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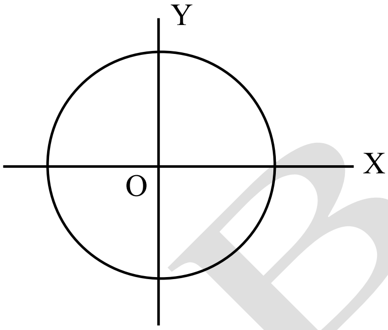
MOTION IN A PLANE

Single Correct Answer Type

1. A particle is projected with a velocity of $20\ \mathrm{ms}^{-1}$ at an angle of $60°$ to the horizontal. The particle hits the horizontal plane again during its journey. What will be the time of impact?
   a) 3.53 s b) 2.4 s
   c) 1.7 s d) 1 s
2. A body is just revolved in a vertical circle of radius 'R'. When the body is at highest point, the string breaks. The horizontal distance covered by the body after the string breaks is
   a) R b) 3R
   c) 2R d) 4R
3. The figure shows a circular path of a moving particle. If the velocity of the particle at some instant is $v = -3\hat{i} - 4\hat{j}$, through which quadrant is the particle moving when clockwise and anti-clockwise respectively



   a) 1st and 4th b) 2nd and 4th
   c) 2nd and 3rd d) 3rd and 4th
4. A particle performing U.C.M. of radius $\frac{\pi}{2}$ m makes 'x' revolutions in time 't'. Its tangential velocity is
   a) $\frac{\pi x}{t^2}$ b) $\frac{\pi x^2}{t}$
   c) $\frac{\pi^2 x}{t}$ d) $\frac{\pi t}{x^2}$
5. A particle is performing U.C.M. along the circumference of a circle of diameter 50 cm with frequency 2 Hz. The acceleration of the particle in $\mathrm{m/s^2}$ is
   a) $2\pi^2$ b) $4\pi^2$
   c) $8\pi^2$ d) π^2
6. 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) $\frac{p^2}{rm}$
7. Two bodies of masses 'm' and '3m' are rotating in horizontal circles of radius 'r' and '$\frac{r}{3}$' respectively. The tangential speed of body of mass 'm' is n times that of the value of heavier body, while the centripetal force is same for both. The value of n is
   a) 1 b) 9
   c) 6 d) 3
8. Two bodies are thrown up at angles of 45^0 and 60^0 with the horizontal respectively. If same vertical height is attained by both the bodies, then the ratio of velocities with which they are thrown is
   $(\sin 45^0 = \cos 45^0 = \frac{1}{\sqrt{2}}, \sin 60^0 = \cos 30^0 = \frac{\sqrt{3}}{2}, \sin 30^0 = \cos 60^0 = \frac{1}{2})$
   a) $\sqrt{\frac{2}{3}}$ b) $\sqrt{\frac{3}{2}}$
   c) $\frac{2}{\sqrt{3}}$ d) $\frac{\sqrt{3}}{2}$
9. 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 increases in the horizontal range will be
   a) 20% b) 15%
   c) 10% d) 5%
10. A body moving in a circular path with a constant speed has constant
    a) Kinetic energy b) Momentum
    c) Velocity d) Acceleration
11. An object moves from positions $(6, 8)$ to $(12, 10)$ in the XY-plane. Magnitude and direction of displacement is

a) $\sqrt{40}$ and 18.43°		b) $\sqrt{40}$ and 71.56°
c) 10 and 53°		d) $\sqrt{244}$ and 53°

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

13. A particle of mass m is performing UCM along a circle of radius r. The relation between centripetal acceleration a and kinetic energy E is given by
a) $a = \frac{2E}{mr}$		b) $a = 2Em$
c) $a = \frac{E}{mr}$		d) $a = \left(\frac{2E}{mr}\right)^2$

14. A projectile thrown from the ground has initial speed 'u' and its direction makes an angle 'θ' with the horizontal. If at maximum height from ground, the speed of projectile is half its initial speed of projection, then the maximum height reached by the projectile is
[g = acceleration due to gravity, $\sin 30^0 = \cos 60^0 = 0.5, \cos 30^0 = \sin 60^0 = \frac{\sqrt{3}}{2}$]
a) $\frac{2u^2}{g}$		b) $\frac{u^4}{4g}$
c) $\frac{3u^2}{8g}$		d) $\frac{u^2}{g}$

15. For a projectile, the ratio of maximum height reached to the square of flight time is (Take, $g = 10\ ms^{-2}$)
a) 5 : 4		b) 5 : 2
c) 5 : 1		d) 10 : 1

16. The relative angular speed of hour hand and minute hand of a clock is (in rad/s)
a) $\frac{11\pi}{21600}$		b) $\frac{9\pi}{1860}$
c) $\frac{4\pi}{243}$		d) $\frac{7\pi}{1480}$

17. Two stones of masses m and 3m are whirled in horizontal circles, the heavier one in radius $\left(\frac{r}{3}\right)$ and lighter one in radius 'r'. The tangential speed of lighter stone is 'n' times that of the value of heavier stone, when they experience same centripetal force. The value of n is
a) 4		b) 1
c) 2		d) 3

18. An object is thrown along a direction inclined at an angle of 45° with the horizontal direction. The horizontal range of the particle is equal to
a) vertical height		b) twice the vertical height
c) thrice the vertical height		d) four times the vertical height

19. Angular speed of hour hand of a clock in degree per second is
a) $\frac{1}{30}$		b) $\frac{1}{60}$
c) $\frac{1}{120}$		d) $\frac{1}{720}$

20. When a ceiling fan is switched off, its angular velocity falls to half while it makes 36 rotations. How many more rotations will it make before coming to rest?
a) 24		b) 36
c) 18		d) 12

21. Two trains are each 50 m long moving parallel towards each other at speeds $10\ ms^{-1}$ and $15\ ms^{-1}$ respectively, at what time will they pass each other?
a) 8 s		b) 4 s
c) 2 s		d) 6 s

22. The angular speed of the minute hand of a clock in degrees per second is
a) 0.1		b) 10
c) 1		d) 0.1

23. A stationary man observes that the rain is falling vertically downward. When he starts running with a velocity of $12\ kmh^{-1}$, he observes that the rain is falling at an angle 60° with the vertical. The actual velocity of rain is
a) $12\sqrt{3}\ kmh^{-1}$		b) $6\sqrt{3}\ kmh^{-1}$
c) $4\sqrt{3}\ kmh^{-1}$		d) $2\sqrt{3}\ kmh^{-1}$

24. The engine of an aero-plane during take-off exerts a force of 150×10^3 N. Mass of aeroplane is 25×10^3 kg. If the take-off speed is 60 m/s, the length of the runway required is
a) 300 m		b) 100 m
c) 200 m		d) 400 m

25. A particle is performing a uniform circular motion along a circle of radius 'R'. In half the period of revolution, its displacement and distance covered are respectively
a) $2R, 2\pi R$		b) $2R, \pi R$
c) $\sqrt{2}R, 2\pi R$		d) $R, \pi R$

26. A man can throw a stone such that it acquires

maximum horizontal range 80 m. The maximum height to which it will rise for the same projectile in metre is

a) 10 b) 20
c) 40 d) 50

27. An aeroplane is moving with a velocity u. It drops a packet from a height h. The time t taken by the packet in reaching the ground will be

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

28. The equation of the trajectory of a ball projected at an angle 'θ' with the horizontal, is given as $y = \sqrt{3}x - \frac{gx^2}{2}$. The initial velocity of the ball is

$$\left[\sin 30^0 = 0.5 = \cos 60^0, \cos 30^0 = \frac{\sqrt{3}}{2} = \sin 60^0\right]$$

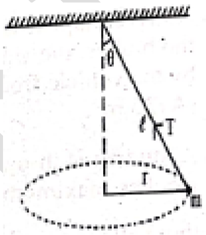
[g = acceleration due to gravity]

a) 3 m/s b) 2 m/s
c) 1 m/s d) 5 m/s

29. Two stones having different masses m_1 and m_2 are projected at angles α and $(90° - \alpha)$ with same speed from same point. The ratio of their maximum heights is

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

30. The string of length 'l' fixed at one end carries a mass 'm' at the other end. The string makes 3/π revolutions/second around the vertical axis through the fixed end as shown in figure. The tension 'T' in the string is



a) 36ml b) 3ml
c) 18ml d) 9ml

31. A particle is projected from ground with speed u and at an angle θ with horizontal. If at maximum hieight from ground, the speed of particle is 1/2 times of its initial velocity of projection, then find its maximum height attained.

a) $\frac{u^2}{g}$ b) $\frac{2u^2}{g}$
c) $\frac{u^2}{2g}$ d) $\frac{3u^2}{8g}$

32. The ratio of the angular speed of the hour hand of a clock to that of its minute hand is

a) 3600: 1 b) 1: 24
c) 1: 12 d) 12: 1

33. A weightless thread can bear tension upt 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}

34. A ball is dropped from the tower of height 'h'. The total distance covered by it in last second of its motion is equal to the distance covered by it in first 3 seconds. The value of 'h' is ($g = 10\ m/s^2$)

a) 200 m b) 125 m
c) 100 m d) 80 m

35. A rotating wheel changes angular speed from 1800 rpm to 3000 rpm in 20 s. What is the angular acceleration assuing to be uniform?

a) 60 π $rads^{-2}$ b) 90 π $rads^{-2}$
c) 2 π r ads^{-2} d) 40 π $rads^{-2}$

36. A vehicle moving with 15 km/hr comes to rest by covering 5 m distance by applying brakes. If the same vehicle moves at 45 km/hr, then by applying brakes, it will come to rest by covering a distance

a) 60 m b) 15 m
c) 45 m d) 30 m

37. The range of a projectile when launched at angle θ is same as when launched at angle 2θ. What is the value of θ?

a) 15° b) 30°
c) 45° d) 60°

38. The coordinates of a moving particle at any time t are given by $x = ct^2$ and $y = bt^2$. The speed of the particle is given by

a) $2t\sqrt{c^2 + b^2}$ b) $\frac{2t}{\sqrt{c^2 + b^2}}$
c) $t\sqrt{c^2 + b^2}$ d) $\frac{t}{\sqrt{c^2 + b^2}}$

39. A particle is performing UCM along the circumference of a circle of diameter 50 cm with frequency Hz. The acceleration of the

particle in m/s^2 is

a) $2\pi^2$ b) $8\pi^2$

c) π^2 d) $4\pi^2$

40. 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) $\alpha = \frac{av}{\omega}$ d) $\alpha = \frac{a}{\omega v}$

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

a) 60° b) 37°

c) 30° d) 45°

42. A particle of mass m is rotating in a plane in circular path of radius r. Its angular momentum is L. The centripetal force acting on the particle is

a) $\frac{L^2}{mr}$ b) $\frac{L^2 m}{r}$

c) $\frac{L^2}{m^2 r^2}$ d) $\frac{L^2}{mr^3}$

43. A particle is moving along the circular path of radius 'r' with velocity 'v'. The magnitude of average acceleration after half revolution is

a) $\frac{3v^2}{\pi r}$ b) $\frac{3v^2}{2\pi r}$

c) $\frac{2v^2}{\pi r}$ d) $\frac{v^2}{\pi r}$

44. A particle moves in a circular orbit of radius 'r' under a central attractive force, $F = -\frac{k}{r}$, where k is a constant. The periodic time of its motion is proportional to

a) $r^{1/2}$ b) $r^{2/3}$

c) r d) $r^{3/2}$

45. A body of mass 'm' is performing a U.C.M. in a circle of radius 'r' with speed 'v'. The work done by the centripetal force in moving it through $\left(\frac{2}{3}\right)^{rd}$ of the circular path is

a) $mv^2\pi r$ b) $\frac{2\pi m v^{2r}}{3}$

c) Zero d) $\frac{2mv^2\pi}{3}$

46. The ratio of angular speed of a second - hand to the hour - hand of a watch is

a) 3600 : 1 b) 720 : 1

c) 72 : 1 d) 60 : 1

47. The greatest height to which a man can throw a stone is h. The greatest distance to which he can throw it will be

a) $\frac{h}{2}$ b) h

c) 2h d) 3h

48. A body is projected at an angle of 30° with the horizontal with momentum p. At its highest point, the magnitude of the momentum is

a) $\frac{\sqrt{3}}{2}p$ b) $\frac{2}{\sqrt{3}}p$

c) p d) $\frac{p}{2}$

49. A car is moving with uniform speed along horizontal, concave and convex shaped roads. The surface of road on which, the normal reaction on car is maximum is

a) horizontal b) concave

c) convex d) same on all surfaces

50. When the bob of mass 'm' moves in a horizontal circle of radius 'r' with uniform speed 'V' having length of string 'L' describes a cone of semi vertical angle 'θ'. The centripetal force acting on the bob is given by [g = acceleration due to gravity]

a) $\frac{mgr}{L^2 - r^2}$ b) $\frac{mgr}{\sqrt{L^2 - r^2}}$

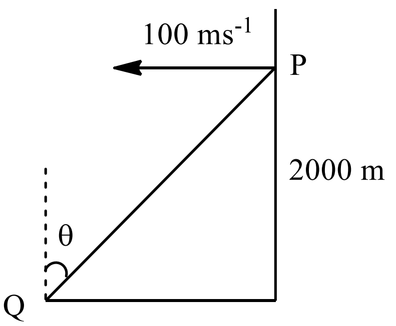
c) $\frac{mgL}{\sqrt{L^2 - r^2}}$ d) $\frac{\sqrt{L^2 - r^2}}{mgL}$

51. A particle has an initial velocity of $4\hat{i} + 3\hat{j}$ and an acceleration of $0.4\hat{i} + 0.3\hat{j}$. Its speed after 10 s is

a) 10 units b) 7 units

c) $7\sqrt{2}$ units d) 8.5 units

52. An aeroplane is travelling horizontally at a height of 2000 m from the ground. The aeroplane, when at a point P, drops a bomb to hit a stationary target Q on the ground.
In order that the bomb hits the target, what angle θ must the line PQ make with the vertical? (Take, $g = 10\ ms^{-2}$)



a) 45° b) 30°

c) 60° d) 90°

53. A particle is moving in a circle of radius 'R' with constant speed 'V'. The magnitude of

average acceleration after half revolution is

a) $\frac{V^2}{\pi R}$ b) $\frac{V^2}{\pi R}$
c) $\frac{2V^2}{\pi R}$ d) $\frac{V^2}{2\pi R}$

54. A particle moves in xy-plane from positions (2m, 4m) to (6m, 8m) in 2 s. Magnitude and direction of average velocity is

a) $\sqrt{2}\ \mathrm{ms^{-1}}$ and 45° b) $2\sqrt{2}\ \mathrm{ms^{-1}}$ and 45°
c) $4\sqrt{2}\ \mathrm{ms^{-1}}$ and 30° d) $3\sqrt{2}\ \mathrm{ms^{-1}}$ and 60°

55. Two projectiles A and B are projected with velocities $\sqrt{2}V$ and V respectively. They have the same range. If A is thrown at angle of 15^0 with the horizontal, the angle of projection of B with horizontal will be ($\sin 30^0 = \cos 60^0 = \frac{1}{2}, \sin 90^0 = \cos 0^0 = 1$)

a) 90^0 b) 60^0
c) 30^0 d) 45^0

56. A mass of 100 g is tied to one end of a string 2 m long. The body is revolving in a horizontal circle making a maximum of 200 rev min^{-1}. 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

57. A ball is thrown at different angles with the same speed u and from the same point. It has the same range in both cases. If y_1 and y_2 be the heights attained in the two cases, then $y_1 + y_2$ equals to

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

58. A particle of mass 2 kg is moving along a circular path of radius 1 m. If its angular speed is 2π rads^{-1}, the centripetal force on it is

a) 4π N b) 8π N
c) $4\pi^4$ N d) $8\pi^2$ N

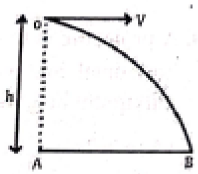
59. A body starts falling from height 'h' and travels a distance h/2 during last second of its motion then time of flight in second is

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

60. The initial position of an object at rest is given by $3\hat{i} - 8\hat{j}$. It moves with constant acceleration and reaches to the position $2\hat{i} + 4\hat{j}$ after 4 s. What is its acceleration?

a) $-\frac{1}{8}\hat{i} + \frac{3}{2}\hat{j}$ b) $2\hat{i} - \frac{1}{8}\hat{j}$
c) $-\frac{1}{2}\hat{i} + 8\hat{j}$ d) $8\hat{i} - \frac{3}{2}\hat{j}$

61. An aero-plane is flying in a horizontal direction with a velocity of 540 km/hr 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. The distance AB is equal to ($g = 9.8\ \mathrm{m/s^2}$)



a) 3600 m b) 3000 m
c) 4000 m d) 2000 m

62. If the radius of the circular path and frequency of revolution of a particle of mass 'm' are doubled then the change in its kinetic energy will be (E_i and E_f are the initial and final kinetic energies of the particle respectively)

a) $8E_i$ b) $15E_i$
c) $12E_i$ d) $16E_i$

63. The change in the centripetal force of a body moving in a circular path, if speed is made half and radius is made 5 times the original value, will

a) increase by $\frac{18}{20}$ b) decrease by $\frac{19}{20}$
c) decrease by $\frac{9}{20}$ d) increase by $\frac{17}{20}$

64. A string of length 0.1 m cannot bear a tension more than 100 N. It is tied to a body of mass 100 g and rotated in a horizontal circle. The maximum angular velocity can be

a) 100 rad $\mathrm{s^{-1}}$ b) 1000 rad $\mathrm{s^{-1}}$
c) 10000 $\mathrm{s^{-1}}$ d) 0.1 rad $\mathrm{s^{-1}}$

65. At any instant, the magnitude of the centripetal force on a particle of mass 'm' performing circular motion is given by (ω = angular velocity and v = linear velocity of the particle)

a) $\frac{m\omega^2}{v}$ b) $\frac{mv^2}{\omega}$
c) $\frac{m^2\omega^2}{v}$ d) $m\omega v$

66. Two racing cars having masses m_1 and m_2 move in concentric circles of radii r_1 and r_2, respectively. If their angular speeds are same, then the ratio of their linear speeds is

a) $m_1 : m_2$ b) $r_1 : r_2$

c) 1: 1 d) $m_1r_1 : m_2r_2$

67. In hydrogen atom, the electron is moving round the nucleus with velocity $2.18 \times 10^6\ ms^{-1}$ in an orbit of radius 0.528 Å. The acceleration of the electron is
a) $9 \times 10^{18}\ ms^{-2}$ b) $9 \times 10^{22}\ ms^{-2}$
c) $9 \times 10^{-22}\ ms^{-2}$ d) $9 \times 10^{12}\ ms^{-2}$

68. The difference between angular speed of minute hand and second hand of a clock is
a) $\frac{59\pi}{900}$ rads^{-1} b) $\frac{59\pi}{1800}$ rads^{-1}
c) $\frac{59\pi}{2400}$ rads^{-1} d) $\frac{59\pi}{3600}$ rads^{-1}

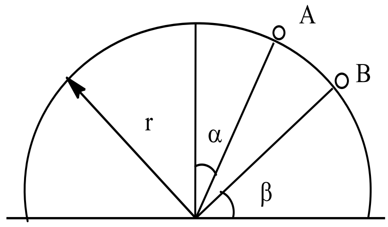
69. A player caught a cricket ball of mass 120 gram moving at the rate of 30 ms^{-1}. If the catching process is completed in 0.2 s, the force of the blow exerted by the ball on the hands of the player is
a) 9 N b) 18 N
c) 36 N d) 72 N

70. A wheel has a speed of 1200 revolutions per minute and is made to slow down at a rate of 4 rad s^{-2}. The number of revolutions it makes before coming to rest is
a) 143 b) 272
c) 314 d) 722

71. Mass of 0.5 kg is attached to a string moving in horizontal circle with angular velocity 10 cycle/min. Keeping the radius constant, tension in the string in made 4 times by increasing angular velocity 'ω' of that mass will be
a) $\frac{1}{4}$ cycle/s b) $\frac{1}{2}$ cycle/s
c) $\frac{1}{5}$ cycle/s d) $\frac{1}{3}$ cycle/s

72. A particle is moving along the circular path with constant speed and centripetal acceleration 'a'. If the speed is doubled, the ratio of its acceleration after and before the change is
a) 3: 1 b) 1: 4
c) 2: 1 d) 4: 1

73. A particle moves from rest at A on the surface of a, smooth circular cylinder of radius r as shown in figure. At B, it leaves the cylinder. The equation relating α and β is



a) $3 \sin \alpha = 2 \cos \beta$ b) $2 \sin \alpha = 3 \cos \beta$
c) $3 \sin \beta = 2 \cos \alpha$ d) $2 \sin \beta = 3 \cos \alpha$

74. A particle performing U.C.M. of radius '$\frac{\pi}{2}$ m' makes 'x' revolutions in time 't'. Its tangential velocity is
a) $\frac{\pi^2 x}{t}$ b) $\frac{\pi x}{t}$
c) $\frac{2\pi x}{t}$ d) $\frac{\pi^2 x^2}{t}$

75. 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

76. A body is moving along a circular track of radius 100 m with velocity 20 ms^{-1}. Its tangential acceleration is 3 ms^{-2}, then its resultant acceleration will be
a) 5 ms^{-2} b) 4 ms^{-2}
c) 2 ms^{-2} d) 3 ms^{-2}

77. If ω_1 is angular velocity of hour hand of clock and ω_2 is angular velocity of the earth, then the ratio $\omega_1 : \omega_2$ is
a) 1: 2 b) 2: 3
c) 3: 2 d) 2: 1

78. 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

79. A body performing uniform circular motion of radius 'R' has frequency 'n'. It centripetal acceleration is
a) $8\pi^2 nR^2$ b) $4\pi^2 n^2 R$
c) $4\pi^2 n^2 R^2$ d) $8\pi^2 n^2 R^2$

80. Two boys are standing at the ends A and B of a ground where AB = a. The boy at B starts running in a direction perpendicular to AB with velocity v_1.
The boy at A starts running simultaneously with velocity v and catches the other boy in a time t_1 where t is
a) $a/\sqrt{v^2 + v_1^2}$ b) $\sqrt{a^2/(v^2 - v_1^2)}$

c) $a/(v - v_1)$ d) $a/(v + v_1)$

81. A particle starting from rest moves along the circumference of a circle of radius $r = \sqrt{2}$ m with an angular acceleration $\propto = \frac{\pi}{2}$ rad/s^2. The magnitude of its average velocity in the time it completes a quarter rotation, is

a) $\frac{\pi}{2\sqrt{2}}$ m/s b) $\frac{\pi}{2\sqrt{2}}$ m/s

c) $\frac{\pi}{2}$ m/s d) $\frac{2\sqrt{2}}{\pi}$ m/s

82. A body of mass 'm' is tied to one end of a spring and whirled round in a horizontal circle with a constant angular velocity. The elongation in the spring is 1 cm. If the angular velocity is doubled, the elongation in the spring is 5 cm. The original length of the spring is

a) 16 cm b) 14 cm

c) 13 cm d) 15 cm

83. A vehicle moving with 15 km/hr comes to rest by covering 5 m distance after applying brakes. If the same vehicle moves at 45 km/hr then by applying brakes it will come to rest by covering a distance

a) 30 m b) 15 m

c) 60 m d) 45 m

84. A stone is thrown at an angle θ with 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) $\frac{\sqrt{2H\sin\theta}}{g}$

85. A cylindrical vessel partially filled with water is rotated about its vertical central axis. Its surface will

a) rise equally b) rise from the sides

c) rise from the middle d) lowered equally

86. A car is moving with speed 30 ms^{-1} on a circular path of radius 500 m. Its speed is increasing at a rate of 2 ms^{-2}, what is the acceleration of the car?

a) 2 ms^{-2} b) 2.7 ms^{-2}

c) 1.82 ms^{-2} d) 9.82 ms^{-2}

87. Two particles are performing uniform circular motion about a centre of two concentric circles of radii 'r_1' and 'r_2', respectively. The two particles and the centre of circles lie on a straight line during the motion, then the ratio of their angular velocities will be

a) 3: 1 b) 2: 1

c) 0.5: 1 d) 1: 1

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

a) 25 ms^{-2} b) 36 ms^{-2}

c) 5 ms^{-2} d) 15 ms^{-2}

89. A stone of mass 'm' is tied to a string of length 'L' and moved in a vertical circle at the rate of 'n' revolutions per minute. The tension in the string when it is at its lowest point is [g = acceleration due to gravity]

a) $m\left[g + \frac{\pi^2 n^2 L^2}{60}\right]$ b) $m[g + 4\pi^2 L]$

c) $m[g + n^2 L^2]$ d) $m\left[g + \frac{\pi^2 n^2 L}{900}\right]$

90. In U.C.M. when time interval $\delta t \to 0$, the angle between change velocity ($\delta\overline{V}$) and linear velocity ($\overline{V}$) will be

a) 0^0 b) 45^0

c) 90^0 d) 180^0

91. The ratio of angular speeds of minute hand and hour hand of a wall clock is

a) 6:1 b) 1:6

c) 1:12 d) 12:1

92. If mass, speed and radius of the circle of a particle moving uniformly in a circular path are all increased by 50%, the necessary force required to maintain the body moving in the circular path will have to be increased by

a) 225% b) 125%

c) 150% d) 100%

93. A particle is moving on a circular path of 10 m radius. At any instant of time, its speed is 5 ms^{-1} and the speed is increasing at a rate of 2 ms^{-2}. At this instant, the magnitude of the net acceleration will be

a) 3.2 ms^{-2} b) 2 ms^{-2}

c) 2.5 ms^{-2} d) 4.3 ms^{-2}

94. A body covers half of its distance with speed 'u' and the other half with a speed 'v' the average speed of the body is

a) $\frac{2uv}{u+v}$ b) $\frac{v+v}{2uv}$

c) $\frac{u+v}{2}$ d) $\frac{u-v}{2}$

95. A string of length 'l' is fixed at one end and carries a mass 'm' at the other end. The mass is revolving along a horizontal circle of radius 'r' making 'θ' as the semi-vertical angle of cone

and $\left(\frac{1}{\pi}\right)$ revolutions per second around the vertical axis through fixed end. The tension in the string is

a) 2ml b) 8ml
c) 4ml d) 16ml

96. In a non-uniform circular motion, the ratio of tangential to radial acceleration is (where, r = radius of circle, v = speed of the particle and α = angular acceleration)

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

97. A stone is projected vertically upwards with velocity 'V'. Another stone of same mass is projected at an angle of 60^0 with the vertical with the same speed (V). The ratio of their potential energies at the highest points of their journey, is
$[\sin 30^0 = \cos 60^0 = 0.5, \cos 30^0 = \sin 60^0 = \frac{\sqrt{3}}{2}]$

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

98. Galileo writes that for angle 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

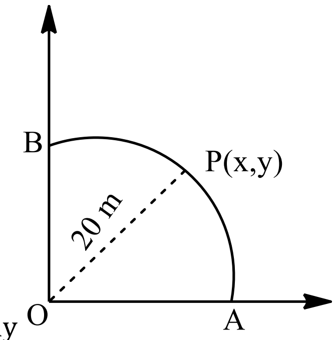
99. Two bodies A and B are projected with same velocity. If bodies A and B are projected at an angle of 30^0 and 60^0 with the horizontal respectively, the ratio of maximum height reached by the body A to that of body B is
$(\sin 30^0 = \cos 60^0 = \frac{1}{2} \sin 60^0 = \cos 30^0 = \frac{\sqrt{3}}{2})$

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

100. A wheel completes 2000 revolutions to cover the distance of 9.42 km. The diameter of this wheel is $\pi = 3.14$

a) 1 cm b) 1 m
c) 1.5 cm d) 1.5 m

101. 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 metre and t is in second. The radius of the path is 20 m. The acceleration of P when t = 2 s is



nearly

a) 13 ms^{-2} b) 12ms^{-2}
c) 7.2 ms^{-2} d) 14 ms^{-2}

102. A particle is performing uniform circular motion. If '0', 'ω', 'α' and 'a' are its angular displacement, angular velocity, angular acceleration and centripetal respectively, then which of the following is 'WRONG'?

a) $\bar{\omega} \perp \bar{v}$ b) $\bar{v} \perp \bar{a}$
c) $\bar{\omega} \perp \bar{\alpha}$ d) $\bar{\omega} \perp \bar{a}$

103. Angular velocity of hour hand of a watch is

a) $\frac{\pi}{43200}$ rad s^{-1} b) $\frac{\pi}{30}$ rad s^{-1}
c) $\frac{\pi}{21600}$ rad s^{-1} d) $\frac{\pi}{1800}$ rad s^{-1}

104. Velocity and acceleration of a particle at some instant of time are $v = (3\hat{i} + 4\hat{j})ms^{-1}$ and $a = -(6\hat{i} + 8\hat{j})ms^{-2}$, respectively. At the same instant, particle is at origin. Maximum x-coordinate of particle will be

a) 1.5 m b) 0.75 m
c) 2.25 m d) 4 m

105. A projectile is thrown with an initial velocity $(a\hat{i} + b\hat{j})$ m/s, where $\hat{i}$ and $\hat{j}$ are unit vectors along horizontal and vertical directions respectively. If the range of the projectile is twice the maximum height reached by it, then

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

106. 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 and 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

107. Two bodies 'A' and 'B' start from the same point at the same instant and move along a straight line. 'A' moves with uniform acceleration (a) and 'B' moves with uniform velocity (V). They meet after time 't'. The value of 't' is

a) $\frac{2V}{a}$　　b) $\sqrt{\frac{V}{a}}$

c) $\frac{a}{2V}$　　d) $\frac{V}{2a}$

108. A particle is projected horizontally with speed $20\ ms^{-1}$ from the top of a tower. After what time velocity of particle will be at $45°$ angle from initial direction of projection?

a) 1 s　　b) 2 s

c) 3 s　　d) 4 s

109. A car travelling at a speed 'U' m/s, stops within a distance 'S', when the brakes are applied. If the car is travelling at '2U' m/s then the stopping distance

a) More than 'S'　　b) Less than 'S'

c) Equal to 'S'　　d) Zero

110. Match the following columns and choose the correct option from the codes given below.

For uniform circular motion,

Column I	Column II
A. Speed	1. Constant
B. Velocity	2. Variable
C. Magnitude of acceleration	3. Zero
D. Acceleration	

a) A-1, B-2, C-2, D-1　　b) A-1, B-2, C-1, D-2

c) A-1, B-1, C-1, D-2　　d) A-2, B-1, C-1, D-2

111. A projectile can have same range from two angles of projection with same initial speed. If h_1 and h_2 be the maximum heights, then

a) $R = \sqrt{h_1 h_2}$　　b) $R = \sqrt{2 h_1 h_2}$

c) $R = 2\sqrt{h_1 h_2}$　　d) $R = 4\sqrt{h_1 h_2}$

112. Two cars of mass 'm_1' and 'm_2' are moving in the circles of radii 'r_1' and 'r_2' respectively. Their angular speed 'ω_1' and 'ω_2' are such that they both complete one revolution in the same time 't'. The ratio of linear speed of 'm_1' to the linear speed of 'm_2' is

a) $\omega_1^2 : \omega_2^2$　　b) $T_1^2 : T_2^2$

c) $r_1 : r_2$　　d) $m_1 : m_2$

113. A projectile, thrown with velocity v_0 at an angle α to the horizontal, has a range R. It will strike a vertical wall at a distance R/2 from the point of projection with a speed of

a) v_0　　b) $v_0 \sin\alpha$

c) $v_0 \cos\alpha$　　d) $\sqrt{\frac{gR}{2}}$

114. The angular displacement of body performing circular motion is given by $\theta = 5\sin\frac{\pi t}{6}$. The angular velocity of the body at $t = 3$ second will be $[\sin\frac{\pi}{2} = 1, \cos\pi/2 = 0]$

a) $5\frac{rad}{s}$　　b) $1\frac{rad}{s}$

c) $2.5\frac{rad}{s}$　　d) zero $\frac{rad}{s}$

115. The speed of boat is $5\ kmh^{-1}$ in still water. It crosses a river of width 1 km along the shortest possible path in 15 min. Then, velocity of river will be

a) $4.5\ kmh^{-1}$　　b) $4\ kmh^{-1}$

c) $15\ kmh^{-1}$　　d) $3\ kmh^{-1}$

116. If the initial velocity of a projection be doubled, keeping the angle of projection same, the maximum height reached by it will

a) remain the same　　b) be doubled

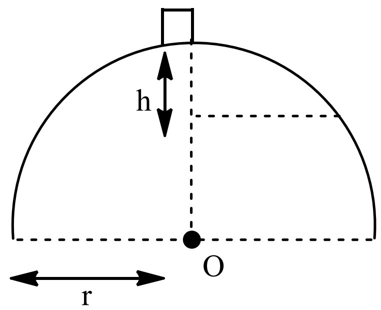
c) become four times　　d) be halved

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

a) 1.5 km　　b) 3 km

c) 6 km　　d) 0.75 km

118. A small body of mass m slides without friction from the top of a hemispherical cup of radius r as shown in figure. If it leaves the surface to the cup at vertical distance h below the highest point, then



a) $h = r$　　b) $h = r/2$

c) $h = r/3$　　d) $2r/3$

119. At any instant, for a body performing uniform circular motion, velocity vector and acceleration vector are

a) In opposite direction
b) Along the same direction
c) Normal to each other
d) Make an angle of 45^0 with each other

120. A body of mass 'm' is moving with speed 'V' along a circular path of radius 'r'. Now, the speed is reduced to $\frac{V}{2}$ and radius in increased to '3r'. For this change, initial centripetal force needs to be
a) Increased by $\frac{7}{12}$ times
b) Increased by $\frac{10}{12}$ times
c) Decreased by $\frac{11}{12}$ times
d) Decreased by $\frac{1}{12}$ times

121. A particle is moving in uniform circular motion with speed 'V' and radius 'R'. The angular acceleration of the particle is
a) $\frac{V^2}{R}$ along tangent to the circle
b) Zero
c) $\frac{V^2}{R}$ along the radius towards the centre of the circle
d) $\frac{V^2}{R}$ perpendicular to the plane of the circle

122. A stone of mass 3 kg attached at one end of a 2m long string is whirled in horizontal circle. The string makes an angle of 45^0 with the vertical then the centripetal force acting on the string is $(g = 10\ m/s^2, \tan 45^0 = 1)$
a) 20 N
b) 30 N
c) 10 N
d) 40 N

123. The rowing speed of a man relative to water is $5\ kmh^{-1}$ and the speed of water flow is $3\ kmh^{-1}$. At what angle to the river flow should he head if he wants to reach a point on the other bank, directly opposite to starting point?
a) 127°
b) 143°
c) 120°
d) 150°

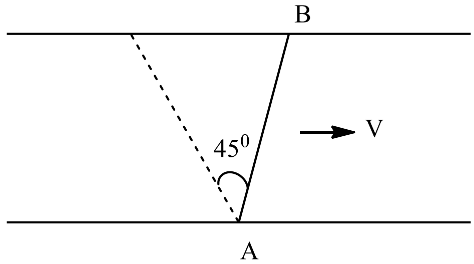
124. A student is throwing balls vertically upwards such that he throws the 2nd ball when the 1st ball reaches maximum height. If he throws balls at an interval of 3 second, the maximum height of the ball is $(g = 10\ m/s^2)$
a) 45 m
b) 35 m
c) 25 m
d) 30 m

125. A bomb is dropped by an aero-plane flying horizontally with a velocity 200 km/hr and at an height of 980 m. At the time of dropping a bomb, the distance of the aeroplane from the target on the ground to hit directly is $(g = 9.8\ m/s^2)$
a) $\frac{\sqrt{2} \times 10^4}{9}$ m
b) $\frac{10^4}{9}$ m
c) $\frac{10^4}{9\sqrt{2}}$ m
d) $\frac{10^4}{18}$ m

126. Two balls A and B are projected at an angle of 45^0 and 60^0 respectively so that the maximum heights reached are same for both. The ratio of initial velocity of projection of the ball A to that for ball B is $\left(\sin 45^0 = \cos 45^0 = \frac{1}{\sqrt{2}}, \sin 60^0 = \cos 30^0 = \frac{\sqrt{3}}{2}\right)$
a) $2:\sqrt{3}$
b) $\sqrt{3}:\sqrt{2}$
c) $\sqrt{2}:\sqrt{3}$
d) $\sqrt{3}:2$

127. Two bodies A and B move in same straight line starting from the same position. Body A moves with constant velocity 'u' and B moves with constant acceleration 'a'. When their velocities become equal, the distance between them is
a) $2au^2$
b) $\frac{u^2}{2a}$
c) $\frac{u^2}{3a}$
d) $\frac{2u^2}{a}$

128. A man wants to reach point B on the opposite bank of a river flowing at a speed as shown in figure. With what minimum speed and in which direction should the man swim relative to water, so that he can reach point B ?



a) u, 45° North-West
b) u, 45° North-East
c) $\frac{u}{\sqrt{2}}$, 45° North-West
d) $\frac{u}{\sqrt{2}}$, 45° North-East

129. 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 25 N. What is the maximum speed with which ball can be moved?
a) $14\ ms^{-1}$
b) $3\ ms^{-1}$
c) $3.92\ ms^{-1}$
d) $5\ ms^{-1}$

130. A particle suspended by a light inextensible thread of length / is projected horizontally from its lowest position with velocity $\sqrt{7gl/2}$. The string will slack after swinging through an angle equal to

a) 30° b) 90°
c) 120° d) 150°

131. The equation of projectile is $y = \sqrt{3}x - \frac{g}{2}x^2$, the angle of its projection is
a) 90° b) Zero
c) 60° d) 30°

132. The position vector of an object at any time t is given by $3t^2\hat{i} + 6t\hat{j} + \hat{k}$. Its velocity along Y-axis has the magnitude
a) 6t b) 6
c) 0 d) 9

133. The motor of an engine is rotating about its axis with an angular velocity of 100revm^{-1}. It comes to rest in 15 s, after being switched OFF. Assuming, constant angular deceleration. What are the numbers of revolutions made by it before coming to rest?
a) 12.5 b) 40
c) 32.6 d) 15.6

134. A particle moves through angular displacement θ on a circular path of radius r. The linear displacement will be
a) 2 r sin (θ /2) b) 2 r cos (θ /2)
c) 2 r tan (θ / 2) d) 2 r cot (θ /2)

135. An aeroplane is flying at a constant height of 1960 m with speed 600 kmh^{-1} above the ground towards point directly over a person struggling in flood water. At what angle of sight with the vertical should the pilot release a survival kit, if it is to reach the person in water? (Take, $g = 9.8 \text{ms}^{-2}$)
a) 45° b) 30°
c) 60° d) 90°

136. 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) 4737.4 ms^{-2}
c) 2370 ms^{-2} d) 5055 ms^{-2}

137. A ball of mass 'm' is attached to the free end of an inextensible string of length 'l'. Let 'T' be the tension in the string. The ball is moving in horizontal circular path about the vertical axis. The angular velocity of the ball at any particular instant will be
a) $\sqrt{\frac{Tm}{l}}$ b) $\sqrt{\frac{Tl}{m}}$
c) $\sqrt{\frac{T}{ml}}$ d) $\sqrt{\frac{ml}{T}}$

138. A train is moving towards East and a car is along North, both with same speed. The observed direction of car to the passenger in the train is
a) East-North direction b) West-North direction
c) South-East direction d) None of these

139. The real force F acting on a particle of mass m performing circular motion acts along the radius of circle r and is directed towards the centre of circle. The square root of magnitude of such force is (T = periodic time)
a) $\frac{2\pi}{T}\sqrt{mr}$ b) $\frac{Tmr}{4\pi}$
c) $\frac{2\pi T}{\sqrt{mr}}$ d) $\frac{T^2mr}{4\pi}$

140. A ball is moving in a circular path of radius 5 m. If tangential acceleration at any instant is 10 ms^{-2} and the net acceleration makes an angle 30° with the centripetal acceleration, then the instantaneous speed is
a) $50\sqrt{3} \text{ ms}^{-1}$ b) 9.3ms^{-1}
c) 6.6 ms^{-1} d) 5.4 ms^{-1}

141. A shell fired at an angle of 30^0 to the horizontal with velocity 196 m/s. The time of flight is $[\sin 30^0 = \frac{1}{2} = \cos 60^0]$
a) 10 s b) 20 s
c) 6.5 s d) 16.5 s

142. A particle moves along a circle of radius r with constant tangential acceleration. If the velocity of the particle is v at the end of second revolution, after the revolution has started, then the tangential
a) $\frac{v^2}{8\pi r}$ b) $\frac{v^2}{6\pi r}$
c) $\frac{v^2}{4\pi r}$ d) $\frac{v^2}{2\pi r}$

143. A car is travelling with linear velocity v on a circular road of radius R. If its speed is increasing at the rate of $a \text{ ms}^{-2}$, then the net acceleration will be
a) $\frac{v^2}{R} + a$ b) $\frac{V^2}{R} - a$
c) $\sqrt{\left(\frac{v^2}{R}\right)^2 + a^2}$ d) $\sqrt{\left(\frac{v^2}{R}\right)^2 - a^2}$

144. A football player throws a ball with a velocity of 50 ms^{-1} at an angle 30° from the horizontal. The ball remains in the air for (Take, $g = 10 \text{ ms}^{-2}$)
a) 2.5 s b) 1.25 s
c) 5 s d) 0.625 s

145. A mass 'm' is tied to one end of a spring and whirled in a horizontal circle with constant angular velocity. The elongation in the spring is 1 cm. if the angular speed is doubled, the elongation in the spring is 6 cm. The original length of the spring is
a) 3 cm b) 12 cm
c) 6 cm d) 9 cm

146. A 100 m long train crosses a man travelling at 5kmh^{-1}, in opposite direction, in 7.2 s, then the velocity of train is
a) 40 ms^{-1} b) 25 ms^{-1}
c) 20 ms^{-1} d) 45 ms^{-1}

147. A projectile is thrown upward with a velocity v_0 at an angle α to the horizontal. The change in velocity of the projectile when it strikes the same horizontal plane is
a) $v_0 \sin\alpha$ vertically dov b) $2v_0 \sin\alpha$ vertically d
c) $2v_0 \sin\alpha$ vertically u d) Zero

148. The angular speed of the minute hand of a clock in degrees per second is
a) 0.1 b) 0.4
c) 0.3 d) 0.2

149. A particle is performing a uniform circular motion along the circumference of a circle of radius 'R' and 'T' is the periodic time. In the time 'T/4' its displacement and distance covered are respectively
a) $\sqrt{2}R, \frac{\pi R}{4}$ b) $\frac{\pi R}{2}, \sqrt{2}R$
c) $\sqrt{2}R, \pi R$ d) $\sqrt{2}R, \frac{\pi R}{2}$

150. A projectile is thrown with a velocity of 10 ms^{-1} at an angle of 60° with horizontal. The interval between the moments when speed is $\sqrt{5g}$ m/s is (Take, $g = 10 \text{ ms}^{-1}$)
a) 1 s b) 3 s
c) 2 s d) 4 s

151. If two balls are projected at angles 45° and 60° and the maximum heights reached are same, what is the ratio of their initial velocities?
a) $\sqrt{2} : \sqrt{3}$ b) $\sqrt{3} : \sqrt{2}$
c) 3 : 2 d) 2 : 3

152. The maximum range of a gun on horizontal terrain is 1 km. If $g = 10 \text{ ms}^{-2}$, what must be the muzzle velocity of the shell?
a) 400 ms^{-1} b) 200 ms^{-1}
c) 100 ms^{-1} d) 50 ms^{-1}

153. A body is just revolved in a vertical circle of radius 'R'. When the body is at highest point, the string breaks. The horizontal distance covered by the body after the string breaks is
a) R b) 4R
c) 2R d) 3R

154. Two bodies are held separated by 9.8 m vertically one above the other. They are released simultaneously to fall freely under gravity. After 2 s, the relative distance between them is
a) 4.9 m b) 19.6 m
c) 9.8 m d) 39.2 m

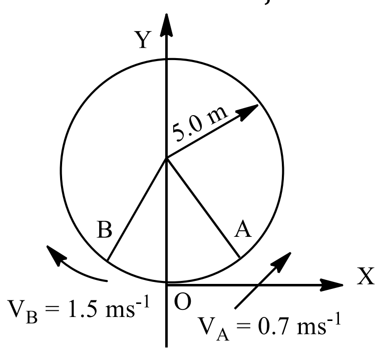
155. A body at rest falls through a height 'h' with velocity 'V'. If it has a fall down further for its velocity to become three times, the distance travelled in that interval is
a) 8 h b) 6 h
c) 4 h d) 12 h

156. A car A moves along North with velocity 30 km/h and another car B moves along East with velocity 40 km/h. The relative velocity of A with respect to B is
a) 50 km/h North -East b) 50 km/h North -west
c) 50 km/h at angle $\tan^{-1}(3/4)$ North of West d) 50 km/h at angle $\tan^{-1}(4/3)$ West of North

157. A moving body is covering distances which are proportional to square of the time. Then the acceleration of the body is
a) Constant but not zero b) Increasing
c) Zero d) Decreasing

158. The angular velocity of the minute hand of a clock in degrees per second is
a) 0.6 b) 0.1
c) 0.24 d) 0.12

159. Two particles A and B start at the origin O and travel in opposite directions along the circular path at constant speeds $v_A = 0.7 \text{ ms}^{-1}$ and $v_B = 1.5 \text{ ms}^{-1}$, respectively. Determine the time when they collide and the magnitude of the acceleration of B just before this happens.



a) 14.3s, 0.45 ms^{-2} b) 12.6s, 0.25 ms^{-2}
c) 11.2s, 1 ms^{-2} d) 10.9s, 2 ms^{-2}

160. A particle moves along the positive branch of the curve $y = \frac{x^2}{2}$, where $x = \frac{t^2}{2}$. Here, x and y are measured in metres and t in second.
At $t = 2$ s, the velocity of the particle is
a) $(2\hat{i} - 4\hat{j})ms^{-1}$ b) $(4\hat{i} + 2\hat{j})ms^{-1}$
c) $(2\hat{i} + 4\hat{j})ms^{-1}$ d) $(4\hat{i} - 2\hat{j})ms^{-1}$

161. A body of mass 'm' is moving along a circle of radius 'r' with linear speed 'v'. Now, to change the linear speed to $\frac{v}{2}$ and to move it along the circle of radius '4r', required change in the centripetal force of the body is
a) Decrease by 15/16 b) Decrease by 5/16
c) Increase by 9/16 d) Increase by 11/16

162. A particle's velocity changes from $(2\hat{i} + 3\hat{j})ms^{-1}$ to $(2\hat{i} - 3\hat{j})ms^{-1}$ in 2 s. The acceleration in ms^{-2} is
a) $-(\hat{i} + 5\hat{j})$ b) $(\hat{i} + 5\hat{j})/2$
c) zero d) $(-3\hat{j})$

163. A mass of 2 kg is whirled in a horizontal circle by means of a string at an initial speed of 5 rev min^{-1}. Keeping the radius constant the tension in the string is doubled. The new speed is nearly
a) $\frac{5}{\sqrt{2}}$ rpm b) 10 rpm
c) $10\sqrt{2}$ rpm d) $5\sqrt{2}$ rpm

164. A driver applies the brakes on seeing the red traffic signal 400 m ahead. At the time of applying the brakes, the vehicle was moving with 15 m/s and retarding at 0.3 m/s^2. The distance covered by the vehicle from the traffic light 1 minute after the application of brakes is
a) 25 m b) 360 m
c) 40 m d) 375 m

N.B.Navale

Date : 28.03.2025
Time : 02:27:36
Marks : 164

TEST ID: 38
PHYSICS

MOTION IN A PLANE

: ANSWER KEY :

1)	a	2)	c	3)	b	4)	c
5)	b	6)	d	7)	d	8)	b
9)	c	10)	a	11)	a	12)	a
13)	a	14)	c	15)	a	16)	a
17)	d	18)	d	19)	c	20)	d
21)	b	22)	d	23)	c	24)	a
25)	b	26)	b	27)	d	28)	b
29)	d	30)	a	31)	d	32)	c
33)	b	34)	b	35)	c	36)	c
37)	b	38)	a	39)	d	40)	a
41)	c	42)	d	43)	c	44)	c
45)	c	46)	b	47)	c	48)	a
49)	b	50)	b	51)	a	52)	a
53)	c	54)	b	55)	d	56)	d
57)	c	58)	d	59)	c	60)	a
61)	b	62)	b	63)	b	64)	a
65)	d	66)	b	67)	b	68)	b
69)	b	70)	c	71)	d	72)	d
73)	c	74)	a	75)	b	76)	a
77)	d	78)	c	79)	b	80)	b
81)	a	82)	d	83)	d	84)	b
85)	b	86)	b	87)	d	88)	c
89)	d	90)	c	91)	d	92)	b
93)	a	94)	a	95)	c	96)	c
97)	b	98)	c	99)	d	100)	d
101)	d	102)	c	103)	c	104)	b
105)	a	106)	c	107)	a	108)	b
109)	a	110)	b	111)	d	112)	c
113)	c	114)	d	115)	d	116)	c
117)	b	118)	c	119)	c	120)	c
121)	b	122)	a	123)	a	124)	a
125)	c	126)	b	127)	b	128)	c
129)	a	130)	c	131)	c	132)	b
133)	a	134)	a	135)	c	136)	b
137)	c	138)	b	139)	a	140)	b
141)	b	142)	a	143)	c	144)	c
145)	d	146)	d	147)	b	148)	a
149)	d	150)	c	151)	b	152)	c
153)	c	154)	c	155)	a	156)	c
157)	a	158)	b	159)	a	160)	c
161)	a	162)	d	163)	d	164)	c

N.B.Navale

Date : 28.03.2025 **TEST ID: 38**
Time : 02:27:36 **PHYSICS**
Marks : 164

MOTION IN A PLANE

: HINTS AND SOLUTIONS :

Single Correct Answer Type

1 **(a)**
The particle hits the horizontal plane again at time,

$$T = \frac{2u\sin\theta}{g} = \frac{40 \times \sin 60^\circ}{9.8} = 3.53 \text{ s}$$

2 **(c)**
The velocity of the body at the highest point is given by

$$V = \sqrt{gR}$$

After the string breaks, it will fall under gravity with initial horizontal velocity $V = \sqrt{gR}$. Its initial velocity is vertical direction is zero.

If it falls through a height h, in time t, then

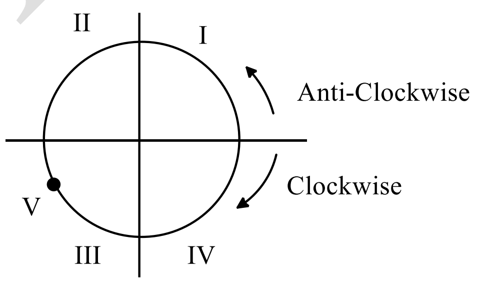
$$h = \frac{1}{2}gt^2 \text{ or } t = \sqrt{\frac{2h}{g}}$$

in horizontal direction its velocity will remain constant equal to V.

Distance covered in horizontal direction is $x = Vt = \sqrt{gR} \times \sqrt{\frac{2h}{g}} = \sqrt{2hR}$

If $h = 2R$, then $x = \sqrt{4R^2} = 2R$

3 **(b)**
The figure shows a circular path of a moving particle. At any instant, velocity of particle,



$V = -3\,\hat{i} - 4\,\hat{j} = (-3, -4)$ (in coordinate form)

The coordinates of velocity show that particle is in 3rd quadrant at that instant. While moving anti-clockwise particle will enter into 4th quadrant and then into 3rd and while moving clockwise particle will enter into 2nd quadrant and then into 3rd quadrant.
$\therefore$ 2nd and 4 th quadrants, respectively.

4 **(c)**
frequency $f = \frac{x}{t}, \omega = 2\pi f = \frac{2\pi x}{t}$

tangential velocity $V = \omega r = \frac{2\pi x}{t} . \frac{\pi}{2} = \frac{\pi^2 x}{t}$

5 **(b)**
$d = 50$ cm

$\therefore r = 25 \times 10^{-2}\text{m}, f = 2$ Hz

$$a = \frac{v^2}{r} = \frac{r^2\omega^2}{r} = r\omega^2 = 4\pi^2 f^2 r$$
$$= 4\pi^2 \times 4 \times 25 \times 10^{-2} = 4\pi^2$$

6 **(d)**
Radial force $= \frac{mv^2}{r} = \frac{m}{r}\left(\frac{p}{m}\right)^2 = \frac{p^2}{mr}$

7 **(d)**
For mass m, radius = r, velocity = nV

For mass 3m, radius $=\frac{r}{3}$, velocity = V

Centripetal force is same for both

$$\therefore \frac{m(nV)^2}{r} = \frac{3mV^2}{\frac{r}{3}}$$

$$\therefore \frac{mn^2V^2}{r} = \frac{9mV^2}{r}$$

$\therefore n^2 = 9$

$n = 3$

8 **(b)**

Maximum height

$$H=\frac{u_1^2\sin^2\theta_1}{2g}=\frac{u_2^2\sin^2\theta_2}{2g}$$

$$\therefore u_1\sin\theta_1=u_2\sin\theta_2$$

$$\therefore \frac{u_1}{u_2}=\frac{\sin\theta_2}{\sin\theta_1}=\frac{\sin 60^0}{\sin 45^0}=\frac{\sqrt{3}}{2}\times\frac{\sqrt{2}}{1}=\sqrt{3/2}$$

9 **(c)**
H and R both are proportional to u^2. Hence, percentage increase in horizontal range will also be 10%.

10 **(a)**
Since direction of velocity is changing, velocity and momentum are not constant. The direction of acceleration also changes. Hence only kinetic energy is constant.

11 **(a)**
Positions of the particle are

$$r_1=6\hat{i}+8\hat{j} \text{ and } r_2=12\hat{i}+10\hat{j}$$
$$\therefore\ \Delta r=r_2-r_1=6\hat{i}+2\hat{j}\Rightarrow|\Delta r|=\sqrt{40}$$
$$\theta=\tan^{-1}\left(\frac{\Delta y}{\Delta x}\right)=\tan^{-1}\left(\frac{1}{3}\right)=18.43^\circ$$

12 **(a)**
$F=\frac{mv^2}{r}$. If m and v are constants, then $F\propto\frac{1}{r}$.
$\therefore\ \frac{F_1}{F_2}=\left(\frac{r_2}{r_1}\right)$

13 **(a)**
Let the velocity of the particle be v.
The kinetic energy possessed by the particle in uniform circular motion,
$E=\frac{1}{2}mv^2$
$v^2=\frac{2E}{m}$
The acceleration of the particle in circular motion,
$a=\frac{v^2}{r}=\frac{2E/m}{r}\Rightarrow a=\frac{2E}{mr}$

14 **(c)**
Initial velocity = u

At the highest point its vertical component becomes zero and has only the horizontal component $u\cos\theta$

$$\therefore u\cos\theta=\frac{u}{2}$$

$$\therefore \cos\theta=\frac{1}{2}$$

$$\therefore \theta=60^0$$

The maximum height is given by

$$H=\frac{u^2\sin^2 60}{2g}$$

$$=\frac{3u^2}{8g}\quad\left(\because \sin 60^0=\frac{\sqrt{3}}{2}\right)$$

15 **(a)**
Maximum height, $H=\frac{u^2\sin^2\theta}{2g}$ and time of flight, $T=\frac{2u\sin\theta}{g}$

So, $\frac{H}{T^2}=\frac{u^2\sin^2\theta/2g}{4u^2\sin^2\theta/g^2}=\frac{g}{8}=\frac{5}{4}$

16 **(a)**
Angular speed of minute hand

$$\omega_1=\frac{2\pi}{3600}=\frac{\pi}{1800}\text{rad/s}$$

Angular speed of hour hand

$$\omega_2=\frac{2\pi}{12\times3600}\text{ rad/s}$$

$$\therefore \omega_1-\omega_2=\frac{\pi}{1800}-\frac{\pi}{12\times1800}=\frac{(12-1)\pi}{12\times1800}$$
$$=\frac{(11)\pi}{21600}\text{ rad/s}$$

17 **(d)**

$$\text{Centripetal force}=\frac{mV_1^2}{r}=\frac{3mV_2^2}{\frac{r}{3}}$$

$$\frac{V_1^2}{V_2^2}=9\ \therefore\frac{V_1^2}{V_2^2}=3$$

18 **(d)**

$$\because\ \frac{R}{H}=\frac{\frac{u^2\sin2\theta}{g}}{\frac{u^2\sin^2\theta}{2g}}=\frac{2\sin\theta\cos\theta}{g}\times\frac{2g}{\sin^2\theta}=4\cot\theta$$

$\Rightarrow R=4H\cot\theta$, if $\theta=45^\circ$ then R
$=4H\cot(45^\circ)=4H$
Hence, the horizontal range of the particle is equal to four times the vertical height.

19 **(c)**

$$\omega=\frac{\theta}{t}=\frac{2\pi^c}{12\times3600}=\frac{1}{12\times10}=\frac{1}{120}\text{deg/sec}$$

20 **(d)**
From third equation of angular motion,

$\omega^2 = \omega_0^2 - 2\alpha\theta \left[\text{Here, } \omega = \dfrac{\omega_0}{2}, \theta = 36 \times 2\pi\right]$

$\therefore \left(\dfrac{\omega_0}{2}\right)^2 = \omega_0^2 - 2\alpha \times 36 \times 2\pi$

or $4 \times 36\pi\alpha = \frac{3\omega_0^2}{4}$ or $\alpha = \frac{\omega_0^2}{16 \times 12\pi}$ ...(i)

According to the question again applying the third equation of angular motion

$\omega^2 = \omega_0^2 - 2\pi\theta$ [Here, ω=0]

$\therefore 0 = \left(\dfrac{\omega_0}{2}\right)^2 - 2 \times \dfrac{\omega_0^2 \cdot \theta}{16 \times 12\pi}$

or $\theta = 24\pi$

or $\theta = 12 \times 2\pi$

But $2\pi = 1$ cycle

So, $n = 12$ cycle

21 **(b)**

$v_r = 10 + 15 = 25\ ms^{-1}$

where, v_r is relative velocity.

$\therefore t = \dfrac{50 + 50}{25} = 4\ s$

22 **(d)**

Angular velocity $= \dfrac{\text{angle discribed}}{\text{time taken}} = \dfrac{360^0}{3600s} = 0.1^0/s$

23 **(c)**

$\tan 60° = \frac{v_H}{v_v}$ or $\sqrt{3} = \frac{12}{v_v}$

$\therefore v_V = 4\sqrt{3} kmh^{-1}$

24 **(a)**

$F = 150 \times 10^3 N, M = 25 \times 10^3\ kg, V = 60 \dfrac{m}{s}, u = 0$

Acceleration, $a = \dfrac{F}{M} = \dfrac{150 \times 10^3}{25 \times 10^3} = 6 \dfrac{m}{s^2}$

$v^2 = u^2 + 2as = 2as \ \ (\because u = 0)$

$\therefore s = \dfrac{v^2}{2a} = \dfrac{60 \times 60}{2 \times 6} = 300\ m$

25 **(b)**

The magnitude of displacement is given by the straight line joining the starting point to end point. Hence displacement = 2R

The distance covered is the length of the actual path, which is half the circumference. Hence distance covered= πR

26 **(b)**

$\theta = 45°, R_{max} = \dfrac{u^2}{g} = 80$

$\therefore \ u^2 = 800\ ms^{-2}$

Now, $H = \frac{u^2 \sin^2 45°}{2g}$

$= \dfrac{(800)(1/2)}{20} = 20\ m$

27 **(d)**

The initial velocity of aeroplane is horizontal. Hence, the vertical component of velocity of packet will be zero.

$\therefore h = \frac{1}{2} g t^2$

$\Rightarrow \quad t = \sqrt{\dfrac{2h}{g}}$

28 **(b)**

$y = \sqrt{3}x - \dfrac{9x^2}{2}$

The standard equation of trajectory is

$y = (\tan\theta) \times -\dfrac{1}{2}\left(\dfrac{g}{u^2\cos^2\theta}\right)x^2$

Comparing the given equation we get

$\tan\theta = \sqrt{3}$

$\therefore \theta = 60^0$

Also, $\dfrac{g}{2} = \dfrac{g}{2u^2\cos^2\theta}$

$\therefore u^2\cos^2\theta = 1$

$\therefore u^2\cos^2 60^0 = 1$ or $u^2 \times \dfrac{1}{4} = 1$

$\therefore u^2 = 4$

$\therefore u = 2\ m/s$

29 **(d)**

Maximum height, $H = \frac{u^2\sin^2\alpha}{2g}$

$\Rightarrow H \propto \sin^2\alpha$

$\therefore \dfrac{H_1}{H_2} = \dfrac{\sin^2\alpha}{\sin^2(90° - \alpha)} = \tan^2\alpha$

30 **(a)**

The horizontal component of the tension, $T\sin\theta$ provides the centripetal force.

$\therefore T\sin\theta = mr\omega^2$

$r = l \sin\theta$

$\therefore T\sin\theta = m\omega^2 l \sin\theta$

$\therefore T = m\omega^2 l$

$\omega = 2\pi f = 2\pi \frac{3}{\pi} = 6$

$\therefore \omega^2 = 36$

$\therefore T = 36\ ml$

31 **(d)**
Given at maximum height

$u\cos\theta = \frac{1}{2}u$

$\Rightarrow \cos\theta = \frac{1}{2}$

$\therefore \theta = 60°$

$\therefore H = \frac{u^2\sin^2\theta}{2a} = \frac{u^2\sin^2 60°}{2a} = \frac{3u^2}{8g}$

32 **(c)**

$\omega_h = \frac{2\pi}{12\times 60}, \omega_m = \frac{2\pi}{60}$

$\therefore \omega_h : \omega_m = 1:12$

33 **(b)**
Maximum tension in the thread is given by

$T_{max} = mg + \frac{mv^2}{r} = mg + mr\omega^2 \quad (\because v = r\omega)$

or $\omega^2 = \frac{T_{max} - mg}{mr}$

$\therefore \quad \omega^2 = \frac{37 - 0.5\times 10}{0.5\times 4} = \frac{37-5}{2}$ or $\omega^2 = 16$

or Maximum angular velocity, $\omega = 4\ \text{rad s}^{-1}$

34 **(b)**
Distance covered in first 3 seconds is given by

$y = \frac{1}{2}gt^2 = \frac{1}{2}\times 10\times (3)^2 = 45\ m$

Distance covered in nth second is given by

$S_{n^{th}} = g\left(n - \frac{1}{2}\right)$

$\therefore 45 = 10\left(n - \frac{1}{2}\right)$

$\therefore 4.5 = n - \frac{1}{2}$

$\therefore n = 5$

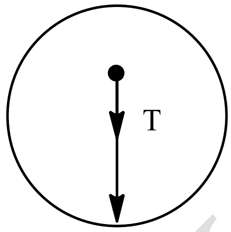
$\therefore$ Total time = 5 sec

$\therefore h = \frac{1}{2}gt^2 = \frac{1}{2}\times 10\times (5)^2 = 5\times 25 = 125\ m$

35 **(c)**
We know that, $\omega = 2\pi n$

$\therefore \quad \omega_1 = 2\pi n_1$

where, $n_1 = 1800$ rpm, $n_2 = 3000$ rpm and $\Delta t = 20$ s.



$\omega_1 = 2\pi\times\frac{1800}{60} = 2\pi\times 30 = 60\pi$

Similarly, $\omega_2 = 2\pi n_2 = 2\pi\times\frac{3000}{60}$

$= 2\pi\times 50 = 100\pi$

$\therefore \alpha = \frac{\text{Change in angular velocity}}{\text{Time interval}}$

$\alpha = \frac{\omega_2 - \omega_1}{\Delta t} = \frac{100\pi - 60\pi}{20}$

$= \frac{40\pi}{20} = 2\pi\ \text{rad s}^{-2}$

36 **(c)**

$u = 15\frac{km}{hr} = \frac{15\times 1000}{60\times 60} = \frac{150}{36}\ m/s$

$v^2 = u^2 - 2as$

$\therefore a = \frac{u^2}{2s} = \frac{150\times 150}{36\times 36\times 2\times 5}\ m/s^2$

Next $s = \frac{u^2}{2a} = \frac{45000}{60\times 60}\times\frac{45000}{60\times 60}\times\frac{1}{2}\times\frac{36\times 36}{150\times 15}$
$= 45\ m$

37 **(b)**
Range of projectile launched at an angle θ is same as the range of projectile launched at angle 2θ.

$\Rightarrow \quad \frac{u^2\sin 2(2\theta)}{g} = \frac{u^2\sin 2\theta}{g}$

$\Rightarrow \ \sin 2(2\theta) = \sin 2\theta$

$\Rightarrow \ 2\sin 2\theta\cos 2\theta = 2\sin\theta\cos\theta$

$\Rightarrow\ 4\sin\theta\cos\theta\cos 2\theta = 2\sin\theta\cos\theta$

$\Rightarrow\ 4\cos 2\theta = 2 \Rightarrow \cos 2\theta = \frac{1}{2}$

$\Rightarrow\ \cos 2\theta = \cos 60^\circ$

$\Rightarrow\ 2\theta = 60^\circ$

$\Rightarrow \theta = 30^\circ$

38 **(a)**

Given, $x = ct^2$

$\therefore\ v_x = \frac{dx}{dt} = 2ct$

Also, $y = bt^2$

$\therefore\ v_y = \frac{dy}{dt} = 2bt$

$\therefore\ v = \sqrt{v_x^2 + v_y^2} = 2t\sqrt{c^2 + b^2}$

39 **(d)**

Given, diameter of circle, $d = 50\text{ cm} = 50 \times 10^{-2}\text{ m}$ and frequency, $f = 2\text{ Hz}$

The acceleration of particle in a uniform circular motion (UCM) can be given as, $a = \omega^2 x$

Where, $\omega =$ angular frequency $= 2\pi f$

$x =$ distance from centre $= \frac{d}{2}$

$\Rightarrow\ a = 4\pi^2 f^2 \times \frac{d}{2}$ ...(i)

Substituting given values in Eq. (i), we get

$a = 4\pi^2 \times 4 \times \frac{50 \times 10^{-2}}{2} = 4\pi^2\text{ m/s}^2$

40 **(a)**

Angular acceleration, $\alpha = \frac{\omega}{t} = \frac{\omega v}{vt}$ and $\alpha = \frac{\omega a}{v}$.

41 **(c)**

Given range, $R = 4\sqrt{3}H$

$\Rightarrow \frac{2u^2\sin\theta\cos\theta}{g} = 4\sqrt{3}\left(\frac{u^2\sin^2\theta}{2g}\right)$

$\Rightarrow\ \tan\theta = \frac{1}{\sqrt{3}}$

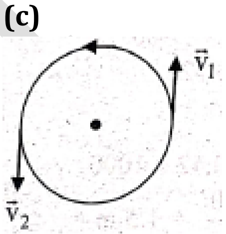
$\Rightarrow\ \theta = 30^\circ$

42 **(d)**

Centripetal force, $F = \frac{mv^2}{r} = \frac{m}{r}\cdot\frac{L^2}{m^2r^2} = \frac{L^2}{mr^3}$

$\left[\text{as, } L = mvr \Rightarrow v = \frac{L}{mr}\right]$

43 **(c)**



Change in velocity$= \bar{v}_2 - \bar{v}_1 = v — v = 2v$

Time taken $= t = \frac{\pi r}{v}$

$\therefore$ Average acceleration $= \frac{2v}{\frac{\pi r}{v}} = \frac{2v^2}{\pi r}$

44 **(c)**

$mr\omega^2 = \frac{k}{r}$

$\therefore\ \omega^2 = \frac{k}{mr^2}$

$\therefore\ \omega^2 \propto \frac{1}{r^2}$

$\therefore\ \omega \propto \frac{1}{r}, T = \frac{2\pi}{\omega}$

$\therefore\ T \propto r$

45 **(c)**

The direction of force and velocity is perpendicular to each other.

46 **(b)**

We know that, angular speed of a watch,

$\omega = \frac{\theta}{t} \Rightarrow \omega \propto \frac{1}{t}$

Hence, $\frac{\omega_{sec}}{\omega_{hour}} = \frac{t_{hour}}{t_{sec}}$

$= \frac{12 \times 3600}{60}$

$= \frac{720}{1}$

47 **(c)**

Maximum height $\frac{u^2}{2g} = h$

Now, $R_{max} = \frac{u^2\sin 90^\circ}{g} = \frac{u^2}{g} = 2h$

48 **(a)**

At highest point, velocity will remain $v\cos 30^\circ$ or $\frac{\sqrt{3}v}{2}$.

Therefore, momentum will also remain $\frac{\sqrt{3}\rho}{2}$.

49 **(b)**

On horizontal surface, $R = mg$

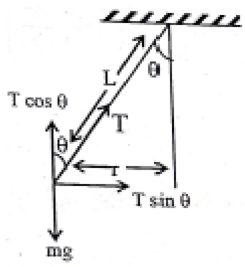
On concave shaped surface, $R = mg + \frac{mv^2}{r}$

On convex shaped surface, $R = mg - \frac{mv^2}{r}$

We can see that, the surface of the road on which, the normal reaction on the car is maximum is concave.

50 **(b)**

Centripetal force $F = T\sin\theta$



$\mathrm{mg} = \mathrm{T}\sin\theta$

$\therefore \mathrm{T} = \dfrac{\mathrm{mg}}{\cos\theta}$

$\therefore \mathrm{F} = \mathrm{mg}\tan\theta = \mathrm{mgr}/\sqrt{\mathrm{L}^2 - \mathrm{r}^2}$

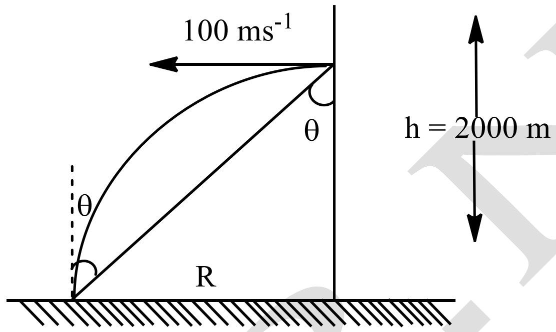
51 **(a)**
$\mathrm{v} = \mathrm{u} + \mathrm{at} = (4\hat{\imath} + 3\hat{\jmath}) + (0.4\hat{\imath} + 0.3\hat{\jmath})(10) = (8\hat{\imath} + 6\hat{\jmath})$

$\therefore\ \mathrm{v} = \sqrt{(8)^2 + (6)^2} = 10$ units

52 **(a)**
Let t be the time taken by bomb to hit the target

$\mathrm{h} = 2000 = \dfrac{1}{2}\mathrm{gt}^2$

$\Rightarrow \mathrm{t} = 20\ \mathrm{s}$



$\mathrm{R} = \mathrm{ut} = (100)\ (20) = 2000\ \mathrm{m}$

$\because\ \tan\theta = \dfrac{\mathrm{R}}{\mathrm{h}} = \dfrac{2000}{2000} = 1$

$\Rightarrow \theta = 45°$

53 **(c)**

$\text{Average acceleration} = \dfrac{\text{Change in velocity}}{\text{time}}$

Change in velocity in half revolution= V— V = 2V

$\text{Time} = \dfrac{\text{distance}}{\text{speed}} = \dfrac{\pi\mathrm{R}}{\mathrm{V}}$

$\therefore \text{acceleration} = \dfrac{2\mathrm{V}^2}{\pi\mathrm{R}}$

54 **(b)**
Displacement, $\Delta \mathrm{r} = r_2 - r_1 = 4\hat{\imath} + 4\hat{\jmath}$

$\therefore\ \mathrm{v}_{\mathrm{av}} = \dfrac{\Delta\mathrm{r}}{\Delta\mathrm{t}} = \dfrac{4\hat{\imath} + 4\hat{\jmath}}{2} = 2(\hat{\imath} + \hat{\jmath})\mathrm{ms}^{-1}$

$\Rightarrow$ Magnitude of velocity,

$|\mathrm{v}_{\mathrm{av}}| = 2\sqrt{1^2 + 1^2} = 2\sqrt{2}\ \mathrm{ms}^{-1}$

Direction, $\theta = \tan^{-1}\left(\frac{\Delta\mathrm{v}_\mathrm{y}}{\Delta\mathrm{v}_\mathrm{x}}\right) = \tan^{-1}\left(\frac{2}{2}\right) = \tan^{-1}1 = 45°$

55 **(d)**
Horizontal range is given by

$\mathrm{R} = \dfrac{\mathrm{u}^2\sin 2\theta}{\mathrm{g}}$

$\therefore \mathrm{u}_1^2\sin 2\theta_1 = \mathrm{u}_2^2\sin 2\theta_2$

$\therefore 2\mathrm{V}^2 \times \dfrac{1}{2} = \mathrm{V}^2\sin 2\theta_2$

$\therefore \sin 2\theta_2 = 1$

$\therefore 2\theta_2 = 90^0$

$\therefore \theta_2 = 45^0$

56 **(d)**
Maximum tension in string,
$\mathrm{T}_{\max} = \mathrm{m}\omega^2\mathrm{r}$

$= \mathrm{m} \times 4\pi^2 \times \mathrm{n}^2 \times \mathrm{r} \qquad (\because \omega = 2\pi\mathrm{n})$

$\Rightarrow\ \mathrm{T}_{\max} = 100 \times 10^{-3} \times 4\pi^2 \times \left(\dfrac{200}{60}\right)^2 \times 2$

We get $\mathrm{T}_{\max} = 87.64\ \mathrm{N}$

57 **(c)**

$\mathrm{y}_1 + \mathrm{y}_2 = \dfrac{\mathrm{u}^2\sin^2\theta}{2\mathrm{g}} + \dfrac{\mathrm{u}^2\sin^2(90° - \theta)}{2\mathrm{g}} = \dfrac{\mathrm{u}^2}{2\mathrm{g}}$

58 **(d)**
Centripetal force
$= \mathrm{mR}\omega^2 = (2)(1)(2\pi)^2 = 8\pi^2\mathrm{N}$

59 **(c)**
Let t be the time of flight. Then

$\mathrm{h} = \dfrac{1}{2}\mathrm{gt}^2 \quad \ldots(\mathrm{i})$

and $\dfrac{\mathrm{h}}{2} = \dfrac{1}{2}\mathrm{g}(\mathrm{t} - 1)^2 \quad \ldots(\mathrm{ii})$

Eq(i)/(ii): $2 = \dfrac{\mathrm{t}^2}{(1 - \mathrm{t})^2}$

$2(\mathrm{t} - 1)^2 = \mathrm{t}^2$

simplifying: $t^2 - 4t + 2 = 0$

Roots of this quadratic equation are

$$t = \frac{4 \pm \sqrt{16 - 4 \times (2)}}{2} = 2 \pm \sqrt{2}$$

Since t cannot be less than 1

$\therefore t = 2 + \sqrt{2}$

60 **(a)**
Initial position vector, $r_1 = 3\hat{i} - 8\hat{j}$
Final position vector, $r_2 = 2\hat{i} + 4\hat{j}$

Change in position vector,
$\Delta r = r_2 - r_1 = 2\hat{i} + 4\hat{j} - 3\hat{i} + 8\hat{j} = -\hat{i} + 12\hat{j}$
Using $s = u_0 t + \frac{1}{2}at^2$

$$\Rightarrow -\hat{i} + 12\hat{j} = 0 + \frac{1}{2}a(4)^2 \Rightarrow a = \frac{-\hat{i} + 12\hat{j}}{8}$$
$$= -\frac{1}{8}\hat{i} + \frac{3}{2}\hat{j}$$

61 **(b)**
Velocity is in horizontal direction

$$V_x = 540 \text{ km/hr} = 540 \times \frac{5}{18} \text{m/s} = 150 \text{ m/s}$$

$h = 1960$ m

In vertical direction initial velocity is zero.

For vertical motion $h = \frac{1}{2}gt^2$

Where t is the time taken to reach the ground

$$\therefore t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 1960}{9.8}} = \sqrt{400} = 20 \text{ s}$$

The horizontal distance covered during this time is

$x = V_x t = 150 \times 20 = 3000$ m

62 **(b)**

$$E_i = \frac{1}{2}mV^2 = \frac{1}{2}mr^2\omega^2 = \frac{1}{2}m4\pi^2r^2f^2$$

$$E_f = \frac{1}{2}m4\pi^2 4r^2 4f^2 = 16E_i$$

$\therefore E_f - E_i = 16E_i - E_i = 15E_i$

63 **(b)**

Centripetal force, $F = \frac{mv^2}{r}$

$$F_1 = \frac{m\,(v/2)^2}{5r} = \frac{mv^2}{4 \times 5r} = \frac{mv^2}{20r}$$
$$\Delta F = F - F_1 = \frac{mv^2}{r} - \frac{mv^2}{20r} = \frac{19}{20}\frac{mv^2}{r}$$
Hence, centripetal force is decrease by 19/20.

64 **(a)**
Tension, $T = 100 \text{ N} = m\omega_m^2 r$
$\Rightarrow 100 = 100 \times 10^{-3} \times \omega_m^2 \times 0.1$
$\Rightarrow \omega_m = 100 \text{ rad s}^{-1}$

65 **(d)**

Centripetal force $F = \frac{mv^2}{r} = mr\omega^2 = mv\omega$ $(\because v = r\omega)$

66 **(b)**
We know that, $v = r\omega$
Thus, $\frac{v_1}{v_2} = \frac{r_1\omega_1}{r_2\omega_2}$
$\because \omega_1 = \omega_2$
$\therefore \frac{v_1}{v_2} = \frac{r_1}{r_2}$

67 **(b)**
Acceleration of electron

$$= \frac{v^2}{r} = \frac{(2.18 \times 10^6)^2}{0.528 \times 10^{-10}} = 9 \times 10^{22} \text{ ms}^{-2}$$

68 **(b)**
Angular speed of minute hand

$\omega_m = 360°$ per hour

$= \left(360 \times \frac{\pi}{180}\right)$ per hour

$= \frac{2\pi}{3600}$ rads $^{-1}$ $\left[\because 1° = \frac{\pi}{180} \text{rad and } 1 \text{ h} = 3600 \text{ s}\right]$

Angular speed of second hand.

$\omega_s = 360°$ per minute $= \frac{2\pi}{60}$ rads^{-1}

$\therefore$ Difference between angular speeds of minute hand and second hand of a clock $= \omega_m - \omega_s$

$$= \frac{2\pi}{3600} - \frac{2\pi}{60} = -\frac{59\pi}{1800}$$

$\therefore$ Difference between ω_m and ω_s is $\frac{59\,\pi}{1800}$ rads^{-1}.

69 **(b)**
$m = 120 \text{ g} = 0.12 \text{ kg}, U = 30 \text{ ms}^{-1}, t = 0.2 \text{ s}, v = 0$

$$F = \frac{m(v - u)}{t}$$

$$= \frac{0.12(0 - 30)}{0.2} = -\frac{0.12 \times 30}{0.2} = -18 \text{ N}$$

(This is force on the ball. Force on the hands will be in opposite direction.)

70 **(c)**

$\omega^2 = \omega_0^2 - 2a\theta$ or $0 = 4\pi^2 n^2 - 2a\theta$

$$\theta = \frac{4\pi^2\left(\frac{1200}{60}\right)^2}{2 \times 4} = 200\pi^2 \text{rad}$$

$\therefore\ \theta = 2\pi n = 200\pi^2$

$\Rightarrow n\ = 100\pi = 314$ rev

71 **(d)**

Tension $T = mr\omega^2$

$\therefore T \propto \omega^2 \quad \therefore \sqrt{T} \propto \omega$

$$\therefore \frac{\omega_2}{\omega_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{4} = 2$$

$$\therefore \omega_2 = 2\omega_1 = 2 \times 10\frac{\text{cycles}}{\text{min}} = 20\frac{\text{cycles}}{\text{units}}$$

$$= \frac{\frac{20}{60}\text{cycle}}{\text{s}} = \frac{1}{3}\text{cycle/s}$$

$\therefore\therefore$

72 **(d)**

Centripetal acceleration is given by

$$a = \frac{v^2}{r}$$

$\therefore a \propto v^2$

$$\therefore \frac{a_2}{a_1} - \left(\frac{v_2}{v_1}\right)^2 = (2)^2 = 4$$

73 **(c)**

We have, $h_{AB} = (r\cos\alpha - r\sin\beta)$

Velocity of particle at B,

$v = \sqrt{2gh_{AB}} = \sqrt{2g\,(r\cos\alpha - r\sin\beta)}$

Particle will leave contact at B, if component of weight is just equal to centripetal force (towards centre).

or $mg\sin\beta = \frac{mv^2}{r}$

$\Rightarrow \sin\beta = 2\cos\alpha - 2\sin\beta$

$\therefore 3\sin\beta = 2\cos\alpha$

74 **(a)**

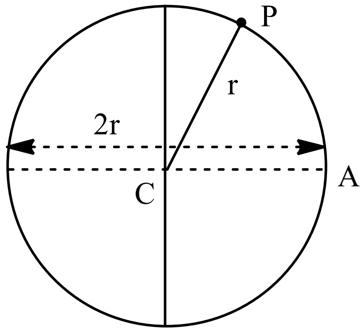
Radius $r = \frac{\pi}{2}$m, frequency $f = \frac{x}{t}$

Tangential velocity $V = \omega r = 2\pi f r = 2\pi \times \frac{x}{t} \times \frac{\pi}{2}$

$= \pi^2 x/t$

75 **(b)**

Angular velocity about A, $\omega_1 = v/2r$



Angular velocity about C, $\omega_2 = v/r$

$\therefore \omega_1 \omega_2 = (v/2r)/(v/r) = 1/2$

76 **(a)**

Given, tangential acceleration, $a_t = 3\ ms^{-2}$, radius of track, $r = 100$ m and velocity, $v = 20\ ms^{-1}$

The radial acceleration of body,

$$a_r = \frac{v^2}{r} = \frac{(20)^2}{100} = 4\ ms^{-2}$$

$\therefore$ Resultant acceleration,

$$a = \sqrt{a_t^2 + a_r^2} = \sqrt{(3)^2 + (4)^2} = 5\ ms^{-2}$$

77 **(d)**

If ω_1 is angular velocity of hour hand of clock and ω_2 is the angular velocity of the earth, then the ratio of $\omega_1 : \omega_2$ is

$$\frac{\omega_1}{\omega_2} - \frac{T_2}{T_1} - \frac{24 \text{ hours}}{12 \text{ hours}} = 2$$

78 **(c)**

Linear velocity, $v = r\omega$

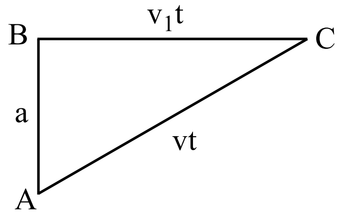
$\Rightarrow \omega = \frac{v}{r}$

79 **(b)**

Centripetal acceleration $a = r\omega^2 = r(2\pi n)^2 = 4\pi^2 n^2 r$

80 **(b)**

Let two boys meet at point C after time t from the starting, then AC = ut, BC = v_1 t (see figure).



$$(AC)^2 = (AB)^2 + (BC)^2$$

$$\Rightarrow \quad v^2t^2 = a^2 + v_1^2 t^2$$

By solving, we get $t = \sqrt{\frac{a^2}{v^2 - v_1^2}}$

81 **(a)**

In one quarter rotation, the angular displacement

$\theta = \frac{\pi^c}{2}$

Also $\theta = \frac{1}{2}\alpha t^2, \alpha = \frac{\pi}{2}$ rad/s^2

$\therefore \frac{\pi}{2} = \frac{1}{2}.\frac{\pi}{2}.t^2$

$\therefore t = \sqrt{2}$s

Average (angular) velocity= $\frac{\theta}{t} = \frac{\pi}{2\sqrt{2}}$ rad/s (Unit should be rad/s)

82 **(d)**
If x is the extension then $F = kx$

$\therefore m(L+1)\omega^2 = kx_1$

and $m(L+5)(2\omega^2) = kx_2$

$\therefore \frac{L+1}{4(L+5)} = \frac{x_1}{x_2} = \frac{1}{5}$

$\therefore 5L + 5 = 4L + 20$

$\therefore L = 15$ cm

83 **(d)**
$V^2 = u^2 - 2as$

$V = 0, \therefore u^2 = 2as$

$\therefore \frac{u_2^2}{u_1^2} = \frac{s_2}{s_1}$

$\therefore \frac{s_2}{s_1} = \left(\frac{45}{15}\right)^2 = (3)^2 = 9$

$\therefore s_2 = 9s_1 = 9 \times 5 = 45$ m

84 **(b)**
$H = \frac{u^2 \sin^2\theta}{2g}$ and $T = \frac{2u\sin\theta}{g} \Rightarrow T^2 = \frac{4u^2\sin^2\theta}{g^2}$

$\therefore \frac{T^2}{H} = \frac{8}{g} \Rightarrow T = \sqrt{\frac{8H}{g}} = 2\sqrt{\frac{2H}{g}}$

86 **(b)**
Net acceleration in non-uniform circular motion.

$a = \sqrt{a_1^2 + a_c^2}$

$= \sqrt{(2)^2 + \left[\frac{900}{500}\right]^2} = 2.7$ ms^{-2}

87 **(d)**
Since the two particles and the centre of the circle lie on straight line during the motion, they are describing the same angle in same time. Hence, their angular velocities are same.

88 **(c)**
Given, $r = 5$ cm $= 5 \times 10^{-2}$m and $T = 0.2\,\pi$ s
We know that, acceleration

$a = r\omega^2 = \frac{4\pi^2}{T^2} r = \frac{4 \times \pi^2 \times 5 \times 10^{-2}}{(0.2\,\pi)^2} = 5$ ms^{-2}

89 **(d)**
Tension in the string at the lowest point is given by

$T = mg + mL\omega^2$

$\omega = \frac{2\pi n}{60}\frac{rad}{s} = \omega^2 = \frac{4\pi^2 n^2}{3600} = \frac{\pi^2 n^2}{900}$

$\therefore T = mg + \frac{mL\pi^2 n^2}{900} = m\left[g + \frac{\pi^2 n^2 L}{900}\right]$

90 **(c)**
Since δV is along the radius and $\vec{V}$ is along the tangent.

91 **(d)**
Angular speed of hour hand is given by

$\omega_1 = \frac{2\pi}{12 \times 60 \times 60}$

Angular speed minute hand is given by $\omega_2 = \frac{2\pi}{60 \times 60}$

Hence, $\frac{\omega_2}{\omega_1} = \frac{2\pi\,/\,60 \times 60}{2\pi/12 \times 60 \times 60} = 12$

$\therefore\ \omega_2/\omega_1 = 12 : 1$

92 **(b)**
$F = \frac{mv^2}{r}$ if quantities are increased by 50%, then

$F' = \frac{(15m)(15v)^2}{(15r)} = 2.25\frac{mv^2}{r} = 2.25$ F

Percentage increase $= \frac{2.25F - F}{F} \times 100 = 125\%$

Therefore, F has to be increased by 125%

93 **(a)**
Magnitude of the net acceleration, $a = \sqrt{a_t^2 + a_n^2}$
where, a_t = rate of change of speed = 2 ms^{-2}.

$a_n = \frac{v^2}{R} = \frac{(5)^2}{10} = 2.5 \Rightarrow a = \sqrt{(2)^2 + (2.5)^2}$
$= 3.2$ ms^{-2}

94 **(a)**
Let the total distance be 2d.

Time taken to cover first half

$$t_1 = \frac{d}{u}$$

Time taken to cover second half

$$t_2 = \frac{d}{v}$$

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{2d}{\frac{d}{u} + d/v} = \frac{2uv}{u+v}$$

95 **(c)**

Frequency $f = \frac{1}{\pi}$ rps, $\omega = 2\pi f = 2\pi \times \frac{1}{\pi} = 2$ rad/s

In a conical pendulum, the horizontal component of the tension $T \sin\theta$ provides the centripetal force.

$\therefore T\sin\theta = mr\omega^2$

but $r = L\sin\theta$ and $\omega^2 = 4$

$\therefore T = 4mL$

96 **(c)**

Given, radius of circle = r

Speed of particle = v

We know that,

tangential acceleration $= \alpha r$ ...(i)

Radial acceleration $= \frac{v^2}{r}$ ...(ii)

On dividing Eq. (i) by Eq. (ii), we get

$$\frac{\text{Tangential acceleration}}{\text{Radial acceleration}} = \frac{\alpha r}{v^2} \times r = \frac{\alpha r^2}{v^2}$$

97 **(b)**

Maximum height $h = \dfrac{u^2\sin^2\theta}{2g}$

For the first stone $\theta = 90^0, \sin 90^0 = 1$

$$\therefore h_1 = \frac{u^2}{2g} = \frac{v^2}{2g}$$

For the second stone $h_2 = \dfrac{v^2\sin^2 30^0}{2g} = \lambda$

$$= \frac{v^2}{2g} \times \frac{1}{4}$$

The masses are same.

Hence, ratio of potential energies $\frac{p_1}{p_2} = 4$

98 **(c)**

For angle $(45° - \theta), R_1 = \frac{u^2\sin(90° - 2\theta)}{g} = \frac{u^2\cos 2\theta}{g}$ ...(i)

For angle $(45° + \theta), R_2 = \frac{u^2\sin(90° + 2\theta)}{g} = \frac{u^2\cos 2\theta}{g}$ ... (ii)

Hence, from Eqs. (i) and (ii), $R_1 = R_2$, i.e. 1: 1

99 **(d)**

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

$$\therefore \frac{h_A}{h_B} = \frac{\sin^2 30^0}{\sin^2 60^0} = \frac{1}{4} \times \frac{4}{3} = \frac{1}{3}$$

100 **(d)**

$(2\pi r).(2000) = 9.42 \times 1000$

$$2r = \frac{9.42 \times 1000}{3.14 \times 2000} = 1.5 \text{ m}$$

101 **(d)**

Given, $s = t^3 + 5$

$\therefore$ Speed, $v = \frac{ds}{dt} = 3\,t^2$

and rate of change of speed, $a_f = \frac{dv}{dt} = 6\,t$

$\therefore$ Tangential acceleration at $t = 2$ s, $a_t = 6 \times 2 = 12$ ms^{-2} and at $t = 2$ s, $v = 3(2)^2 = 12$ ms^{-1}

$\therefore$ Centripetal acceleration, $a_c = \frac{v^2}{R} = \frac{144}{20}$ ms^{-2}

$\therefore$ Net acceleration $= a_t^2 + a_1^2 = 14$ ms^{-2}

103 **(c)**

Angular velocity $= \frac{\text{Angle traced}}{\text{Time taken}}$

Time period of hour hand is 12 h,

so, $\omega = \frac{2\pi}{12}$ rad h^{-1} $= \frac{2\pi}{12 \times 60 \times 60}$ rad s^{-1}

$= \frac{\pi}{21600}$ rad s^{-1}

104 **(b)**

Given, $u_x = 3$ ms^{-1}, $a_x = -6$ ms^{-1}

$$\therefore x_{max} = \frac{u_x^2}{2|a_x|} = \frac{9}{12} = 0.75 \text{ m}$$

105 **(a)**

$u_x = a$ = Horizontal component of the velocity

$u_y = b$ = Vertical component of the velocity

Maximum height $H = \dfrac{u_y^2}{2g} = \dfrac{b^2}{2g}$

Range $R = \dfrac{2u_y u_x}{g} = \dfrac{2ba}{g}$

$R = 2H$

$$\therefore \frac{2ba}{g} = \frac{2b^2}{2g}$$

$\therefore b = 2a$

106 **(c)**

$\therefore$ α is the uniform angular acceleration

$\therefore \theta_1 = \omega_0 t + \frac{1}{2}\alpha t^2 \Rightarrow \omega_0 = 0$ and $t = 2$ s

$\therefore \; \theta_1 = 0 + \frac{1}{2}\alpha 4 = 2\alpha$ ... (i)

Again, $\theta = \omega_0 t + \frac{1}{2}\alpha t^2 \Rightarrow t = 4$ s

$$\theta = 0 + \frac{1}{2}\alpha \cdot 4 \times 4 = 8\alpha$$

$\therefore \; \theta_2 = \theta - \theta_1 = 8\alpha - 2\alpha = 6\alpha$ .... (ii)

and $\frac{\theta_2}{\theta_1} = \frac{6\alpha}{2\alpha} = 3$

107 **(a)**

For uniform velocity, the distance travelled is given by

$x = vt$

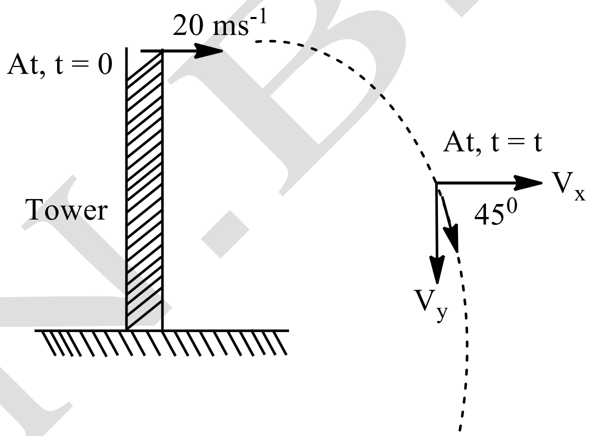
For uniform acceleration $x = \frac{1}{2}at$

$$\therefore \frac{1}{2}at^2 = Vt$$

$$\therefore t = \frac{2V}{a}$$

108 **(b)**

After time t, $v_x = u_x = 20\ ms^{-1}$



Velocity in y - direction,

$v_y = u_y + a_y t = 0 + gt = gt$

$\tan\alpha = \frac{u_y}{u_x} = \frac{gt}{20}$, if $\alpha = 45°$

Then, $1 = \frac{10 \times t}{20} \Rightarrow t = 2s$

109 **(a)**

$$S = \frac{U^2}{2a}; S' = \frac{(2U)^2}{2a} = \frac{4U^2}{2a}$$

$\therefore S' > S$

110 **(b)**

Fou uniform circular motion,

Speed $\rightarrow$ Constant

Velocity $\rightarrow$ Variable

Magnitude of acceleration $\rightarrow$ Constant

Acceleration $\rightarrow$ Variable

Hence, A $\rightarrow$ 1, B $\rightarrow$ 2, C $\rightarrow$ 1 and D $\rightarrow$ 2.

111 **(d)**

$R = \frac{u^2 \sin\theta}{g}$, at angles θ and $90° - \theta$

Now, $h_1 = \frac{u^2 \sin^2\theta}{2g}$ and

$$h_2 = \frac{u^2 \sin^2(90° - \theta)}{2g} = \frac{u^2 \cos^2\theta}{2g}$$

$$\therefore h_1 h_2 = \left(\frac{u^2 \sin 2\theta}{g}\right)^2 \cdot \frac{1}{16} = \frac{R^2}{16}$$

$\therefore \; R = 4\sqrt{h_1 h_2}$ $\quad (\because \sin 2\theta = 2\sin\theta\cos\theta)$

112 **(c)**

They complete one revolution in the same time.

$\therefore \omega_1 = \omega_2$

$$\therefore \frac{V_1}{r_1} = \frac{V_2}{r_2}$$

$$\therefore \frac{V_1}{V_2} = \frac{r_1}{r_2}$$

113 **(c)**

Projectile will strike at highest point of its path with its horizontal component of velocity, i.e. $v_0 \cos\alpha$.

114 **(d)**

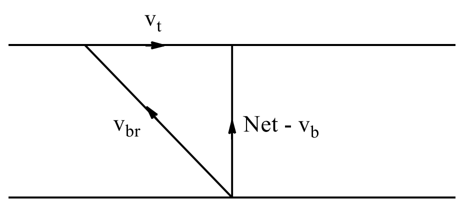
$$\theta = 5\sin\frac{\pi t}{6}$$

$$\therefore \frac{d\theta}{dt} = \frac{\pi}{6}.5\cos\frac{\pi t}{6}$$

$$\text{At } t = 3\text{ s}, \frac{d\theta}{dt} = 5\cos\frac{\pi \times 3}{6} = \frac{5\pi}{6}\cos\frac{\pi}{2}$$
$$= 0 \;\left(\cos\frac{\pi}{2} = 0\right)$$

115 **(d)**

$$\text{Here, } v_b = \frac{1\text{km}}{(15/60)\text{h}} = 4\text{kmh}^{-1}$$



Given, $V_{br} = 5\ kmh^{-1}$

$\therefore$ Velocity of river, $V_r = V_{br} - V_b = \sqrt{5^2 - 4^2} = 3\ kmh^{-1}$

116 **(c)**

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

$\Rightarrow\ H \propto u^2$

If initial velocity be doubled, then maximum height reached by the projectile will become four times.

117 **(b)**

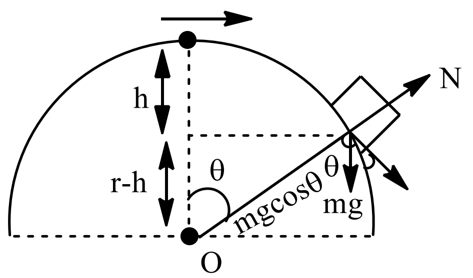
$$R_{15^\circ} = \frac{u^2 \sin(2 \times 15^\circ)}{g} = \frac{u^2}{2g} = 1.5\ km$$

$$\Rightarrow R_{45^0} = \frac{u^2 \sin(2 \times 45^\circ)}{g} = \frac{u^2}{g} = 1.5 \times 2 = 3\ km$$

118 **(c)**

From figure,

$g\cos\theta = \frac{v^2}{r}$



$v^2 = gr\cos\theta$

$\cos\theta = \frac{r-h}{r}$

$\therefore v^2 = gr\frac{(r-h)}{r} = g(r-h)$ ...(i)

By third kinematical equation of motion,

$v^2 = 2gh$ ...(ii)

From Eqs. (i) and (ii), we get,

$g(r-h) = 2gh$

$\therefore\ h\ \frac{r}{3}$

119 **(c)**

At any instant, for a body performing uniform circular motion, velocity vector and acceleration vector are normal to each other.

120 **(c)**

Centripetal force $F = \frac{mv^2}{r}$

$F_1 = \frac{mv_1^2}{r_1}$ and $F_2 = \frac{mv_2^2}{r_2}$

$\therefore \frac{F_2}{F_1} = \frac{v_2^2}{v_1^2} . \frac{r_1}{r_2}$

$v_2 = \frac{v_1}{2}$ and $r_2 = 3r_1$

$\therefore \frac{F_2}{F_1} = \left(\frac{1}{2}\right)^2 . \frac{1}{3} = \frac{1}{12}$

$\therefore F_2 = \frac{F_1}{12}$

$\therefore F_2 < F_1$

$\therefore F_1 - F_2 = F_1 - \frac{F_1}{12} = \frac{11}{12}F_1$

121 **(b)**

In uniform circular motion, the angular velocity of the particle remains constant and hence its angular acceleration is zero.

122 **(a)**

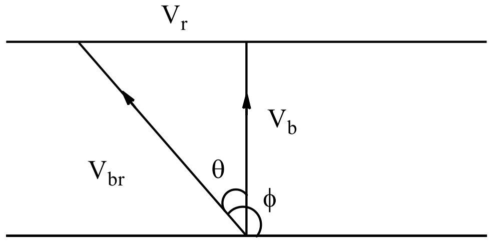
For conical pendulum $\tan\theta = \frac{v^2}{rg}$

$\therefore \frac{v^2}{t} = g\tan\theta = 10 \times \tan 45^0 = 10 \times 1 = 10\frac{m}{s^2}$

Centripetal force $F = \frac{mv^2}{r} = 2 \times 10 = 20\ N$

123 **(a)**

As we know, $\sin\theta = \frac{v_r}{v_{br}}$



$\therefore\ \theta = \sin^{-1}(3/5) \Rightarrow \theta = 37^\circ$

The required angle is therefore

$\phi = 90^\circ + \theta = 90^\circ + 37^\circ = 127^\circ$

124 **(a)**

At the highest point $v = 0$

$\therefore 0 = u - gt$

$\therefore u = gt = 10 \times 3 = 30\ m/s$

Also $0 = u^2 - 2gh$

$\therefore h = \frac{u^2}{2g} = \frac{(30)^2}{2 \times 10} = 45\ m$

125 **(c)**

The plane is flying horizontally. Hence initial vertical component of the velocity is zero.

If it reaches the ground in time t, then

$$h = \frac{1}{2}gt^2$$

$$\therefore t^2 = \frac{2h}{g} = \frac{2 \times 980}{9.8} = 200$$

$$\therefore t = 10\sqrt{2}\,s$$

The horizontal component of the velocity is $V = 200\frac{km}{hr} = 200 \times \frac{5}{18} = \frac{1000}{18}\,m/s$

The horizontal distance to be covered is $d = Vt = \frac{1000}{18} \times 10\sqrt{2} = \frac{10^4}{9\sqrt{2}}\,m$

126 **(b)**

Maximum height $H = \dfrac{u^2 \sin\theta}{2g}$

$$\therefore \frac{u_1^2 \sin^2\theta_1}{2g} = \frac{u_2^2 \sin^2\theta_2}{2g}$$

$$\therefore \frac{u_1^2}{u_2} = \frac{\sin^2\theta_2}{\sin^2\theta_1} = \frac{\sin^2 60^0}{\sin^2 45} = \left(\frac{\sqrt{3}}{2}\right)^2 \times \left(\sqrt{2}\right)^2$$

$$= \frac{3}{4} \times 2 = \frac{3}{2}$$

$$\therefore u_1/u_2 = \sqrt{\frac{3}{2}}$$

127 **(b)**

For body B moving with acceleration a, initial velocity is zero and final velocity is u.

$$\therefore u^2 = 2as$$

$$\therefore s = \frac{u^2}{2a}$$

If the time taken to attain this velocity is t, then $u = at$ or $t = \frac{u}{a}$

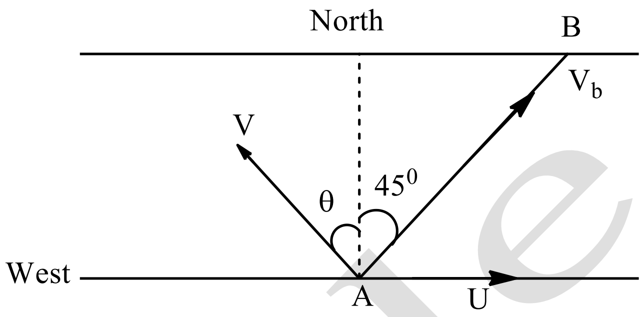
For body A, distance travelled is given by $s' = ut = u \times \frac{u}{a} = \frac{u^2}{a}$

Hence distance between A and B is

$$s' - s = \frac{u^2}{a} - \frac{u^2}{2a} = \frac{u^2}{2a}$$

128 **(c)**

Let v be the speed of boatman in still water. Resultant of v and u should be along AB. Components of v_b (absolute velocity of boatman) along x and y directions are



$v_x = u - v\sin\theta$ and $v_y = v\cos\theta$

Further, $\tan 45° = \frac{v_y}{v_x}$ or $1 = \frac{v\cos\theta}{u - v\sin\theta}$

$$\therefore \quad v = \frac{u}{\sin\theta + \cos\theta} = \frac{u}{\sqrt{2}\sin(\theta + 45°)}$$

v is minimum at, $\theta + 45° = 90°$

or $\theta = 45°$ (North-West) and $v_{min} = \frac{u}{\sqrt{2}}$

129 **(a)**

Tension of string, $T = \frac{mv^2}{r}$

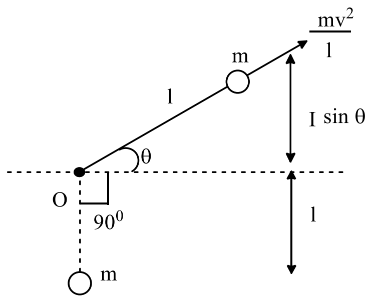
$$\Rightarrow 25 = \frac{0.25 \times v^2}{196}$$

$$\Rightarrow v = 14\ ms^{-1}$$

130 **(c)**

Here, height, $h = l + l\sin\theta = l\,(1 + \sin\theta)$

$$v^2 = u^2 - 2gh = u^2 - 2gl(1 + \sin\theta)$$



String will slack, where component of weight towards centre is just equal to centripetal force

or $mg\sin\theta = \frac{mv^2}{l} = \frac{m}{l}[u^2 - 2gl(1 + \sin\theta)]$

On substituting, $u^2 = \frac{7gl}{2}$

we get $\sin\theta = \frac{1}{2}$ or $\theta = 30°$

$\therefore$ The desired angle is $(90° + 30°)$ or $120°$.

131 **(c)**

Compare the given equation with

$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta} \Rightarrow \tan\theta = \sqrt{3} \Rightarrow \theta = 60°$$

132 **(b)**

Position vector, $r = 3t^2\hat{i} + 6\hat{j} + \hat{k}$

$\therefore$ Velocity vector, $v = \frac{dr}{dt} = 6\hat{i} + 6\hat{j} + 0 = 6t\hat{i} + 6\hat{j}$

$\therefore$ Magnitude of the velocity of the object along Y-axis = 6

133 **(a)**

From equation of motion, $0 = \omega_0 - \alpha\, t \Rightarrow \alpha = \frac{\omega_0}{t}$

$= \frac{(10 \times 2\pi)/60}{15} = 0.7 \text{ rad s}^{-2}$

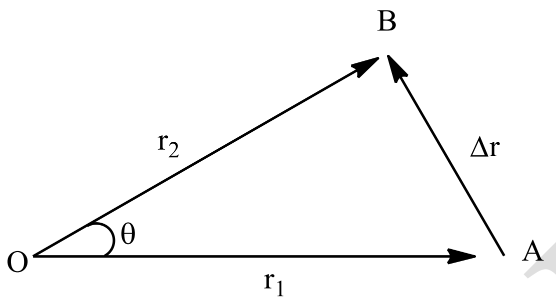
Now, angle rotated before coming to rest,

$$\theta = \frac{\omega_0^2}{2\alpha} = \frac{\left(\frac{100\times 2\pi}{60}\right)^2}{2 \times 0.7} = 78.25 \text{ rad s}^{-2}$$

Number of rotations, $n = \frac{\theta}{2\pi} = \frac{78.25}{2 \times 3.14} = 12.5$

134 **(a)**

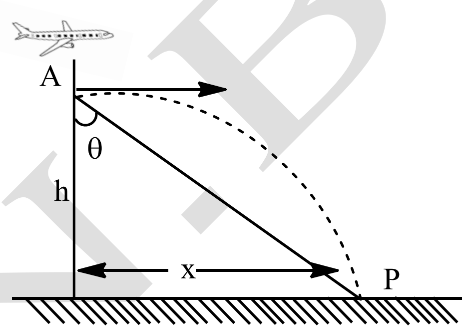
$\Delta r = r_2 - r_1$, where $r_2 = r_1 = r$.



Hence, $\Delta r = \sqrt{r_2^2 + r_1^2 - 2r_2 r_1 \cos\theta} = 2r \sin\frac{\theta}{2}$

135 **(c)**

Plane is flying at a speed $= 600 \times \frac{5}{18} = \frac{500}{3} \text{ms}^{-1}$ horizontally (at a height 1960 m)



Time taken by the kit to reach the ground,

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 1960}{9.8}} = 20 \text{ s}$$

In this time, the kit will move horizontally by

$$X = ut = \frac{500}{3} \times 20 = \frac{10000}{3} \text{m}$$

So the angle of sight,

$\tan\theta = \frac{X}{h} = \frac{1000}{3 \times 1960} = \frac{10}{5.88} = 1.7 = \sqrt{3}$ or $\theta = 60°$

136 **(b)**

Here, acceleration of a point at the tip of the blade

= centripetal acceleration

$= \omega^2 R = (2\pi f)^2 R$

$$= \left(2 \times \frac{22}{7} \times \frac{1200}{60}\right)^2 \times \frac{30}{100}$$

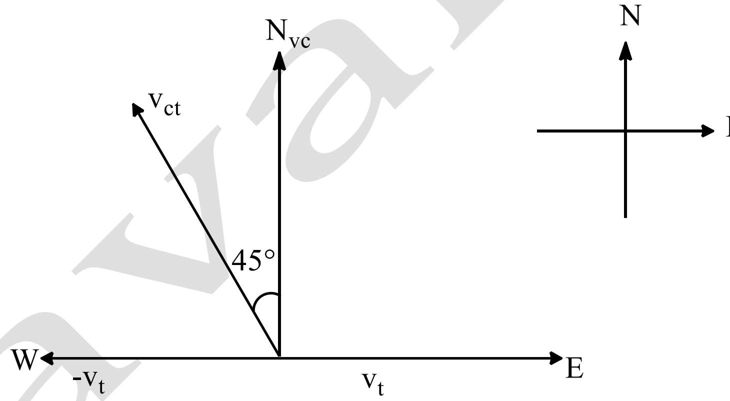
$= 4737.4 \text{ ms}^{-2}$

137 **(c)**

$T = ml\omega^2$

$$\therefore \omega = \sqrt{\frac{T}{ml}}$$

138 **(b)**



Observed direction of car w.r.t. train

$v_{at} = V_c - V_t \Rightarrow V_{ct} = V_c + (-V_t)$

Velocity of car w.r.t. train (V_{ct}) is towards West - North.

139 **(a)**

Force F acting on a body of mass m peforming circular motion of radius r,

$F = \frac{mv^2}{r}$ (centripetal force) ...(i)

where, v = velocity of the particle.

The time period of one complete cycle,

$$T = \frac{\text{perimeter of a circular path}}{\text{velocity of body}} = \frac{2\pi r}{V}$$

$\Rightarrow v = \frac{2\pi r}{T}$ ...(ii)

From Eqs. (i) and (ii), we get

$$F = \frac{m}{r}\left(\frac{2\pi r}{T}\right)^2 = mr\left(\frac{2\pi}{T}\right)^2 \text{ or } \sqrt{F} = \frac{2\pi}{T}\sqrt{mr}$$

140 **(b)**

From relation, $\tan\theta = \frac{a_t}{a_c} = \frac{a_t r}{v^2}$ $\left(\because a_c = \frac{v^2}{r}\right)$

$v^2 = \frac{a_t r}{\tan\theta} = \frac{10 \times 5}{\tan 30°} = 50\sqrt{3}$

$\Rightarrow v^2 = 50 \times 1.732 = 86.6$

$\therefore v = \sqrt{86.6} = 9.3 \text{ ms}^{-1}$

141 **(b)**

$u = 196\frac{m}{s}, \theta = 30^0$

time of flight $T = \frac{2u\sin\theta}{g} = \frac{2 \times 196 \times 0.5}{9.8} = 20$ s

142 **(a)**

According to question, applying equation of motion,

$v^2 = u^2 + 2as$

[Symbols have their usual meanings]

Given, $u = 0$ and $s = 2 \times 2\pi r = 4\pi r$

So, $v^2 = 2a \times 4\pi r$

$\Rightarrow a = \frac{v^2}{8\pi r}$

143 **(c)**

Speed is increasing at the rate of a m s^{-2}, so linear acceleration = a and tangential acceleration = v^2/R.

Hence, net acceleration $= \sqrt{\left(\frac{v^2}{R}\right)^2 + a^2}$

144 **(c)**

Time of flight, $T = \frac{2u\sin\theta}{g} = \frac{2 \times 50 \times \sin 30^\circ}{10}$

$= 5s$

145 **(d)**

Let l be the original length of the spring.

Let the initial angular velocity be ω and the corresponding elongation $e_1 = 1$ cm

When the angular velocity is doubled the elongation $e_2 = 6$ cm

If k is the spring constant then we have

$m(l + e_1)\omega^2 = ke_1$ ... (i)

and $m(l + e_2)(2\omega)^2 = ke_2$

or $m(l + e_2).4\omega^2 = ke_2$ ... (ii)

Dividing Eq (i) by Eq (ii), we get

$\frac{l + e_1}{4(l + e_2)} = \frac{e_1}{e_2}$

Solving we get $l = 9$ cm

146 **(d)**

Here, $7.2 = \frac{100}{(v + 5)(5/18)}$ or $v = 45\ ms^{-1}$

147 **(b)**

$\Delta v = a\,\Delta t$ (as, a = constant)

$= (-g\,\hat{j})\left(\frac{2v_0 \sin\alpha}{g}\right) = (-2V_0 \sin\alpha)\hat{j}$

i.e. Change in velocity is $2V_0 \sin\alpha$, vertically downwards.

148 **(a)**

$\omega = \frac{2\pi}{T} = \frac{360^0}{6 \times 60} = 0.1^0/s$

149 **(d)**

Displacement $= \sqrt{R^2 + R^2} = \sqrt{2}R$

Distance $= \frac{2\pi R}{4} = \frac{\pi R}{2}$

150 **(c)**

$v^2 = v_y^2 + v_x^2$

Or $5g = \left(u_y - gt\right)^2 + u_x^2$

Since, $v_y = u\sin 30^\circ = 10\sin 30^\circ = 5\sqrt{3}\ ms^{-1}$

$v_x = u\cos 30^\circ = 10\cos 30^\circ = 5\ ms^{-1}$

or $50 = (5\sqrt{3} - 10t)^2 + (5)^2$

$\therefore (5\sqrt{3} - 10t) = \pm 5$

$\because$ It has two solutions

Hence $t_1 = \frac{5\sqrt{3} + 15}{10}$

and $t_2 = \frac{5\sqrt{3} - 5}{10}$

$\therefore\ t_1 - t_2 = 2s$

151 **(b)**

$\frac{u_1^2 \sin^2 45^\circ}{2g} = \frac{u_2^2 \sin 60^\circ}{2g}$

$\therefore\ \frac{u_1}{u_2} = \frac{\sin 60^\circ}{\sin 45^\circ} = \frac{\sqrt{3}/2}{(1/\sqrt{2})} = \sqrt{3}:\sqrt{2}$

152 **(c)**

$R_{max} = \frac{u^2}{g}$ at $\theta = 45^\circ$

$\therefore\ U = \sqrt{g\,R_{max}} = 100\ ms^{-1}$

153 **(c)**

The velocity of the body at the highest point is given by

$V = \sqrt{gR}$

After the string breaks, it will fall under gravity with initial horizontal velocity $V = \sqrt{gR}$. Its initial velocity is vertical direction is zero.

If it falls through a height h, in time t, then

$h = \frac{1}{2}gt^2$ or $t = \sqrt{\frac{2h}{g}}$

in horizontal direction its velocity will remain constant equal to V.

distance covered in horizontal direction is x =

$$Vt = \sqrt{gR} \times \sqrt{\frac{2h}{g}} = \sqrt{2hR}$$

If $h = 2R$, then $x = \sqrt{4R^2} = 2R$

154 **(c)**
Both the particles will fall same distance in same time interval.
So, the relative separation will remain unchanged.

155 **(a)**
The body acquired velocity V when it falls through a height h, starting from rest.

$\therefore V^2 = 2gh$

$\therefore h = \dfrac{V^2}{2g}$

If it falls further and attains velocity 3V and if the total height through which it falls is h', then

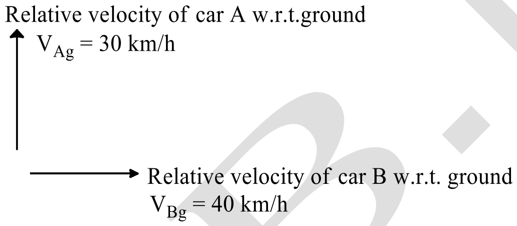
$(3V)^2 = 2gh'$

$\therefore 9V^2 = 2gh'$

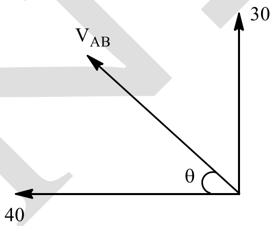
$\therefore h' = \dfrac{9V^2}{2g} = 9h$

$\therefore h' - h = 9h - h = 8h$

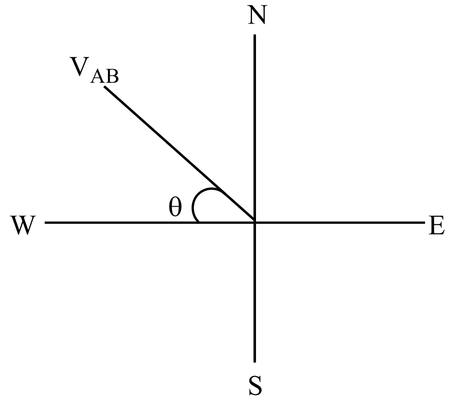
156 **(c)**



$\therefore$ Relative velocity of A w.r.t. B,
$V_{AB} = V_{Ag} - V_{Bg} = V_{Ag} + (-V_{Bg})$
$|V_{AB}| = \sqrt{(30)^2 + (40)^2} = 50$ km/h



$\Rightarrow \theta = \tan^{-1}(3/4)$



50 km/h, at angle $\tan^{-1}(3/4)$ North of West

157 **(a)**
$s \propto t^2$

$s = kt^2$

$\dfrac{ds}{dt} = 2kt$

$d^2s/dt^2 = 2k$

158 **(b)**
Angular velocity $\omega = \dfrac{2\pi^c}{T} = \dfrac{360^0}{3600} = 0.1^0/s$

159 **(a)**
From the figure, $1.5\,t + 0.7\,t = 2\pi R \Rightarrow 2.2t = 10\pi$

$\therefore \quad t = \dfrac{10\pi}{2.2} = 14.3$ s

Acceleration, $a = \frac{v_B{}^2}{R} = 0.45\ ms^{-2}$

160 **(c)**
As, $v_x = \frac{dx}{dt} = \frac{2t}{2} = t$
At $t = 2$ s, $v_x = 2\ ms^{-1}$
Further, $y = \frac{x^2}{2} = \frac{(t^2/2)^2}{2} = \frac{t^4}{8} \Rightarrow v_y = \frac{dy}{dt} = \frac{t^3}{2}$
At $\quad t = 2$ s, $v_y = 4\ ms^{-1}$
Hence, $v = v_x\hat{i} + v_y\hat{j} = (2\hat{i} + 4\hat{j})ms^{-1}$

161 **(a)**
$F_1 = \dfrac{mv^2}{r}$

$F_2 = \dfrac{m}{4r}.\dfrac{v^2}{4} = \dfrac{1}{16}\dfrac{mv^2}{r} = \dfrac{F_1}{16}$

$\therefore F_1 - F_2 = F_1 - \dfrac{F_1}{16} = \dfrac{15}{16}F_1$

162 **(d)**

$$a = \frac{v_f - v_i}{\Delta t} = \frac{(2\hat{i} - 3\hat{j}) - (2\hat{i} + 3\hat{j})}{2} = \frac{-6\hat{j}}{2}$$
$$= -3\hat{j}ms^{-2}$$

163 **(d)**

Tension in the string,

$T = m\omega^2 r = 4\pi^2 n^2 mr$

$$\therefore T \propto n^2 \Rightarrow \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}}$$

$$\therefore n_2 = 5\sqrt{\frac{2T}{T}} = 5\sqrt{2}\ \text{rpm}$$

164 **(c)**

$$u = 15\frac{m}{s}, a = -0.3\frac{m}{s^2}, t = 60\ s$$

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

$$= 15 \times 60 + \frac{1}{2} \times (-0.3) \times (60)^2 = 900 - 540$$
$$= 360\ m$$

Distance from traffic light= $400 - 360 = 40$ m