)$ m $= 25$ m

218 **(a)**

Given, $\omega_1 = 2\pi \times 400 \text{ rad s}^{-1}$

$\omega_2 = 2\pi \times 200 \text{ rad s}^{-1}$

$\therefore \alpha = \frac{2\pi(400-200)}{2} = 200\pi \text{ rad s}^{-2}$

219 **(c)**

In uniform circular motion tangential acceleration remains zero but magnitude of radial acceleration remains constant.

220 **(b)**

$H_1 + H_2 = \frac{u^2}{2g}(\sin^2 30° + \sin^2 60°)$

$= \frac{20^2}{2 \times 10}\left(\frac{1}{4} + \frac{3}{4}\right) = 20\, m$

221 **(b)**

Horizontal range

$R = \frac{u^2 \sin 2\theta}{g}$ ...(i)

Maximum height

$H = \frac{u^2 \sin^2 \theta}{2g}$ ...(ii)

Here (i)=(ii)

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

$2\cos\theta = \frac{\sin\theta}{2}$

$\theta = \tan^{-1}(4)$

222 **(d)**

For critical condition at the highest point $\omega = \sqrt{g/R}$

$\Rightarrow T = \frac{2\pi}{\omega} = 2\pi\sqrt{R/g} = 2 \times 3.14\sqrt{4/9.8} = 4$ sec

223 **(c)**

Since displacement is long the Y-direction, hence displacement $\vec{s} = 10\hat{j}$.

Work done $= \vec{F} \cdot \vec{s} = (-2\hat{i} + 15\hat{j} + 6\hat{k}).10\hat{j} = 150$ J

224 **(d)**

$\frac{d^2y}{dt^2} = \alpha$ and $\frac{d^2x}{dt^2} = 0$

$\frac{dy}{dt} = 2\beta x.\frac{dx}{dt}$

$\frac{d^2y}{dt^2} = 2\beta\left[x.\frac{d^2x}{dt^2} + \left(\frac{dx}{dt}\right)^2\right]$

$\because \alpha = 2\beta v_x^2$

$\therefore v_x = \sqrt{\frac{\alpha}{2\beta}}$

225 **(d)**

$\tan\theta = \frac{L}{A}$

$\tan 30° = \frac{10v}{3400}$

$v = \frac{340}{\sqrt{3}} = 196.3$ m/s

226 **(d)**

$v_{\max} = \sqrt{\mu r g} = \sqrt{0.2 \times 100 \times 9.8} = 14 m/s$

228 **(b)**

$nh = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\left(\frac{2nh}{g}\right)}$ ...(i)

Horizontal distance travelled by ball

$nb = ut, nb = u\sqrt{\left(\frac{2nh}{g}\right)}$ ....(ii)

Squaring Eq. (ii), we get

$n^2b^2 = \frac{u^2 2nh}{g}$

$\therefore n = \frac{2u^2h}{gb^2}$

230 **(b)**

$F = \frac{mv^2}{r}$. For same mass and same speed if radius is doubled then force should be halved

231 **(a)**

We know that $\tan\theta = \frac{v^2}{Rg}$ and $\tan\theta = \frac{h}{b}$

Hence $\frac{h}{b} = \frac{v^2}{Rg} \Rightarrow h = \frac{v^2 b}{Rg}$

232 **(b)**

It is a vector quantity

233 **(a)**

$R=\frac{v^2\sin 2\theta}{g}=200, T=\frac{2v\sin\theta}{g}=5$

Dividing, $\frac{v^2\times 2\sin\theta\cos\theta}{g}\times\frac{g}{2v\sin\theta}=\frac{200}{5}=40$

or $v\cos\theta=40\text{ms}^{-1}$

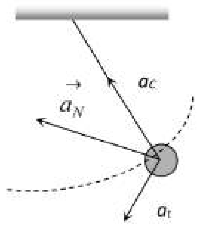
It may be noted here that the horizontal component of the velocity of projection remains the same during the flight of the projectile

234 **(c)**

a_c = centripetal acceleration

a_t = tangential acceleration

a_N = net acceleration = Resultant of a_c and a_t



235 **(a)**

$R_{\max}=R=\frac{u^2}{g}$

$\Rightarrow u^2=Rg$

Now, as range $=\frac{u^2\sin 2\theta}{g}$

then $\frac{R}{2}=\frac{Rg\sin 2\theta}{g}$

$\Rightarrow \sin 2\theta=\frac{1}{2}=\sin 30°\Rightarrow\theta=15°$

236 **(c)**

Velocity at the lowest point, $v=\sqrt{2gl}$

At the lowest point, the tension in the string

$T=mg+\frac{mv^2}{l}=mg+\frac{m}{l}(2gl)=3mg$

237 **(a)**

$v=K(y\hat{\imath}+x\hat{\jmath})$

$v_x=Ky$

$\frac{dx}{dt}=Ky$

Similarly, $\frac{dy}{dt}=Kx$

Hence $\frac{dy}{dx}=\frac{x}{y}$

$\Rightarrow y\,dy=x\,dx$, by integrating

$y^2=x^2+c$

238 **(d)**

Tension is string = centrifugal force

In first case, $F=m\,r\,\omega^2$

In second case, $F'=m(2r)(2\omega)^2=8mr\,\omega^2=8\,F$

239 **(d)**

At 45°, $v_x=v_y$

or $u_x=u_y-gt$

$\therefore\ t=\frac{u_y-u_x}{g}$

$=\frac{40(\sin 60°-\sin 30°)}{9.8}=1.5\text{ s}$

240 **(d)**

$\because$ Angular momentum $\vec{L}=\vec{r}\times\vec{p}$

Where

$\vec{r}=v_0\cos\theta\,t\hat{\imath}+\left(v_0\sin\theta t-\frac{1}{2}gt^2\right)\hat{\jmath}$

$\vec{p}=m[v_0\cos\theta\,\hat{\imath}+(v_0\sin\theta-gt)\hat{\jmath}]$

$\vec{L}=\vec{r}\times\vec{p}=-\frac{1}{2}mgv_0t^2\cos\theta\,\hat{k}$

241 **(c)**

$F=\frac{mv^2}{r}=\frac{500\times(10)^2}{50}=1000\text{N}$

242 **(b)**

$F=\frac{mv^2}{r}=\frac{500\times 100}{50}=10^3\ N$

243 **(a)**

At the highest point of trajectory, the velocity becomes horizontal. So, it is perpendicular to acceleration (which is directed vertically downwards)

244 **(a)**

Angular velocity $=\frac{2\pi}{T}=\frac{2\pi}{24}\ rad/hr=\frac{2\pi}{86400}\ rad/s$

245 **(a)**

$H_1=\frac{u^2\sin^2\theta}{2g}$ and $H_2=\frac{u^2\sin^2(90-\theta)}{2g}=\frac{u^2\cos^2\theta}{2g}$

$H_1H_2=\frac{u^2\sin^2\theta}{2g}\times\frac{u^2\cos^2\theta}{2g}=\frac{(u^2\sin 2\theta)^2}{16g^2}=\frac{R^2}{16}$

$\therefore R=4\sqrt{H_1H_2}$

246 **(b)**

Area in which bullet will spread $=\pi r^2$

For maximum area, $r=R_{\max}=\frac{v^2}{g}$ [When $\theta=45°$]

Maximum area $\pi R_{\max}^2=\pi\left(\frac{v^2}{g}\right)^2=\frac{\pi v^4}{g^2}$

247 **(a)**

Time to reach max. height $=t_m$

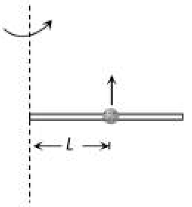
Time to reach back to ground $=t_m$

Total time of flight $T_f=t_m+t_m$

$T_f=2t_m$

248 **(a)**

Let the bead starts slipping after time t



For critical condition Frictional force provides the centripetal force

$m\omega^2 L = \mu R = \mu m \times a_t = \mu L m\alpha$

$\Rightarrow m(\alpha t)^2 L = \mu m L\alpha$

$\Rightarrow t = \sqrt{\frac{\mu}{\alpha}}$ [As $\omega = \alpha t$]

249 **(a)**

$t = \sqrt{\frac{2h}{g}}$

Distance from the foot of the tower

$d = vt = v\sqrt{\frac{2h}{g}} = 250\text{m}$

When velocity $= \frac{v}{2}$

and height of tower$= 4h$

Then distance $x = \frac{v}{2}\sqrt{\frac{2(4h)}{g}}$

$x = v\sqrt{\frac{2h}{g}} = 250$ m

250 **(c)**

$\vec{A} \cdot \vec{B} = AB\cos\theta = 6$

and $|\vec{A} \times \vec{B}| = AB\sin\theta = 6\sqrt{3}$

$\therefore \frac{AB\sin\theta}{AB\cos\theta} = \frac{6\sqrt{3}}{6} = \sqrt{3}$

or $\tan\theta = \sqrt{3}$

and $\theta = 60°$

251 **(c)**

Using relation $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\theta_1 = \frac{1}{2}(\alpha)(2)^2 = 2\alpha$ ...(i)

As $\omega_0 = 0, t = 2\ sec$

Now using same equation for $t = 4\ sec, \omega_0 = 0$

$\theta_1 + \theta_2 = \frac{1}{2}\alpha(4)^2 = 8\alpha$ ...(ii)

From (i) and (ii), $\theta_1 = 2\alpha$ and $\theta_2 = 6\alpha$ $\therefore \frac{\theta_2}{\theta_1} = 3$

252 **(b)**

$\vec{S} = (10\hat{i} - 2\hat{j} + 7\hat{k}) - (6\hat{i} + 5\hat{j} - 3\hat{k})$

$= 4\hat{i} - 7\hat{j} + 10\hat{k}$

$\vec{W} = \vec{F} \cdot \vec{S}$

$= (10\hat{i} - 3\hat{j} + 6\hat{k}) \cdot (4\hat{i} - 7\hat{j} + 10\hat{k})$

$= (40 + 21 + 60)\text{J} = 121$ J

253 **(b)**

The amplitude is the radius of the circle

$R = \frac{0.8}{2} = 0.4$ m

The frequency of the shadow is the same as that of the circular motion, so

$\omega = 30$ rev/min

$= 0.5\text{rev/s} = \pi\ \text{rads}^{-1}$

and $v = \frac{\omega}{2\pi} = \frac{\pi}{2\pi} = 0.5$ Hz.

254 **(c)**

$S_x = u_x t + \frac{1}{2}a_x t^2 \Rightarrow S_x = \frac{1}{2} \times 6 \times 16 = 48\ m$

$S_y = u_y t + \frac{1}{2}a_y t^2 \Rightarrow S_y = \frac{1}{2} \times 8 \times 16 = 64\ m$

$S = \sqrt{S_x^2 + S_y^2} = 80\ m$

255 **(a)**

Here, $r = 92$ m, $v = 26\ \text{ms}^{-1}, \mu = ?$

As $\frac{mv^2}{r} = F = \mu R = \mu\ mg$

$\mu = \frac{v^2}{rg} = \frac{26 \times 26}{92 \times 9.8} = 0.75$

257 **(c)**

$\vec{P}.\vec{Q} = (3\hat{j} + 4\hat{k}).(2\hat{i} + 5\hat{k}) = 6 + 20 = 26$

258 **(b)**

$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 0.2} = 2\ m/s$

259 **(b)**

$\frac{\omega_1}{\omega_2} = \frac{T_2}{T_1} = \frac{12\text{h}}{1\text{h}} = 12 : 1$

260 **(c)**

Given condition $h_1 = h_2$

$u_1^2 \sin^2 45° = u_2^2 \sin^2\theta$

$\sin^2\theta = \frac{u_1^2}{u_2^2}\sin^2 45°$

$= \frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4}$

$\sin\theta = \frac{1}{2} \Longrightarrow \theta = 30°$

261 **(c)**

The speed of projectile is v and angle of projection is45°.

$v_x = v\cos 45° = \frac{v}{\sqrt{2}}$

$v_y = v\sin 45° - gt = \frac{v}{\sqrt{2}} - gt$

At highest point $v_y = 0, v_x = \frac{v}{\sqrt{2}}$

Maximum height achieved,

$H = \frac{v^2 \sin^2 45°}{2g} = \frac{v^2}{4g}$

Now, angular momentum about O

$= \frac{mv}{\sqrt{2}} \cdot \frac{v^2}{4g} = \frac{mv^3}{4\sqrt{2g}}$

262 **(b)**

$E' = E\cos^2\theta = E\cos^2(45°) = \frac{E}{2}$

263 **(b)**

Maximum height of projectile, $h_0 = \frac{u^2 \sin^2\theta}{2g}$

$\therefore h_0 = \frac{(10)^2 \times \sin^2 30°}{2 \times 10} = \frac{5}{4} = 1.25\ m$

Time for attaining maximum height , $t = \frac{u \sin\theta}{g}$

$\therefore t = \frac{10 \times \sin 30°}{10} = 0.5$ sec

$\therefore$ Distance of vertical fall in 0.5 sec, $S = \frac{1}{2}gt^2$

$\Rightarrow S = \frac{1}{2} \times 10 \times (0.5)^2 = 1.25m$

$\therefore$ Height of second ball $= 1.25 + 1.25 = 2.50m$

264 **(a)**

When particle moves in a circle, then the resultant force must act towards the centre and its magnitude F must satisfy, $F = \frac{mv^2}{l}$

This resultant force is directed towards the centre and it is called centripetal force. This force originates from the tension T

Hence, $F = \frac{mv^2}{l} = T$

265 **(c)**

$y = ax - bx^2$

For height or y to be maximum

$\frac{dy}{dx} = 0$ or $a - 2bx = 0$ or $x = \frac{a}{2b}$

$\therefore\ y_{\max} = a\left(\frac{a}{2b}\right) - b\left(\frac{a}{2b}\right)^2 = \frac{a^2}{4b}$

and $\left(\frac{dy}{dx}\right)_{x=0} = a = \tan\theta$

where $\theta =$ angle of projection

$\therefore\ \theta \tan^{-1}(a)$

266 **(c)**

Displacement, $\vec{r} = (a\hat{i} + a\hat{j}) - (a\hat{i}) = a\hat{j}$

$\vec{F} = -K(y\hat{i} + x\hat{j}) = -K(a\hat{i} + a\hat{j})$

Workdone, $W = \vec{F}.\vec{r}$

$= -K(a\hat{i} + a\hat{j}).a\hat{j} = -Ka^2$

267 **(c)**

At the two points of the trajectory during projection, the horizontal component of the velocity is the same

$\Rightarrow u\cos 60° = v\cos 45°$

$\Rightarrow 147 \times \frac{1}{2} = v \times \frac{1}{\sqrt{2}} \Rightarrow v = \frac{147}{\sqrt{2}}\ m/s$

Vertical component of $u = u\sin 60° = \frac{147\sqrt{3}}{2}\ m$

Vertical component of $v = v\sin 45° = \frac{147}{\sqrt{2}} \times \frac{1}{\sqrt{2}}$

$= \frac{147}{2}\ m$

but $v_y = u_y + a_y^t \Rightarrow \frac{147}{2} = \frac{147\sqrt{3}}{2} - 9.8t$

$\Rightarrow 9.8t = \frac{147}{2}(\sqrt{3} - 1) \Rightarrow t = 5.49\ s$

268 **(b)**

$\cos\theta = \frac{(\hat{k}).(\hat{\imath} + \hat{\jmath} + \sqrt{2}\hat{k})}{1\sqrt{1^2 + 1^2(\sqrt{2})^2}}$

or $\cos\theta = \frac{\sqrt{2}}{2} = \frac{1}{\sqrt{2}}$ or $\theta = 45°$

269 **(d)**

$\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = 0.1047\ rad/s$

And $v = \omega r = 0.1047 \times 3 \times 10^{-2} = 0.00314\ m/s$

270 **(b)**

Here the tangential acceleration also exists which requires power

Given that $a_C = k^2rt^2$ and $a_C = \frac{v^2}{r} \therefore \frac{v^2}{r} = k^2rt^2$

Or $v^2 = k^2r^2t^2$ or $v = krt$

Tangential acceleration $a = \frac{dv}{dt} = kr$

Now force $F = m \times a = mkr$

So power $P = F \times v = mkr \times krt = mk^2r^2t$

271 **(b)**

$R_{\max} = \frac{u^2}{g} = \frac{(20)^2}{10} = 40\ m$

272 **(b)**

$T_L - T_H = 6\ mg$

273 **(d)**

Net displacement in one loop = 0

Average velocity $= \frac{\text{net displacement}}{\text{time}} = \frac{0}{t} = 0$

Distance travelled in one rotation (loop) $= 2\pi r$

$\therefore$ Average speed $= \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{t}$

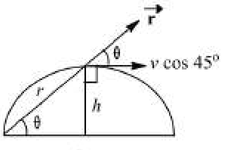
$= \frac{2 \times 3.14 \times 100}{62.8} = 10m/s.$

275 **(b)**

The angular momentum of a particle is given by

$\vec{\mathbf{L}} = \vec{\mathbf{r}} \times m\vec{\mathbf{v}}$

$L = mvr\sin\theta$



From figure,

$L = rm(v\cos 45°)\sin\theta$

$= \frac{mv}{\sqrt{2}}(r\sin\theta)$

$= \frac{mvh}{\sqrt{2}} \left(\because \sin\theta = \frac{h}{r}\right)$

276 **(c)**

Kinetic energy = potential energy

$\frac{1}{2}m(kv_e)^2 = \frac{mgh}{1+\frac{h}{R}}$

$\Rightarrow \frac{1}{2}mk^2 2gR = \frac{mgh}{1+\frac{h}{R}} \Rightarrow h = \frac{Rk^2}{1-k^2}$

Height of projectile from the earth's surface $= h$

Height from centre $r = R + h = R + \frac{Rk^2}{1-k^2}$

By solving $r = \frac{R}{1-k^2}$

277 **(c)**

Tension = Centrifugal force + weight $= \frac{mv^2}{r} + mg$

278 **(a)**

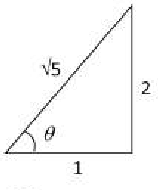
$R = 2H$ Given

We know $R = 4H\cot\theta \Rightarrow \cot\theta = \frac{1}{2}$

From triangle we can say that $\sin\theta = \frac{2}{\sqrt{5}}, \cos\theta = \frac{1}{\sqrt{5}}$

$\therefore$ Range of projectile $R = \frac{2v^2\sin\theta\cos\theta}{g}$

$= \frac{2v^2}{g} \times \frac{2}{\sqrt{5}} \times \frac{1}{\sqrt{5}} = \frac{4v^2}{5g}$



279 **(d)**

Second's hand of a watch completes its one rotation in 1 min. So, its time period is 1 min.

280 **(c)**

Here, $P = (A+B),\ Q = (A-B)$,

$R = \sqrt{A^2+B^2}$;

$\cos\theta = \frac{R^2-P^2-Q^2}{2PQ}$

$= \frac{(A^2+B^2)-(A+B)^2-(A-B)^2}{2(A+B)(A-B)}$

$= -\left[\frac{A^2+B^2}{2(A^2-B^2)}\right]$

$\therefore \quad \theta = \cos^{-1}\left[-\frac{A^2+B^2}{2(A^2-B^2)}\right]$

281 **(c)**

$v = \sqrt{2gl(1-\cos\theta)}$

$= \sqrt{2\times 9.8\times 2(1-\cos 60°)}$

$= 4.43\ m/s$

282 **(b)**

$\omega = 2\pi n/t = 2\pi \times 100/60 = 10.47\ \text{rad s}^{-1}$

283 **(b)**

As the speed is constant throughout the circular motion therefore its average speed is equal to instantaneous speed

284 **(b)**

$H = \frac{u^2\sin^2\theta}{2g}$ and $T = \frac{2u\sin\theta}{g} \Rightarrow T^2 = \frac{4u^2\sin^2\theta}{g^2}$

$\therefore \frac{T^2}{H} = \frac{8}{g} \Rightarrow T = \sqrt{\frac{8H}{g}} = 2\sqrt{\frac{2H}{g}}$

285 **(a)**

For both cases $t = \sqrt{\frac{2h}{g}}$ = constant

Because vertical downward component of velocity will be zero for both the particles

286 **(a)**

Centripetal acceleration $= \frac{v^2}{r} = \frac{(10)^2}{20} = 5\text{m/s}^2$

287 **(b)**

For maximum range $\theta = 45°$

$\frac{R_{max}}{T^2} = \frac{u^2\sin 2\theta}{g} \Big/ \frac{4u^2\sin^2\theta}{g^2}$

$\Rightarrow \frac{R_{max}}{T^2} = \frac{\sin 90° \times g}{4\times\sin^2 45°} = \frac{49}{10}$

288 **(c)**

Taking vertical downward motion of projectile from point of projection to ground, we have

$u = -50\sin 30° = -25\ \text{ms}^{-1}$

$a = +10\ \text{ms}^{-2}, s = 70\ \text{m}, t = ?$

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

So, $70 = -25\times t + \frac{1}{2}\times 10\times t^2$

or $5t^2 - 25t - 70 = 0$ or $t^2 - 5t - 14 = 0$

On solving $t = 7$ s

289 **(a)**

Using $v^2 - u^2 = 2as$, we get

$s = \frac{v^2}{2g}$

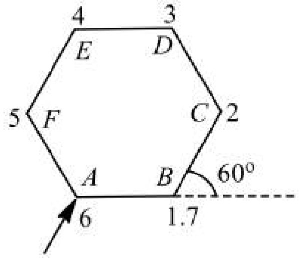
Now, $\frac{v^2\sin 2\theta}{g} = \frac{v^2}{2g}$ or $\sin 2\theta = \frac{1}{2}$

or $\sin 2\theta = \sin 30°$ or $\theta = 15°$

The other possible angle of projection is $(90° - 15°)$, *ie*, 75°

291 **(a)**

In 6 turns each of 60°, the cyclist traversed a regular hexagon path having each side 100 m. So, at 7th turn, he will be again at



Starting point

Point B (as shown) which is at distance 100 m from starting point A. Hence, net displacement of cyclist is 100 m.

292 **(a)**

When speed is constant in circular motion, it means work done by centripetal force is zero

293 **(a)**

$F = \frac{mv^2}{r}$ or $v = \sqrt{\frac{Fr}{m}}$

294 **(b)**

Change in momentum $= 2mu \sin\theta$

$= 2 \times 0.5 \times 98 \times \sin 30 = 49\ N\text{-}s$

295 **(d)**

At highest point $\frac{mv^2}{R} = mg \Rightarrow v = \sqrt{gR}$

296 **(b)**

Difference in KE $= \frac{1}{2}m\left[\left(\sqrt{5gr}\right)^2 - \sqrt{gr}\right]^2$

$= 2mgr = 2 \times 1 \times 10 \times 1 = 20$ J

298 **(d)**

We know that $R = \frac{u^2 \sin 2\theta}{g}$

$= \frac{10 \times 10 \times \sin 60°}{10} = 10 \times \frac{\sqrt{3}}{2}$

$= 5 \times 1.732 = 8.66$ m

299 **(c)**

Velocity of particle at maximum height h is $v' = v\cos\theta$ where $v =$ initial velocity of particle at which it is projected, $\theta =$ angle of projection

Angular momentum, $L = mv'h = mv\cos\theta\, h$

$= mvh\cos 45° = \frac{mvh}{\sqrt{2}}$

300 **(b)**

$v = 72 km/hour = 20 m/sec$

$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left(\frac{20 \times 20}{20 \times 20}\right) = \tan^{-1}(2)$

301 **(c)**

Horizontal component of velocity of A is 10 cos 60° or 5 ms^{-1} which is equal to the velocity of B in horizontal direction. They will collide at C if time of flight of the particles are equal or $t_A = t_B$

$\frac{2u\sin\theta}{g} = \sqrt{\frac{2h}{g}} \quad \left(\because h = \frac{1}{2}gt_B^2\right)$

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

$= \frac{2(10)^2\left(\frac{\sqrt{3}}{2}\right)^2}{10} = 15$ m

302 **(c)**

Equation of trajectory for oblique projectile motion

$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

Substituting $x = D$ and $u = v_0$

$h = D\tan\theta - \frac{gD^2}{2u_0^2\cos^2\theta}$

303 **(d)**

Given $\theta_1 = \pi/3 = 30°$

Horizontal range is same if $\theta_1 + \theta_2 = 90°$

$\therefore \quad \theta_2 = 90° - 30° = 60°$

$y_1 = \frac{u^2\sin^2 30°}{2g}$ and $y_2 \frac{u^2\sin^2 60°}{2g}$

$\therefore \frac{y_2}{y_1} = \frac{\sin^2 30°}{\sin^2 60°} = \left(\frac{1/4}{\sqrt{3}/4}\right)^2 = \frac{1}{2}$ or $y_2 = \frac{y_1}{3}$

304 **(d)**

Since range is given to be the same therefore the other angle is (90° − 30°), *ie*, 60°

$H = \frac{v^2\sin^2 30°}{2g} = \frac{1}{4}\left[\frac{v^2}{2g}\right]$

$H' = \frac{v^2\sin^2 60°}{2g} = \frac{3}{4}\left[\frac{v^2}{2g}\right]$

$\frac{H'}{H} = \frac{3}{4} \times \frac{4}{1} = 3$ or $H' = 3H$

305 **(d)**

From force diagram shown in figure

$T_1\cos 30° + T_2\cos 45° = mg$ ...(i)

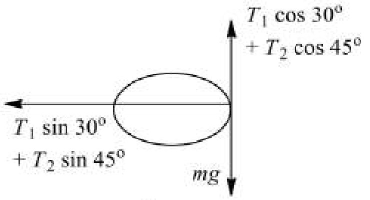
$T_1\sin 30° + T_2\sin 45° = \frac{mv^2}{r}$ ...(ii)

After solving Eq. (i) and eq. (ii), we get

$T_1 = \frac{mg - \frac{mv^2}{r}}{\left(\frac{\sqrt{3}-1}{2}\right)}$

But $T_1 > 0$

$\therefore \frac{mg - \frac{mv^2}{r}}{\frac{\sqrt{3}-1}{2}} > 0$



or $mg > \frac{mv^2}{r}$

or $v < \sqrt{rg}$

$\therefore v_{\max} = \sqrt{rg} = \sqrt{1.6 \times 9.8} = 3.96 \text{ ms}^{-1}$

306 **(a)**

Given $(\hat{\imath} + 2\hat{\jmath} - \hat{k}) + (\hat{\imath} - \hat{\jmath} + 2\hat{k}) + \vec{C} = \hat{\jmath}$

$\therefore \vec{C} = \hat{\jmath} - (\hat{\imath} - 2\hat{\jmath} - \hat{k}) - (\hat{\imath} + \hat{\jmath} + 2\hat{k})$

$= -2\hat{\imath} - \hat{k}$.

307 **(b)**

For a particle moving in a circle with constant angular speed, velocity vector is always tangent to the circle and the acceleration vector always points towards the center of circle or is always along radius of the circle. Since, tangential vector is perpendicular to the acceleration vector. But in no case acceleration vector is tangent to the circle.

308 **(a)**

$$\frac{u^2 \sin 2\theta}{g} = 4\sqrt{3} \times \frac{u^2 \sin \theta}{2g}$$

or $\frac{u^2}{g} 2 \sin\theta \cos\theta = 2\sqrt{3} \frac{u^2}{g} \sin^2\theta$

309 **(b)**

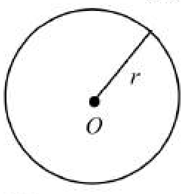
The time taken by the particle for one complete revolution.

$$t = \frac{2\pi r}{\text{speed}}$$

$$= \frac{2 \times 3.14 \times 100}{31.4} = 20\text{s}$$

Hence, averge speed is

$$v_{\text{av}} = \frac{2 \times 3.14 \times 100}{20} = 31.4 \text{ ms}^{-1}$$



310 **(a)**

$$F = \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{rF}{m}}$$

311 **(d)**

At the two point of the trajectory during projectile motion, the horizontal component of the velocity is same. Then,

$u\cos 60° = v\cos 45°$

$147 \times \frac{1}{2} = v \times \frac{1}{\sqrt{2}}$ or $v = \frac{147}{\sqrt{2}} \frac{\text{m}}{\text{s}}$

Initially, $u_y = u\sin 60° = \frac{147\sqrt{3}}{2}$ m/s

Finally, $v_y = v\sin 45° = \frac{147}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{147}{\sqrt{2}}$ m/s

But $v_y = u_y + a_y t$ or $\frac{147}{2} = \frac{147\sqrt{3}}{2} - 9.8\,t$

$9.8\,t = \frac{147}{2}(\sqrt{3} - 1)$ or $t = 5.49\,s$

312 **(c)**

$v_x = \frac{dx}{dt} = \frac{d}{dt}(3t^2 - 6t) = 6t - 6$. At $t = 1, v_x = 0$

$v_y = \frac{dy}{dt} = \frac{d}{dt}(t^2 - 2t) = 2t - 2$. At $t = 1, v_y = 0$

Hence $v = \sqrt{v_x^2 + v_y^2} = 0$

313 **(a)**

The maximum velocity for a banked road with friction,

$$v^2 = gr\left(\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right)$$

$$\Rightarrow v^2 = 9.8 \times 1000 \times \left(\frac{0.5 + 1}{1 - 0.5 \times 1}\right) \Rightarrow v$$

$$= 172 m/s$$

314 **(a)**

For horizontal planes potential energy remains constant equal to zero, if we assumes surface to be the zero level.

315 **(c)**

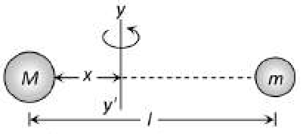
Change in momentum of the ball $= mv\sin\theta - (-mv\sin\theta)$

$= 2mv\sin\theta = 2mgv\frac{\sin\theta}{g} = mg \times \frac{2v\sin\theta}{g}$

= weight of the ball × total time of flight

316 **(b)**

If the both mass are revolving about the axis yy' and tension in both the threads are equal then



$M\omega^2 x = m\omega^2(l - x)$

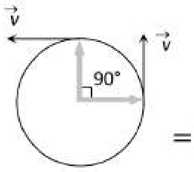
$\Rightarrow Mx = m(l - x)$

$\Rightarrow x = \frac{ml}{M + m}$

317 **(d)**

In 15 second's hand rotate through 90°

Change in velocity $|\overrightarrow{\Delta v}| = 2v\sin(\theta/2)$



$= 2(r\omega)\sin(90°/2)$

$= 2 \times 1 \times \frac{2\pi}{T} \times \frac{1}{\sqrt{2}}$

$= \frac{4\pi}{60\sqrt{2}} = \frac{\pi\sqrt{2}}{30}\frac{cm}{sec}$ [As $T = 60$ sec]

318 **(b)**

$F = mr\omega^2 = mr(2\pi v)^2$ $ie, F \propto v^2$

$\frac{2F}{F} = \left(\frac{v'}{v}\right)^2$ or $v' = v\sqrt{2} = 5\sqrt{2} = 7$rpm

319 **(b)**

Since $\vec{F} = 4\hat{\imath} - 3\hat{\jmath}$ is lying in $X - Y$ plane, hence the vector perpendicular to $\vec{F}$ must be lying perpendicular to $X - Y$ plane *ie*, along Z-axis.

320 **(c)**

$\mu = \frac{v^2}{rg} = \frac{(60 \times 5/18)^2}{40 \times 9.8} = 0.71$

321 **(c)**

$F = m\omega^2 R$ $\therefore R \propto \frac{1}{\omega^2}$ (m and F are constant)

If ω is doubled then radius will become 1/4 times i.e. $R/4$

322 **(b)**

Because here tension is maximum

323 **(d)**

$T\sin\theta = M\omega^2 R$ ...(i)

$T\sin\theta = M\omega^2 L\sin\theta$ ...(ii)

$T = M\omega^2 L$

$= M \cdot 4\pi^2 n^2 L$

$= M \cdot 4\pi^2 \left(\frac{2}{\pi}\right)^2 L$

$= 16\,ML$

324 **(c)**

$h = v\sin\theta\, t - \frac{1}{2}gt^2$

or $\frac{1}{2}gt^2 - v\sin\theta\, t + h = 0$

$t_1 + t_2 = -\frac{-v\sin\theta}{\frac{1}{2}g}$ or $t_1 + t_2 = \frac{2v\sin\theta}{g} = T$

or $T = (1+3)s = 4s$

325 **(c)**

$V_{max} = \sqrt{\mu rg} = \sqrt{0.75 \times 60 \times 9.8} = 21 m/s$

326 **(a)**

There is no change in the angular velocity, when speed is constant

327 **(a)**

By doing so component of weight of vehicle provides centripetal force

328 **(c)**

Let t be time taken by the bullet to hit the target

$\therefore 200\,m = 2000\,ms^{-1}t$

$\Rightarrow t = \frac{200m}{2000ms^{-1}} = \frac{1}{10}s$

For vertical motion,

Here $u = 0$

$\therefore h = \frac{1}{2}gt^2$

$h = \frac{1}{2} \times 10 \times \left(\frac{1}{10}\right)^2 = \frac{1}{20}m = 5\,cm$

$\therefore$ Gun should be aimed 5 cm above the target

329 **(b)**

Component of velocity perpendicular to plane remains the same (in opposite direction)

ie, $u\sin\theta = 20\sin 30° = 10$ ms^{-1}

330 **(c)**

Total time of flight $= \frac{2u\sin\theta}{g} = \frac{2\times50\times1}{2\times10} = 5s$

Time to cross the wall = 3 *sec* (Given)

Time in air after crossing the wall = (5 − 3) = 2 *sec*

$\therefore$ Distance travelled beyond the wall $= (u\cos\theta)t$

$= 50 \times \frac{\sqrt{3}}{2} \times 2 = 86.6\,m$

331 **(a)**

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

$W = F \cdot d\cos\theta$

$= F \cdot d\cos 90°$ $(\because \theta = 90°)$

$= 0$ $(\because \cos 90° = 0)$

333 **(a)**

$T = m\omega^2 r \Rightarrow \omega \propto \sqrt{T}$ $\therefore \frac{\omega_2}{\omega_1} = \sqrt{\frac{1}{4}} \Rightarrow \omega_2 = \frac{\omega_1}{2}$

$= 5\,rpm$

334 **(c)**

Because vertical downward displacement of both (target and bullet) will be equal

335 **(c)**

At time t_1 the velocity of ball will be maximum and it goes on decreasing with respect to time

At the highest point of path its velocity becomes zero, then it increases but direction is reversed

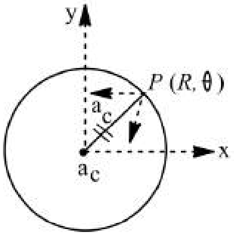
This explanation matches with graph (c)

336 **(c)**

$\alpha = \frac{d\omega}{dt} = 0 \qquad$ [As ω = constant]

337 **(c)**

For a particle in uniform circular motion



$\mathbf{a} = \frac{v^2}{R}$ = towards center of circle

$\mathbf{a} = \frac{v^2}{R}(-\cos\theta\,\hat{\mathbf{i}} - \sin\theta\,\hat{\mathbf{j}})$

or $\mathbf{a} = \frac{v^2}{R}\cos\theta\,\hat{\mathbf{i}} - \frac{v^2}{R}\sin\theta\,\hat{\mathbf{j}}$

338 **(c)**

$R = \frac{u^2\sin 2\theta}{g}$, At $\theta = 45°$, R = max.

$\therefore\ R_{\max} = \frac{u^2}{g}$

339 **(a)**

If the horizontal range is the same then the angle of projection of an object is θ or $(90° - \theta)$ with the horizontal direction. So, the angle of projection of first particle is θ and the other particle is $(90° - \theta)$

$t_1 = \frac{2u\sin\theta}{g}$

$t_2 = \frac{2u\sin\theta(90° - \theta)}{g}$

$t_2 = \frac{2u\cos\theta}{g}$

$\because\ t_1 t_2 = \frac{2u\sin\theta}{g} \cdot \frac{2u\cos\theta}{g}$

$t_1 t_2 = \frac{2u^2\sin 2\theta}{g^2}$

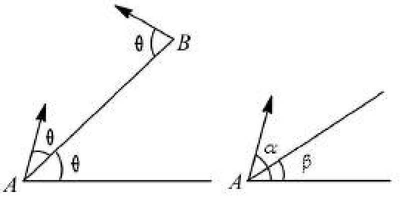
or $\ t_1 t_2 = \frac{2R}{g} \quad \left(\because R = \frac{u^2\sin 2\theta}{g}\right)$

340 **(c)**

In uniform circular motion, acceleration causes due to change in direction and is directed radially towards centre

341 **(a)**

Here, $\alpha = 2\theta, \beta = \theta$



(a) (b)

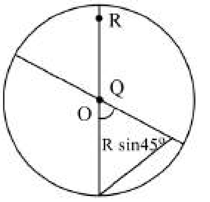
Time of flight of A is, $T_1 = \frac{2u\sin(\alpha-\beta)}{g\cos\beta}$

$= \frac{2u\sin(2\theta - \theta)}{g\cos\theta} = \frac{2u}{g}\tan\theta$

Time of flight of B is, $T_2 = \frac{2u\sin\theta}{g\cos\theta} = \frac{2u}{g}\tan\theta$

So, $T_1 = T_2$. The acceleration of both the particles is g downwards. Therefore, relative acceleration between the two is zero or relative motion between the two is uniform. The relative velocity of A w.r.t. B is towards AB, therefore collision will take place between the two in mid air.

342 **(a)**



To reach the unshaded portion particle P needs to travel horizontal range greater than $R\sin 45°$ or $(0.7\,R)$ but its range is less than $\frac{R}{2}$. So it will fall on shaded portion

Q is near to origin, its velocity will be nearly along QR so its will fall in unshaded portion

343 **(b)**

Since the projectile is released its initial velocity is the same as the velocity of the plane at the time of release

Take the origin at the point of release

Let x and $y(= -730\text{m})$ be the coordinates of the point on the ground where the projectile hits and let t be the time when it hits. Then

$y = -v_0 t\cos\theta - \frac{1}{2}gt^2$

where $\theta = 53.0°$

This equation gives

$v_0 = -\frac{y + \frac{1}{2}gt^2}{t\cos\theta}$

$= -\frac{-730 + \frac{1}{2}(9.8)(5)^2}{5\cos 53°} = 202\ \text{ms}^{-1}$

344 **(b)**

Only horizontal component of velocity $(u\cos\theta)$

345 **(a)**

Water will not fall down, if weight, $mg =$ centrifugal force

$= mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$

346 **(a)**

$(0.5)^2 + (0.8)^2 + c^2 = 1$

$0.25+0.64+c^2 = 1$

or $c^2 = 1 - 0.25 - 0.64 = 0.11$

or $c = \sqrt{0.11}$

347 **(c)**

$\mu = \frac{v^2}{rg} = \frac{(4.9)^2}{4 \times 9.8} = 0.61$

348 **(b)**

If $|\vec{A}| = |\vec{B}| = x$, then $|\vec{C}| = \sqrt{2}x$

Now, $\vec{A} + \vec{B} = -\vec{C}$

or $(\vec{A} + \vec{B}) \cdot (\vec{A} + \vec{B}) = (-\vec{C}) \cdot (-\vec{C})$

or $\cos\theta = 0$ or $\theta = 90°$

or $\vec{A} \cdot \vec{A} + \vec{C} \cdot \vec{C} + 2\vec{A} \cdot \vec{C} = B^2$

or $x^2 + 2x^2 + 2x^2\sqrt{2}\cos\theta = x^2$

or $\cos\theta = -\frac{1}{\sqrt{2}}$

$\therefore$ or $\theta = 135°$

Again, $\vec{B} + \vec{C} = -\vec{A}$

or $(\vec{B} + \vec{C}) \cdot (\vec{B} + \vec{C}) = -(-\vec{A}) \cdot (-\vec{A})$

or $x^2 + 2x^2 + 2x^2\sqrt{2}\cos\theta = x^2$

or $\cos\theta = -\frac{2x^2}{2x^2\sqrt{2}\cos\theta} = -\frac{1}{2}$ or $\theta = 135°$

349 **(d)**

Tension in the string $T = m\omega^2 r = 4\pi^2 n^2 mr$

$\therefore T \propto n^2 \Rightarrow \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}} \Rightarrow n_2 = 5\sqrt{\frac{2T}{T}} = 7\ rpm$

350 **(b)**

For same range angle of projection should be θ and $90 - \theta$

So, time of flights $t_1 = \frac{2u\sin\theta}{g}$ and

$t_2 = \frac{2u\sin(90-\theta)}{g} = \frac{2u\cos\theta}{g}$

By multiplying $= t_1 t_2 = \frac{4u^2\sin\theta\cos\theta}{g^2}$

$t_1 t_2 = \frac{2}{g}\frac{(u^2\sin 2\theta)}{g} = \frac{2R}{g} \Rightarrow t_1 t_2 \propto R$

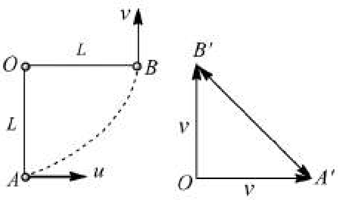
351 **(d)**

Radial force $= \frac{mv^2}{r} = \frac{m}{r}\left(\frac{p}{m}\right)^2 = \frac{p^2}{mr}$[As $p = mv$]

352 **(d)**

The velocity at B is v, where

$v^2 = u^2 - 2g\,L$, in vertically upward direction. As is clear from figure change in velocity



$\overrightarrow{OB}' = \overrightarrow{OA} = \overrightarrow{A'B'}$

$= \sqrt{u^2 + v^2} = \sqrt{u^2 + (u^2 - 2gL)} = \sqrt{2(u^2 - gL)}$

353 **(a)**

Time period of earth on its own axis

$T = 24$ h

$= 24 \times 60 \times 60$ s

$\therefore$ Angular velocity $\omega = \frac{2\pi}{T}$

$= \frac{2\pi}{24 \times 60 \times 60}$

$= \frac{2\pi}{86400}$ rads^{-1}

354 **(a)**

When body is released from the position p (inclined at angle θ from vertical) then velocity at mean position

$v = \sqrt{2gl(1 - \cos\theta)}$

$\therefore$ Tension at the lowest point $= mg + \frac{mv^2}{l}$

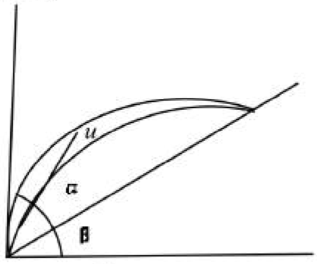
$= mg + \frac{m}{l}[2gl(1 - \cos 60)] = mg + mg = 2mg$

355 **(c)**

$\because W = FS\cos\theta \ \therefore \theta = 90°$

356 **(b)**

Let α' be the angle of projection of the second body



$R = \frac{u^2}{g\cos^2\beta}[\sin(2\alpha - \beta) - \sin\beta]$

Range of both the body is same. Therefore

$\sin(2\alpha - \beta) = \sin(2\alpha' - \beta)$

or $2\alpha' - \beta = \pi - (2\alpha - \beta)$

$\alpha' = \frac{\pi}{2} - (\alpha - \beta)$

Now, $T = \frac{2u\sin(\alpha - \beta)}{g\cos\beta}$ and $T' = \frac{2u\sin(\alpha' - \beta)}{g\cos\beta}$

$\therefore \frac{T}{T'} = \frac{\sin(\alpha - \beta)}{\sin(\alpha' - \beta)} = \frac{\sin(\alpha - \beta)}{\sin\left\{\frac{\pi}{2} - (\alpha - \beta) - \beta\right\}}$

$$\frac{\sin(\alpha-\beta)}{\sin\left(\frac{\pi}{2}-\alpha\right)}=\frac{\sin(\alpha-\beta)}{\cos\alpha}$$

357 **(a)**

$\vec{B}+(\hat{i}+2\hat{j}-3\hat{k})=\hat{i}$

or $\quad \vec{B}=\ -2\hat{j}+3\hat{k}$

358 **(d)**

$\cos\theta=\frac{(\hat{i}+2\hat{j}+2\hat{k}).\hat{i}}{(1^2+2^2+2^2)^{1/2}}=\frac{1}{\sqrt{3}}=\frac{1}{3}$

$=0.4472=\cos 63°12'$

359 **(a)**

Centripetal velocity at highest point $=\sqrt{gR}=\sqrt{10\times 1.6}=4m/s$

360 **(a)**

Centripetal acceleration

$a=\frac{v}{t}$

Angular acceleration $\propto=\frac{\omega}{t}=\frac{\omega v}{vt}$

$\therefore \propto=\frac{\omega\ a}{v}$

361 **(c)**

The velocity of the particle at any time t

$\vec{v}=\vec{v}0+\vec{a}t$

The x-component is

$v_x=v_{ax}+a_x t$

The y-component is

$v_y=v_{ay}+a_x=(-0.5t)\text{ms}^{-1}$

When the particle reaches its maximum x-coordinates, $v_x=0$. That is

$3-t=0$

$\Rightarrow t=3\text{s}$

The y-component of the velocity of this time is

$v_y=-0.5\times 3=-1.5\ \text{ms}^{-1}$

362 **(b)**

$\vec{A}=2\hat{i}-\hat{j}+3\hat{k};\ \vec{B}=3\hat{i}-2\hat{j}-2\hat{k}\ ;\ \vec{C}=?$

$\vec{R}=\hat{k}=\vec{A}+\vec{B}+\vec{C}$

$\hat{k}=(2\hat{i}-\hat{j}+3\hat{k})+(3\hat{i}-2\hat{j}-2\hat{k})+\vec{C}$

$=5\hat{i}-3\hat{j}+\hat{k}+\vec{C}$

$\therefore\ \vec{C}=-5\hat{i}+3\hat{j}$

363 **(a)**

Tangential acceleration $a=L\alpha$

$\therefore$ Normal relation $N=Ma=ML\alpha$

$\therefore$ Frictional force $F=mN=\mu ML\alpha$

For no sliding along the length frictional force $\geq$ centripetal force

$ie, \mu ML\alpha\geq ML\omega^2$

As $\ \omega=\omega_0+\alpha t=\alpha t$

$\therefore\ \mu ML\alpha\geq ML(\alpha t)^2\Rightarrow t=\sqrt{\frac{\mu}{\alpha}}$

364 **(b)**

$\frac{mv^2}{r}\propto\frac{K}{r}\Rightarrow v\propto r^o$

$i.e.$ speed of the particle is independent of r

365 **(b)**

$E_k'=E_k\cos^2 30°=\frac{3E_k}{4}$

366 **(a)**

$v'=v_0\cos\theta$

$\frac{v_0}{2}=v_0\cos\theta$

$\cos\theta=\frac{1}{2}$

$\theta=60°$

367 **(c)**

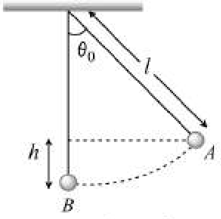
All the balls are projected from the same height, therefore their velocities will be equal.

So, $v_1=v_2=v_3$

368 **(d)**

Maximum tension in the string is

$T_{\max}=mg+\frac{mv_B^2}{l}$



$=mg+\frac{2mgl}{l}(1-\cos\theta_0)$

$=mg+\frac{2mgl}{l}.2\sin^2\frac{\theta_0}{2}$

$\because\left(1-\cos\theta_0=2\sin^2\frac{\theta_0}{2}\right)$

[Since θ_0 is small]

$=mg(1+\theta_0^2)$

369 **(b)**

$R^2=P^2+P^2+2P^2\cos\theta$ or $R^2=2P^2+2P^2\cos\theta$

or $\quad R^2=2P^2(1+\cos\theta)$

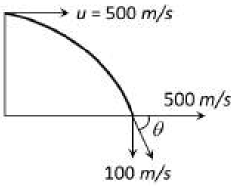
or $\quad R^2=2P^2\left(1+2\cos^2\frac{\theta}{2}-1\right)$

or $\quad R^2=4P^2\cos^2\frac{\theta}{2}$

or $\quad R=2P\cos\frac{\theta}{2}$

370 **(a)**

Horizontal component of velocity $v_x=500\ m/s$ and vertical components of velocity while striking the ground



$v_y = 0 + 10 \times 10 = 100\ m/s$

∴ Angle with which it strikes the ground

$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{100}{500}\right) = \tan^{-1}\left(\frac{1}{5}\right)$

371 **(a)**

Here, Mass of a stone, $m = 2kg$

Length of a string, $r = 0.5\ m$

Breaking tension, $T = 900\ N$

As $T = mr\omega^2$ or $\omega^2 = \frac{T}{mr} = \frac{900}{2\times 0.5} = 900$

$\omega = 30$ rad s^{-1}

372 **(b)**

$T_{\text{top}} = \frac{mv^2}{r} - mg = 2mg$

$\frac{T_{\text{top}}}{T_{\text{bottom}}} = \frac{2mg}{2mg + 6mg} = \frac{1}{4}$

373 **(a)**

$AB \cos\theta = AB$ or $\cos\theta = 1$ or $\theta = 0°$

374 **(b)**

$v_{\max} = \sqrt{\mu rg} = \sqrt{0.5 \times 40 \times 9.8} = 14\ m/s$

375 **(c)**

For projectile A

Maximum height, $H_A = \frac{u_A^2 \sin^2 45°}{2g}$

For projectile B

Maximum height $H_B = \frac{u_B^2 \sin^2 \theta}{2g}$

As per equation

$H_A = H_B$

$\frac{u_A^2 \sin^2 45°}{2g} = \frac{u_B^2 \sin^2 \theta}{2g}$

$\Rightarrow \frac{\sin^2\theta}{\sin^2 45°} = \frac{u_A^2}{u_B^2}$

$\Rightarrow \sin^2\theta = \left(\frac{u_A}{u_B}\right)^2 \sin^2 45°$

$\Rightarrow \sin^2\theta = \left(\frac{1}{\sqrt{2}}\right)^2 \left(\frac{1}{\sqrt{2}}\right)^2 \left[\because \frac{u_A}{u_B} = \frac{1}{\sqrt{2}} \text{ (Given)}\right]$

$\Rightarrow \sin\theta = \frac{1}{2} \Rightarrow \theta \sin^{-1}\left(\frac{1}{2}\right) = 30°$

376 **(a)**

Extension is first case

$\Delta l_1 = 2a - a = a$

From Hooke's law

$F = k\Delta l_1$

$mr\omega^2 = ka$

$m(2a)\omega^2 = ka$

$2ma\left(\frac{2\pi}{T}\right)^2 = ka$

In second case,

$m(3a)\left(\frac{2\pi}{T'}\right)^2 = k(3a - 2a)$

On dividing Eq. (ii) by Eq. (i)

$T' = \sqrt{\frac{3}{2}}T$

377 **(c)**

Centripetal acceleration $= 4\pi^2 n^2 r = 4\pi^2\left(\frac{1}{2}\right)^2 \times 4 = 4\pi^2$

378 **(b)**

$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4$

$= (5\hat{i} - 5\hat{j} + 5\hat{k}) + (2\hat{i} + 8\hat{j} + 6\hat{k})$

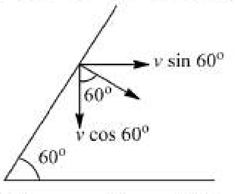
$+(-6\hat{i} + 4\hat{j} - 7\hat{k}) + (-\hat{i} - 3\hat{j} - 2\hat{k})$

$= 4\hat{i} + 2\hat{k}$

This fore is in $y - z$ plane. Therefore, particle will move in $y - z$ plane.

379 **(c)**

Let v be the velocity at the time of collision



Then, $u\sqrt{2}\cos 45° = v \sin 60°$

$(u\sqrt{2})\left(\frac{1}{\sqrt{2}}\right) = \frac{\sqrt{3}v}{2} \quad \therefore v = \frac{2}{\sqrt{3}}u$

381 **(a)**

Given, $r = (20/\pi)$m

$v = 80$ m/s

$\theta = 2$ rev $= 4\pi$ rad

$\omega_0 = 0$

From the equation

$\omega^2 = \omega_0^2 + 2\alpha\theta$, we have

$\omega^2 = 2\alpha\theta$

or $\frac{v^2}{r^2} = 2 \cdot \frac{a}{r}\theta$

or $a = \frac{v^2}{2r\theta} = \frac{(80)^2}{2\times(20/\pi)\times 4\pi}$

$= 40$ ms^{-2}

382 **(b)**

$R = \frac{u^2 \sin 2\theta}{g} = \frac{(500)^2 \times \sin 30°}{10} = 12.5 \times 10^3\ m$

383 **(d)**

Angular velocity of second's hand

$= \frac{2\pi}{60} = \frac{\pi}{30} = \frac{3.14}{30}$

$= 0.1047$ rad s^{-1}

Linear velocity, $v = r\omega$

$= 3 \times 10^{-2} \times 0.1047 = 0.00314\ ms^{-1}$

385 **(d)**

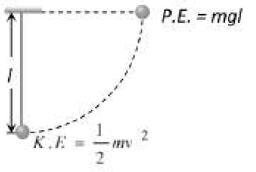
Here, $r = 5$ m, $\mu = 0.5, \omega = ?, g = 10ms^{-2}$

$mr\omega^2 = F = \mu R = \mu\, mg$

$\omega = \sqrt{\frac{\mu g}{r}} = \sqrt{\frac{0.5\times10}{5}} = 1\ rad\ s^{-1}$

386 **(d)**

Kinetic energy given to a sphere at lowest point = potential energy at the height of suspension



$\Rightarrow \frac{1}{2}mv^2 = mgl$

$\therefore v = \sqrt{2gl}$

387 **(b)**

Centripetal force $= mr\omega^2 = 5 \times 1 \times 4 = 20N$

388 **(b)**

$T = \frac{2u \sin\theta}{g} = \frac{2 \times 9.8 \times \sin 30}{9.8} = 1\ s$

389 **(c)**

A particle performing a uniform circular motion has a transverse velocity and radial acceleration

390 **(d)**

In equilibrium position along y-direction

$2 \sin 60° = \sqrt{3} + F \cos\theta$

or $2 \times \frac{\sqrt{3}}{2} = \sqrt{3} + F\cos\theta$ or $F\cos\theta = 0$

As $F \neq 0$

$\therefore \cos\theta = 0$ or $\theta = 90°$

Along x-direction, $F \sin 90° = 1 + 2\cos 60°$

$= 1 + 2 \times \frac{1}{2}$

$F = 2N$

391 **(b)**

$\tan\theta = \frac{v^2}{rg}$ or $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

392 **(a)**

$\frac{mv^2}{r} = \frac{k}{r^2} \Rightarrow mv^2 = \frac{k}{r}\ \therefore$ K. E. $= \frac{1}{2}mv^2 = \frac{k}{2r}$

P.E. $= \int F\,dr = \int \frac{k}{r^2}\,dr = -\frac{k}{r}$

$\therefore$ Total energy = K. E. + P. E. $= \frac{k}{2r} - \frac{k}{r} = -\frac{k}{2r}$

393 **(a)**

When the angle of projection is very far from 45° then range will be minimum

394 **(c)**

Difference in K.E. = Difference in P.E. = $2mgr$

395 **(c)**

$v = \sqrt{\mu\, rg} = \sqrt{0.64 \times 20 \times 10} = 11.2\ ms^{-1}$

396 **(b)**

Tangential acceleration, $a_t = \frac{v_f - v_i}{t}$

$= \left(\frac{45-60}{8}\right)\frac{22}{15}$ fts^{-1}

$= -\frac{11}{4}$ fts^{-2}

Radial acceleration, $a_r = \frac{v^2}{r} = \frac{\left(60 \times \frac{22}{15}\right)^2}{2500}$

$= 3.1$ fts^{-2}

Then, $a = \sqrt{a_r^2 + a_t^2} = 4.14$ fts^{-2}

397 **(d)**

$\vec{A} \cdot (\vec{B} \times \vec{A}) = (\vec{A} \times \vec{A}) \cdot \vec{B} = (\vec{0}) \cdot \vec{B} = 0$

398 **(c)**

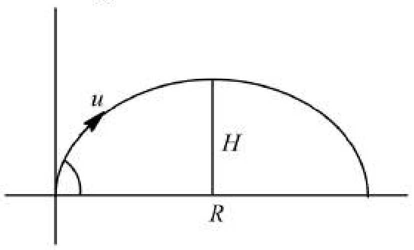
The range of particle is

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

$R = \frac{u^2 \sin 2 \times 45°}{g}$ $(\because \theta = 45°)$

or $R = \frac{u^2 \sin 90°}{g}$

or $R = \frac{u^2}{g}$ ....(i)



Now, the maximum height of the particle is

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

$= \frac{u^2 \sin^2 45°}{2g} = \frac{u^2\left(\frac{1}{\sqrt{2}}\right)^2}{2g}$

$= \frac{u^2}{4g}$ ... (ii)

Dividing Eqs. (i) by Eq. (ii),

$\frac{R}{H} = \frac{u^2/g}{u^2/4g}$

or $R = 4H$

399 **(c)**

T = tension, W = weight and F = centrifugal force

400 **(d)**

$r_1 = v/\omega; r_2 = 2v/(\omega/2) = 4v/\omega = 4r_1$

$a_1 = v^2/r_1; a_2 = (2v)^2/r_2 = 4v^2/r_1 = v^2/r_1 = a_1$

401 **(d)**

$|\vec{a} \times \vec{b}| = ab \ \sin\theta$

$\sin\theta$ cannot be greater than 1.

$\therefore |\vec{a} \times \vec{b}|$ cannot be greater than ab.

402 **(d)**

Angular acceleration $= \frac{d^2\theta}{dt^2} = 2\theta_2$

403 **(b)**

To keep the mass M steady, let T is the tension in the string joining the two. Then for particle m,

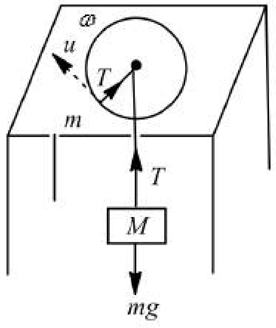
$T = \frac{mv^2}{R}$ ... (i)

For mass M,

$T = Mg$ ... (ii)

From Eqs. (i) and (ii)

$\frac{mv^2}{R} = Mg \Rightarrow v = \sqrt{\frac{MgR}{m}}$



404 **(b)**

Since range is max, therefore $\theta = 45°$

Hence, $V_x = V\cos\theta = V\cos 45° = \frac{V}{\sqrt{2}}$

At the highest point, the net velocity of the projectile is

$V_x = V\cos 45°$

$\therefore$ K. E. $= \frac{1}{2}mV_x^2 = \frac{1}{2}m\frac{V^2}{2} = 0.5\,K$

405 **(b)**

Acceleration of electron

$= \frac{v^2}{r} = \frac{(2.18 \times 10^6)^2}{0.528 \times 10^{-10}} = 9 \times 10^{22}\ \text{ms}^{-2}$

406 **(d)**

Given, equation is

$y = 9x^2$ .... (i)

Since, x-component of velocity remains constant, we have

$\frac{dx}{dt} = \frac{1}{3}\text{ms}^{-1}$ ... (ii)

From Eq. (i), we have y-component of velocity.

$\frac{dy}{dt} = 18x \cdot \left(\frac{dx}{dt}\right)^2$

$\frac{dy}{dt} = 18\left(\frac{dx}{dt}\right)^2 = 18 \times \left(\frac{1}{3}\right)^2 = 2\text{ms}^{-2}$

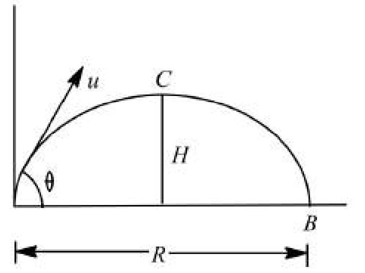
$\therefore \mathbf{a}_y = 2\,\hat{\mathbf{j}}\ \text{ms}^{-2}$

407 **(a)**

Because velocity is always tangential and centripetal acceleration is radial.

408 **(b)**

Let a body be projected at a velocity u at an angle θ with the horizontal. Then horizontal range covered is given by



$R = \frac{u^2 \sin 2\theta}{g}$ ... (i)

and height H is

$H = \frac{u^2\sin^2\theta}{2g}$ ... (ii)

Given, $R = 3H$

$\frac{u^2 \sin 2\theta}{g} = 3 \times \frac{u^2\sin^2\theta}{2g}$

Also, $\sin 2\theta = 2\sin\theta\cos\theta$

$\therefore \frac{u^2 2\sin\theta\cos\theta}{g} = 3 \times \frac{u^2\sin^2\theta}{2g}$

or $2\cos\theta = 1.5\sin\theta$

or $\tan\theta = \frac{2}{1.5} = 1.33$

or $\theta = 53°7''$

Hence, angle of projection is $53°7'$

409 **(d)**

When the string makes an angle θ with the vertical, then

$T - mg\cos\theta = \frac{mv^2}{r}$

Substituting the values, we obtain

$6 - (1)(10)\cos\theta = \frac{1 \times (4)^2}{1}$

or $6 - 10\cos\theta = 16$

or $\cos\theta = -1 = \cos 180°$

$\therefore = 180°$

410 **(b)**

Range, $R = \frac{u^2 \sin 2\theta}{g}$

$\therefore 20 = \frac{u^2 \sin(2 \times 30°)}{g}$

$\Rightarrow \frac{u^2}{g} = \frac{20}{\sin 60°} = \frac{20}{\sqrt{3}} \times 2 = \frac{40}{\sqrt{3}}$

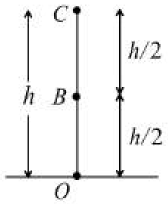
Now, $H = \frac{u^2 \sin^2 \theta}{2g}$

$= \frac{40}{\sqrt{3}} \times \frac{\sin^2 30°}{2}$

$= \frac{40}{\sqrt{3}} \times \frac{\left(\frac{1}{2}\right)^2}{2} = \frac{5}{\sqrt{3}} \text{m}$

412 **(b)**

$v^2 = u^2 + 2as$ ...(i)



At $B, u = 10\ m/s$

at max. height, $v = 0$

$a = -10\ m/s^2; s = h/2$

From equation (i)

$0 = (10)^2 + 2(-10)h/2 \Rightarrow h = 10\ m$

413 **(c)**

When two bullets are fired simultaneously, horizontally with different speeds, then they cover different horizontal distance because there is no acceleration in this direction.

Since, horizontal distance(R) = velocity $\times$ time.

But there is a vertical acceleration towards the earth (g), so the vertical distance covered by both bullet are

given by

$y = \frac{1}{2} g t^2$, which is independent of initial velocity.

So, both the bullets will hit the ground simultaneously .

414 **(b)**

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

$dH = \frac{2u \sin^2 \theta}{2g} du$

$\therefore \frac{dH}{H} = \frac{2du}{u} = 2 \times \frac{1}{10}$

$\therefore$% increase in $H = \frac{dH}{H} \times 100$

$= \frac{2}{10} \times 100 = 20\%$

415 **(d)**

For vertically upward motion of a projectile,

$y = (u \sin \alpha)t - \frac{1}{2} g t^2$

or $h = (u \sin \alpha)t - \frac{1}{2} g t^2$

or $g t^2 - (2u \sin\alpha)t + 2h = 0$

$\therefore t = \frac{2u \sin\alpha \pm \sqrt{(4u^2 \sin^2\alpha) - 8gh}}{2g}$

If two roots of quadratic Eq.(i) are t_1, t_2 then

$t_1 = \frac{2u \sin\alpha + \sqrt{4u^2 \sin^2\alpha - 8gh}}{2g}$

$t_2 = \frac{2u \sin\alpha - \sqrt{4u^2 \sin^2\alpha - 8gh}}{2g}$

If particle crosses the wall at times t_1 and t_2 respectively, then time of flight t is

$t = \sqrt{t_1 t_2}$

or $t^2 = t_1 t_2$

$\therefore \left(\frac{2u \sin\alpha}{g}\right)^2 = \frac{(2u \sin\alpha)^2 - (4u^2 \sin^2 \alpha - 8gh)}{4g^2}$

or $\frac{4u^2 \sin^2 \alpha}{g^2} = \frac{8gh}{4g^2}$

or $2u^2 \sin^2 \alpha = gh$

Given, $u = \sqrt{2gh}$

$\therefore\ 2(2gh)\sin^2 \alpha = gh$

or $\sin^2 \alpha = \frac{1}{4}$

or $\sin\alpha = \frac{1}{2}$

$\therefore\ \alpha = 30°$

416 **(b)**

According to given problem $\frac{1}{2} m v^2 = a s^2$

$\Rightarrow v = s\sqrt{\frac{2a}{m}}$

So $a_R = \frac{v^2}{R} = \frac{2as^2}{mR}$ ...(i)

Further more as

$a_t = \frac{dv}{dt} = \frac{dv}{ds} \cdot \frac{ds}{dt} = v \frac{dv}{ds}$ ...(ii)

[By chain rule]

Which is light of equation (i) i.e. $v = s\sqrt{\frac{2a}{m}}$ yields

$a_t = \left[s\sqrt{\frac{2a}{m}}\right]\left[\sqrt{\frac{2a}{m}}\right] = \frac{2as}{m}$ ...(iii)

So that $a = \sqrt{a_R^2 + a_t^2} = \sqrt{\left[\frac{2as^2}{mR}\right]^2 \left[\frac{2as}{m}\right]^2}$

Hence $a = \frac{2as}{m}\sqrt{1 + [s/R]^2}$

$\therefore F = ma = 2as\sqrt{1 + [s/R]^2}$

417 **(a)**

$F = \frac{mv^2}{r}$. If m and v are constants then $F \propto \frac{1}{r}$

$\therefore \frac{F_1}{F_2} = \left(\frac{r_2}{r_1}\right)$

418 **(d)**

For horizontal motion,

$nw = v_0 t$ or $t = \frac{nw}{v_0}$

For vertical motion, $nh = \frac{1}{2}gt^2$

or $\frac{1}{2}g\left(\frac{n^2w^2}{v_0^2}\right) = nh$ or $n = \frac{2hv_0^2}{gw^2}$

419 **(d)**

It spends negligible time on earth *ie*, it performs projectile motion

Here maximum range $R_{max} = 1$ m

$\frac{u^2}{g} = 1$

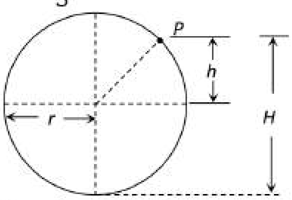
$u^2 = 1 \times 9.8$

$u = \sqrt{9.8} = 3.13$ ms^{-1}

420 **(c)**

As we know for hemisphere the particle will leave the sphere at height $h = 2r/3$

$h = \frac{2}{3} \times 21 = 14m$



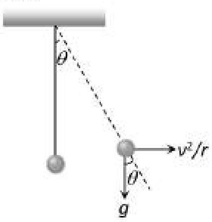
But from the bottom

$H = h + r = 14 + 21 = 35$ *metre*

421 **(c)**

Speeds at the top point of each wheel will equal and is equal to the speed of centre of mass.

422 **(c)**



$\tan\theta = \frac{v^2}{rg}$

$\therefore \theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left(\frac{10 \times 10}{10 \times 10}\right)$

$\therefore \theta = \tan^{-1}(1) = 45°$

423 **(d)**

Let u be initial velocity of projection at angle θ with the horizontal. Then, horizontal range,

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

and maximum height $H = \frac{u^2 \sin 2\theta}{2g}$

Given, $R = 4\sqrt{3}H$

$\therefore \frac{u^2 \sin 2\theta}{g} = 4\sqrt{3} \cdot \frac{u^2 \sin^2\theta}{2g}$

$\therefore 2\sin\theta\cos\theta = 2\sqrt{3}\sin^2\theta$

or $\frac{\cos\theta}{\sin\theta} = \sqrt{3}$

or $\cot\theta = \sqrt{3} = \cot 30°$

424 **(d)**

Time period $= 40$ *sec*

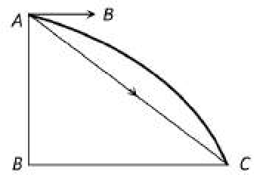
No. of revolution $= \frac{\text{Total time}}{\text{Time period}} = \frac{140 \text{ sec}}{40 \text{ sec}} = 3.5$ *Rev.*

So, distance $= 3.5 \times 2\pi R = 3.5 \times 2\pi \times 10 = 220m$.

425 **(a)**

The horizontal distance covered by the bomb,

$BC = v_H \times \sqrt{\frac{2h}{g}} = 150\sqrt{\frac{2 \times 80}{10}} = 600\ m$



∴ The distance of target from dropping point of bomb,

$AC = \sqrt{AB^2 + BC^2} = \sqrt{(80)^2 + (600)^2}$

$= 605.3\ m$

426 **(b)**

By using equation $\omega^2 = \omega_0^2 - 2\alpha\theta$

$\left(\frac{\omega_0}{2}\right)^2 = \omega_0^2 - 2\alpha(2\pi n) \Rightarrow \alpha = \frac{3}{4}\frac{\omega_0^2}{4\pi \times 36}, (n = 36)$

..(i)

Now let fan completes total n' revolution from the starting to come to rest

$0 = \omega_0^2 - 2\alpha(2\pi n') \Rightarrow n' = \frac{\omega_0^2}{4\alpha\pi}$

Substituting the value of α from equation (i)

$n' = \frac{\omega_0^2}{4\pi}\frac{4 \times 4\pi \times 36}{3\omega_0^2} = 48$ revolution

Number of rotation $= 48 - 36 = 12$

427 **(a)**

One force must lie in between sum and difference of two other forces.

428 **(c)**

$F = m\omega^2 R$ $\therefore F \propto \omega^2$ (m and R are constant)

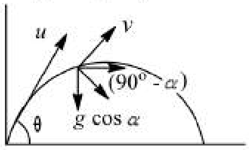
If angular velocity is doubled force will becomes four times

429 **(a)**

$v_H = \sqrt{rg} = \sqrt{1 \times 9.8} = 3.1$ ms^{-1}

430 **(c)**

Refer figure when the velocity vector makes an angle α with the horizontal, the component of acceleration, perpendicular to velocity, *ie*, the centripetal acceleration is g cos α. As horizontal component of velocity remains unchanged in angular projection of projectile, hence



$v\cos\alpha = u\cos\theta$ or $v = \frac{u\cos\theta}{\cos\alpha}$

As, g cos α provides centripetal acceleration, hence

$g\cos\alpha = \frac{v^2}{r}$ or $\frac{v^2}{g\cos\alpha} = \frac{u^2\cos^2\theta}{g\cos^3\alpha}$

431 **(a)**

$(\vec{A}+\vec{B})\cdot(\vec{A}-\vec{B}) = 0$

$A^2 - B^2 = 0$ or $A = B$.

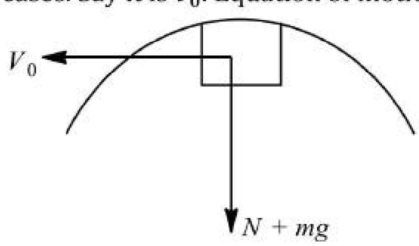
432 **(b)**

Angular momentum $\vec{L} = \vec{r}\times\vec{p}$

$= (2\hat{i}+2\hat{j}+\hat{k})\times(2\hat{i}-2\hat{j}+\hat{k}) = 4\hat{i}-8\hat{k}$

433 **(a)**

Since the block rises to the same heights in all the four cases, from conversation of energy, speed of the block at highest point will be same in all four cases. Say it is v_0. Equation of motion will be



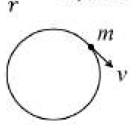
$N + mg = \frac{mv_0^2}{R}$

or $N = \frac{mv_0^2}{R} - mg$

R (the radius of curvature) in first case minimum. Therefore, normal reaction *N* will be maximum in first case.

434 **(a)**

$\frac{v^2}{r} = a$, the centripetal acceleration [Given]



If v is doubled, $a'' = \frac{4v^2}{r} = 4a$

435 **(b)**

Using the relation

$\frac{mv^2}{r} = \mu R, \quad R = mg$

$\frac{mv^2}{r} = \mu mg \Rightarrow v^2 = \mu rg$

$v^2 = 0.6\times 150\times 10$

$v = 30\ \text{ms}^{-1}$

436 **(c)**

As seen from the cart the projectile moves vertically upward and comes back.

The time taken by cart to cover 80 m

$= \frac{s}{v} = \frac{80}{30} = \frac{8}{3}$ s

Given, $u = ?, v = 0, a = -g = 10\text{ms}^{-2}$

(for a projectile going upward)

and $t = \frac{8/3}{2} = \frac{4}{3}$ s

From first equation of motion

$v = u + at$

$0 = u - 10\times\frac{4}{3}$

$= \frac{40}{3}\text{ms}^{-1}$

438 **(a)**

$T = \frac{2u\sin\theta}{g} \Rightarrow u = \frac{T\times g}{2\sin\theta} = \frac{2\times 9.8}{2\times\sin 30}$

$= 19.6\ m/s$

439 **(a)**

Direction of velocity is always tangent to path, so at the top of trajectory it is in horizontal direction and acceleration due to gravity is always in vertically downward direction. Hence, **v** and **g** are perpendicular to each other.

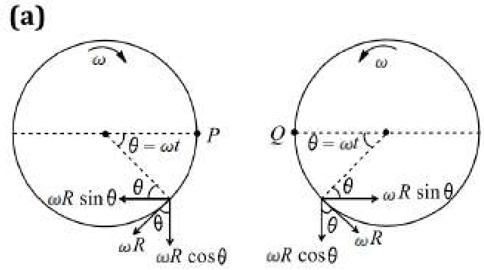
441 **(a)**

If air resistance is taken into consideration then range and maximum height, both will decrease

443 **(b)**

$v = \sqrt{\mu rg} = \sqrt{0.6\times 150\times 10} = 30m/s$

444 **(a)**



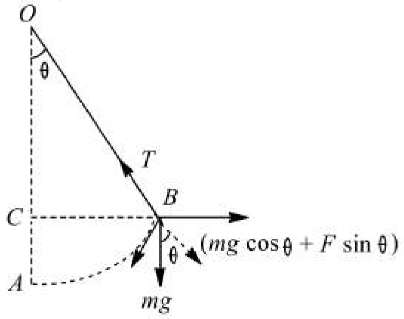
So, $V_r = 2\omega R\sin(\omega t)$

At $t = T/2, V_r = 0$

So two half cycles will take place

445 **(c)**

Centrifugal force on rod, $F = \frac{mv^2}{r}$ along *BF*. Let θ be the angle which the rod makes with the vertical. Forces acting on the rod are shown in figure



Resolving mg and F into two rectangular components, we have,

Forces parallel to rod,

$mg\cos\theta + \frac{mv^2}{r}\sin\theta = T$

Force perpendicular rod

$= mg\sin\theta - \frac{mv^2}{r}\cos\theta$

The rod will be balanced if

$mg\sin\theta = \frac{mv^2}{r}\cos\theta = 0$

or $mg\sin\theta = \frac{mv^2}{r}\cos\theta$

or $\tan\theta = \frac{v^2}{rg} = \frac{(10)^2}{10\times10} = 1 = \tan 45°$ or $\theta = 45°$

446 **(c)**

Horizontal range of the object fired,

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

At the highest point, when object is exploded into two equal masses, then

$2mu\cos\theta = m(0) + mv$

or $v = 2u\cos\theta$

It means, the horizontal velocity becomes double at the highest point, hence it will cover double the distance during the remaining flight.

∴ Total horizontal range of the other part

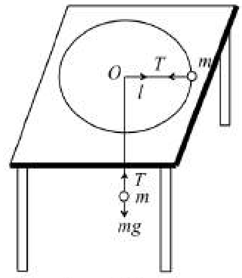
$= \frac{R}{2} + R = \frac{3R}{2}$

$= \frac{3}{2}\frac{u^2\sin 2\theta}{g}$

$= \frac{3}{2}\times\frac{(100)^2\times 2\sin\theta\cos\theta}{g}$

$= \frac{3}{2}\times\frac{(100)^2\times 2\times\frac{3}{5}\times\frac{4}{5}}{10} = 1440\text{ m}$

448 **(b)**



Tension T in the string will provide centripetal force

$\Rightarrow \frac{mv^2}{l} = T$ ...(i)

Also, tension T is provided by the hanging ball of mass m,

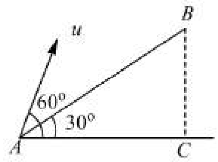
$\Rightarrow T = mg$ ...(ii)

$mg = \frac{mv^2}{l} \Rightarrow g = \frac{v^2}{l}$

It is the centripetal acceleration of a moving ball

449 **(d)**

Horizontal component of velocity at A



$v_H = u\cos 60° = \frac{u}{2}$ ∴ $AC = u_H \times t = \frac{ut}{2}$

$AB = AC\sec 30° = \frac{ut}{2}\times\frac{2}{\sqrt{3}} = \frac{ut}{2}$

450 **(b)**

$mg = 20N$ and $\frac{mv^2}{r} = \frac{2\times(4)^2}{1} = 32N$

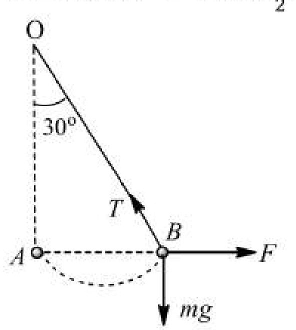
It is clear that 52 N tension will be at the bottom of the circle. Because we know that $T_{\text{Bottom}} = mg + \frac{mv^2}{r}$

451 **(d)**

$T\cos 30° = mg$

or $T = \frac{mg}{\cos 30°} = \frac{\sqrt{3}\times 9.8}{\sqrt{3}/2} = 19.6\text{N}$

$F = T\sin 30° = 19.6\times\frac{1}{2} = 9.8\text{N}$



452 **(a)**

When particle moves in circle, then the resultant force must act towards the center and its magnitude F must satisfy

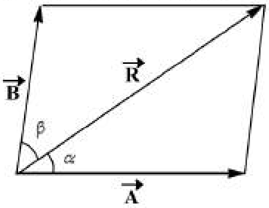
$$F = \frac{mv^2}{l}$$

This resultant force is directed towards the center and it is called centripetal force. This force originates form tension T.

$$\therefore F = \frac{mv^2}{l} = T$$

454 **(c)**

$\alpha < \beta$ if $\vec{B} < \vec{A}$ or $B < A$



455 **(b)**

Due to centrifugal force

456 **(c)**

Horizontal component of velocity at angle 60°

= Horizontal component of velocity at angle 45°

ie, $\cos 60° = u \cos 45°$

$$147 \times \frac{1}{2} = v \times \frac{1}{\sqrt{2}}$$

or $v = \frac{147}{\sqrt{2}} \text{ms}^{-1}$

vertical component of velocity at angle 60°

$$u = u \sin 60° = \frac{147\sqrt{3}}{2} \text{ m}$$

vertical component of velocity at angle 45° = $v \sin 45°$

$$= \frac{147}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{147}{2} \text{m}$$

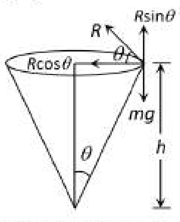
But $v_y = u_y + at$

$$\therefore \frac{147}{2} = \frac{147\sqrt{3}}{2} - 9.8t$$

or $9.8t = \frac{147}{2}(\sqrt{3} - 1)$

$\therefore \ t = 5.49 \text{ s}$

457 **(d)**



The particle is moving in circular path

From the figure, $mg = R \sin \theta$ ... (i)

$$\frac{mv^2}{r} = R \cos \theta \quad \text{... (ii)}$$

From equation (i) and (ii) we get

$\tan \theta = \frac{rg}{v^2}$ but $\tan \theta = \frac{r}{h}$

$$\therefore h = \frac{v^2}{g} = \frac{(0.5)^2}{10} = 0.025m = 2.5\ cm$$

458 **(c)**

At the topmost point of the projectile there is only horizontal component of velocity and acceleration due to gravity is vertically downward, so velocity and acceleration are perpendicular to each other.

460 **(c)**

In projectile motion, horizontal component of velocity remains constant

$\therefore v \cos \theta = u \cos 2\theta$

$$\Rightarrow v = \frac{u \cos 2\theta}{\cos \theta} = \frac{u(2\cos^2 \theta - 1)}{\cos \theta}$$

$$= u(2\cos \theta - \sec \theta)$$

461 **(a)**

Since $v^2 - v_0^2 = 2\vec{a}.\vec{s} = 2\vec{a}.\left(\frac{\vec{v}+\vec{v}_0}{2}\right)t$

or $\vec{v}.\vec{v} - \vec{v}_0.\vec{v}_0 = (\vec{v} + \vec{v}_0).\vec{a}t$

or $\vec{v}.(\vec{v} - \vec{a}t) = \vec{v}_0.(\vec{v}_0 + \vec{a}t)$

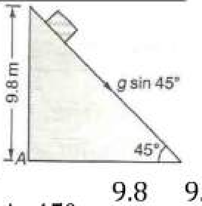
462 **(d)**

In complete revolution change in velocity becomes zero so average acceleration will be zero

463 **(d)**

The time of ascent = time of descent = t_0

T = total time of flight = $2t_0$



$$\sin 45° = \frac{9.8}{BC} = \frac{9.8}{s}$$

$\therefore \ s = 9.8\sqrt{2}$

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

$$s = 0 \times t + \frac{1}{2}(g \sin 45°)t_0^2$$

or $9.8\sqrt{2} = \frac{9.8}{2\sqrt{2}} t_0^2$

$\therefore \ t_0^2 = 4$

$\therefore \ t_0 = 2\text{s}$

$\therefore \ T = 2t_0 - 4\text{s}$

465 **(a)**

$$\omega = \frac{v}{r} = \frac{100}{100} = 1\ rad/s$$

466 **(d)**

$$\text{Range } = \frac{u^2 \sin 2\theta}{g} = 200\ m$$

$\Rightarrow \frac{u^2(2\sin\theta\cos\theta)}{g} = 200\ m$ ...(i)

Time of flight $= \frac{2u \sin \theta}{g} = 5s$ ...(ii)

From equations (i) and (ii)

$u\cos\theta = 40\ m/s$

467 **(a)**

$|\hat{A}\times\hat{B}| = (1)(1)\sin\theta = \sin\theta.$

469 **(c)**

Equating the moments about R

$6\times PR = 4\times RQ$

$PR = \frac{4}{6}RQ = \frac{2}{3}RQ$

470 **(b)**

Centripetal force $= mr\omega^2 = 5\times 1\times(2)^2 = 20\ N$

471 **(c)**

$H = \frac{u^2\sin^2\theta}{2g} \Longrightarrow \frac{H_1}{H_2} = \frac{u^2\sin^2\theta_1}{u^2\sin^2\theta_2}$

$\frac{3}{1} = \frac{\sin^2\theta_1}{\sin^2\theta_2} \Longrightarrow \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sqrt{3}}{1}$

Logically, we can conclude that

$\theta_1 = 60°, \quad \theta_2 = 30°$

Again $R = \frac{u^2\sin 2\theta}{g}$

$\therefore \frac{R_1}{R_2} = \frac{4\,u^2\sin 2\theta_1}{u^2\sin 2\theta_2}$

$\frac{R_1}{R_2} = \frac{4\sin 2(60°)}{\sin 2(30°)} = \frac{4\sin 120°}{\sin 60°}$

or $\frac{R_1}{R_2} = \frac{4\times\frac{\sqrt{3}}{2}}{\frac{\sqrt{3}}{2}} = 4$

472 **(b)**

$\frac{v}{g} = 20$ or $v^2 = 20g = 20\times 9.8 = 196, v$

$= 14\ \text{ms}^{-1}$

473 **(d)**

$h_{\max} = \frac{u^2}{2g} = 10 \quad [\because \theta = 90°]$

$u^2 = 200$

$R_{\max} = \frac{u^2}{g} = 20m$

474 **(d)**

For successfully completing the loop,

$h = \frac{5}{4}R \Rightarrow R = \frac{2h}{5} = \frac{2\times 5}{5} = 2\text{cm}$

475 **(a)**

$\vec{P}.\vec{Q} = 0 \Rightarrow \vec{P}\perp\vec{Q}$ or $\theta = 90°$

$|\vec{P}\times\vec{Q}| = PQ\sin 90° = PQ$ or $|\vec{P}|\,|\vec{Q}|$

476 **(a)**

Here, $r = 100\text{m}, v = 7\text{ms}^{-1}, m = 60\text{kg}$

Reading registered= resultant force =?

Two force are acting, weight mg and centripetal force $\frac{mv^2}{r}$ at 90° to each other

$\therefore$ Resultant force $= \sqrt{(mg)^2 + \left(\frac{mv^2}{r}\right)^2} =$

$mg\left[1 + \left(\frac{v^2}{rg}\right)^2\right]^{1/2}$

$= 60\times 9.8\left[1 + \left(\frac{7\times 7}{100\times 9.8}\right)^2\right]^{1/2}$

$= 60.075\times 9.8\ \text{N} = 60.075$ kg-wt

477 **(d)**

$R = \frac{v^2\sin 2\theta}{g}$

In the given problem $v^2\sin 2\theta =$ constant

$v^2\sin 2\theta = \left(\frac{v}{2}\right)^2\sin 30° = \frac{v^2}{8}$

or $\sin 2\theta = \frac{1}{8}$ or $2\theta = \sin^{-1}\left[\frac{1}{8}\right]$ or $\theta = \frac{1}{2}\sin^{-1}\left[\frac{1}{8}\right]$

478 **(b)**

$\omega^2 R = 4\pi^2 n^2 r = 4\pi^2\left(\frac{1200}{60}\right)^2\times 30\times 10^{-2}$

$= 4732\ m/s^2$

479 **(b)**

$ma\cos\theta = mg\cos(90-\theta)$

$\Rightarrow \frac{a}{g} = \tan\theta \Rightarrow \frac{a}{g} = \frac{dy}{dx}$

$\Rightarrow \frac{d}{dx}(kx)^2 = \frac{a}{g} \Rightarrow x = \frac{a}{2gk}$

480 **(d)**

$\theta = 30°$

$\frac{R}{H} = \frac{v^2(2\sin\theta\cos\theta)}{g}\times\frac{2g}{v^2\sin^2\theta} = \frac{4\cos\theta}{\sin\theta}$

or $R = 4\cot 30°\times H = 4\sqrt{3}$

481 **(b)**

$\omega = \frac{v}{r} = \frac{10}{100} = 0.1 rad/s$

482 **(d)**

Height, $h = \frac{1}{2}gt^2 \Longrightarrow t = \sqrt{\frac{2\times 1960}{9.8}} = 20\text{s}$

$s = AB = ut = 600\times\frac{20}{60\times 60} = 3.33$ km

483 **(c)**

The vector is $\hat{\imath} - [\vec{A}+\vec{B}+\vec{C}]$

$= \hat{\imath} - [(2\hat{\imath} - 4\hat{\jmath} + 7\hat{k}) + (7\hat{\imath} + 2\hat{\jmath} - 5\hat{k}) + (-4\hat{\imath} + 7\hat{\jmath} + 3\hat{k})]$

$= -4\hat{\imath} - 5\hat{\jmath} - 5\hat{k}$

484 **(a)**

Distance covered in 'n' revolution $= n\,2\pi r = n\pi D$

$\Rightarrow 2000\pi D = 9500$[As $n = 200$, distance $= 9500\ m$]

$\Rightarrow D = \frac{9500}{2000\times\pi} = 1.5\ m$

485 **(c)**

$|\vec{A}\times\vec{B}| = AB\sin\theta$. As $\sin\theta \le 1$, therefore $AB\sin\theta$ can not be more than AB.

486 **(c)**

$R^2 = R^2 + R^2 + 2R^2\cos\theta$ or $R^2 = 2R^2 + 2R^2\cos\theta$

$\frac{1}{2} = 1 + \cos\theta$ or $\cos\theta = -\frac{1}{2}$ or $\theta = 120°$

487 **(a)**

Linear velocity,

$v = \omega r = 2\pi nr = 2\times 3.14\times 3\times 0.1 = 1.88\ m/s$

Acceleration, $a = \omega^2 r = (6\pi)^2 \times 0.1 = 35.5\ m/s^2$

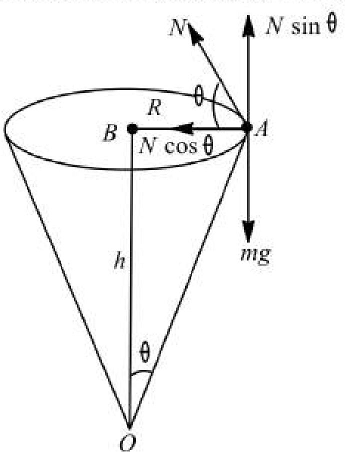
Tension in string, $T = m\omega^2 r = 1\times(6\pi)^2\times 0.1 = 35.5\ N$

488 **(b)**

Work done by centripetal force is always zero

489 **(d)**

The various forces acting on the particle, are its weight mg acting vertically downwards, normal reaction N. Equating the vertical forces, we have



$N\sin\theta = mg$ ... (i)

Also, centripetal force,

$\frac{mv^2}{R} = N\cos\theta$ .... (ii)

From Eqs. (i) and (ii), we get

$\tan\theta = \frac{Rg}{v^2}$ .... (iii)

Also, from triangle OAB,

$\tan\theta = \frac{R}{h}$ ..... (iv)

Equating Eqs. (iii) and (iv), we get

$h = \frac{v^2}{g}$

Given, $v = 0.5\ \text{ms}^{-1}$ and $g = 10\ \text{ms}^{-2}$

$\therefore\ h\frac{(0.5)^2}{10} = 0.025\ \text{m} = 2.5\ \text{cm}$

490 **(b)**

Given, $\vec{u} = \hat{i} + 2\hat{j} = u_x\hat{i} + u_y\hat{j}$

Then $u_x = u\cos\theta$

and $u_y = 2 = u\cos\theta$

$\therefore\ \tan\theta = \frac{u\sin\theta}{u\cos\theta} = \frac{2}{1} = 2$

The equation of trajectory of a projectile motion is

$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$= x\tan\theta - \frac{gx^2}{2(u\cos\theta)^2}$

$= x\times 2 - \frac{10\times x^2}{2(1)^2} = 2x - 5x^2$

491 **(d)**

$T = mg + m\omega^2 r = m\{g + 4\pi^2 n^2 r\}$

$= m\left\{g + \left(4\pi^2\left(\frac{n}{60}\right)^2 r\right)\right\} = m\left\{g + \left(\frac{\pi^2 n^2 r}{900}\right)\right\}$

492 **(d)**

Kinetic energy $= \frac{1}{2}mv^2 = K = as^2$

or $mv^2 = 2as^2$

Centripetal force $= \frac{mv^2}{R} = \frac{2as^2}{R}$

493 **(b)**

$\vec{A} = A\hat{A} = B\hat{B}$. let θ be the angle between $\vec{A}$ and $\vec{B}$.

As per question,

$\cos\alpha = \frac{(A\hat{A} + B\hat{B}).(A\hat{B} + B\hat{A})}{|A\hat{A} + B\hat{B}||A\hat{B} + B\hat{A}|}$

or $\cos\alpha = \frac{2AB + (A^2+B^2)\cos\theta}{(\sqrt{A^2+B^2+2AB\cos\theta})^2}$

or $2AB + (A^2+B^2)\cos\theta = (A^2+B^2)\cos\alpha + 2AB\cos\theta\cos\alpha$

or $2AB(1 - \cos\alpha\cos\theta)$

$= (A^2+B^2)(\cos\alpha - \cos\theta)$

or $\frac{2AB}{A^2+B^2} = \frac{\cos\alpha - \cos\theta}{1 - \cos\alpha\cos\theta}$

or $\frac{2AB}{(A^2+B^2)} = \frac{\cos\alpha - \cos\theta}{1 - \cos\alpha\cos\theta}$

or $\frac{2AB + (A^2+B^2)}{(A^2+B^2) - AB}$

$= \frac{(\cos\alpha\cos\theta) + (1 - \cos\alpha\cos\theta)}{(1 - \cos\alpha\cos\theta) + (\cos\alpha\cos\theta)}$

or $\frac{(A+B)^2}{(A-B)^2} = \frac{(1+\cos\alpha)(1-\cos\theta)}{(1+\cos\theta)(1-\cos\alpha)}$

$= \frac{\tan^2\theta/2}{\tan^2\theta/2}$

or $\tan\frac{\alpha}{2} = \left(\frac{A-B}{A+B}\right)\tan\frac{\theta}{2}$

494 **(b)**

$10A^2 = 4A^2 + 2A^2 + 2\times 2A\times\sqrt{2}A\times\cos\theta$

or $4A^2 = 4\sqrt{2}A\cos\theta$

or $\cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45°$

495 **(d)**

$T \sin\theta = M\omega^2 R$ ...(i)

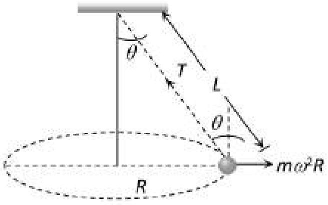
$T \sin\theta = M\omega^2 L \sin\theta$ ...(ii)

From (i) and (ii)

$T = M\omega^2 L$

$= M\, 4\pi^2 n^2 L$

$= M\, 4\pi^2 \left(\frac{2}{\pi}\right)^2 L = 16\, ML$



496 **(d)**

$R = \frac{u^2 \sin 2\theta}{g}$ $\therefore R \propto u^2$. If initial velocity be doubled then range will become four times

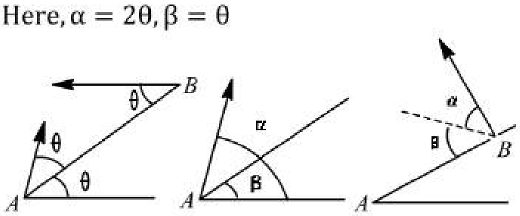
497 **(a)**

$$t = \sqrt{\frac{2 \times 2000}{10}} = \sqrt{400} = 20 \text{ s}$$

$x = 100\text{ms}^{-1} \times 20\text{s} = 2000 \text{ m} = 2\text{km}$

498 **(a)**

Here, $\alpha = 2\theta, \beta = \theta$



Time of flight of A is,

$$T_1 = \frac{2u \sin(\alpha - \beta)}{g \cos\beta}$$

$$= \frac{2u \sin(2\theta - \theta)}{g \cos\theta}$$

$$= \frac{2u}{g} \tan\theta$$

Time of flight of B is, $T_2 = \frac{2u \sin\theta}{g \cos\theta}$

$$= \frac{2u}{g} \tan\theta$$

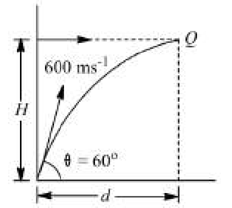
So, $T_1 = T_2$. The acceleration of both the particles is g downwards. Therefore, relative acceleration between the two I zero or relative motion between the two is uniform. The relative velocity of A w.r.t. B is towardsAB, therefore collision will take place between the two in mid air.

499 **(a)**

If it is being hit then

$$d = v_0 t + \frac{1}{2} a t^2 = (u \cos\theta) t$$

or $t = \frac{u \cos\theta - v_0}{a/2}$



$$\therefore\ t = \frac{600 \times \frac{1}{2} - 250}{10} = 5 \text{ s}$$

$$H = (u \sin\theta) t - \frac{1}{2} \times g t^2$$

$$= 600 \times \frac{\sqrt{3}}{2} \times 5 - \frac{1}{2} \times 10 \times 25$$

$H = 2473$ m

500 **(b)**

$a^2 + b^2 + 2ab \cos\theta$

$= -a^2 + b^2 - 2ab \cos\theta$

or $4ab \cos\theta = 0$

But $4ab \neq 0 \therefore \cos\theta = 0$ or $\theta = 90°$

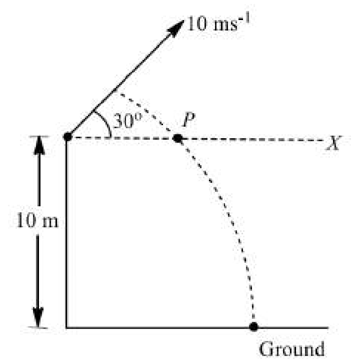
Again

$|\vec{a} + \vec{b}|$ and $|\vec{a} - \vec{b}|$ are the diagonals of parallelogram whose adjacent sides are $\vec{a}$ and $\vec{b}$.

Since $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$, therefore, the two diagonals of a parallelogram are equal. So, think of square. This leads to $\theta = 90°$.

501 **(d)**

The ball will be at point P when it is at height of 10 m from the ground. So, we have to find distance OP, which can be calculated by directly considering it as a projectile on a level (OX).



$$OP = R = \frac{u^2 \sin 2\theta}{g}$$

$$= \frac{10^2 \sin(2 \times 30°)}{10}$$

$$= \frac{10\sqrt{3}}{2} = 5\sqrt{3}$$

$= 8.66$ m

502 **(b)**

$$\vec{v}=\vec{\omega}\times\vec{r}=\begin{vmatrix}\hat{\imath} & \hat{\jmath} & \hat{k}\\ 3 & -4 & 1\\ 5 & -6 & 6\end{vmatrix}=-18\hat{\imath}-13\hat{\jmath}+2\hat{k}$$

503 **(a)**

Given $\vec{C}=|\vec{B}|\hat{\jmath} \Rightarrow \vec{C}=5\hat{\jmath}$

Let $\vec{C}=\vec{A}+\vec{B}=A+3\hat{\imath}+4\hat{\jmath}$

$5\hat{\jmath}=A+3\hat{\imath}+4\hat{\jmath}$

$\Rightarrow \vec{A}=-3\hat{\imath}+\hat{\jmath}$

$|\vec{A}|=\sqrt{(3)^2+(1)^2}$

$=\sqrt{10}$

504 **(a)**

Time of flight $=\frac{2u\sin\theta}{g}=\frac{2u_y}{g}=\frac{2\times u_{\text{vertical}}}{g}$

505 **(c)**

Change in velocity $=2v\sin(\theta/2)=2v\sin 20°$

506 **(d)**

At maximum height H, the horizontal component of the velocity of the bullet $=u\cos\theta=$ $u\cos 60°=u/2$

507 **(d)**

Tension at the top of the circle, $T=m\omega^2r-mg$

$T=0.4\times 4\pi^2n^2\times 2-0.4\times 9.8=122.2N$

$\approx 115.86N$

508 **(c)**

Displacement $=AB$

angle between $\vec{r_1}$ and $\vec{r_2}$

$\theta=75°-15°=60°$

From figure

$AB^2=r_1^2+r_2^2-2r_1r_2\cos\theta$

$=3^2+4^2-2\times 3\times 4\cos 60°$

$=13$

$AB=\sqrt{13}$

509 **(b)**

The ball reaches nth step in time t, then $bn=ut$ or $t=bn/u$,

$nh=\frac{1}{2}gt^2=\frac{1}{2}g\times\frac{b^2n^2}{u^2}$; so $n=\frac{2u^2h}{gb^2}$

Time taken to travel vertical distance nh is

$$t=\sqrt{\frac{2nh}{g}}=\sqrt{\frac{2h}{g}\times\frac{2u^2h}{gb^2}}=\frac{2uh}{gb}$$

510 **(b)**

We know, $F=mr\omega^2$

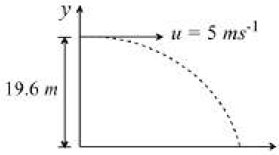
$r\omega^2=$constant

$\omega^2\propto\frac{1}{r}$

$\left(\frac{\omega_2}{\omega_1}\right)^2=\frac{r_1}{r_2}$

$\frac{4\omega_1^2}{\omega_1^2}=\frac{8}{r_2}\quad\therefore r_2=2\text{ cm}$

512 **(b)**



Let t s be time taken by the ball to hit the ground

$$\therefore H=\frac{1}{2}gt^2\Rightarrow t=\sqrt{\frac{2H}{g}}=\sqrt{\frac{2\times 19.6m}{9.8\ ms^{-2}}}=2s$$

513 **(c)**

Equating velocities along the vertical,

$v_2=v_1\sin 30°$ or $\frac{v_2}{v_1}=\frac{1}{2}$

514 **(d)**

Given, $m=1\times 10^{-3}$ kg, $\omega=1$ rad s^{-1} and r $=1$m

Hence, centrifugal force $=m\omega^2r=10^{-3}$N

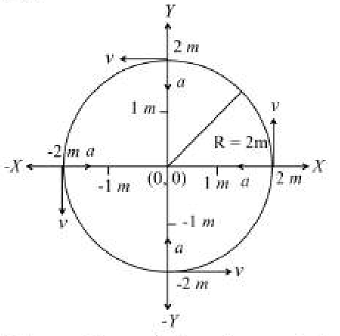
1N $=10^5$ dyne

$\therefore$ Centrifugal force $=100$ dyne

515 **(a)**

$$a=4\pi^2n^2r=4\pi^2\left(\frac{1}{2}\right)^2\times 50=493\ cm/s^2$$

516 **(a)**



The radius of circular path is $2m$ and the speed of the object is $4m/s$

The magnitude of acceleration is

$$a=\frac{v^2}{R}=\frac{16}{2}=8m/s^2$$

The acceleration is directed towards the centre

Therefore, when an object is at $y=2m$, its acceleration is $-8\hat{\jmath}\ m/s^2$

517 **(b)**

Maximum height of projectile

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

$$\therefore\ H=\frac{(10)^2\times\sin^2(30°)}{2\times 10}$$

$=\frac{5}{4}=1.25$ m

Time to reach maximum height

$t = \frac{u\sin\theta}{g}$

$\therefore\ t = \frac{10 \times \sin 30°}{10} = 0.5s$

So, distance of vertical fall in 0.5s

$h = \frac{1}{2}gt^2$

or $h = \frac{1}{2} \times 10 \times (0.5)^2 = 1.25$ m

$\therefore$ Height of second ball = 1.25 + 1.25 = 2.5 m

518 **(b)**

Initial velocity

$v_1 = v$

Final velocity $v_2 = -v$

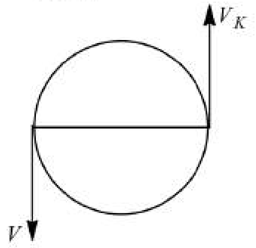
Initial momentum $p_1 = mv$

Final momentum $p_1 = m(-v) = -mv$

Change in momentum $\Delta p = p_1 - p_2$

$= mv - (-mv)$

$= 2mv$j



519 **(d)**

Given, initial velocity $= v_0$

final velocity = 0

deceleration $a = -\alpha x^2$ ….(i)

Let the distance travelled by the particle be s,

Now, we know that

$a = \frac{dv}{dt} = \frac{dv}{dt} \times \frac{dx}{dx} = \frac{vdv}{dx}$

or $a = v\frac{dv}{dx}$ ...(ii)

From Eqs. (i)and (ii)

$v\frac{dv}{dx} = -\alpha x^2$

or $vdv = -\alpha x^2 dx$

On integrating with limit $v_0 \to 0$ and $0 \to s$

$\therefore \int_{v_0}^{0} vdv = \int_0^s -\alpha x^2 dx$

or $\left[\frac{v^2}{2}\right]_{v_0}^{0} = -\alpha\left[\frac{x^3}{3}\right]_0^s$

$-\frac{v_0^2}{2} = -\frac{\alpha(s)^3}{3}$

or $\frac{v_0^2}{2} = \frac{\alpha s^3}{3}$

or $\frac{3v_0^2}{2\alpha} = s^3$

or $s = \left[\frac{3v_0^2}{2\alpha}\right]^{1/3}$

520 **(a)**

$H = \frac{u^2\sin^2\theta}{2g}$ and $T = \frac{2u\sin\theta}{g}$

So $\frac{H}{T^2} = \frac{u^2\sin^2\theta/2g}{4u^2\sin^2\theta/g^2} = \frac{g}{8} = \frac{5}{4}$

521 **(a)**

$T_{max} = m\omega_{max}^2 r + mg \Rightarrow \frac{T_{max}}{m} = \omega^2 r + g$

$\Rightarrow \frac{30}{0.5} - 10 = \omega_{max}^2 r \Rightarrow \omega_{max} = \sqrt{\frac{50}{r}} = \sqrt{\frac{50}{2}}$

$= 5\ rad/s$

522 **(d)**

Tension in the string $T_0 = mR\omega_0^2$

In the second case $T = m(2R)(4\omega_0^2) = 8mR\omega_0^2 = 8T_0$

523 **(a)**

The object will slip if centripetal force acting on it is more than friction force.

So, $mr\omega^2 > \mu mg$

$r\omega^2 \geq \mu g$

$r\omega^2 =$ constant

$\frac{r_1}{r_2} = \left(\frac{\omega_2}{\omega_1}\right)^2$

$\frac{4}{r_2} = \left(\frac{2\omega}{\omega}\right)^2$

$r_2 = 1$ cm

524 **(c)**

Kinetic energy at highest point$= K\cos^2 45° = \frac{K}{2}$

525 **(b)**

$F^2 = F^2 + F^2 + 2F^2\cos\theta$

or $F^2 = 2F^2(1 + \cos\theta)$

or $1 + \cos\theta = \frac{1}{2}$

or $\cos\theta = -\frac{1}{2}$ or $\theta = 120°$

$\therefore \cos 120° = -\frac{1}{2}$

526 **(a)**

The value of frictional force should be equal or more than required centripetal force. i.e. $\mu mg \geq \frac{mv^2}{r}$

527 **(d)**

The centripetal force, $F = \frac{mv^2}{r} \Rightarrow r = \frac{mv^2}{F}$

$\therefore r \propto v^2$ or $v \propto \sqrt{r}$ [If m and F are constant]

$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}} = \sqrt{\frac{1}{2}}$

528 **(b)**

Here, $r = 100 \text{ m}, t = 62.8 \text{ s}$

In one circular loop, displacement $= 0$

$\therefore$ Velocity=0

Distance traveled $= 2\pi r$

$\therefore$ Speed $= \frac{2\pi r}{t} = \frac{2.14\times100}{62.8} = 10 \text{ ms}^{-1}$

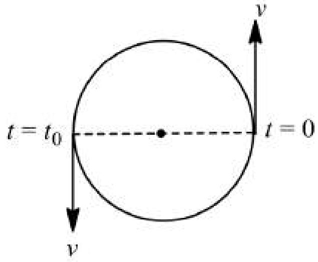
530 **(b)**

$$R = \frac{2 \times 30 \times 30 \sin 30° \cos 60°}{10 \cos^2 30°}$$

$$= 180 \times \frac{1}{2} \times \frac{1}{2} \times \frac{2 \times 2}{3} \text{m} = 60 \text{ m}$$

531 **(b)**

Time $T = \frac{2\pi r}{v}$



and $t_0 = \frac{T}{2} = \frac{\pi r}{\text{v}}$

$\therefore \text{v}_{av} = \frac{2r}{\pi r/\text{v}} = \frac{2\text{v}}{\pi}$

532 **(b)**

When a particle moves in a circular motion, it is acted upon by centripetal force directed towards the centre. Hence, centripetal acceleration is

$$a_N = \frac{dv}{dt} = \frac{v^2}{R}$$

or $\int_0^t \frac{dt}{R} = \int_{v_0}^v \frac{dv}{v^2}$

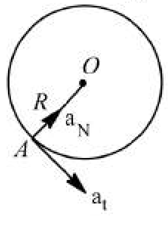
or $t = -R\left[\frac{1}{v}\right]_{v_0}^v$

$$v = \frac{v_0 R}{R - v_0 t}$$

Also $\frac{dr}{dt} = \frac{v_0 R}{(R - v_0 t)}$

$$\int_0^{2\pi R} dr = v_0 R \int_0^T \frac{dt}{R - v_0 t}$$

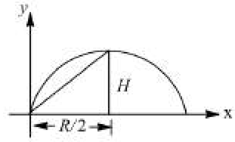
$$\Rightarrow T = \frac{R}{v_0}(1 - 1 - e^{-2\pi})$$



533 **(c)**

Average velocity $= \frac{\text{displacement}}{\text{time}}$

$$V_{av} = \frac{\sqrt{H^2 + \frac{R^2}{4}}}{T/2} \quad ....(i)$$



Here H =maximum height $= \frac{v^2 \sin^2 \theta}{2g}$

R =range $= \frac{v^2 \sin 2\theta}{g}$

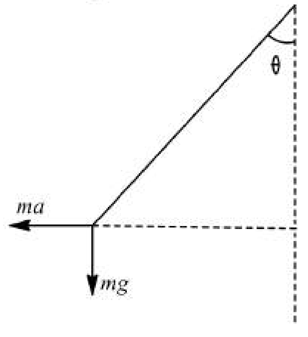
and T =time of flight $= \frac{2v \sin \theta}{g}$

Substituting in Eq. (i), we get

$$v_{av} = \frac{v}{2}\sqrt{1 + 3\cos^2 \theta}$$

535 **(a)**

Let the angle from the vertical beθ. The diagram showing the different forces is given



Form the figure, $\tan \theta = \frac{a}{g}$

$$\theta = \tan^{-1}\frac{a}{g}$$

536 **(d)**

Centripetal acceleration, $a_c = \frac{v^2}{R}$

Where v is the speed of an object and R is the radius of the circle

It is always directed towards the centre of the circle. Since v and R are constants for a given uniform circular motion, therefore the magnitude of centripetal acceleration is also constant. However, the direction of centripetal acceleration changes continuously. Therefore, a centripetal acceleration is not a constant vector

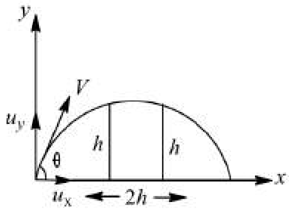
537 **(a)**

$\vec{A} + \vec{B} = 8\hat{i} - 2\hat{j} + 16\hat{k}$

$$m = \frac{0}{|\vec{A} + \vec{B}|} = 0$$

538 **(d)**

Let Δt be the time interval. Then,



$2h = (u_x)(\Delta t)$

or $u_x = \frac{2h}{\Delta t}$ ...(i)

Further, $h = u_y t - \frac{1}{2}gt^2$

or $gt^2 - 2u_y t + 2h = 0$

$$\therefore\ t_1 = \frac{2u_y + \sqrt{4u_y^2 - 8gh}}{2g}$$

and $t_2 = \frac{2u_y - \sqrt{4u_y^2 - 8gh}}{2g}$

$$\Delta t = t_1 - t_2 = \frac{\sqrt{4u_y^2 - 8gh}}{g}$$

or $u_y^2 = \frac{g^2(\Delta t)^2}{4} + 2gh$

Given, $u_x^2 + u_y^2 = \left(2\sqrt{gh}\right)^2$

$$\therefore\ \frac{4h^2}{(\Delta t)^2} + \frac{g^2(\Delta t)^2}{4} + 2gh = 4gh$$

$$\frac{g^2}{4}(\Delta t)^4 - 2gh(\Delta t)^2 + 4h^2 = 0$$

$$(\Delta t)^2 = \frac{2gh \pm \sqrt{4g^2h^2 - 4g^2h^2}}{g^2/2} = \frac{4h}{g}$$

or $\Delta t = 2\sqrt{\frac{h}{g}}$

539 **(c)**

$\vec{A} \perp \vec{B}$, if $\vec{A}.\vec{B} = AB\cos 90° = 0$

$(2\hat{\imath} + a\hat{\jmath} + \hat{k})\cdot(4\hat{\imath} - 2\hat{\jmath} - \hat{k}) = 0$

or $8 - 2a - 2 = 0$ or $a = 3$.

540 **(c)**

$v = r\omega \Rightarrow \omega = \frac{v}{r} =$ constant [As v and r are constant]

541 **(d)**

In a circular motion

$$a = \frac{v^2}{r} \Rightarrow \frac{a_2}{a_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{2v_1}{v_1}\right)^2 = 4$$

542 **(d)**

$u = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20\ \text{ms}^{-1}$

Time of ascent= time of descent

$$= \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 20}{10}} = 2\text{s}$$

$\therefore$ time of flight = 2 +2 = 4s

543 **(d)**

If the string suddenly breaks, the centripetal force will be zero only tangential force will be present, then the stone travels in tangential direction.

544 **(a)**

Time of flight (T) is $2t$.

$$\therefore\ T = t2 = \frac{2\,u\sin\theta}{g}$$

$$= \frac{2}{8} \times U_{\text{vertical}}$$

545 **(d)**

Let v the velocity of projectile at this instants. Horizontal component of velocity remains unchanged. Therefore,

$v\cos 30° = 10\cos 60°$

or $v\frac{\sqrt{3}}{2} = \frac{10}{2}$ or $v = \frac{10}{\sqrt{3}}\ \text{ms}^{-1}$

546 **(a)**

$$T = \frac{mv^2}{r} \Rightarrow 25 = \frac{0.25 \times v^2}{1.96} \Rightarrow v = 14\ m/s$$

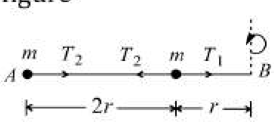
547 **(a)**

Maximum speed $v = \sqrt{\mu r g} = \sqrt{0.4 \times 30 \times 9.8}$

$= 10.84\text{ms}^{-1}$

548 **(a)**

Tensions in the respective parts are shown in figure



Let ω be angular velocity, then

$T_1 - T_2 = m\omega^2 \times r$ ...(i)

and $T_2 = m\omega^2(r + 2r)$

$T_2 = 3m\omega^2 r$ ...(ii)

From equation (i) and (ii)

$$T_1 = 4m\omega^2 r \Rightarrow \frac{T_1}{T_2} = \frac{4}{3}$$

549 **(c)**

The tension of the string,

$T = mr\omega^2$

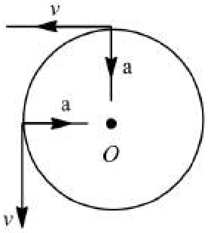
$= 1 \times 1 \times (2)^2 = 4\text{N}$

550 **(c)**

The forces acting on the ball will be (i) in the direction opposite to its motion *ie*, frictional force and(ii) weight mg.

552 **(c)**

An object moving in uniform circular motion is moving around the perimeter of the circle with a constant speed. While the speed of object is constant, its velocity is changing. Velocity being a vector quantity has a constant magnitude but a changing direction. The direction is always directed tangent line is always pointing in a new direction. Also when it is moving in circular motion towards the centre, hence acceleration is perpendicular to velocity.



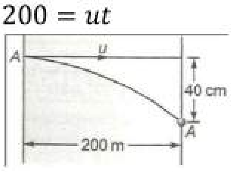
553 **(b)**

Centripetal acceleration $a_c = v^2/r$

It acts along the radius and directed towards the centre of the circular path

554 **(d)**

$200 = ut$



or $t = 200/u$

Also, $\frac{40}{100} = \frac{1}{2} \times 9.8 \left(\frac{200}{u}\right)^2$

On solving $u = 700 \text{ ms}^{-1}$

555 **(c)**

Maximum force of friction = centripetal force

$\frac{mv^2}{r} = \frac{100 \times (9)^2}{30} = 270\ N$

556 **(d)**

$v = r\omega = \frac{r \times 2\pi}{T} = \frac{0.06 \times 2\pi}{60} = 6.28 mm/s$

Magnitude of change in velocity = $|\vec{v_2} - \vec{v_1}|$

$= \sqrt{v_1^2 + v_2^2} = 8.88\ mm/s$ [As $v_1 = v_2 = 6.28 mm/s$]

557 **(a)**

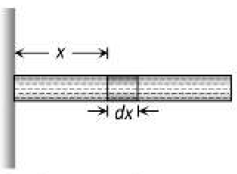
Power, $P = \vec{F}.\vec{v} = (7\hat{i} + 6\hat{k}).(3\hat{j} + 4\hat{k}) = 24$

559 **(a)**

$dM = \left(\frac{M}{L}\right) dx$

Force on 'dM' mass is

$dF = (dM)\omega^2 x$



By integration we can get the force exerted by whole liquid

$\Rightarrow F = \int_0^L \frac{M}{L}\omega^2 x\, dx = \frac{1}{2}M\omega^2 L$

560 **(c)**

Given, $m = 500$ kg,

$v = 36 \text{ kmh}^{-1} = 36 \times \frac{5}{18} = 10\ \text{ ms}^{-1}$ and $r = 50$ m

Centripetal force $F = \frac{mv^2}{r}$

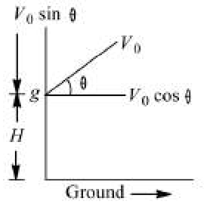
Hence, $F = \frac{500 \times (10)^2}{50} = 1000$ N

561 **(d)**

Vertical force on the roller = weight of roller + component of force in vertical downward direction = $(70 \times 10 + 200 \cos 45°)$N

562 **(c)**

From figure,



$H = (-v_0 \sin \theta)t + \frac{1}{2}gt^2$

$v_x = v_0 \cos \theta$

$v_y^2 = (v_0 \sin \theta)^2 + 2gH$

$v = \sqrt{v_x^2 + v_y^2}$ at ground

$v = \sqrt{v_0^2 + 2gH}$

It means speed is independent of angle of projection

Also, $\frac{1}{2}gt^2 = H + t\, v_0 \sin \theta$

From this, where θ increases, t increases

Hence, (c) is correct

563 **(d)**

$R = \frac{u^2 \sin 2\theta}{g} = \frac{2u_x v_y}{g}$

∴ Range ∝ horizontal initial velocity (u_x)

In path 4 range is maximum so football possess maximum horizontal velocity in the path

564 **(a)**

Normal reaction at the highest point

$R = \frac{nv^2}{r} - mg$

Reaction is inversely proportional to the radius of the curvature of path and radius is minimum for path depicted in (a)

565 **(b)**

To reach the height of suspension, $h = l$

$v = \sqrt{2gh} = \sqrt{2gl}$

566 **(d)**

$\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 7 & 2 & 1 \\ -3 & 1 & 5 \end{vmatrix}$

$= \hat{i}[15-1] + \hat{j}[-3-35] + k[7+9]$

$= 14\hat{i} - 38\hat{j} + 16\hat{k}$

567 **(c)**

$x = \alpha t^3$ and $y = \beta t^3$ [Given]

$v_x = \frac{dx}{dt} = 3\alpha t^2$ and $v_y = \frac{dy}{dt} = 3\beta t^2$

Resultant velocity $= v = \sqrt{v_x^2 + v_y^2} =$

$3t^2\sqrt{\alpha^2 + \beta^2}$

568 **(d)**

$F = mg - \frac{mv^2}{r}$

569 **(a)**

Given, $v = 400 \text{ ms}^{-1}, r = 160 \text{ m}, a = ?$

Centripetal force, $F = \frac{mv^2}{r}$

$ma = \frac{mv^2}{r}$

or $a = \frac{v^2}{r}$

So, $a = \frac{(400)^2}{160} = \frac{16 \times 10^4}{160}$

$= 10^3 \text{ ms}^{-2} = 1 \text{ kms}^{-2}$

570 **(b)**

$F = \frac{mv^2}{r} \Rightarrow F \propto v^2$. If v becomes double then F (tendency to overturn) will become four times

571 **(c)**

$A_x = 50, \theta = 60°$

Then $\tan\theta = A_y/A_x$ or $A_y = A_x \tan\theta$

Or $A_y = 50 \tan 60° = 50 \times \sqrt{3} = 87$ N

572 **(b)**

Here, $T = \frac{2\pi r}{4v} = \frac{\pi r}{2v}$

Change in velocity is going from A to $B = v\sqrt{2}$

Average acceleration $= \frac{v\sqrt{2}}{\pi r/2v} = \frac{2\sqrt{2}v^2}{\pi r}$

573 **(c)**

$H = \frac{u^2 \sin^2\theta}{2g} \Rightarrow \frac{H_1}{H_2} = \frac{\sin^2\theta_1}{\sin^2\theta_2}$

$\frac{\sqrt{3}}{1} = \frac{\sin\theta_1}{\sin\theta_2}$ So, $\frac{\cos\theta_1}{\cos\theta_2} = \frac{1}{\sqrt{3}}$

$\frac{R_1}{R_2} = \frac{(2u)^2 \sin 2\theta_1}{u^2 \sin 2\theta_2} = \frac{4.\sin\theta_1\cos\theta_1}{\sin\theta_2\cos\theta_2} = \frac{4}{1}$

574 **(c)**

For weightlessness state of a body on equator

$mg = mR\omega^2$

or $\omega = \sqrt{\frac{g}{R}} = \sqrt{\frac{10}{6400 \times 100}} = \frac{1}{800} \text{ rads}^{-1}$

575 **(c)**

At the lowest point, $\frac{mv^2}{r} = T_L - mg$ ...(i)

At the highest point, $\frac{mv^2}{r} = T_H + mg$ ...(ii)

As $\frac{T_{max}}{T_{min}} = \frac{T_L}{T_H} = 2$

$\therefore T_L = 2T_H$

From Eqs. (i) and (ii),

$2T_H - mg = T_H + mg$

$T_H = 2mg$

From Eq. (ii), $\frac{mv^2}{r} = 3mg$ or $\frac{v^2}{rg} = 3$

576 **(c)**

$F = mr\omega^2$

$= \frac{2}{125} \times \frac{1.25}{2\pi} \times (100\pi)^2$ $(\because \omega = 2\pi f$

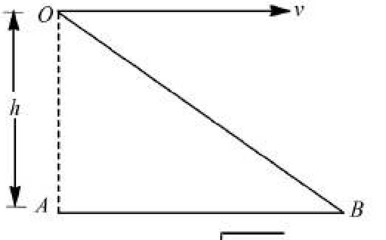
$= 2 \times 50 \times \pi)$

$= 100\pi\text{N} = 314\text{N}$

577 **(b)**

Time taken by the bomb to reach the ground is given by

$h_{OA} = \frac{1}{2} g t_{OB}^2$



we have $t_{OB} = \sqrt{\frac{2h_{OA}}{g}}$

given, $h_{OA} = 80\text{m}$, $g = 10 \text{ ms}^{-2}$

$\therefore \quad t_{OB} = \sqrt{\frac{2 \times 80}{10}} 4\text{s}$

Horizontal velocity of bomb

$v = 150 \text{ ms}^{-1}$

Horizontal distance covered by the bomb

$AB = vt_{OB}$

$= 150 \times 4$

$= 600$ m

Hence, the bomb should be dropped 600 m before the target.

578 **(a)**

$\vec{A} \times \vec{B} = (4\hat{i} + 6\hat{j}) \times (2\hat{i} + 3\hat{j})$

$= 12(\hat{\imath}\times\hat{\jmath}) + 12(\hat{\jmath}\times\hat{\imath}) = 12(\hat{\imath}\times\hat{\jmath}) - 12(\hat{\imath}\times\hat{\jmath})$
$= 0$

Again, $\vec{A}\cdot\vec{B} = (4\hat{\imath}+6\hat{\jmath})\cdot(2\hat{\jmath}+3\hat{\imath}) = 8+18 = 26$

Again, $\frac{|\vec{A}|}{|\vec{B}|} = \frac{\sqrt{16+36}}{\sqrt{4+9}} \neq \frac{1}{2}$

Again , $\vec{B} = \frac{1}{2}\vec{A}$

579 **(c)**

Let $\vec{C}$ be a vector perpendicular to $\vec{A}$ and $\vec{B}$

Then as per question $k\vec{C} = \vec{A}\times\vec{B}$

or $k = \frac{(\vec{A}\times\vec{B})}{\vec{C}}$

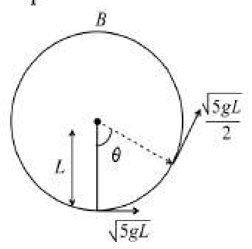
$$= \frac{(2\hat{\imath}+3\hat{\jmath}+6\hat{k})\times(3\hat{\imath}-6\hat{\jmath}+2\hat{k})}{(6\hat{k}+2\hat{\jmath}-3\hat{k})}$$

$$= \frac{(42\hat{\imath}+14\hat{\jmath}-21\hat{k})}{(6\hat{\imath}+2\hat{\jmath}-3\hat{k})} = 7$$

580 **(d)**

$V^2 = U^2 - 2g(L - L\cos\theta)$

$$\frac{5gL}{4} = 5gL - 2gL(1-\cos\theta)$$



$5 = 20 - 8 + 8\cos\theta$

$$\cos\theta = -\frac{7}{8}$$

$$\frac{3\pi}{4} < \theta < \pi$$

581 **(a)**

Here,

$v = \sqrt{(8)^2+(6)^2} = 10$ and $\tan\theta = \frac{6}{8}$

$\therefore$ Hypotenuse, $h = 10\text{m}$

$\therefore \sin\theta = \frac{6}{10}, \cos\theta = \frac{8}{10}$

$$R = \frac{2u^2\sin\theta\cos\theta}{g}$$

$$R = \frac{2\times10\times10\times\frac{6}{10}\times\frac{8}{10}}{10}$$

$$R = \frac{96}{10} = 9.6\text{m}$$

582 **(d)**

At A, $v_A = \sqrt{gl}$

At B, $v_B = \sqrt{5gl}$

and at D, $v_D = \sqrt{3gl}$

Thus, $v_B > v_D > v_A$

Also, $T = 3\,mg(1+\cos\theta)$

So, D, $\theta = 90°$

$\therefore T = 3\,mg(1+\theta) = 3\,mg$

583 **(d)**

$$t = \sqrt{\frac{2\times490}{9.8}} = \sqrt{\frac{2\times49\times100}{98}} = \sqrt{100}\text{ s} = 10\text{ s}$$

584 **(a)**

Here, $v = 900\text{ km h}^{-1}$

$$= \frac{900\times1000}{60\times60}\text{ms}^{-1} = 250\text{ ms}^{-1}$$

Minimum force is at the bottom of the vertical circle

$$F_{max} = \frac{mv^2}{r} + mg = 5\,mg$$

$\therefore v^2 = 4\,gr$

or $r = \frac{v^2}{4g} = \frac{250\times250}{4\times980} = 1594\text{ m}$

585 **(c)**

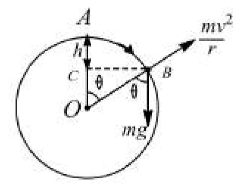
If v velocity acquired at B, then

$v^2 = 2gh$

The particle will leave the sphere at B, when

$$\frac{mv^2}{r} \geq mg\cos\theta$$

$$\frac{2gh}{r} = \frac{g(r-h)}{r},$$



Which gives $h = \frac{r}{3}$

586 **(a)**

$T = m\omega^2 r \Rightarrow 10 = 0.25\times\omega^2\times0.1 \Rightarrow \omega$
$= 20\,rad/s$

587 **(c)**

Time taken to cover horizontal distance D with constant horizontal velocity, $t = D/v_0\cos\theta$.

Taking vertical motion for time t, we have

$$h = v_0\sin\theta\times t - \frac{1}{2}gt^2$$

$$= v_0\sin\theta\times\frac{D}{v_0\cos\theta} - \frac{1}{2}g\left(\frac{D}{v_0\cos\theta}\right)^2$$

$$= D\tan\theta - \frac{1}{2}\frac{gD^2}{v_0^2\cos^2\theta}$$

588 **(a)**

$$(\text{KE})_L - (\text{KE})_H = \frac{1}{2}m(v_L^2 - v_H^2)$$

$$= \frac{1}{2}m(5\,gr - gr) = 2mgr$$

$= 2\times1\times10\times1 = 20\text{ J}$

589 **(d)**

From figure here $\vec{A} = \sqrt{3}\hat{\imath} - \hat{k}$

so $\tan i_1 = \frac{\sqrt{3}}{1} = \sqrt{3} = \tan 60°$

$i_1 = 60°$

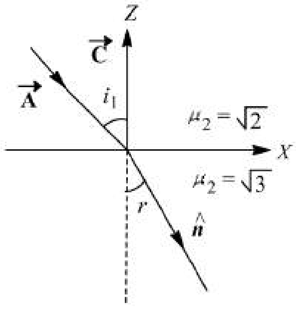
Using snell's law $\mu_1 \sin i_1 = \mu_2 \sin r$

or $\sin r = \frac{\mu_1}{\mu_2} \sin i_1 = \frac{\sqrt{2}}{\sqrt{3}} \sin 60° = \frac{1}{\sqrt{2}} = \sin 45°$

or $r = 45°$

The unit vector in the direction of the refracted ray will be

$\hat{n} = 1 \sin 45° \hat{\imath} - 1 \cos 45° \hat{k} = \frac{1}{\sqrt{2}}(\hat{\imath} - \hat{k})$



590 **(a)**

Resultant $\vec{R} = (\vec{P} + \vec{Q}) + (\vec{P} - \vec{Q}) = 2\vec{P}$. Thus angle between $\vec{R}$ and $\vec{P}$ is 0°.

591 **(a)**

$|\vec{P}| = A + B \Rightarrow |\vec{P}|^2 = (A + B)^2$

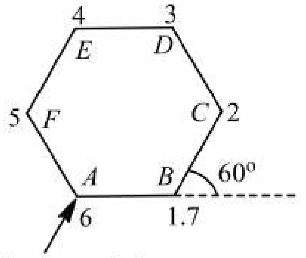
$|\vec{A} + \vec{B}|^2 = (A + B)^2$

or $A^2 + B^2 + 2AB \cos\theta = A^2 + B^2 + 2AB$

or $\cos\theta = 1$ or $\theta = 0°$

592 **(a)**

In 6 turns each of 60°, the cyclist traversed a regular hexagon path having each side 100 m. So, at 7th turn, he will be again at



Starting point

Point B (as shown) which is at distance 100 m from starting point A. Hence, net displacement of cyclist is 100 m.

594 **(c)**

Angular momentum $L = r \times p = r \times m \times v$

$v = \frac{L}{mr}$ ....(i)

Now, as centripetal force, $F_c = \frac{mv^2}{r}$ ....(ii)

Substituting the value of v from Eq. (i) in Eq. (ii), we get

$F_c = \frac{m}{r}\left[\frac{L}{mr}\right]^2 = \frac{L^2}{mr^3}$

595 **(b)**

Angular speed of minute hand,

$\omega_m = \frac{2\pi}{60 \times 60}$ rad s^{-1}

Angular speed of hour hand,

$\omega_h = \frac{2\pi}{12 \times 60 \times 60}$ rad s^{-1}

$\therefore \frac{\omega_m}{\omega_h} = 12$

596 **(b)**

$T = mg + \frac{mv^2}{l} = mg + 2mg = 3mg$

Where $v = \sqrt{2gl}$ from $\frac{1}{2}mv^2 = mgl$

597 **(d)**

A coin files off when centrifugal force just exceeds the force of friction *ie*,

$mr\omega^2 \geq \mu mg$

or $\omega \geq \frac{\sqrt{\mu g}}{r}$

Thus ω does not depend upon mass and will remain the same

598 **(d)**

Maximum tension, $F = mr\omega^2 = mr4\pi^2 v^2$

$= 0.1 \times 2 \times 4 \times \pi^2 \times (200/60)^2 = 87.64$ N

599 **(a)**

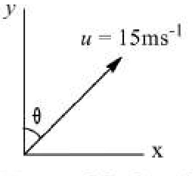
$2\pi r = 34.3 \Rightarrow r = \frac{34.3}{2\pi}$ and $v = \frac{2\pi r}{T} = \frac{2\pi r}{\sqrt{22}}$

Angle of banking $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = 45°$

600 **(c)**

Here $u_y = u \cos\theta = 15 \cos\theta$

$u_x = u \sin\theta = 15 \sin\theta$



Time of flight of the ball is

$T = \frac{2u_y}{g} = \frac{2 \times 15 \cos\theta}{10} = 3\cos\theta$ ...(i)

The boy will catch the ball in time T, displacement of the ball in horizontal direction should also be zero, so

$0 = u_x T - \frac{1}{2} a_x T^2$

or $T = \frac{2u_x}{a_x} = \frac{2(15 \sin\theta)}{3} = 10 \sin\theta$ ...(ii)

From Eqs. (i) and (ii), $3\cos\theta = 10 \sin\theta$

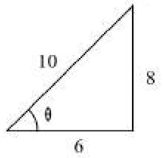
or $\tan\theta = \frac{3}{10} = 0.3$ or $\theta = \tan^{-1}(0.3)$

601 **(b)**

$\vec{\mathbf{v}} = 6\hat{\mathbf{i}} - 8\hat{\mathbf{j}}$

Comparing with

$\vec{\mathbf{v}} = v_x\hat{\mathbf{i}} = v_y = \hat{\mathbf{j}}$, we get



and $u_x = 6\text{ ms}^{-2}$

Also, $u^2 = v_x^2 + v_y^2$

36+64=100

or $v = 10\text{ms}^{-1}$

$\sin\theta = \frac{8}{10}$ and $\cos\theta = \frac{6}{10}$

$$R = \frac{v^2 \sin 2\theta}{g} = \frac{2v^2 \sin\theta\cos\theta}{g}$$

$$R = 2 \times 10 \times 10 \times \frac{8}{10} \times \frac{6}{10} \times \frac{1}{10}\text{m} = 9.6\text{ m}$$

602 **(b)**

For complementary angles range will be equal

603 **(d)**

$$h_{\text{max.}} = \frac{v^2\sin^2\theta}{2g}$$

In the given problem, $h_{\text{max.}}$ is same in both the cases

$\therefore\ v_1^2\sin^2 60° = v_2^2 \sin^2 30°$

or $\frac{v_1}{v_2} = \frac{\sin 30°}{\sin 60°} = \frac{1}{2} \times \frac{2}{\sqrt{3}} = \frac{1}{\sqrt{3}}$

604 **(c)**

Here, $r = 25\text{m}, v = 5\text{ ms}^{-1}, \text{m} = 500\text{ kg}$

$a_t = 1\text{ ms}^{-2}$,

$$a_r = \frac{v^2}{r} = \frac{5 \times 5}{25} = 1\text{ ms}^{-2}$$

$$a_{\text{net}} = \sqrt{a_r^2 + a_t^2} = \sqrt{1^2 + 1^2} = \sqrt{2}\text{ ms}^{-2}$$

$F = ma_{\text{net}} = 500\sqrt{2}\text{ N}$

605 **(d)**

Velocity of the bob at the point A

$v = \sqrt{5gL}$ .....(i)

$\left(\frac{v}{2}\right)^2 = v^2 - 2gh$ .... (ii)

$h = L(1 - \cos\theta)$ ... (iii)

Solving Eqs. (i), (ii)and (iii), we get

$$\cos\theta = -\frac{7}{8}$$

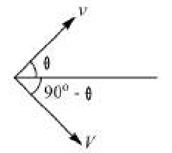
or $\theta = \cos^{-1}\left(-\frac{7}{8}\right) = 151°$

606 **(d)**

Equating horizontal components, we get

$V\cos(90° - \theta) = v\cos\theta$

or $V\sin\theta = v\cos\theta$ or $V = v\cot\theta$



607 **(c)**

Centripetal acceleration$= 4\pi^2n^2r = 4\pi^2 \times (1)^2 \times 0.4 = 1.6\pi^2$

608 **(b)**

Here, $A_1 = A_2 = 1$

and $A_1^2 + A_2^2 + 2A_1A_2\cos\theta = (\sqrt{3})^2 = 3$

or 1+1+2× 1 × 1 ×cosθ = 3 or $\cos\theta = \frac{1}{2}$

Now, $(\vec{A}_1 - \vec{A}_2)\cdot(2\vec{A}_1 + \vec{A}_2)$

$= 2A_1^2 - A_2^2 - A_1A_2\cos\theta$

$$= 2 \times 1^2 - 1^2 - 1 \times 1 \times \frac{1}{2} = \frac{1}{2}$$

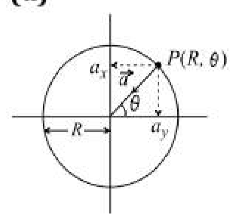
609 **(b)**

At the highest point, velocity along y-axis is zero.

Therefore, change in linear momentum

$= m(u\sin\alpha - 0) = mu\sin\alpha$

610 **(d)**



$$\vec{a} = -\frac{v^2}{R}\cos\theta\hat{\imath} - \frac{v^2}{R}\sin\theta\hat{\jmath}$$

611 **(d)**

$\mathbf{L} = m(\mathbf{r} \times \mathbf{v})$

Direction of $(\mathbf{r} \times \mathbf{v})$, hence the direction of angular momentum remains the same.

612 **(c)**

Velocity at the lowest point

$v = \sqrt{2gl}$

At the lowest point, the tension in the string

$$T = mg + \frac{mv^2}{l}$$

$$= mg + \frac{m}{l}(2gl) = 3\text{ }mg$$

613 **(a)**

$v = \sqrt{\mu rg} = \sqrt{0.4 \times 30 \times 9.8} = 10.84\ m/s$

614 **(a)**

$v_x = 8t - 2$

or $\frac{dx}{dt} = 8t - 2$

or $\int_{14}^{x} dx = \int_2^t (8t - 2)dt$

or $x - 14 = [4t^2 - 2t]_2^t = 4t^2 - 2t - 12$

or $x = 4t^2 - 2t + 2$ ...(i)

Further, $v_y = 2$

or $\frac{dy}{dt} = 2$

$\therefore \int_4^y dy = \int_2^t 2dt$

or $y - 4 = [2t]_2^t = 2t - 4$

or $y = 2t$

or $t = \frac{y}{2}$ ...(ii)

Substituting value of t from Eq. (ii) in Eq. (i), we have

$x = y^2 - y + 2$

615 **(a)**

Here, centripetal force,

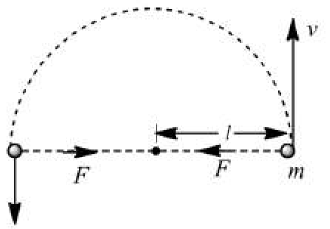
$F = \frac{mv^2}{l}$

But the angle between force and displacement is 90° because the direction of centripetal force is always towards the center and direction of displacement is always tangential.

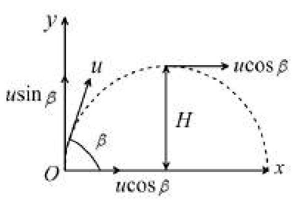
Then work done

$W = \mathbf{F} \cdot \mathbf{s} = Fs\cos 90°$

$\Rightarrow \quad W = 0$



616 **(a)**



Initial kinetic energy at the point of projection O is

$K = \frac{1}{2}mu^2$

Where, m = mass of the body

u = initial velocity of the projection

At the highest point (i.e. at maximum height H)

Velocity is $v = u\cos\beta$,

Where β is the angle of projection

$\therefore$ Kinetic energy at the highest point is

$K'' = \frac{1}{2}mv^2 \Rightarrow K'' = \frac{1}{2}m(u\cos\beta)^2$

$= \frac{1}{2}mu^2\cos^2\beta$

According to given problem, $K'' = \frac{3}{4}K$

$\frac{1}{2}mu^2\cos^2\beta = \frac{3}{4}\left(\frac{1}{2}mu^2\right) \Rightarrow \cos^2\beta = \frac{3}{4}$

$\cos\beta = \frac{\sqrt{3}}{2}$ or $\beta = \cos^{-1}\left(\frac{\sqrt{3}}{2}\right) = 30°$

617 **(c)**

$F = \frac{mv^2}{r}$. When v is doubled, F becomes 4 times

$\therefore$ Tendency to overturn is quadrupted

618 **(c)**

For angle $(45° - \theta)$, $R = \frac{u^2\sin(90°-2\theta)}{g} = \frac{u^2\cos 2\theta}{g}$

For angle $(45° + \theta)$, $R = \frac{u^2\sin(90°+2\theta)}{g} = \frac{u^2\cos 2\theta}{g}$

620 **(b)**

Increment in angular velocity $\omega = 2\pi(n_2 - n_1)$

$\omega = 2\pi(1200 - 600)\frac{rad}{min} = \frac{2\pi \times 600}{60}\frac{rad}{s}$

$= 20\pi\frac{rad}{s}$

621 **(d)**

Maximum tension $= \frac{mv^2}{r} = 16N$

$\Rightarrow \frac{16 \times v^2}{144} = 16 \Rightarrow v = 12\ m/s$

622 **(a)**

Distance covered in n revoulation=n$2\pi r = n\pi D$

$\Longrightarrow 2000\pi D = 9500$

$\Longrightarrow D = \frac{9500}{2000 \times \pi} = 1.5$m

623 **(b)**

$h = 145 - 22.5 = 122.5$ m

Now, $40 = v\sqrt{\frac{2\times122.5}{9.8}}$

or $40 = v \times 5$ or $v = 8\ ms^{-1}$

624 **(a)**

Range of projectile,

$R = \frac{2u^2\sin^2\theta}{g}$ ...(i)

Height, $H = \frac{u^2\sin^2\theta}{2g}$ ...(ii)

$H_1 = \frac{u^2\sin^2(90°-\theta)}{2g} = \frac{u^2\cos^2\theta}{g}$ ...(iii)

Then $HH_1 = \frac{u^2\sin^2\theta \times u^2\cos^2\theta}{2g\times2g}$ ...(iv)

From Eq. (i) we get,

$R^2 = \frac{4u^2\sin^2\theta \times u^2\cos^2\theta \times 4}{2g \times 2g}$

$R = \sqrt{16HH_1}$ [from Eq. (iv)]

$\therefore R = 4\sqrt{HH_1}$

625 **(d)**

$120\ rev/\text{min} = 120 \times \frac{2\pi}{60}\ rad/sec = 4\pi\ rad/sec$

626 **(c)**

$R = 4H\cot\theta$, if $R = 4H$ then $\cot\theta = 1 \Rightarrow \theta = 45°$

627 **(a)**

$\overrightarrow{F_1} = F_1\hat{\imath}$; $\overrightarrow{F_1} \times \overrightarrow{F_2}$ is equal to zero only I angle between $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$ is either 0° or 180°. So $\overrightarrow{F_2}$ will be $4\hat{\jmath}$.

628 **(c)**

Maximum height, $H = \frac{u^2\sin^2\theta}{2g}$

Time of flight, $T = \frac{2u\sin\theta}{g}$

$\therefore \frac{H}{T^2} = \frac{u^2\sin^2\theta/2g}{4u^2\sin^2\theta/g^2} = \frac{g}{8} = \frac{10}{8} = \frac{5}{4}$

629 **(c)**

$x + y = 16$, Also $y^2 = 8^2 + x^2$

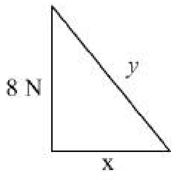
or $y^2 = 64 + (16 - y)^2$

$[\because x = 16 - y]$

or $y^2 = 64 + 256 + y^2 - 32y$

or $32y = 320$ or $y = 10N$

$\therefore x + 10 = 16$ or $x = 6N$



630 **(c)**

For $\theta = 45°$

$H_{max} = \frac{u^2\sin^2 45°}{2g} = \frac{u^2}{4g}$ $\left[\because \sin 45° = \frac{1}{\sqrt{2}}\right]$

$R = \frac{u^2\sin 90°}{g} = \frac{u^2}{g}$; $\therefore \frac{R}{H} = \frac{u^2}{g} \times \frac{4g}{u^2} = 4 \Rightarrow R = 4H$

631 **(d)**

Here, $n = 2$ rps, $r = 5$ cm $= 0.05$ m, $\mu = ?$

As $\frac{mv^2}{r} = F = \mu R = \mu mg$

$\mu = \frac{v^2}{rg} = \frac{(r2\pi n)^2}{rg} = \frac{4\pi^2n^2r}{g}$

$= 4 \times \frac{22}{7} \times \frac{22}{7} \times \frac{2^2 \times 0.05}{9.8} = 0.8$

632 **(a)**

$v_{min} = \sqrt{5\,gr} = 17.7\ m/sec$

633 **(c)**

$\cos\theta = \vec{A} \cdot \vec{B}/AB$

634 **(a)**

$\tan\theta = \frac{v^2}{rg} = \frac{30\times30}{900\times9.8} = 0.102$

$\therefore \theta = 6°$

635 **(d)**

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times396.9}{9.8}} \simeq 9$ sec and $u = 720km/hr = 200\ m/s$

$\therefore R = u \times t = 200 \times 9 = 1800\ m$

636 **(c)**

Suppose t_0 be the time to reach maximum height in the absence of air resistance, then from the relation

$t_0 = \frac{u\sin\alpha}{g}$ ...(i)

When a is retardation caused by air resistance, then total retardation will be $g + a$

$t_1 = \frac{u\sin\alpha}{g+a} = \frac{u\sin\alpha}{g+\left(\frac{1}{10}\right)g} = \frac{10u\sin\alpha}{11g}$ ...(ii)

Now from equations (i) and (ii), we have

$\therefore t_1 = \frac{10}{11}t_0 \Rightarrow t_0 - t_1 = t_0 - \frac{10}{11}t_0 = \frac{1}{11}t_0$

$= 0.09\,t_0$

$\therefore$ Time will decrease by 9%

637 **(b)**

$v = \sqrt{3gr}$ and $a = \frac{v^2}{r} = \frac{3gr}{r} = 3g$

638 **(a)**

Time of flight, $T = \frac{2u\sin\theta}{g}$

$\therefore dT = \frac{2du\sin\theta}{g}$

Now, $\therefore \frac{dT}{T} = \frac{du}{u} = \frac{1}{20}$

$\therefore$ % increase in $T = \frac{dT}{T} \times 100$

$= \frac{1}{20} \times 100 = 5\%$

639 **(c)**

$t = \sqrt{\frac{2 \times 8 \times 10^3}{10}} = 40$ s

$x = vt = 200 \times 40 = 8000$m

640 **(d)**

Maximum height and time of flight depend on the vertical component of initial velocity

$H_1 = H_2 \Rightarrow u_{y_1} = u_{y_2}$

Here $T_1 = T_2$

Range $R = \frac{u^2\sin 2\theta}{g} = \frac{2(u\sin\theta)(u\cos\theta)}{g}$

$= \frac{2u_xu_y}{g}$

$R_2 > R_1 \therefore u_{x_2} > u_{x_1}$ or $u_2 > u_1$

641 **(d)**

Centripetal force, $F = \frac{mv^2}{r}$

$v = \sqrt{\left(\frac{rF}{m}\right)} = \sqrt{\frac{0.5 \times 10 \times 1000}{100}}$

$= \sqrt{50}\text{ms}^{-1} = 7.07\text{ms}^{-1}$

642 **(d)**

The maximum speed without skidding is

$v = \sqrt{\mu rg}$

$\therefore \frac{v_2}{v_1} = \sqrt{\frac{\mu_2}{\mu_1}} = \sqrt{\frac{\mu/2}{\mu}} = \frac{1}{\sqrt{2}}$

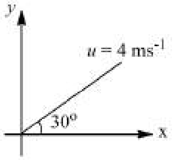
$v_2 = \frac{v_1}{\sqrt{2}} = 5\sqrt{2}\ \text{ms}^{-1}$

643 **(c)**

Apply right handed screw rule for the direction of $(\vec{A} \times \vec{B})$

644 **(b)**

Components of velocity of ball relative to lift are



$u_x = 4\cos 30° = 2\sqrt{3}\text{ms}^{-1}$

and $u_y = 4\sin 30° = 2\text{ms}^{-1}$

and acceleration of ball relative to lift is 12 ms^{-2} in negative y-direction or vertically downwards.

Hence, time of flight

$T = \frac{2u_y}{12} = \frac{u_y}{6} = \frac{2}{6} = \frac{1}{3}\text{s}$

645 **(c)**

Horizontal displacement of the bomb

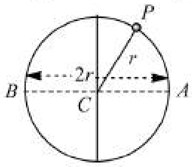
AB =Horizontal velocity × time available

$$\text{AB} = u \times \sqrt{\frac{2h}{g}} = 600 \times \frac{5}{18} \times \sqrt{\frac{2 \times 1960}{9.8}}$$

$$= 3.33\ km$$

646 **(b)**

Angular velocity about $A, \omega_1 = v/2r$



Angular velocity about, $\omega_1 = v/2r$

$\therefore \omega_1/\omega_2 = (v/2r)/(v/r) = 1/2$

647 **(b)**

$v = \sqrt{gr} = \sqrt{10 \times 40} = 20ms^{-1}$

648 **(d)**

Electrostatic force provides necessary centripetal force for circular motion of electron.

649 **(a)**

Kinetic energy

$E = \frac{1}{2}mv^2$

or $\frac{1}{2}mr\frac{v^2}{r} = E$

or $\frac{1}{2}mra = E$

or $a = \frac{2E}{mr}$

650 **(a)**

Acceleration $= \omega^2 r = \frac{v^2}{r} = \omega v = \frac{2\pi}{T}v$

651 **(b)**

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 490}{9.8}} = \sqrt{100} = 10\text{ s}$$

$$x = vt = \left(60 \times \frac{5}{18}\right)\text{ms}^{-1} \times 10\text{ s} = \frac{500}{3}\text{m}$$

652 **(b)**

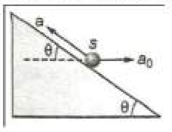
Change in momentum is the product of force and time

$$\Delta p = mg \times \frac{2\sin\theta}{g}$$

$$= 2mv\sin\theta = 2mv\sin 45° = \frac{2mv}{\sqrt{2}} = \sqrt{2}\,mv$$

653 **(c)**

Acceleration of insect with respect to car $\vec{\mathbf{a}}_{sc}$ is a in the direction shown in figure. Absolute acceleration of insect is



$\vec{\mathbf{a}}_s = \vec{\mathbf{a}}_{sc} + \vec{\mathbf{a}}_c$

Component of $\vec{\mathbf{a}}_s$ along horizontal is $a_0 - a\cos\theta$ and perpendicular to screen is $a_0 \sin\theta$

654 **(c)**

We know that range of projectile is same for complementary angles *ie*, for θ and (90° − θ).

$$\therefore T_1 = \frac{2u\sin\theta}{g}$$

$$T_2 = \frac{2u\sin(90° - \theta)}{g} = \frac{2u\cos\theta}{g}$$

and $R = \frac{u^2\sin\theta}{g}$

Therefore, $T_1 T_2 = \frac{2u\sin\theta}{g} \times \frac{2u\cos\theta}{g}$

$$= \frac{2u^2(2\sin\theta\cos\theta)}{g^2}$$

$$= \frac{2u^2(2\sin\theta)}{g^2} = \frac{2R}{g}$$

$\therefore T_1 T_2 \propto R$

655 **(b)**

When a body is projected at an angle θ with the horizontal with initial velocity u, then the horizontal range R of projectile is

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

Clearly, for maximum horizontal range $\sin 2\theta = 1$ or $2\theta = 90°$ or $\theta = 45°$. Hence, in order to achieve maximum range, the body should be projected at 45°.

In this case

$R_{max} = \frac{u^2}{g}$

Hence, range of A and C are less than that of B.

656 **(d)**

During time of flight vertical displacement becomes zero

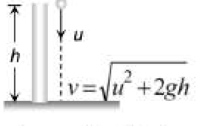
i.e., $y = 0$

$KT(1 - \alpha T) = 0 \Rightarrow T = \frac{1}{\alpha}$

$\therefore$ Time taken by particle to attain max, height $t = T/2 = \frac{1}{2\alpha}$; $\therefore Y_{max} = K.\frac{1}{2\alpha}\left(1 - \alpha.\frac{1}{2\alpha}\right) \Rightarrow = \frac{K}{4\alpha}$

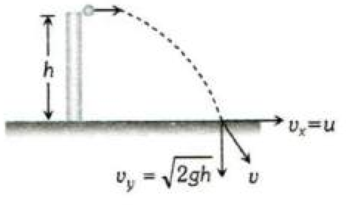
657 **(c)**

When a particle is thrown in vertical downward direction with velocity u then final velocity at the ground level



$v^2 = u^2 + 2gh \;\therefore v = \sqrt{u^2 + 2gh}$

Another particle is thrown horizontally with same vertically then at the surface of earth



Horizontal component of velocity $v_x = u$

$\therefore$ Resultant velocity, $v = \sqrt{u^2 + 2gh}$

For both the particle final velocities when they reach the earth's surface are equal

659 **(a)**

We know that the range of projectile projected with velocity u, making an angle θ with the horizontal direction up the inclined plane, whose inclination with the horizontal direction is θ_0, is

$R = \frac{u^2}{g\cos^2\theta_0}[\sin(2\theta - \theta_0) - \sin\theta_0]$

Here, $u = v, \theta = (90° + \theta), \theta_0 = \theta$

$\therefore R = \frac{v^2}{g\cos^2\theta_0}\{\sin[2(90° + \theta)] - \theta\} - \sin\theta\}$

$= \frac{v^2}{g\cos^2\theta_0}[\sin(180° + \theta) - \sin\theta]$

$= -\frac{v^2}{g\cos^2\theta_0} 2\sin\theta = -\frac{2u^2}{g}\tan\theta\sec\theta$

$= \frac{2v^2}{g}\tan\theta$ (in magnitude)

660 **(b)**

$60^2 = 30^2 + v^2$ or $v^2 = 90 \times 30$

or $v = 30\sqrt{3}$ km h^{-1}.

661 **(b)**

$T = mg + \frac{mv^2}{l} = mg + \frac{m}{l}[2gl(1 - \cos\theta)]$

$= mg + 2mg(1 - \cos 60°) = 2mg = 2 \times 0.1 \times 9.8$

$= 1.96N$

662 **(d)**

If the three vectors are coplanar then their scalar triple product is zero. So $(\vec{A} \times \vec{C}).\vec{B} = 0$

or $\left[(2\hat{\imath} + 3\hat{\jmath} - 2\hat{k}) \times (-\hat{\imath} + 2\hat{\jmath} + 3\hat{k})\right].\left[5\hat{\imath} + a\hat{\jmath} + \hat{k}\right] = 0$

or $\left[13\hat{\imath} - 4\hat{\jmath} + 7\hat{k}\right].\left[5\hat{\imath} + a\hat{\jmath} + 5\hat{k}\right] = 0$

or $65 - 4a + 7 = 0$ or $a = 18$

663 **(d)**

Centripetal acceleration, $a = \omega^2 r$

$= 4\pi^2 n^2 r = 4\pi^2\left(\frac{1}{2}\right)^2 \times 100$

$\pi^2 \times 100\text{ms}^{-2} = 985.9\text{ms}^{-2}$

664 **(b)**

Centripetal acceleration $= r4\pi^2 v^2$

665 **(c)**

Minimum angular velocity $\omega_{min} = \sqrt{g/R}$

$\therefore T_{max} = \frac{2\pi}{\omega_{min}} = 2\pi\sqrt{\frac{R}{g}} = 2\pi\sqrt{\frac{2}{10}} \cong 3s$

666 **(d)**

Given, $s = t^3 + 5$

Speed, $v = \frac{ds}{dt} = 3t^2$

and rate of change of speed, $a_t = \frac{dv}{dt} = 6t$

$\therefore$ Tangential acceleration at $t = 2$ s,

$a_t = 6 \times 2 = 12$ ms^{-2}

and at $t = 2s, v = 3(2)^2 = 12\text{ms}^{-1}$

$\therefore$ Centripetal acceleration, $a_c = \frac{v^2}{R} = \frac{144}{20}\text{ms}^{-2}$

$\therefore$ Net acceleration $= a_t^2 + a_t^2 \approx 14\text{ms}^{-2}$

667 **(d)**

As maximum value of $T = mg$ from $2T\cos\theta = mg$.

$2\cos\theta = 1, \cos\theta = \frac{1}{2}, \theta = 60°$

Angle between two arms $= 2\theta = 120°$

668 **(c)**

The pilot will see the ball falling in straight line because the reference frame is moving with the same horizontal velocity but the observer at rest will see the ball falling in parabolic path

669 **(d)**

In the given condition friction provides the required centripetal force and that is constant.

$i.e.\ m\omega^2 r = \text{constant}$

$\Rightarrow r \propto \frac{1}{\omega^2} \therefore r_2 = r_1\left(\frac{\omega_1}{\omega_2}\right)^2 = 9\left(\frac{1}{3}\right)^2 = 1\ cm$

670 **(b)**

New kinetic energy $E' = E = \cos^2\theta$

$= E\cos^2(45°)$

$\frac{E}{2}$

671 **(b)**

$\tan\theta = \frac{v^2}{rg} = \frac{400}{20 \times 9.8} \Rightarrow \theta = 63.9°$

672 **(d)**

Since the maximum tension T_B in the string moving in the vertical circle is at the bottom and minimum tension T_T is at the top

$\therefore T_B = \frac{mv_B^2}{L} + mg$ and $T_T = \frac{mv_T^2}{L} - mg$

$\therefore \frac{T_B}{T_T} = \frac{\frac{mv_B^2}{L} + mg}{\frac{mv_T^2}{L} - mg} = \frac{4}{1}$ or $\frac{v_B^2 + gL}{v_T^2 - gL} = \frac{4}{1}$

Or $v_B^2 + gL = 4v_T^2 - 4gL$ but $v_B^2 = v_T^2 + 4gL$

$\therefore v_T^2 + 4gL + gL = 4v_T^2 - 4gL \Rightarrow 3v_T^2 = 9gL$

$\therefore v_T^2 = 3 \times g \times L = 3 \times 10 \times \frac{10}{3}$ or v_T

$= 10\ m/\text{sec}$

673 **(b)**

$v = \sqrt{gr} = \sqrt{9.8 \times 5} = 7\ \text{ms}^{-1}$

674 **(c)**

$\vec{P} + \vec{Q} = 5\hat{i} - 4\hat{j} + 3\hat{k}$

$\cos\ \alpha = \frac{5}{\sqrt{5^2+4^2+3^2}} = \frac{5}{\sqrt{50}}$

or $\alpha = \cos^{-1}\left(\frac{5}{\sqrt{50}}\right)$

675 **(b)**

Centripetal force is given by

$F = \frac{mv^2}{R}$

$\Longrightarrow F \propto \frac{1}{R}$

or $\frac{F_2}{F_1} = \frac{R_1}{R_2}$

Given, $r_2 = 2r_1$

$\therefore \frac{F_2}{F_1} = \frac{R_1}{2R_1} = \frac{1}{2}$

or $F_2 = \frac{F_1}{2}$

therefore, centripetal force will become half.

676 **(b)**

Maximum height, $H = \frac{u^2\sin^2\theta}{2g}$

$\frac{dH}{du} = \frac{2u^2\sin^2\theta}{2g}$ or $dH = \frac{u\sin^2\theta}{g}du$

$\therefore \frac{dH}{H} = \frac{2du}{u}$

Since H is increased by 10%

So, $\frac{dH}{H} = \frac{10}{100} = \frac{1}{10} = \frac{2du}{u}$

Now horizontal range, $dR = \frac{2u}{g}\sin 2\theta\, du$

or $\frac{dR}{R} = \frac{2du}{u} = \frac{1}{10}$

$\therefore$ % increase in $R = \frac{dR}{R} \times 100$

$= \frac{1}{10} \times 100 = 10\ \%$

677 **(a)**

$m4\pi^2 n^2 r = 4 \times 10^{-13} \Rightarrow n$

$= 0.08 \times 10^8\ cycles/sec.$

678 **(c)**

$H_{\max} = \frac{u^2\sin^2\theta}{2g}$

According to problem $\frac{u_1^2\sin^2 45°}{2g} = \frac{u_2^2\sin^2 60°}{2g}$

$\Rightarrow \frac{u_1^2}{u_2^2} = \frac{\sin^2 60°}{\sin^2 30°} \Rightarrow \frac{u_1}{u_2} = \frac{\sqrt{3}/2}{1/\sqrt{2}} = \sqrt{\frac{3}{2}}$

679 **(d)**

Acceleration $a = \alpha x^2 \Rightarrow \frac{dV}{dt} = \alpha x^2$

$\Rightarrow dV = \alpha x^2 dt \Rightarrow dV = \alpha x^2 dx\frac{dt}{dx}$

$\Rightarrow \int_0^{v_0} V dV = \int_0^x \alpha x^2 dx \Rightarrow \frac{V_0^2}{2} = \frac{\alpha.x^3}{3}$

$\Rightarrow x = \left[\frac{3V_0^2}{2\alpha}\right]^{-1/3}$

680 **(c)**

$q(\vec{v} \times \vec{B}) = \frac{mv^2}{r}$

or acceleration $= \frac{v^2}{r} = \frac{q}{m}(\vec{v} \times \vec{B})$

$= 9.6 \times 10^7 \times [(3\hat{i} + 2\hat{j})10^5 \times (2\hat{i} + 3\hat{k})]$

$= 9.6 \times 10^{12} \times [6\hat{i} - 9\hat{j} - 4\hat{k}]\text{ms}^{-2}$

681 **(d)**

Standard equation of projectile motion

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

Comparing with given equation

$A = \tan\theta$ and $B = \frac{g}{2u^2\cos^2\theta}$

So $\frac{A}{B} = \frac{\tan\theta \times 2u^2\cos^2\theta}{g} = 40$

[As $\theta = 45°, u = 20\, m/s, g = 10 m/s^2$]

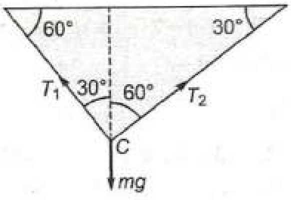
682 **(c)**

From figure in equilibrium position

$T_1 \sin 30° = T_2 \sin 60°$

or $T_1 \times \frac{1}{2} = T_2 \times \frac{\sqrt{3}}{2}$

or $\frac{T_1}{T_2} = \sqrt{3}$



683 **(b)**

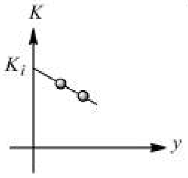
From conservation of mechanical energy

$K = K_i - mgy$ ....(i)

(Here K_i= initial kinetic energy = constant)

ie, $K - y$ graph is straight line. It first decreases linearly becomes minimum at highest point and then becomes equal to K_i in the similar manner.

Therefore, $K - y$ graph should be as shown below



Eq. (i) we can written as

$$K = K_i - mg\left(u_y t - \frac{1}{2}gt^2\right)$$

ie, $K - y$ graph is a parabola. Kinetic energy first decreases and then increases.

Eq. (i) can also written as

$$K = K_i - mg\left(x\tan\theta - \frac{gx^2}{2u_x^2}\right)$$

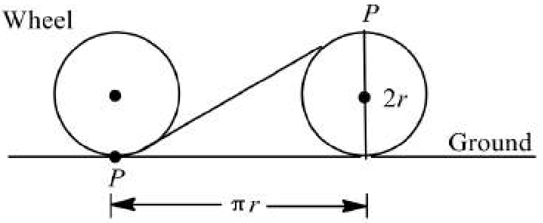
Again $K - x$ graph is a parabola

Further, $p^2 = 2Km$ *ie*, $p^2 = 2Km$ *ie*, $p^2 = K$ or K *versus* p^2

Graph is a straight line passing through origin

684 **(c)**

When wheel rolls half a revolution, the point (P) of the wheel which is in contact with the ground initially, moves at the top of the wheel as shown.



Horizontal displacement of point P,

$y = 2r$

Net displacement $= \sqrt{x^2 + y^2}$

$= \sqrt{(\pi r)^2 + (2r)^2}$

$= r\sqrt{\pi^2 + 4}$

$= \sqrt{\pi^2 + 4}$

685 **(a)**

Max. tension that string can bear = 3.7 $kgwt$ = 37 N

Tension at lowest point of vertical loop $= mg + m\omega^2 r$

$= 0.5 \times 10 + 0.5 \times \omega^2 \times 4 = 5 + 2\omega^2$

$\therefore 37 = 5 + 2\omega^2 \Rightarrow \omega = 4$ rad/s

686 **(c)**

$$F = \sqrt{\left(\frac{P}{2}\right)^2 + \left(\frac{P}{2}\right)^2} = \sqrt{2}\,\frac{P}{2} = \frac{P}{\sqrt{2}}$$

687 **(a)**

Balancing the force, we get

$$Mg - N = M\frac{v^2}{R}$$

For weightlessness, $N = 0$

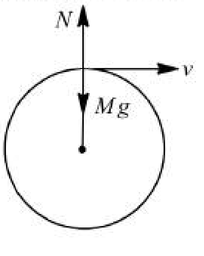
$$\therefore \frac{Mv^2}{R} = Mg$$

or $v = \sqrt{Rg}$

Putting the values, $R = 20$ m, $g = 10.0$ ms^{-2}

So, $v = \sqrt{20 \times 10.0} = 14.14$ ms^{-1}

Thus, the speed of the car at the top of the hill is between 14 ms^{-1} and 10 ms^{-1}



688 **(b)**

Required numerical value is

$\sqrt{3^2 + 4^2 + 5^2}$, *ie*, $\sqrt{50}$ or $5\sqrt{2}$

689 **(c)**

Tension in the string

$T = mv^2/r = (r\omega)^2 = mr\omega^2$

If $r_1 = r/2$ and $\omega_1 = 2\omega$, then
$T_1 = m(r/2)(2\omega)^2 = 2mr\omega^2 = 2T$

690 **(a)**

The centre of gravity of other tube will be at length $L/2$

So radius $r = L/2$

Centripetal force, $= M\, r\, \omega^2 = M(L/2)\omega^2 = ML\omega^2/2$

691 **(a)**

Motion is along the time ; $Y = X + 4$;

Differentiating it wrt time, we have

$\frac{dY}{dt} = \frac{dX}{dt}$ ie, $v_Y = v_X$

As, $v = (v_X^2 + v_Y^2)^{1/2} = 3\sqrt{2}$ and $v_X = v_Y$, therefore,

$(v_X^2 + v_X^2)^{1/2} = 3\sqrt{2}$ or $v_X = 3 = v_Y$

When $X = 0$, from the given equation,

$Y = 0 + 4 = 4$

Magnitude o angular momentum of particle

$= m\, v\, r = m\, v\, y \quad (\because y = r)$

$= 5 \times 3 \times 4 = 60$ units

692 **(b)**

$y = bx^2$

Differentiating w.r.t. t, on both sides, we get

$\frac{dy}{dt} = b2x\frac{dx}{dt} \Rightarrow v_y = 2bxv_x$

Again, differentiating w.r.t. t, on both sides, we get

$\frac{dv_y}{dt} = 2bv_x\frac{dx}{dt} + 2bx\frac{dv_x}{dt} = 2bv_x^2 + 0$

$\left[\frac{dv_x}{dt} = 0\right.$, because the particle has constant acceleration along y-direction]

As per question

$\frac{dv_y}{dt} = a = 2bv_x^2;\ v_x^2 = \frac{a}{2b} \Rightarrow v_x = \sqrt{\frac{a}{2b}}$

693 **(c)**

Area $= |\vec{A}| \times |\vec{B}| = |(4\hat{i} + 3\hat{j}) \times (2\hat{i} + 4\hat{j})| = |10\hat{k}| = 10$units

694 **(b)**

As $H = \frac{u^2 \sin^2\theta}{2g}$ $\therefore \frac{H_1}{H_2} = \frac{\sin^2\theta_1}{\sin\theta_2} = \frac{\sin^2 30°}{\sin^2 60} = \frac{1/4}{3/4} = \frac{1}{3}$

696 **(c)**

The vertical component of velocity of the balls will be same if they stay in air for the same period of time. Hence vertical height attained will be same

697 **(a)**

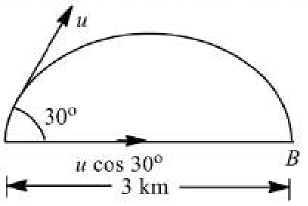
Given, $5 = \frac{2u\sin\theta}{2g}$ or $\frac{u\sin\theta}{g} = \frac{5}{2}$

Maximum height $= \frac{u^2\sin\theta}{2g} = \frac{g}{2}\left(\frac{u^2\sin^2\theta}{g^2}\right)$

$= \frac{g}{2} \times \left(\frac{5}{2}\right)^2 = \frac{10}{2} \times \frac{25}{4} = 31.25$ m

698 **(b)**

The body covers a horizontal distance AB during its flight. This horizontal range is given by



$R = \frac{u^2 \sin 2\theta}{g}$ .... (i)

For maximum horizontal range, $\sin 2\theta = 1$

$\therefore R_{\max} = \frac{u^2}{g}$ ... (ii)

Given, $R = 3$km, $\theta = 30°$

$\therefore$ From Eq. (i)

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

$\frac{u^2}{g} = 3.464$m or $R_{\max} = 3.46$cm

Hence, maximum range with velocity of projection u cannot be more than 3.464 m, Hence, it is not possible to hit a target 5 km away.

699 **(a)**

$\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = \frac{\pi}{30}\ rad/s$

700 **(c)**

As time periods are equal therefore ration of angular speeds will be one. $\omega = \frac{2\pi}{T}$

701 **(a)**

$x = 36t \ \therefore v_x = \frac{dx}{dt} = 36\ m/s$

$y = 48t - 4.9t^2 \ \therefore v_y = 48 - 9.8t$

at $t = 0$ $v_x = 36$ and $v_y = 48\ m/s$

So, angle of projection $\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{4}{3}\right)$

Or $\theta = \sin^{-1}(4/5)$

702 **(d)**

$u = -50\cos 60°\ \text{ms}^{-1} = -25\text{ms}^{-1}$

$a = 10\ \text{ms}^{-2}, t = ?, s = 70$ m

Using $s = ut + \frac{1}{2}at^2$, we get

$70 = -25 + 5t^2$ or $5t^2 - 25t - 70 = 0$

or $t^2 - 5t - 14 = 0$ or $t^2 - 7t + 2t - 14 = 0$

or $t(t-7) + 2(t-7) = 0$ or $(t-7)(t+2) = 0$

or $t = 7$s [Rejecting –ve value of t]

703 **(b)**

Both the particles will meet at C, if their time of flight is the same. The time of flight of A is

$$T = \frac{2u\sin\theta}{g} = \frac{2\times 10\times \sin 60^\circ}{10} = \sqrt{3}\text{s}$$

For vertical downward motion of particle B from B to C

We have

$$h = \frac{1}{2}gT^2 = \frac{1}{2}\times 10\times(\sqrt{3})^2 = 15\text{ m}$$

704 **(d)**

Here, $h = 1$ m, $r = 100$ m, $2x = 1.5$ m

For no skidding

$$\frac{mv^2}{r}\times h = mg\,x$$

$$v = \sqrt{\frac{g\,r\,x}{h}} = \sqrt{\frac{9.8\times 100\times 0.75}{1}}$$

$v = 27.1\text{ ms}^{-1}$

705 **(a)**

$R_{\max} = \frac{u^2}{g} = 4\,H$ [For $\theta = 45°$]

$4H = 400 \Rightarrow H = 100\,m$

706 **(c)**

Centripetal acceleration, $a_c = w^2R$

$$= \frac{(2\pi)^2\times 1.5\times 10^{11}}{(365\times 86400)^2} = 6\times 10^{-3}ms^{-2}$$

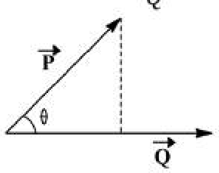
707 **(c)**

K. E. $= \frac{1}{2}mv^2$. Which is scalar, so it remains constant

708 **(b)**

Projection of $\vec{P}$ on $\vec{Q}$ is $P\cos\theta$

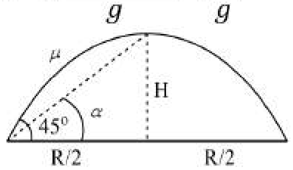
$$P\cos\theta = \frac{PQ\cos\theta}{Q} = \frac{\vec{P}\cdot\vec{Q}}{Q} = \vec{P}\cdot\vec{Q}$$



709 **(d)**

$H = \frac{u^2\sin^2 45°}{2g} = \frac{u^2}{4g}$ ...(i)

$$R = \frac{u^2\sin 90°}{g} = \frac{u^2}{g}$$



$\therefore \frac{R}{2} = \frac{u^2}{2g}$ ...(ii)

$$\therefore \tan\alpha = \frac{H}{R/2}$$

$$= \frac{\frac{u^2}{4g}}{\frac{u^2}{2g}} = \frac{1}{2}\ \therefore\ \alpha = \tan^{-1}\left(\frac{1}{2}\right)$$

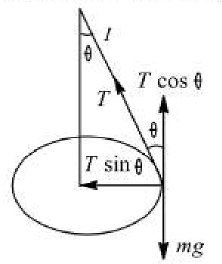
710 **(c)**

$R = \frac{u^2\sin 2\theta}{g} = R \propto u^2$. So if the speed of projection doubled, the range will becomes four times,

i.e., $4\times 50 = 200\,m$

711 **(d)**

As is clear from figure



$$T\sin\theta = \frac{mv^2}{r}, T\cos\theta = mg$$

Dividing, we get

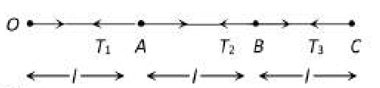
$$\tan\theta = \frac{v^2}{rg} = \frac{r}{g}\left(\frac{2\pi}{T}\right)^2$$

$$\frac{2\pi}{T} = \sqrt{\frac{g\tan\theta}{r}} = \sqrt{\frac{g\tan\theta}{l\sin\theta}} = \sqrt{\frac{g}{l\cos\theta}}$$

or $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$

712 **(d)**

Let ω is the angular speed of revolution



$T_3 = m\omega^2 3l$

$T_2 - T_3 = m\omega^2 2l \Rightarrow T_2 = m\omega^2 5l$

$T_1 - T_2 = m\omega^2 l \Rightarrow T_1 = m\omega^2 6l$

$T_3 : T_2 : T_1 = 3 : 5 : 6$

713 **(b)**

$\hat{A}\cdot\hat{B} = (1)(1)\cos 0° = 1 \neq AB.$

714 **(c)**

$$S = u\times\sqrt{\frac{2h}{g}} \Rightarrow 10 = u\sqrt{2\times\frac{5}{10}} \Rightarrow u = 10\,m/s$$

715 **(d)**

Angular momentum of the projectile

$L = mv_h r_\perp$

$= m(v\cos\theta)h$

(where h is the maximum height)

$$\Rightarrow = m(v\cos\theta)\left(\frac{v^2\sin^2\theta}{2g}\right)$$

$$L = \frac{mv^3 \sin^2\theta \cos\theta}{2g} = \frac{\sqrt{3}mv^3}{16g}$$

716 **(b)**

$$\frac{v^2 \sin 2\theta}{g} = \frac{\sqrt{3}v^2}{2g}$$

or $\sin 2\theta = \frac{\sqrt{3}}{2}$ or $2\theta = 60°$ or $\theta = 30°$

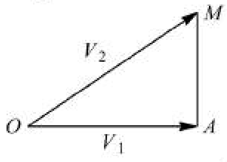
Let us cross-check with the help of data for vertical range

$$\frac{v^2 \sin^2\theta}{2g} = \frac{v^2}{8g} \text{ or } \sin^2\theta = \frac{1}{4}$$

or $\sin\theta = \frac{1}{2}$ or $\theta = 30°$

717 **(b)**

Let v_1 be the velocity of the car and v_2 be the velocity of the parcel. The parcel is thrown at an angle θ from O. It reaches the mass at M.



$$\therefore \cos\theta = \frac{v_1}{v_2} = \frac{10}{10\sqrt{2}} = \frac{1}{\sqrt{2}} = \cos 45°$$

So $\theta = 45°$

718 **(b)**

One circular motion, the force acts along the radius and displacement at a location is perpendicular to the radius *ie*, $\theta = 90°$

As work done $= \vec{\mathbf{F}} \cdot \vec{\mathbf{s}} = Fs \cos 90° = 0$

720 **(d)**

As the mass is attached to the end of a rod. Which does not stacken, therefore, taking $v = 0$ at the highest point, from $v^2 - u^2 = 2a\,s$

$0 - u^2 = 2(-g)2l$

$\therefore u = \sqrt{4gl}$

721 **(a)**

$\vec{A} \times \vec{B} = (2\hat{\imath} + 3\hat{\jmath}) \times (\hat{\imath} + 4\hat{\jmath})$

$= 8(\hat{\imath} \times \hat{\jmath}) + 3(\hat{\jmath} \times \hat{\imath}) = 8\hat{k} - 3\hat{k} = 5\hat{k}$

722 **(a)**

$\frac{1}{2}mv^2 = mg(3-1) = 2mg$ or $v = \sqrt{4g} = 2\sqrt{g}$

Vertical component at $A = 2\sqrt{g} \sin 30° = \sqrt{g}$

723 **(b)**

$x = (u\cos\theta)t = 6$

$u\cos\theta = \frac{x}{t} = 6$

$y = (u\sin\theta)t = -\frac{1}{2}gt^2$

$y = 8t - 5t^2 \Rightarrow u\sin\theta = 8$

$u = 10\text{m/s}$

724 **(b)**

Acceleration of the particle is

$a = r\omega^2 = r(2\pi n)^2$

$= 0.25 \times (2\pi \times 2)^2$

$= 16\pi^2 \times 0.25$

$= 4\pi^2 \text{ ms}^{-2}$

725 **(a)**

For water not to spil, $\frac{mv^2}{r} = mg$

or $v = \sqrt{r\,g} = \sqrt{1.6 \times 10} = 4 \text{ ms}^{-1}$

727 **(b)**

$\vec{\mathbf{p}}_B - \vec{\mathbf{p}}_A = m(\vec{\mathbf{v}}_B - \vec{\mathbf{v}}_A) = mv(\hat{\mathbf{j}} + \hat{\mathbf{i}})$

$= 2mv\hat{\mathbf{j}} = 2\text{kg ms}^{-1}$ ...(i)

$\vec{\mathbf{F}}_B - \vec{\mathbf{F}}_A = \frac{mv^2}{R}(-\hat{\mathbf{i}}) - \frac{mv^2}{R}(+\hat{\mathbf{i}})$

$= \frac{2mv^2}{R}(-\hat{\mathbf{i}}) = 8\text{N}$ ...(ii)

Dividing Eq. (ii) by Eq. (i), $\frac{v}{R} = \omega = 4 \text{ rad s}^{-1}$

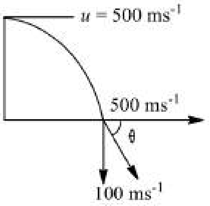
728 **(a)**

Horizontal component of velocity $v_x = 500\text{ms}^{-1}$ and vertical components of velocity while striking the ground

$v_y = 0 + 10 \times 10 = 100 \text{ ms}^{-1}$

$\therefore$ Angle with which it strikes the ground

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{100}{500}\right)$$



$$\theta = \tan^{-1}\left(\frac{1}{5}\right)$$

729 **(c)**

Time of flight. $T = \frac{2u\sin\theta}{g}$

Horizontal range, $R = \frac{u^2 \sin 2\theta}{g}$

Change in angular momentum,

$|d\vec{\mathbf{L}}| = |\vec{\mathbf{L}}_f - \vec{\mathbf{L}}_i|$ about point of projection

$= (mu\sin\theta) \times \frac{u^2 \sin 2\theta}{g}$

$= \frac{mu^3 \sin\theta \sin 2\theta}{g}$

Torque $|\vec{\tau}| = \frac{\text{change in angular momentum}}{\text{time of flight}}$

$= \left|\frac{d\vec{\mathbf{L}}}{T}\right|$

731 **(d)**

$\text{v} = ky\hat{\mathbf{i}} + kx\,\hat{\mathbf{j}}$

$$\frac{dx}{dt} = ky, \frac{dy}{dt} = kx$$
$$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx} = \frac{kx}{ky}$$
$$ydy = xdx$$
$$y^2 = x^2 + c$$

732 **(a)**

In this problem it is assumed that particle although moving in a vertical loop but it speed remain constant

Tension at lowest point $T_{max} = \frac{mv^2}{r} + mg$

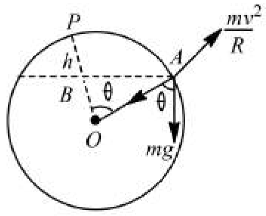
Tension at highest point $T_{min} = \frac{mv^2}{r} - mg$

$$\frac{T_{max}}{T_{min}} = \frac{\frac{mv^2}{r} + mg}{\frac{mv^2}{r} - mg} = \frac{5}{3}$$

$\therefore\ v = \sqrt{4gr} = \sqrt{4 \times 9.8 \times 2.5} = \sqrt{98}\ \mathrm{ms^{-1}}$

733 **(d)**

From law of conservation of energy, potential energy of fall gets converted to kinetic energy.



$\therefore$ PE = KE

$$mgh = \frac{1}{2}mv^2$$

or $v = \sqrt{2gh}$ ….(i)

Also, the horizontal component of force is equal centrifugal force.

$\therefore\ mg\cos\theta = \frac{mv^2}{R}$ ...(ii)

From Eq. (i)

$\therefore\ mg\cos\theta = \frac{2mgh}{R}$ ...(iii)

From ΔAOB,

$$\cos\theta = \frac{(R-h)}{R}$$

$$\Rightarrow\ mg\left(\frac{(R-h)}{R}\right) = \frac{2mgh}{R}$$

$\Rightarrow\ 3h = R$

$\Rightarrow h = \frac{R}{3}$

734 **(c)**

Since, $n = 2, \omega = 2\pi \times 2 = 4\pi\ rad/s^2$

So acceleration $= \omega^2 r = (4\pi)^2 \times \frac{25}{100}\ m/s^2 = 4\pi^2$

735 **(a)**

Here, $2\pi r = 34.3 \Longrightarrow r = \frac{3403}{2\pi}$ and $v = \frac{2\pi r}{T}$

$$= \frac{2\pi r}{\sqrt{22}}$$

Angle of banking $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = 45°$

736 **(d)**

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 980}{9.8}} = 10\sqrt{2}\ \mathrm{s}$$

737 **(d)**

$R = 4H\cot\theta$, if $R = 4\sqrt{3}H$ then $\cot\theta = \sqrt{3} \Rightarrow \theta = 30°$

739 **(b)**

Since the ball reaches from one player to another in 2 s, so the time period of the flite, $T = 2$s

or $\frac{2u\sin\theta}{g} = 2$

or $u\sin\theta = g$ ..(i)

Now, we know that the maximum height of the projection.

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

or $H = \frac{(u\sin\theta)^2}{2g}$

On putting the value of $u\sin\theta$ from Eq.(i), we have

$$H = \frac{g^2}{2g} = \frac{g}{2}$$

or $H = \frac{g}{2} = \frac{10}{2}$ m or $H = 5$m

740 **(a)**

$$a = \frac{v^2}{r} = \frac{(400)^2}{160} = 10^3 m/s^2 = 1\ km/s^2$$

741 **(a)**

$25 = 0.25 \times v^2/1.96$

or $v = (25 \times 1.96/0.25)^{1/2} = 5 \times \frac{14}{5} = 14\mathrm{ms^{-1}}$

742 **(b)**

Given, $f = 1200$ rpm,

$r = 30\ \mathrm{cm} = \frac{30}{100}$ m

Acceleration of a point at the tip of the blade

= centripetal acceleration

$= \omega^2 r = (2\pi f)^2 r$

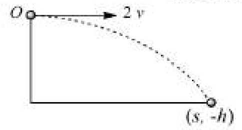
$= \left(2 \times \frac{22}{7} \times \frac{1200}{60}\right)^2 \times \frac{30}{100}$

$= 4740\ \mathrm{ms^{-2}}$

743 **(b)**

Assuming particle 2 to be at rest, substituting in

$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \quad (\theta = 0°)$



We have $-h = \frac{-g}{2(4v^2)}$

or $v = \sqrt{\frac{g}{8h}}$

Which is a straight line passing through origin with slope $\sqrt{\frac{g}{8h}}$

745 **(c)**

Horizontal distance of target is 200 m.

Speed of bullet $= 2000\ ms^{-1}$

Time taken by bullet to cover the horizontal distance

$t = \frac{200}{2000} = \frac{1}{10}$ s

During $\frac{1}{10}$ s, the bullet will fall down vertically due to gravitational acceleration.

Therefore, height above the target, so that the bullet hits the target is

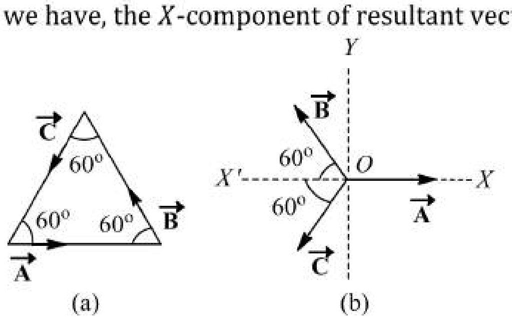
$h = u + \frac{1}{2}gt^2 = \left(0 \times \frac{1}{10}\right) + \frac{1}{2} \times 10 \times (0.1)^2$

$= 0.05$m $= 5$cm

746 **(d)**

The three vectors $\vec{A}, \vec{B}$ and $\vec{C}$ are represented as shown in figure (a) where $A = 1, B = 2$ and $C = 3$. Here the sides of the equilateral triangle represent only the directions and not the magnitudes of the vectors.

In figure (b), these vector are drawn from a common point O and they are lying in $X - Y$ plane. Resolving these vectors into two rectangular components along X-axis and Y-axis, we have, the X-component of resultant vector as



$R_X = |\vec{A}| + |\vec{B}|\cos(180° - 60°) + |\vec{C}|\cos(180° + 60°)$

$= -1 - 2\cos60° - 3\cos60°$

$= -1 - 2 \times \frac{1}{2} - 3 \times \frac{1}{2} = -\frac{3}{2}$

Y-component of resultant vector is

$R_Y = 0 + |B|\sin(180° - 60°) + |\vec{C}|\sin(180° + 60°)$

$= 0 + 2\sin60° - 3\sin60° = -\sin60° = \sqrt{3}/2$

Magnitude of resultant vector,

$R = \sqrt{R_X^2 + R_Y^2} = \sqrt{\left(-\frac{3}{2}\right)^2 + \left(-\frac{\sqrt{3}}{2}\right)^2}$

$= \sqrt{3}$ units

747 **(a)**

$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times2}{9.8}} = 0.64$ s

$v = \frac{10}{t} = 15.62\ ms^{-1}$

$\therefore a = \frac{v^2}{R} = 163\ ms^{-2}$

748 **(d)**

$R = \frac{v^2\sin2\theta}{g} \Rightarrow \theta = \frac{1}{2}\sin^{-1}\left(\frac{gR}{v^2}\right)$

749 **(c)**

Here, $v = 900$ km $h^{-1} = \frac{900\times1000}{60\times60} = 250\ ms^{-1}$

$g = 9.8\ ms^{-2}$

For apparent weightlessness, $\frac{mv^2}{r} = mg$

$r = \frac{v^2}{g} = \frac{250 \times 250}{9.8}$

$= 6377.5$ m $= 6.4$ km

750 **(c)**

$T = \frac{2 \times 50 \times \frac{1}{2}}{10} = 5$ s

Horizontal distance travelled in last 2 s

$= 50 \times \cos30° \times 2$ m

$= 100 \times \frac{2}{\sqrt{3}}$m $= 50\sqrt{3}$m $= 86.6$ m

751 **(b)**

$\vec{F} = \frac{d\vec{p}}{dt} = (-2\sin t)\hat{i} + (2\cos t)\hat{j}$

$\cos\hat{\theta} = \frac{\vec{F}\cdot\vec{P}}{Fp} = 0$

$\therefore \theta = 90°$

752 **(b)**

Change in momentum $= 2mv\sin\theta = 2mv\sin\frac{\pi}{4} = \sqrt{2}mv$

753 **(b)**

Here, $r = 2t, \theta = 4t$

$l = r\theta = (2t)(4t) = 8t^2$

$v = \frac{dl}{dt} = \frac{d}{dt}(8t)^2 = 16t$

$= 16 \times 1 = 16\ ms^{-1}$

754 **(c)**

The vertical component of velocity of projection

$= -50 \sin 30° = -25\ m/s$

If t be the time taken to reach the ground,

$h = ut + \frac{1}{2}gt^2 \Rightarrow 70 = -25t + \frac{1}{2} \times 10t^2$

$\Rightarrow 70 = -25t + 5t^2 \Rightarrow t^2 - 5t - 14 = 0 \Rightarrow t = -2s$ and $7s$

Since, $t = -2\ s$ is not valid $\therefore t = 7s$

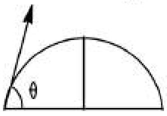
755 **(c)**

Horizontal component $= u \cos \theta$

Vertical component $= u \sin \theta$

$g = -10 ms^{-2}, u = 50 ms^{-1}, h = 5m, t = 2\ s$

$h = u_y t + \frac{1}{2} gt^2$



$\therefore\ 5 = 50 \sin \theta - \frac{1}{2} \times 10 \times 4$

or $5 = 50 \sin \theta - 20$

or $\sin \theta = \frac{25}{50} = \frac{1}{2}$

$\therefore\ \theta = 30°$

756 **(b)**

$(KE)_H = \frac{1}{2}(KE)_i$

$\frac{1}{2}mv^2 \cos^2 \theta = \frac{1}{2}\left(\frac{1}{2}mv^2\right) = \frac{1}{4}mv^2$

or $\cos^2 \theta = \frac{1}{2}$ or $\cos \theta = \frac{1}{\sqrt{2}}$ or $\theta = 45°$

757 **(a)**

$x = (u \cos \theta)t = 6t$

$y = (u \sin \theta)\ t - \frac{1}{2}gt^2 = 8t - 5t^2$

Therefore, $u \sin \theta = 8$

$u \cos \theta = 6$

Range. $R = \frac{u^2 2 \sin 2\theta}{g}$

$= \frac{u^2 \times 2 \sin \theta \cos \theta}{g}$

$= \frac{2(u \sin \theta)\ (\cos \theta)}{g}$

$= \frac{2(8)(6)}{10} = 9.6\ m$

758 **(c)**

Since horizontal component of velocity is constant, hence momentum is constant

759 **(b)**

Horizontal distance travelled by the bomb $S = u \times t$

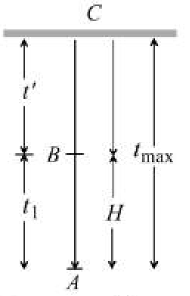
$= 200 \times \sqrt{\frac{2h}{g}} = 200 \times \sqrt{\frac{2 \times 8 \times 10^3}{9.8}} = 8.081\ km$

760 **(c)**

Let time taken by the body to fall from point C to B be t'' Then, $t_1 + 2t'' = t_2$

$t'' = \left(\frac{t_2 - t_1}{2}\right)$ ...(i)

Total time taken, to reach point C



$T = t_1 + t''$

$= t_1 + \frac{t_2 - t_1}{2}$

$= \frac{2t_1 + t_2 - t_1}{2} = \left(\frac{t_1 + t_2}{2}\right)$

Then maximum height attained

$H_{max} = \frac{1}{2}g(T)^2 = \frac{1}{2}g\left(\frac{T_1 + t_2}{2}\right)^2$

$= \frac{1}{2}g.\frac{(t_1 + t_2)^2}{4}$

$\Rightarrow H_{max} = \frac{1}{8}g.(t_1 + t_2)^2 m$

761 **(d)**

Required angle $= \frac{\pi}{2} - \frac{5\pi}{36} = \frac{18\pi - 5\pi}{36} = \frac{13\pi}{36}$ rad

762 **(b)**

Displacement , $\vec{r} = \vec{r}_2 - \vec{r}_1$

$= (\hat{i} - \hat{j} + 2\hat{k}) - (\hat{i} - \hat{j} + 2\hat{k}) = -2\hat{i} + \hat{k}$

$\therefore$ workdone, $W = \vec{F} \cdot \vec{r} = (\hat{i} + 2\hat{j} + 3\hat{k}) \cdot (-2\hat{j} + \hat{k}) = -1\ J$

763 **(a)**

Minimum speed at the lowest point

$= \sqrt{5rg} = \sqrt{5 \times 5 \times 9.8} = 15.65\ ms^{-1}$

765 **(d)**

$R \cos \theta = mg$ ... (i)

$R \sin \theta = \frac{mv^2}{R}$ ... (ii)

From, Eqs. (i) and (ii) we get

$\therefore\ \tan \theta = \frac{v^2}{Rg}$

MOTION IN A PLANE

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 1 to 0. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

1

Statement 1: $\vec{v} = \vec{\omega} \times \vec{r}$ and $\vec{v} \neq \vec{r} \times \vec{\omega}$

Statement 2: Cross product of vector is commutative

2

Statement 1: The path of a projectile is parabolic only when the acceleration of the projectile is constant

Statement 2: Acceleration of projectile is constant, if projectile does not go to very large height, in gravitational field

3

Statement 1: Two bombs of 5kg and 10kg are thrown from a cannon in the same direction with different velocities, then both will reach the earth simultaneously

Statement 2: Time of fight does not depend upon mass

4

Statement 1: During a turn, the value of centripetal force should be less than the limiting frictionless force

Statement 2: The centripetal force is provided by the frictional force between the tyres and the road

5

Statement 1: When a vehicle takes a turn on the road, it travels along a nearly circular path

Statement 2: In circular motion, velocity of vehicle remains same

6

Statement 1: Improper banking of roads causes wear and tear of tyres

Statement 2: The necessary centripetal force is provided by the force of friction between the tyres and the road

7

Statement 1: The trajectory of projectile is quadratic in y and linear in x

Statement 2: y component of trajectory is independent of x-component

8

Statement 1: Angular velocity of seconds hand of a watch is $\frac{\pi}{30}$ rad s^{-1}

Statement 2: $\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = \frac{\pi}{30}$ rad s^{-1}

9

Statement 1: In order to hit a target, a man should point his rifle in the same direction as target

Statement 2: The horizontal range of the bullet is dependent on the angle of projectile with horizontal direction

10

Statement 1: A vector $\vec{A}$ points vertically upwards and $\vec{B}$ points towards North. The vector product $\vec{A} \times \vec{B}$ is along East.

Statement 2: The direction of $\vec{A} \times \vec{B}$ is given by right hand rule.

11

Statement 1: angle between $\hat{i} + \hat{j}$ and $\hat{i}$ is 45°

Statement 2: $\hat{i} + \hat{j}$ is equally include to both $\hat{i}$ and $\hat{j}$ and the angel between $\hat{i}$ and $\hat{j}$ is 90°

12

Statement 1: In case of angular projection of a projectile the maximum height occurs when the projectile covers a horizontal distance equal to half of the horizontal range

Statement 2: Maximum height occurs when angle of projection is 90°

13

Statement 1: When an automobile is going too fast around curve overturns, its inner wheels leave the ground first

Statement 2: For a safe turn the velocity of automobile should be less than the value of safe limiting velocity

14

Statement 1: In projectile motion, the angle between the instantaneous velocity and acceleration at the highest point is 180°

Statement 2: At the highest point, velocity of projectile will be in horizontal direction only

15

Statement 1: Two similar trains are moving along the equatorial line with the same speed but in opposite direction. They will exert equal pressure on the rails

Statement 2: In uniform circular motion the magnitude of acceleration remains constant but the direction continuously changes

16

Statement 1: Two particles of different mass, projected with same velocity at same angles. The maximum height attained by both the particle will be same

Statement 2: The maximum height of projectile is independent of particle mass

17

Statement 1: A body of mass 1 kg is making 1 rps in a circle of radius 1 m. centrifugal force acting on it is $4\pi^2 N$

Statement 2: Centrifugal force is given by $F = \frac{mv^2}{r}$

18

Statement 1: When a particle moves on a circular path with constant speed, it is called uniform circular motion.

Statement 2: For a uniform circular motion, necessary a force is always acting parallel to the direction of velocity

19

Statement 1: A physical quantity cannot be called as a vector if its magnitude is zero.

Statement 2: A vector has both, magnitude and direction.

20

Statement 1: When a body is dropped or thrown horizontally from the same height, it would reach the ground at the same time

Statement 2: Horizontal velocity has no effect on the vertical direction

21

Statement 1: A safe turn by a cyclist should neither be fast nor sharp

Statement 2: The bending angle from the vertical would decrease with increase in velocity

22

Statement 1: A coin is placed on phonogram turn table. The motor is started, coin moves along the moving table

Statement 2: The rotating table is providing necessary centripetal force to the coin

23

Statement 1: For looping a vertical loop of radius r, the minimum velocity at the lowest point should be $\sqrt{5gr}$

Statement 2: In that event, velocity at the highest point would be zero

24

Statement 1: As the frictional force increases, the safe velocity limit for taking a turn on an unbanked road also increases

Statement 2: Banking of roads will increases the value of limiting velocity

25

Statement 1: When range of a projectile is maximum, its angle of projection may be 45° or 135°

Statement 2: Whether θ is 45° or 135°, value of range remains the same, only the sign changes

26

Statement 1: The maximum horizontal range of projectile is proportional to square of velocity

Statement 2: The maximum horizontal range of projectile is equal to maximum height attained by projectile

27

Statement 1: At the highest point of projectile motion given angular projection, the velocity is not zero

Statement 2: Only the vertical component of velocity is zero whereas horizontal component still exists

28

Statement 1: When the velocity of projection of a body is made n time, its time of flight becomes n times

Statement 2: Range of projectile does not depend on the initial velocity of body

29

Statement 1: The resultant of three vectors $\overrightarrow{OA}$ and $\overrightarrow{OB}$ and $\overrightarrow{OC}$ as shown in figure is $R(1+\sqrt{2})$. R is the radius of circle

Statement 2: $\overrightarrow{OA}+\overrightarrow{OC}$ is along $\overrightarrow{OB}$ and $(\overrightarrow{OA}+\overrightarrow{OC})+\overrightarrow{OB}$ is along $\overrightarrow{OB}$.

30

Statement 1: A football whether kicked at 30° or 60° will strike the ground at the same place, although when kicked at 60°, it will remain longer in the air

Statement 2: Air resistance is more for larger angle

31

Statement 1: If both the speed of a body and radius of its circular path are doubled, then centripetal force also gets doubled

Statement 2: Centripetal force is directly proportional to both speed of a body and radius of circular path

32

Statement 1: A safe turn by a cyclist should neither be fast nor sharp

Statement 2: As the bending of angle from the vertical would decrease

33

Statement 1: Improper banking of roads causes wear and tear of tyres

Statement 2: The necessary centripetal force in that event is provided by the force of friction between the tyres and the road

34

Statement 1: In circular motion, the centripetal and centrifugal force acting in opposite direction balance each other

Statement 2: Centripetal and centrifugal forces don't act at the same time

35

Statement 1: The vector $\frac{1}{\sqrt{3}}\hat{\imath} + \frac{1}{\sqrt{3}}\hat{\jmath} + \frac{1}{\sqrt{3}}\hat{k}$ is a unit vector.

Statement 2: Unit vector is one which has unit magnitude and a given direction.

36

Statement 1: When an automobile while going too fast around a curve overturns, its inner wheels leave the ground first

Statement 2: For a safe turn the velocity of automobiles should be less than the value of safe limit velocity

MOTION IN A PLANE

: ANSWER KEY :

1)	c	2)	a	3)	d	4)	a	21)	c	22)	d	23)	d	24)	b
5)	c	6)	a	7)	d	8)	a	25)	a	26)	c	27)	a	28)	c
9)	d	10)	d	11)	a	12)	a	29)	a	30)	c	31)	c	32)	c
13)	a	14)	d	15)	d	16)	a	33)	a	34)	d	35)	a	36)	b
17)	a	18)	c	19)	d	20)	a								

MOTION IN A PLANE

: HINTS AND SOLUTIONS :

1 **(c)**

Cross product of vectors is anticommutative. Therefore, $\vec{\mathbf{v}} = \vec{\omega} \times \vec{\mathbf{r}} = -\vec{\mathbf{r}} \times \vec{\omega}$. Choice (c) is correct

2 **(a)**

Let t be the time taken by the projectile while going through height h. Taking vertical upward motion of projectile, we have

$y_0 = 0, y = h, u_y = 2\sqrt{gh}\sin 60°$

$= 2\sqrt{gh} \times \sqrt{3}/2 = \sqrt{3gh}$

$a_y = -g, t = ?$

As, $y = y_0 + u_y t + \frac{1}{2} a_y t^2$

$\therefore h = 0 + \sqrt{3gh}\, t + \frac{1}{2}(-g)t^2$

or $gt^2 - 2\sqrt{3gh}\, t + 2h = 0$

On solving, we get two value of time, $ie, \left(\frac{\sqrt{3gh}+\sqrt{gh}}{g}\right)$

and $\left(\frac{\sqrt{3gh}-\sqrt{gh}}{g}\right)$, Here, the first time is to reach a height h while going up and second time is to come back at height h. Therefore, time of projectile above the height h is

$$= \left(\frac{\sqrt{3gh}+\sqrt{gh}}{g}\right) - \left(\frac{\sqrt{3gh}-\sqrt{gh}}{g}\right)$$

$$= \frac{2\sqrt{gh}}{g} = \sqrt{\frac{4h}{g}}$$

3 **(d)**

$$\tan\theta = \frac{u_y}{u_x} = \frac{30}{10\sqrt{3}} = \sqrt{3} = \tan 60°$$

$\therefore \theta = 60°$

4 **(a)**

The body is able to move in a circular path due to centripetal force. The centripetal force in case of vehicle is provided by frictional force. Thus if the value of frictional force μmg is less than centripetal force, then it is not possible for a vehicle to take a turn and the body would overturn

Thus condition for safe turning of vehicle is, $\mu mg \geq \frac{mv^2}{r}$

5 **(c)**

In circular motion the frictional force acting towards the centre of the horizontal circular path provides the centripetal force and avoid overturning of vehicle. Due to the change in direction of motion, velocity changes in circular motion

6 **(a)**

When roads are not properly banked, force of friction between tyres and road provides partially the necessary centripetal force. This cause wear and tear of tyres

7 **(d)**

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

8 **(a)**

For second's hand, $T = 60$ s

$\therefore \omega = \frac{2\pi}{T} = \frac{2\pi}{60} = \frac{\pi}{30}$ rad s^{-1}

9 **(d)**

The man should point his rifle at a point higher than the target since the bullet suffers a vertically downward deflection $\left(y = \frac{1}{2}gt^2\right)$ due to gravity

10 **(d)**

In assertion, the direction of $(\vec{A} \times \vec{B})$ according to Right Hand Rule is towards West. Thus assertion is false and reason is true.

11 **(a)**

$\cos\theta = \frac{(\hat{\imath}+\hat{\jmath})\cdot\hat{\imath}}{|\hat{\imath}+\hat{\jmath}||\hat{\imath}|} = \frac{1}{\sqrt{2}} = \cos 45°$

so, $\theta = 45°$

12 **(a)**

Maximum height $= \frac{u^2 \sin^2\theta}{2g}$

$= \frac{\left(2\sqrt{gh}\right)^2 \sin^2 60°}{2g} = \frac{4gh \times 3/4}{2g} = \frac{3h}{2}$

13 **(a)**

Let μ be the coefficient of static friction between the tyres and the road, the magnitude of friction force F will not exceed μmg , so that $F' \leq \mu mg$

Hence, for a safe turn $\frac{mv^2}{r} \leq \mu mg$

or $\mu \geq \frac{v^2}{rg}$ or $v \leq \sqrt{\mu rg}$

Hence, when speed of car (automobile) exceeds the value of $\sqrt{\mu rg}$ then it overturns, as the inner wheels are moving in a circle of smaller radius, the maximum possible velocity is less for it. Therefore, the wheels leave the ground first and car will overturn on the outside

14 **(d)**

At the highest point, vertical component of velocity becomes zero so there will be only horizontal velocity and it is perpendicular to the acceleration due to gravity

15 **(d)**

Due to earth's axial rotation, the speed of the trains relative to earth will be different and hence the centripetal forces on them will be different. Thus their effective weights $mg - \frac{mv^2}{r}$ and $mg + \frac{mv^2}{r}$ will be different. So they exert different pressure on the rails

16 **(a)**

$H = \frac{u^2 \sin^2\theta}{2g}$ $i.e.$ it is independent of mass of projectile

17 **(a)**

From relation

$F = \frac{mv^2}{r} = \frac{m(r\omega)^2}{r} = mr\omega^2$

$= mr(2\pi v)^2 = 4\pi^2 mrv^2$

Here, $m = 1\,kg, v = 1\,rps\,, r = 1m$

$\therefore F = 4\pi^2 \times 1 \times 1 \times 1^2 = 4\pi^2 N$

18 **(c)**

Here assertion is correct but reason is wrong; because in circular motion the direction of centripetal force is perpendicular to the velocity

19 **(d)**

Here assertion is false and reason is true.

20 **(a)**

Both bodies will take same time to reach the earth because vertical downward component of the velocity for both the bodies will be zero and time of descent $= \sqrt{\frac{2h}{g}}$. Horizontal velocity has no effect on the vertical direction

21 **(c)**

For safe turn $\tan\theta \geq \frac{v^2}{rg}$

It is clear that for safe turn v should be small and r should be large. Also blending angle from the vertical would increase in velocity

22 **(d)**

Within a certain speed of the turn table the frictional force between the coin and the turn table supplies the necessary centripetal force required for circular motion. On further increase of speed, the frictional force cannot supply the necessary centripetal force. Therefore the coin files off tangentially

23 **(d)**

When velocity at the lowest point is $\sqrt{5gr}$, velocity at highest point $= \sqrt{gr} \neq$zero. That is why, the vertical loop is completed

24 **(b)**

On an unbanked road, friction provides the necessary centripetal force $\frac{mv^2}{r} = \mu mg \therefore v = \sqrt{\mu r g}$

Thus with increase in friction, safe velocity limit also increases

When the road is banked with angle of θ than its limiting velocity is given by

$$v = \sqrt{\frac{rg(\tan\theta + \mu)}{1 - \mu\tan\theta}}$$

Thus limiting velocity increase with banking of road

25 **(a)**

Range, $R = \frac{u^2 \sin 2\theta}{g}$

When $\theta = 45°, R_{\max} = \frac{u^2}{g}\sin 90° = \frac{u^2}{g}$

When $\theta = 135°, R_{\max} = \frac{u^2}{g}\sin 270° = \frac{-u^2}{g}$

Negative sign shows opposite direction

26 **(c)**

$R = \frac{u^2 \sin 2\theta}{g} \therefore R_{\max} = \frac{u^2}{g}$ when $\theta = 45° \therefore R_{\max} \propto u^2$

Height $H = \frac{u^2 \sin^2\theta}{2g} \Rightarrow H_{\max} = \frac{u^2}{2g}$

When $\theta = 90°$

It is clear that $H_{\max} = \frac{R_{\max}}{2}$

27 **(a)**

Horizontal range $= \frac{u^2 \sin^2\theta}{g}$

$$= \frac{\left(2\sqrt{gh}\right)^2 \sin 2 \times 60°}{g} = 2\sqrt{3}h$$

28 **(c)**

$T \propto u$ and $R \propto u^2$

When velocity of projection of a body is made n times, then its time of flight becomes n times and range becomes n^2 times

29 **(a)**

$OA = OC$

$\overrightarrow{OC} + \overrightarrow{OC}$ is along $\overrightarrow{OB}$ (bisector) and its magnitudes is

$2R\cos 45° = R\sqrt{2}$

$(\overrightarrow{OC} + \overrightarrow{OC}) + \overrightarrow{OB}$ is along $\overrightarrow{OB}$ and its magnitudes is

$R\sqrt{2} + R = R(1 + \sqrt{2})$

30 **(c)**

Time of flight, $T = \frac{2u_y}{g}$

or $u_y = \frac{gT}{2} = \frac{10\times6}{2} = 30 \text{ ms}^{-1}$

Vertical velocity after 2s, $v_y = u_y - gt$

$= 30 - 10 \times 2 = 10\text{ms}^{-1}$

Horizontal velocity after 2 s, $v_x = u_x$

As per question, $\tan 30° = \frac{v_y}{v_x} = \frac{10}{u_x}$

or $u_x = \frac{10}{\tan 30°} = 10\sqrt{3}\text{ms}^{-1}$

$\therefore u = \sqrt{u_x^2 + u_y^2} = \sqrt{\left(10\sqrt{3}\right)^2 + (30)^2}$

$= 20\sqrt{3} \text{ ms}^{-1}$

31 **(c)**

Centripetal force is defined from formula

$$F = \frac{mv^2}{r} \Rightarrow F \propto \frac{v^2}{r}$$

If v and r both are doubled then F also gets doubled

32 **(c)**

$$\tan\theta = \frac{v^2}{rg}$$

When v is large and r is small $\tan\theta$ increases. Therefore θ increases, chances of skidding increase. Choice (c) is correct

33 **(a)**

When roads are not properly banked force of friction between tyres and road provides partially the necessary centripetal force. This causes wear and tear

34 **(d)**

While moving along a circle, the body has a constant tendency to regain its natural straight path

This tendency gives rise to a force called centrifugal force. The centrifugal force does not act on the body in motion, the only force acting on the body in motion is centripetal force. The centrifugal force acts on the source of centripetal force to displace it radially outward from the centre of the path

35 **(a)**

$$\vec{A} = \frac{1}{\sqrt{3}}\hat{\imath} + \frac{1}{\sqrt{3}}\hat{\jmath} + \frac{1}{\sqrt{3}}\hat{k}$$

$$A = \left[\left(\frac{1}{\sqrt{3}}\right)^2 + \left(\left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2\right)\right]^{1/2} = 1$$

36 **(b)**

When automobile moves in circular path then reaction on inner wheel and outer wheel will be different

$R_{\text{inner}} = \frac{M}{2}\left[g - \frac{v^2h}{ra}\right]$ and $R_{\text{outer}} = \frac{M}{2}\left[g + \frac{v^2h}{ra}\right]$

In critical condition $v_{\text{safe}} = \sqrt{\frac{gra}{h}}$

If v is equal or more than the critical value then reaction on inner wheel becomes zero. So it leaves the ground first