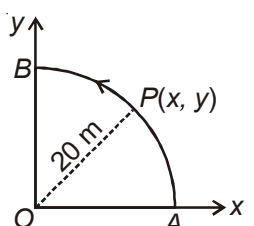
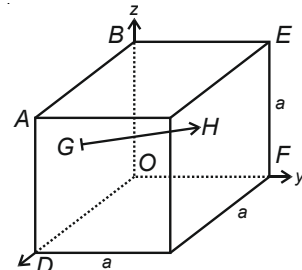


Chapter 2

Motion in a Plane

- A particle has an initial velocity of $3\hat{i} + 4\hat{j}$ and an acceleration of $0.4\hat{i} + 0.3\hat{j}$. Its speed after 10 s is [AIEEE-2009]
 - $7\sqrt{2}$ units
 - 7 units
 - 8.5 units
 - 10 units
- A particle is moving with velocity $\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is [AIEEE-2010]
 - $y^2 = x^2 + \text{constant}$
 - $y = x^2 + \text{constant}$
 - $y^2 = x + \text{constant}$
 - $xy = \text{constant}$
- For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point $P(R, \theta)$ on the circle of radius R is (Here θ is measured from the x-axis) [AIEEE-2010]
 - $\frac{v^2}{R}\hat{i} + \frac{v^2}{R}\hat{j}$
 - $-\frac{v^2}{R}\cos\theta\hat{i} + \frac{v^2}{R}\sin\theta\hat{j}$
 - $-\frac{v^2}{R}\sin\theta\hat{i} + \frac{v^2}{R}\cos\theta\hat{j}$
 - $-\frac{v^2}{R}\cos\theta\hat{i} - \frac{v^2}{R}\sin\theta\hat{j}$
- 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 $t = 2$ s is nearly [AIEEE-2010]
 
 - 14 m/s²
 - 13 m/s²
 - 12 m/s²
 - 7.2 m/s²
- A boy can throw a stone up to a maximum height of 10 m. The maximum horizontal distance that the boy can throw the same stone up to will be [AIEEE-2012]
 - 10 m
 - $10\sqrt{2}$ m
 - 20 m
 - $20\sqrt{2}$ m
- A projectile is given an initial velocity of $(\hat{i} + 2\hat{j})$ m/s where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If $g = 10$ m/s², the equation of its trajectory is [JEE (Main)-2013]
 - $y = x - 5x^2$
 - $y = 2x - 5x^2$
 - $4y = 2x - 5x^2$
 - $4y = 2x - 25x^2$
- A particle is moving with a velocity $\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is [JEE (Main)-2019]
 - $y^2 = x + \text{constant}$
 - $y = x^2 + \text{constant}$
 - $y^2 = x^2 + \text{constant}$
 - $xy = \text{constant}$
- The position co-ordinates of a particle moving in a 3-D coordinate system is given by $x = a \cos \omega t$, $y = a \sin \omega t$ and $z = a\omega t$. The speed of the particle is [JEE (Main)-2019]
 - $2a\omega$
 - $\sqrt{2}a\omega$
 - $\sqrt{3}a\omega$
 - $a\omega$
- In the cube of side 'a' shown in the figure, the vector from the central point of the face $ABOD$ to the central point of the face $BEFO$ will be [JEE (Main)-2019]
 
 - $\frac{1}{2}a(\hat{j} - \hat{i})$
 - $\frac{1}{2}a(\hat{i} - \hat{k})$
 - $\frac{1}{2}a(\hat{j} - \hat{k})$
 - $\frac{1}{2}a(\hat{k} - \hat{i})$

10. Two guns A and B can fire bullets at speeds 1 km/s and 2 km/s respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets fired by the two guns, on the ground is

[JEE (Main)-2019]

- (1) $1 : 4$ (2) $1 : 8$
(3) $1 : 2$ (4) $1 : 16$

11. Two vectors $\vec{A}$ and $\vec{B}$ have equal magnitudes. The magnitude of $(\vec{A} + \vec{B})$ is ' n ' times the magnitude of $(\vec{A} - \vec{B})$. The angle between $\vec{A}$ and $\vec{B}$ is

[JEE (Main)-2019]

- (1) $\cos^{-1}\left[\frac{n-1}{n+1}\right]$ (2) $\cos^{-1}\left[\frac{n^2-1}{n^2+1}\right]$
(3) $\sin^{-1}\left[\frac{n-1}{n+1}\right]$ (4) $\sin^{-1}\left[\frac{n^2-1}{n^2+1}\right]$

12. Two forces P and Q , of magnitude $2F$ and $3F$, respectively, are at an angle θ with each other. If the force Q is doubled, then their resultant also gets doubled. Then, the angle θ is

[JEE (Main)-2019]

- (1) 30° (2) 90°
(3) 60° (4) 120°

13. A particle is moving along a circular path with a constant speed of 10 ms^{-1} . What is the magnitude of the change in velocity of the particle, when it moves through an angle of 60° around the centre of the circle?

[JEE (Main)-2019]

- (1) 10 m/s (2) Zero
(3) $10\sqrt{3} \text{ m/s}$ (4) $10\sqrt{2} \text{ m/s}$

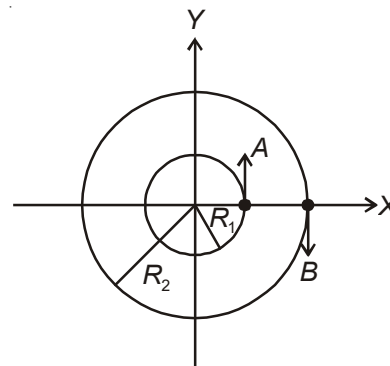
14. A person standing on an open ground hears the sound of a jet aeroplane, coming from north at an angle 60° with ground level. But he finds the aeroplane right vertically above his position. If v is the speed of sound, speed of the plane is

[JEE (Main)-2019]

- (1) $\frac{2v}{\sqrt{3}}$ (2) $\frac{\sqrt{3}}{2}v$
(3) $\frac{v}{2}$ (4) v

15. Two particles A , B are moving on two concentric circles of radii R_1 and R_2 with equal angular speed ω . At $t = 0$, their positions and direction of motion are shown in the figure

[JEE (Main)-2019]



The relative velocity $\vec{v}_A - \vec{v}_B$ at $t = \frac{\pi}{2\omega}$ is given by

- (1) $\omega(R_2 - R_1)\hat{j}$ (2) $\omega(R_1 - R_2)\hat{j}$
(3) $-\omega(R_1 + R_2)\hat{j}$ (4) $\omega(R_1 + R_2)\hat{j}$

16. Ship A is sailing towards north-east with velocity $\vec{v} = 30\hat{i} + 50\hat{j} \text{ km/hr}$ where $\hat{i}$ points east and $\hat{j}$, north. Ship B is at a distance of 80 km east and 150 km north of Ship A and is sailing towards west at 10 km/hr . A will be at minimum distance from B in

[JEE (Main)-2019]

- (1) 2.2 hrs. (2) 4.2 hrs.
(3) 3.2 hrs. (4) 2.6 hrs.

17. Let $|\vec{A}_1| = 3$, $|\vec{A}_2| = 5$ and $|\vec{A}_1 + \vec{A}_2| = 5$. The value of $(2\vec{A}_1 + 3\vec{A}_2) \cdot (3\vec{A}_1 - 2\vec{A}_2)$ is :

[JEE (Main)-2019]

- (1) -106.5
(2) -118.5
(3) -99.5
(4) -112.5

18. The stream of a river is flowing with a speed of 2 km/h . A swimmer can swim at a speed of 4 km/h . What should be the direction of the swimmer with respect to the flow of the river to cross the river straight?

[JEE (Main)-2019]

- (1) 60° (2) 90°
(3) 150° (4) 120°

19. The position vector of a particle changes with time according to the relation $\vec{r}(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$. What is the magnitude of the acceleration at $t = 1$? [JEE (Main)-2019]

- (1) 50
(2) 100
(3) 40
(4) 25

20. A particle of mass m is moving along a trajectory given by

$$x = x_0 + a \cos \omega_1 t$$

$$y = y_0 + b \sin \omega_2 t$$

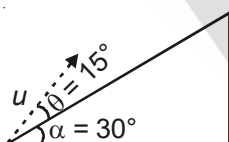
The torque, acting on the particle about the origin, at $t = 0$ is : [JEE (Main)-2019]

- (1) $-m(x_0 b \omega_2^2 - y_0 a \omega_1^2) \hat{k}$
(2) $m(-x_0 b + y_0 a) \omega_1^2 \hat{k}$
(3) $+m y_0 a \omega_1^2 \hat{k}$
(4) Zero

21. A plane is inclined at an angle $\alpha = 30^\circ$ with respect to the horizontal. A particle is projected with a speed $u = 2 \text{ ms}^{-1}$, from the base of the plane, making an angle $\theta = 15^\circ$ with respect to the plane as shown in the figure. The distance from the base, at which the particle hits the plane is close to :

(Take $g = 10 \text{ ms}^{-2}$)

[JEE (Main)-2019]



- (1) 18 cm (2) 20 cm
(3) 14 cm (4) 26 cm

22. A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance R from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product $t_1 t_2$ is :

[JEE (Main)-2019]

- (1) $\frac{R}{2g}$ (2) $\frac{2R}{g}$
(3) $\frac{R}{g}$ (4) $\frac{R}{4g}$

23. The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then ($g = 10 \text{ ms}^{-2}$): [JEE (Main)-2019]

- (1) $\theta_0 = \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} \text{ ms}^{-1}$
(2) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} \text{ ms}^{-1}$
(3) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3} \text{ ms}^{-1}$
(4) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5} \text{ ms}^{-1}$

24. Two particles are projected from the same point with the same speed u such that they have the same range R , but different maximum heights, h_1 and h_2 . Which of the following is correct?

[JEE (Main)-2019]

- (1) $R^2 = 4 h_1 h_2$ (2) $R^2 = 16 h_1 h_2$
(3) $R^2 = 2 h_1 h_2$ (4) $R^2 = h_1 h_2$

25. A particle starts from the origin at $t = 0$ with an initial velocity of $3.0\hat{i} \text{ m/s}$ and moves in the x - y plane with a constant acceleration $(6.0\hat{i} + 4.0\hat{j}) \text{ m/s}^2$. The x -coordinate of the particle at the instant when its y -coordinate is 32 m is D meters. The value of D is [JEE (Main)-2020]

- (1) 60 (2) 32
(3) 40 (4) 50

26. Starting from the origin at time $t = 0$, with initial velocity $5\hat{j} \text{ ms}^{-1}$, a particle moves in the x - y plane

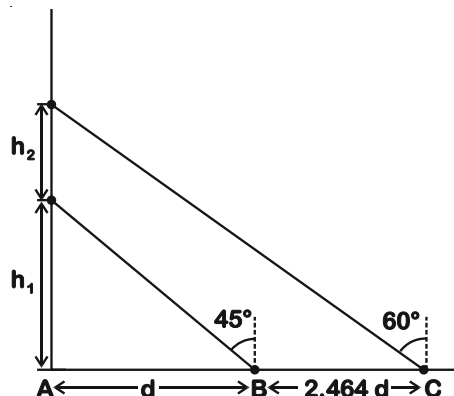
with a constant acceleration of $(10\hat{i} + 4\hat{j}) \text{ ms}^{-2}$. At time t , its coordinates are $(20 \text{ m}, y_0 \text{ m})$. The values of t and y_0 are, respectively [JEE (Main)-2020]

- (1) 4 s and 52 m
(2) 2 s and 24 m
(3) 5 s and 25 m
(4) 2 s and 18 m

27. A balloon is moving up in air vertically above a point A on the ground. When it is at a height h_1 , a girl standing at a distance d (point B) from A (see figure) sees it at an angle 45° with respect to the vertical. When the balloon climbs up a further height h_2 , it is seen at an angle 60° with respect

to the vertical if the girl moves further by a distance $2.464 d$ (point C). Then the height h_2 is (given $\tan 30^\circ = 0.5774$)

[JEE (Main)-2020]



- (1) d (2) $0.732 d$
(3) $1.464 d$ (4) $0.464 d$

28. A clock has a continuously moving second's hand of 0.1 m length. The average acceleration of the tip of the hand (in units of ms^{-2}) is of the order of

[JEE (Main)-2020]

- (1) 10^{-1} (2) 10^{-2}
(3) 10^{-4} (4) 10^{-3}

29. When a car is at rest, its driver sees rain drops falling on it vertically. When driving the car with speed v , he sees that rain drops are coming at an angle 60° from the horizontal. On further increasing the speed of the car to $(1 + \beta)v$, this angle changes to 45° . The value of β is close to

[JEE (Main)-2020]

- (1) 0.37
(2) 0.41
(3) 0.73
(4) 0.50

30. The sum of two forces $\vec{P}$ and $\vec{Q}$ is $\vec{R}$ such that $|\vec{R}| = |\vec{P}|$. The angle θ (in degrees) that the resultant of $2\vec{P}$ and $\vec{Q}$ will make with $\vec{Q}$ is,

[JEE (Main)-2020]

31. A particle is moving along the x -axis with its coordinate with time ' t ' given by $x(t) = 10 + 8t - 3t^2$. Another particle is moving along the y -axis with its coordinate as a function of time given by $y(t) = 5 - 8t^3$. At $t = 1 \text{ s}$, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then v (in m/s) is _____.

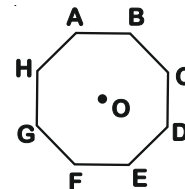
[JEE (Main)-2020]

32. In an octagon ABCDEFGH of equal side, what is the sum of

$$\vec{AB} + \vec{AC} + \vec{AD} + \vec{AE} + \vec{AF} + \vec{AG} + \vec{AH},$$

$$\text{if } \vec{AO} = 2\hat{i} + 3\hat{j} - 4\hat{k}$$

[JEE (Main)-2021]



- (1) $-16\hat{i} - 24\hat{j} + 32\hat{k}$
(2) $16\hat{i} + 24\hat{j} + 32\hat{k}$
(3) $16\hat{i} + 24\hat{j} - 32\hat{k}$
(4) $16\hat{i} - 24\hat{j} + 32\hat{k}$

33. The incident ray, reflected ray and the outward drawn normal are denoted by the unit vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ respectively. Then choose the correct relation for these vectors.

[JEE (Main)-2021]

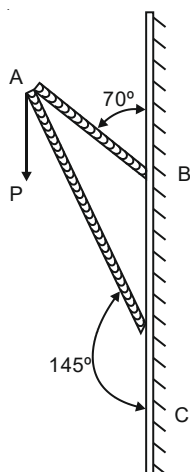
- (1) $\vec{b} = \vec{a} + 2\vec{c}$
(2) $\vec{b} = 2\vec{a} + \vec{c}$
(3) $\vec{b} = \vec{a} - 2(\vec{a} \cdot \vec{c})\vec{c}$
(4) $\vec{b} = \vec{a} - \vec{c}$

34. The trajectory of a projectile in a vertical plane is $y = \alpha x - \beta x^2$, where α and β are constants and x & y are respectively the horizontal and vertical distances of the projectile from the point of projection. The angle of projection θ and the maximum height attained H are respectively given by

[JEE (Main)-2021]

- (1) $\tan^{-1} \alpha, \frac{4\alpha^2}{\beta}$
(2) $\tan^{-1} \beta, \frac{\alpha^2}{2\beta}$
(3) $\tan^{-1} \left(\frac{\beta}{\alpha} \right), \frac{\alpha^2}{\beta}$
(4) $\tan^{-1} \alpha, \frac{\alpha^2}{4\beta}$

35. Consider a frame that is made up of two thin massless rods AB and AC as shown in the figure. A vertical force $\vec{P}$ of magnitude 100 N is applied at point A of the frame. [JEE (Main)-2021]



Suppose the force is $\vec{P}$ resolved parallel to the arms AB and AC of the frame. The magnitude of the resolved component along the arm AC is xN .

The value of x , to the nearest integer, is _____.

[Given : $\sin(35^\circ) = 0.573$,
 $\cos(35^\circ) = 0.819$
 $\sin(110^\circ) = 0.939$,
 $\cos(110^\circ) = -0.342$]

36. A mosquito is moving with a velocity $\vec{v} = 0.5t^2\hat{i} + 3t\hat{j} + 9\hat{k}$ m/s and accelerating in uniform conditions. What will be the direction of mosquito after 2 s? [JEE (Main)-2021]

- (1) $\tan^{-1}\left(\frac{\sqrt{85}}{6}\right)$ from y-axis
- (2) $\tan^{-1}\left(\frac{5}{2}\right)$ from y-axis
- (3) $\tan^{-1}\left(\frac{5}{2}\right)$ from x-axis
- (4) $\tan^{-1}\left(\frac{2}{3}\right)$ from x-axis

37. A closed organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length

of the open pipe is $\frac{x}{3}L\sqrt{\frac{\rho_1}{\rho_2}}$ where x is _____.

(Round off to the Nearest Integer)

[JEE (Main)-2021]

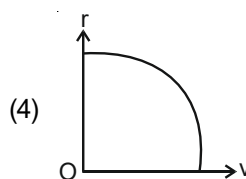
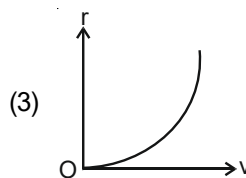
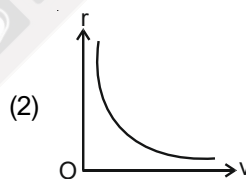
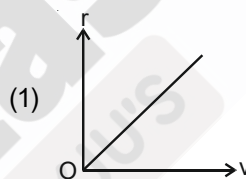
38. A person is swimming with a speed of 10 m/s at an angle of 120° with the flow and reaches to a point directly opposite on the other side of the river. The speed of the flow is ' x ' m/s. The value of ' x ' to the nearest integer is _____.

[JEE (Main)-2021]

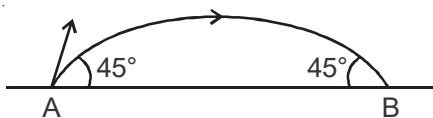
39. A particle of mass m moves in a circular orbit under the central potential field, $U(r) = -\frac{C}{r}$, where C is a positive constant.

The correct radius – velocity graph of the particle's motion is

[JEE (Main)-2021]



40. The projectile motion of a particle of mass 5 g is shown in the figure. [JEE (Main)-2021]



The initial velocity of the particle is $5\sqrt{2} \text{ ms}^{-1}$ and the air resistance is assumed to be negligible. The magnitude of the change in momentum between the points A and B is $x \times 10^{-2} \text{ kgms}^{-1}$.

The value of x , to the nearest integer, is _____.

41. If $\vec{A}$ and $\vec{B}$ are two vectors satisfying the relation $\vec{A} \times \vec{B} = |\vec{A} \times \vec{B}|$. Then the value of $|\vec{A} - \vec{B}|$ will be [JEE (Main)-2021]

- (1) $\sqrt{A^2 + B^2}$ (2) $\sqrt{A^2 + B^2 - \sqrt{2}AB}$
 (3) $\sqrt{A^2 + B^2 + 2AB}$ (4) $\sqrt{A^2 + B^2 + \sqrt{2}AB}$

42. Two vectors $\vec{P}$ and $\vec{Q}$ have equal magnitudes. If the magnitude of $\vec{P} + \vec{Q}$ is n times the magnitude of $\vec{P} - \vec{Q}$, then angle between $\vec{P}$ and $\vec{Q}$ is [JEE (Main)-2021]

- (1) $\cos^{-1}\left(\frac{n^2 - 1}{n^2 + 1}\right)$
 (2) $\sin^{-1}\left(\frac{n - 1}{n + 1}\right)$
 (3) $\sin^{-1}\left(\frac{n^2 - 1}{n^2 + 1}\right)$
 (4) $\cos^{-1}\left(\frac{n - 1}{n + 1}\right)$

43. A body rotating with an angular speed of 600 rpm is uniformly accelerated to 1800 rpm in 10 sec. The number of rotations made in the process is _____. [JEE (Main)-2021]

44. What will be the projection of vector $\vec{A} = \hat{i} + \hat{j} + \hat{k}$ on vector $\vec{B} = \hat{i} + \hat{j}$? [JEE (Main)-2021]

- (1) $\sqrt{2}(\hat{i} + \hat{j} + \hat{k})$
 (2) $(\hat{i} + \hat{j})$
 (3) $\sqrt{2}(\hat{i} + \hat{j})$
 (4) $2(\hat{i} + \hat{j} + \hat{k})$

45. Match List I with List II. [JEE (Main)-2021]

List I	List II
(a) $\vec{C} - \vec{A} - \vec{B} = 0$	(i)
(b) $\vec{A} - \vec{C} - \vec{B} = 0$	(ii)
(c) $\vec{B} - \vec{A} - \vec{C} = 0$	(iii)
(d) $\vec{A} + \vec{B} = -\vec{C}$	(iv)

Choose the correct answer from the options given below:

- (1) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (i), (c) $\rightarrow$ (iii), (d) $\rightarrow$ (ii)
 (2) (a) $\rightarrow$ (i), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (iii)
 (3) (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)
 (4) (a) $\rightarrow$ (iv), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (i), (d) $\rightarrow$ (ii)

46. Two vectors $\vec{X}$ and $\vec{Y}$ have equal magnitude. The magnitude of $(\vec{X} - \vec{Y})$ is n times the magnitude of $(\vec{X} + \vec{Y})$. The angle between $\vec{X}$ and $\vec{Y}$ is : [JEE (Main)-2021]

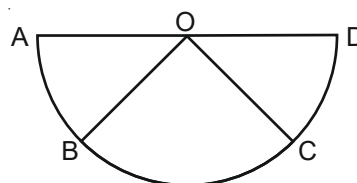
- (1) $\cos^{-1}\left(\frac{n^2 + 1}{n^2 - 1}\right)$ (2) $\cos^{-1}\left(\frac{n^2 + 1}{-n^2 - 1}\right)$
 (3) $\cos^{-1}\left(\frac{-n^2 - 1}{n^2 - 1}\right)$ (4) $\cos^{-1}\left(\frac{n^2 - 1}{-n^2 - 1}\right)$

47. **Assertion A :** If A, B, C, D are four points on a semi-circular arc with centre at 'O' such that $|\vec{AB}| = |\vec{BC}| = |\vec{CD}|$, then

$$\vec{AB} + \vec{AC} + \vec{AD} = 4\vec{AO} + \vec{OB} + \vec{OC}$$

Reason R : Polygon law of vector addition yields

$$\vec{AB} + \vec{BC} + \vec{CD} = \vec{AD} = 2\vec{AO}$$

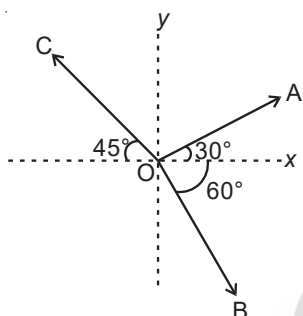


In the light of the above statements, choose the **most appropriate** answer from the options given below [JEE (Main)-2021]

- (1) **A** is not correct but **R** is correct.
 (2) **A** is correct but **R** is not correct.
 (3) Both **A** and **R** are correct and **R** is the correct explanation of **A**.
 (4) Both **A** and **R** are correct but **R** is not the correct explanation of **A**.

48. The magnitude of vectors $\vec{OA}$, $\vec{OB}$ and $\vec{OC}$ in the given figure are equal. The direction of $\vec{OA} + \vec{OB} - \vec{OC}$ with x-axis will be

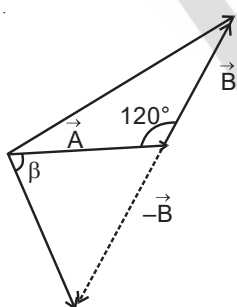
[JEE (Main)-2021]



- (1) $\tan^{-1} \frac{(1 + \sqrt{3} - \sqrt{2})}{(1 - \sqrt{3} - \sqrt{2})}$ (2) $\tan^{-1} \frac{(\sqrt{3} - 1 + \sqrt{2})}{(1 + \sqrt{3} - \sqrt{2})}$
 (3) $\tan^{-1} \frac{(\sqrt{3} - 1 + \sqrt{2})}{(1 - \sqrt{3} + \sqrt{2})}$ (4) $\tan^{-1} \frac{(1 - \sqrt{3} - \sqrt{2})}{(1 + \sqrt{3} + \sqrt{2})}$

49. The angle between vector $(\vec{A})$ and $(\vec{A} - \vec{B})$ is:

[JEE (Main)-2021]



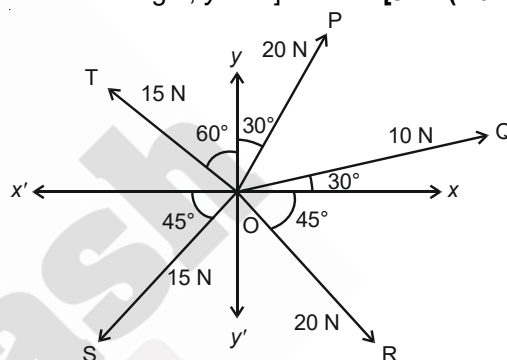
- (1) $\tan^{-1} \left(\frac{-\frac{B}{2}}{A - B \frac{\sqrt{3}}{2}} \right)$ (2) $\tan^{-1} \left(\frac{\sqrt{3}B}{2A - B} \right)$
 (3) $\tan^{-1} \left(\frac{B \cos \theta}{A - B \sin \theta} \right)$ (4) $\tan^{-1} \left(\frac{A}{0.7B} \right)$

50. A bomb is dropped by a fighter plane flying horizontally. To an observer sitting in the plane, the trajectory of the bomb is a : [JEE (Main)-2021]
 (1) Straight line vertically down the plane

- (2) Hyperbola
 (3) Parabola in the direction of motion of plane
 (4) Parabola in a direction opposite to the motion of plane

51. The resultant of these forces $\vec{OP}$, $\vec{OQ}$, $\vec{OR}$, $\vec{OS}$ and $\vec{OT}$ is approximately _____ N.

[Take $\sqrt{3} = 1.7$, $\sqrt{2} = 1.4$. Given $\hat{i}$ and $\hat{j}$ unit vectors along x, y axis] [JEE (Main)-2021]



- (1) $9.25\hat{i} + 5\hat{j}$
 (2) $3\hat{i} + 15\hat{j}$
 (3) $-1.5\hat{i} - 15.5\hat{j}$
 (4) $2.5\hat{i} - 14.5\hat{j}$

52. A player kicks a football with an initial speed of 25 ms^{-1} at an angle of 45° from the ground. What are the maximum height and the time taken by the football to reach at the highest point during motion? (Take $g = 10 \text{ ms}^{-2}$) [JEE (Main)-2021]

- (1) $h_{\max} = 10 \text{ m}$, $T = 2.5 \text{ s}$
 (2) $h_{\max} = 15.625 \text{ m}$, $T = 1.77 \text{ s}$
 (3) $h_{\max} = 3.54 \text{ m}$, $T = 0.125 \text{ s}$
 (4) $h_{\max} = 15.625 \text{ m}$, $T = 3.54 \text{ s}$

53. A helicopter is flying horizontally with a speed ' v ' at an altitude ' h ' has to drop a food packet for a man on the ground. What is the distance of helicopter from the man when the food packet is dropped? [JEE (Main)-2021]

$$(1) \sqrt{\frac{2gh}{v^2} + h^2} \quad (2) \sqrt{2ghv^2 + h^2}$$

$$(3) \sqrt{\frac{2v^2h}{g} + h^2} \quad (4) \sqrt{\frac{2ghv^2 + 1}{h^2}}$$

54. **Statement I:** If three forces $\vec{F}_1, \vec{F}_2$ and $\vec{F}_3$ are represented by three sides of a triangle and $\vec{F}_1 + \vec{F}_2 = -\vec{F}_3$, then these three forces are concurrent forces and satisfy the condition for equilibrium.

Statement II: A triangle made up of three forces $\vec{F}_1, \vec{F}_2$ and $\vec{F}_3$ as its sides taken in the same order, satisfy the condition for translatory equilibrium.

In the light of the above statements, choose the **most appropriate** answer from the options given below:

[JEE (Main)-2021]

- (1) Statement I is false but statement II is true
 (2) Both statement I and statement II are false
 (3) Both statement I and statement II are true
 (4) Statement I is true but statement II is false
55. **Statement I :** Two forces $(\vec{P} + \vec{Q})$ and $(\vec{P} - \vec{Q})$ where $\vec{P} \perp \vec{Q}$, when act at an angle θ_1 to each other, the magnitude of their resultant is $\sqrt{3(P^2 + Q^2)}$, when they act at an angle θ_2 , the magnitude of their resultant becomes $\sqrt{2(P^2 + Q^2)}$. This is possible only when $\theta_1 < \theta_2$.

Statement II : In the situation given above.

$$\theta_1 = 60^\circ \text{ and } \theta_2 = 90^\circ$$

In the light of the above statements, choose the **most appropriate** answer from the options given below :

[JEE (Main)-2021]

- (1) Both Statement I and Statement II are true.
 (2) Statement I is true but Statement II is false.
 (3) Statement I is false but Statement II is true.
 (4) Both Statement I and Statement II are false.
56. The ranges and heights for two projectiles projected with the same initial velocity at angles 42° and 48° with the horizontal are R_1, R_2 and H_1, H_2 respectively. Choose the correct option:

[JEE (Main)-2021]

- (1) $R_1 > R_2$ and $H_1 = H_2$
 (2) $R_1 < R_2$ and $H_1 < H_2$
 (3) $R_1 = R_2$ and $H_1 < H_2$
 (4) $R_1 = R_2$ and $H_1 = H_2$

57. A projectile is projected with velocity of 25 m/s at an angle θ with the horizontal. After t seconds its inclination with horizontal becomes zero. If R represents horizontal range of the projectile, the value of θ will be [use $g = 10 \text{ m/s}^2$]

[JEE (Main)-2022]

$$(1) \frac{1}{2} \sin^{-1} \left[\frac{5t^2}{4R} \right]$$

$$(2) \frac{1}{2} \sin^{-1} \left[\frac{4R}{5t^2} \right]$$

$$(3) \tan^{-1} \left[\frac{4t^2}{5R} \right]$$

$$(4) \cot^{-1} \left[\frac{R}{20t^2} \right]$$

58. Given below are two statements. One is labelled as **Assertion A** and the other is labelled as **Reason R**.

[JEE (Main)-2022]

Assertion A: Two identical balls A and B thrown with same velocity ' u ' at two different angles with horizontal attained the same range R . If A and B reached the maximum height h_1 and h_2 respectively, then $R = 4\sqrt{h_1 h_2}$.

Reason R: Product of said heights.

$$h_1 h_2 = \left(\frac{u^2 \sin^2 \theta}{2g} \right) \left(\frac{u^2 \cos^2 \theta}{2g} \right)$$

Choose the correct answer :

- (1) Both **A** and **R** are true and **R** is the correct explanation of **A**.
 (2) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**.
 (3) **A** is true but **R** is false.
 (4) **A** is false but **R** is true.
59. A fighter jet is flying horizontally at a certain altitude with a speed of 200 ms^{-1} . When it passes directly overhead an anti-aircraft gun, a bullet is fired from the gun, at an angle θ with the horizontal, to hit the jet. If the bullet speed is 400 m/s, the value of θ will be _____°.

[JEE (Main)-2022]

60. A projectile is launched at an angle ' α ' with the horizontal with a velocity 20 ms^{-1} . After 10 s, its inclination with horizontal is ' β '. The value of $\tan\beta$ will be ($g = 10 \text{ ms}^{-2}$). **[JEE (Main)-2022]**

(1) $\tan\alpha + 5\sec\alpha$ (2) $\tan\alpha - 5\sec\alpha$
(3) $2\tan\alpha - 5\sec\alpha$ (4) $2\tan\alpha + 5\sec\alpha$

61. A girl standing on road holds her umbrella at 45° with the vertical to keep the rain away. If she starts running without umbrella with a speed of $15\sqrt{2} \text{ kmh}^{-1}$, the rain drops hit her head vertically. The speed of rain drops with respect to the moving girl is **[JEE (Main)-2022]**

(1) 30 kmh^{-1} (2) $\frac{25}{\sqrt{2}} \text{ kmh}^{-1}$
(3) $\frac{30}{\sqrt{2}} \text{ kmh}^{-1}$ (4) 25 kmh^{-1}

62. Motion of a particle in x-y plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right) \text{ m}$ and $y = 4\sin(\omega t) \text{ m}$. The path of the particle will be **[JEE (Main)-2022]**

(1) Circular (2) Helical
(3) Parabolic (4) Elliptical

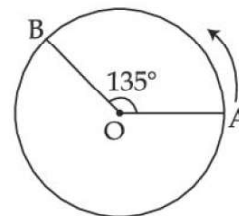
63. A ball is spun with angular acceleration $\alpha = 6t^2 - 2t$, where t is in second and α is in rads^{-2} . At $t = 0$, the ball has angular velocity of 10 rads^{-1} and angular position of 4 rad . The most appropriate expression for the angular position of the ball is : **[JEE (Main)-2022]**

(1) $\frac{3}{4}t^4 - t^2 + 10t$
(2) $\frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$
(3) $\frac{2t^4}{3} - \frac{t^3}{6} + 10t + 12$
(4) $2t^4 - \frac{t^3}{2} + 5t + 4$

64. A person can throw a ball upto a maximum range of 100 m. How high above the ground he can throw the same ball? **[JEE (Main)-2022]**

(1) 25 m (2) 50 m
(3) 100 m (4) 200 m

65. A person moved from A to B on a circular path as shown in figure. If the distance travelled by him is 60 m, then the magnitude of displacement would be (Given $\cos 135^\circ = -0.7$) **[JEE (Main)-2022]**



(1) 42 m (2) 47 m
(3) 19 m (4) 40 m

66. A ball is projected from the ground with a speed 15 ms^{-1} at an angle θ with horizontal so that its range and maximum height are equal, then ' $\tan \theta$ ' will be equal to **[JEE (Main)-2022]**

(1) $\frac{1}{4}$ (2) $\frac{1}{2}$
(3) 2 (4) 4

67. Two projectiles thrown at 30° and 45° with the horizontal respectively, reach the maximum height in same time. The ratio of their initial velocities is : **[JEE (Main)-2022]**

(1) $1 : \sqrt{2}$ (2) $2 : 1$
(3) $\sqrt{2} : 1$ (4) $1 : 2$

68. If the initial velocity in horizontal direction of a projectile is unit vector $\hat{j}$ and the equation of trajectory is $y = 5x(1 - x)$. The y component vector of the initial velocity is $\underline{\hspace{1cm}} \hat{j}$. **[JEE (Main)-2022]**

(Take $g = 10 \text{ m/s}^2$)

69. A ball of mass m is thrown vertically upward. Another ball of mass $2m$ is thrown at an angle θ with the vertical. Both the balls stay in air for the same period of time. The ratio of the heights attained by the two balls respectively is $\frac{1}{x}$. The value of x is $\underline{\hspace{1cm}}$. **[JEE (Main)-2022]**

70. At time $t = 0$ a particle starts travelling from a height $7\hat{z}$ cm in a plane keeping z coordinate constant. At any instant of time its position along the $\hat{x}$ and $\hat{y}$ directions are defined at $3t$ and $5t^3$ respectively. At $t = 1$ s acceleration of the particle will be

[JEE (Main)-2022]

- (1) $-30\hat{y}$
- (2) $30\hat{y}$
- (3) $3\hat{x} + 15\hat{y}$
- (4) $3\hat{x} + 15\hat{y} + 7\hat{z}$

71. A ball is projected with kinetic energy E , at an angle of 60° to the horizontal. The kinetic energy of this ball at the highest point of its flight will become

[JEE (Main)-2022]

- (1) Zero
- (2) $\frac{E}{2}$
- (3) $\frac{E}{4}$
- (4) E

72. An object is projected in the air with initial velocity u at an angle θ . The projectile motion is such that the horizontal range R , is maximum. Another object is projected in the air with a horizontal range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be _____ degree.

[JEE (Main)-2022]

73. If $\vec{A} = (2\hat{i} + 3\hat{j} - \hat{k})$ m and $\vec{B} = (\hat{i} + 2\hat{j} + 2\hat{k})$ m. The magnitude of component of vector $\vec{A}$ along vector $\vec{B}$ will be _____ m

74. A fly wheel is accelerated uniformly from rest and rotates through 5 rad in the first second. The angle rotated by the fly wheel in the next second, will be:

[JEE (Main)-2022]

- (1) 7.5 rad
- (2) 15 rad
- (3) 20 rad
- (4) 30 rad

75. A body is projected from the ground at an angle of 45° with the horizontal. Its velocity after 2 s is 20 ms^{-1} . The maximum height reached by the body during its motion is _____ m. (use $g = 10 \text{ ms}^{-2}$)

[JEE (Main)-2022]

76. Two projectiles are thrown with same initial velocity making an angle of 45° and 30° with the horizontal respectively. The ratio of their respective ranges will be

[JEE (Main)-2022]

- (1) $1 : \sqrt{2}$
- (2) $\sqrt{2} : 1$
- (3) $2 : \sqrt{3}$
- (4) $\sqrt{3} : 2$



Chapter 2

Motion in a Plane

1. Answer (1)

$$\vec{v} = \vec{u} + \vec{a}t$$

$$= (3\hat{i} + 4\hat{j}) + 10(0.4\hat{i} + 0.3\hat{j})$$

$$= (3\hat{i} + 4\hat{j}) + (4\hat{i} + 3\hat{j})$$

$$= 7\hat{i} + 7\hat{j}$$

$$|\vec{v}| = 7\sqrt{2} \text{ units}$$

2. Answer (1)

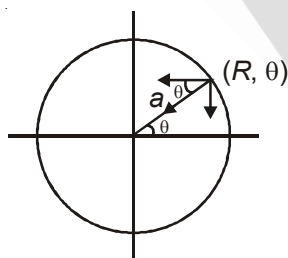
$$\frac{dx}{dt} = Ky ; \frac{dy}{dt} = Kx$$

$$\frac{dy}{dx} = \frac{x}{y} \Rightarrow ydy = xdx$$

$$\Rightarrow y^2 = x^2 + \text{constant}$$

3. Answer (4)

$$\vec{a} = \frac{-v^2}{R} \cos\theta \hat{i} - \frac{v^2}{R} \sin\theta \hat{j}$$



4. Answer (1)

$$S = t^3 + 5$$

$$\frac{dS}{dt} = 3t^2$$

$$v = 3t^2$$

$$\frac{dv}{dt} = 6t$$

At $t = 2$ s

$$v = 12 \text{ m/s}$$

$$\Rightarrow a_c = \frac{(12)^2}{20} = \frac{144}{20} = 7.2 \text{ m/s}$$

$$\frac{dv}{dt} = 12 \text{ m/s}^2$$

$$a = \sqrt{a_c^2 + a_t^2} = \sqrt{12^2 + (7.2)^2}$$

$$\approx 14 \text{ m/s}^2$$

5. Answer (3)

6. Answer (2)

$$y = x \tan\theta - \frac{gx^2}{2u^2 \cos^2\theta}$$

$$\text{Here } \tan\theta = \frac{v_y}{v_x} = 2 \text{ also } \cos\theta = \frac{1}{\sqrt{5}}, u = \sqrt{5}$$

$$\Rightarrow y = 2x - \frac{10x^2}{2 \times 5 \times \frac{1}{5}} = 2x - 5x^2$$

7. Answer (3)

$$\frac{dx}{dt} = ky$$

$$\frac{dy}{dt} = kx$$

$$\Rightarrow \frac{dy}{dx} = \frac{x}{y}$$

$$\therefore ydy = xdx \Rightarrow ydy - xdx = 0$$

$$\Rightarrow y^2 - x^2 = \text{constant}$$

$$\text{Or, } y^2 = x^2 + \text{constant}$$

8. Answer (2)

$$v_x = -a\omega \sin\omega t$$

$$v_y = a\omega \cos\omega t$$

$$v_z = a\omega$$

$$v = \sqrt{v_x^2 + v_y^2 + v_z^2} = \sqrt{2} a\omega$$

9. Answer (1)

$$\text{P.V. of } G = \frac{a}{2}(\hat{i} + \hat{k})$$

$$\text{P.V. of } H = \frac{a}{2}(\hat{j} + \hat{k})$$

$$\vec{GH} = \frac{a}{2}(\hat{j} - \hat{i})$$

10. Answer (4)

$$\frac{A_1}{A_2} = \frac{\pi R_{1,\max}^2}{\pi R_{2,\max}^2} = \left(\frac{u_1^2}{u_2^2}\right)^2 = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$$

11. Answer (2)

$$\text{Clearly, } |\vec{A} + \vec{B}|^2 = A^2 + B^2 + 2AB \cos \theta$$

$$\text{and } |\vec{A} - \vec{B}|^2 = A^2 + B^2 - 2AB \cos \theta$$

$$\text{As, } |\vec{A} + \vec{B}|^2 = n^2 |\vec{A} - \vec{B}|^2$$

$$\therefore A^2 + B^2 + 2AB \cos \theta = n^2(A^2 + B^2 - 2AB \cos \theta)$$

$$\therefore A^2 + B^2 + 2AB \cos \theta = n^2 A^2 + n^2 B^2 - 2n^2 AB \cos \theta$$

$$\therefore \cos \theta \times 2AB(1 + n^2) = A^2(n^2 - 1) + B^2(n^2 - 1)$$

$$\Rightarrow \cos \theta = \frac{(n^2 - 1)(A^2 + B^2)}{2AB(1 + n^2)}$$

$$\Rightarrow \cos \theta = \frac{n^2 - 1}{n^2 + 1}$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{n^2 - 1}{n^2 + 1}\right)$$

12. Answer (4)

 Let θ be the angle between them

$$|\vec{P} + \vec{Q}|^2 = P^2 + Q^2 + 2PQ \cos \theta$$

$$|\vec{P} + \vec{R}|^2 = 4F^2 + 9F^2 + 12F^2 \cos \theta = F_R^2 \quad \dots(i)$$

$$\text{Also, } |\vec{P} + 2\vec{Q}|^2 = 4F^2 + 36F^2 + 24F^2 \cos \theta = 4F_R^2 \quad \dots(ii)$$

Then (i) and (ii)

$$\therefore F^2 + 9F^2 + 6F^2 \cos \theta = 4F^2 + 9F^2 + 12F^2 \cos \theta$$

$$\therefore -3F^2 = 6F^2 \cos \theta \Rightarrow \cos \theta = \left(-\frac{1}{2}\right)$$

$$\Rightarrow \theta = 120^\circ$$

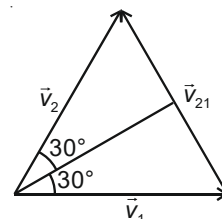
13. Answer (1)

$$\vec{V}_1 + \vec{V}_{21} = \vec{V}_2$$

$$\vec{V}_{21} = \vec{V}_2 - \vec{V}_1$$

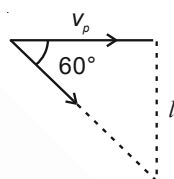
$$= |\vec{V}_{21}| = 2v \sin 30^\circ$$

$$= 2v \times \frac{1}{2} = v$$



14. Answer (3)

$$\frac{l \operatorname{cosec} 60^\circ}{v} = \frac{l \cot 60^\circ}{v_p}$$



$$\Rightarrow v_p = \frac{v}{2}$$

15. Answer (1)

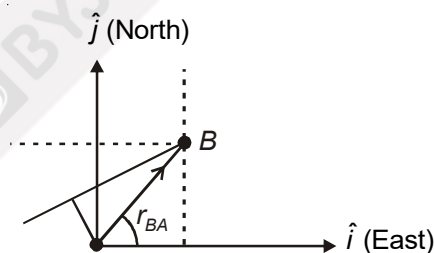
$$\omega t = \omega \frac{\pi}{2\omega} = \frac{\pi}{2}$$

$$\vec{V}_A = \omega R_1(-\hat{i})$$

$$\vec{V}_B = \omega R_2(-\hat{i})$$

$$\vec{V}_A - \vec{V}_B = \omega[R_2 - R_1]\hat{i}$$

16. Answer (4)



$$\vec{V}_A = 30\hat{i} + 50\hat{j} \text{ km/hr}$$

$$\vec{V}_{BA} = (80\hat{i} + 150\hat{j}) \text{ km}$$

$$\vec{V}_B = (-10\hat{i}) \text{ km/hr}$$

$$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A = -10\hat{i} - 30\hat{i} - 50\hat{j} = -40\hat{i} - 50\hat{j}$$

Projection of

$$(\vec{r}_{BA}) \text{ on } \vec{V}_{BA} = \frac{(\vec{r}_{BA}) \cdot (\vec{V}_{BA})}{(\vec{V}_{BA})}$$

$$= \frac{(80\hat{i} + 150\hat{j}) \cdot (-40\hat{i} - 50\hat{j})}{10\sqrt{41}} = \frac{\sqrt{mk}}{qB}$$

$$\therefore t = \frac{10 \times 107}{\sqrt{41} \times 10\sqrt{41}} = \frac{107}{41} = 2.6 \text{ Hrs.}$$

17. Answer (2)

$$\begin{aligned} (2\vec{A}_1 + 3\vec{A}_2) \cdot (3\vec{A}_1 - 2\vec{A}_2) &= 6|\vec{A}_1|^2 + 5\vec{A}_1 \cdot \vec{A}_2 - 6|\vec{A}_2|^2 \\ &= (6 \times 9) + 5\vec{A}_1 \cdot \vec{A}_2 - (6 \times 25) \quad \dots(i) \end{aligned}$$

$$\text{As } 25 = 9 + 25 + 2\vec{A}_1 \cdot \vec{A}_2$$

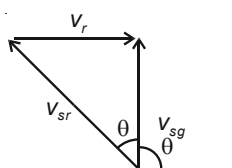
$$\Rightarrow 2\vec{A}_1 \cdot \vec{A}_2 = -9 \quad \dots(ii)$$

From (i) and (ii),

$$\begin{aligned} \Rightarrow (2\vec{A}_1 + 3\vec{A}_2) \cdot (3\vec{A}_1 - 2\vec{A}_2) &= 54 - 22.5 - 150 \\ &= -118.5 \end{aligned}$$

18. Answer (4)

Draw velocity diagram,



$$\sin \theta = \frac{v_r}{v_{sr}} = \frac{1}{2}$$

$$\theta = 30^\circ$$

$$\phi = 90 + \theta = 120^\circ$$

19. Answer (1)

$$\vec{r} = 15t^2\hat{i} + 4\hat{j} - 20t^2\hat{j}$$

$$\frac{d\vec{r}}{dt} = 30t\hat{i} - 40t\hat{j}$$

$$\frac{d^2\vec{r}}{dt^2} = 30\hat{i} - 40\hat{j}$$

$$\therefore \left| \frac{d^2\vec{r}}{dt^2} \right| = 50 \text{ m/s}^2$$

20. Answer (3)

$$x = x_0 + a \cos \omega_1 t$$

$$y = y_0 + b \sin \omega_2 t$$

$$\Rightarrow v_x = -a\omega_1 \sin(\omega_1 t), \quad v_y = b\omega_2 \cos(\omega_2 t)$$

$$a_x = -a\omega_1^2 \cos(\omega_1 t), \quad a_y = -b\omega_2^2 \sin(\omega_2 t)$$

$$\text{At } t = 0, \quad x = x_0 + a, \quad y = y_0$$

$$a_x = -a\omega_1^2, \quad a_y = 0$$

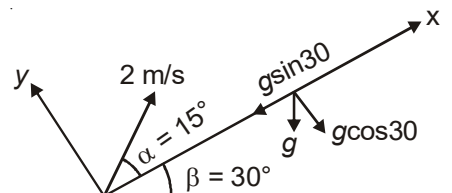
$$\therefore \vec{\tau} = m(-a\omega_1^2) \times y_0(-\hat{k})$$

$$= +my_0a\omega_1^2 \hat{k}$$

21. Answer (2)

$$\text{Time of flight } (T) = \frac{2u \sin \alpha}{g \cos \beta}$$

$$T = \frac{(2)(2 \sin 15)}{g \cos 30} = \frac{4 \sin 15}{10 \cos 30}$$



$$\text{Range } (R) = (2 \cos 15)T - \frac{1}{2}g \sin 30(T)^2$$

$$\begin{aligned} &= (2 \cos 15) \frac{4 \sin 15}{10 \cos 30} - \left(\frac{1}{2} \times 10 \sin 30 \right) \frac{16 \sin^2 15}{100 \cos^2 30} \\ &= \frac{16\sqrt{3} - 16}{60} \approx 0.1952 \text{ m} \approx 20 \text{ cm} \end{aligned}$$

22. Answer (2)

For same horizontal range,

$$\theta_1 = \theta \quad R = \frac{u^2 \sin 2\theta}{g}$$

$$\theta_2 = (90 - \theta)$$

$$\text{so } t_1 = \frac{2u \sin \theta}{g} \text{ and } t_2 = \frac{2u \cos \theta}{g}$$

$$\therefore t_1 t_2 = \frac{u^2 4 \sin \theta \cos \theta}{g^2}$$

$$\Rightarrow t_1 t_2 = \frac{2u^2 \sin 2\theta}{g^2} = \frac{2R}{g}$$

23. Answer (3)

$$y = 2x - 9x^2$$

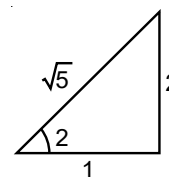
Comparing it with equation of trajectory

$$y = x \tan \theta - \frac{g x^2}{24^2 \cos^2 \theta}$$

$$\therefore \tan \theta = 2$$

$$\text{And } g = \frac{10 \times 5}{2 v_0^2}$$

$$\Rightarrow v_0 = \frac{5}{3} \text{ m/s}$$



24. Answer (2)

At complementary angles, ranges are equal.

$$\therefore h_1 = \frac{u^2 \sin^2 \theta}{2g}, h_2 = \frac{u^2 \cos^2 \theta}{2g}$$

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

$$\Rightarrow 16h_1 h_2 = R^2$$

25. Answer (1)

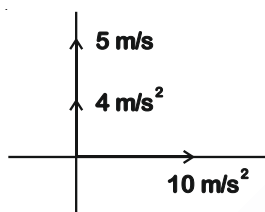
$$\frac{1}{2} \times 4 \times t^2 = 32$$

$$t = 4 \text{ s}$$

$$x = 3 \times 4 + \frac{1}{2} \times 6 \times 4^2 = 60$$

26. Answer (4)

At $t = t$, (20 m, y_0)



$$\therefore t = \sqrt{\frac{20 \times 2}{10}} = 2 \text{ s}$$

$$\therefore y_0 = 5 \times 2 + \frac{1}{2} \times 4 \times 2^2 = 18 \text{ m}$$

27. Answer (1)

$$\frac{h_1}{d} = \tan 45^\circ$$

$$\frac{h_1 + h_2}{d + 2.464d} = \tan 30^\circ$$

$$\Rightarrow h_2 = d$$

28. Answer (4)

$$a = \omega^2 \times \ell$$

$$= \left(\frac{2\pi}{T} \right)^2 \times \ell$$

$$= \left(\frac{2\pi}{60} \right)^2 \times 0.1$$

$$= 1.1 \times 10^{-3} \text{ m/s}^2$$

29. Answer (3)

Given

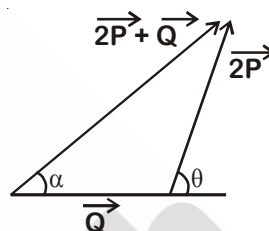
$$\frac{v^1}{v} = \tan 60^\circ \dots (i) \quad \longrightarrow \quad \vec{v} \quad \triangle 60^\circ$$

$$\frac{v^1}{v(1+\beta)} = \tan 45^\circ \dots (ii) \quad \longrightarrow \quad \vec{v(1+\beta)} \quad \triangle 45^\circ$$

From (i) and (ii)

$$\beta = 0.73$$

30. Answer (90)



$$P^2 = P^2 + Q^2 + 2PQ \cdot \cos \theta$$

$$\Rightarrow \cos \theta = -\frac{Q}{2P} \dots (i)$$

$$\tan \alpha = \frac{2P \sin \theta}{Q + 2P \cos \theta} = \infty$$

$$\Rightarrow \alpha = 90^\circ$$

31. Answer (580)

For particle 'A'

$$X_A = -3t^2 + 8t + 10$$

$$\vec{V}_A = (8 - 6t)\hat{i}$$

$$\vec{a}_A = -6\hat{i}$$

at $t = 1 \text{ sec}$

$$\vec{V}_A = 2\hat{i}, \vec{V}_B = -24\hat{j}$$

$$\therefore \vec{V}_{B/A} = -\vec{V}_A + \vec{V}_B = -2\hat{i} - 24\hat{j}$$

$$\text{Speed of B w.r.t. A, } |\vec{V}_{B/A}| = \sqrt{4 + 576} = \sqrt{580}$$

$$\therefore v = 580 \text{ (m/s)}^2$$

32. Answer (3)

$$\overline{AB} + \overline{AC} + \overline{AD} + \overline{AE} + \overline{AF} + \overline{AG} + \overline{AH}$$

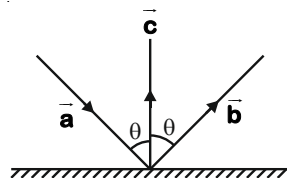
$$= 8\overline{AO}$$

33. Answer (3)

$$\vec{b} - \vec{a} = 2\cos\theta\vec{c}$$

$$\vec{b} = \vec{a} + 2\cos\theta\vec{c}$$

$$\vec{b} = \vec{a} - 2(\vec{a} \cdot \vec{c})\vec{c}$$



34. Answer (4)

$$y = \alpha x - \beta x^2$$

$$\Rightarrow \tan\theta = \alpha \Rightarrow \theta = \tan^{-1}\alpha$$

$$\text{also, } \frac{dy}{dx} = \alpha - 2\beta x$$

$$\frac{dy}{dx} = 0 \Rightarrow x = \frac{\alpha}{2\beta}$$

$$y = \frac{\alpha^2}{2\beta} - \frac{\alpha^2}{4\beta} = \frac{\alpha^2}{4\beta} \quad \text{at } x = \frac{\alpha}{2\beta}$$

35. Answer (164)

Let component be x, y

$$x\cos 35^\circ + y\cos 70^\circ = P$$

$$x\sin 35^\circ + y\sin 70^\circ = 0$$

$$y = \frac{-x}{2\cos 35^\circ}$$

$$x\cos 35^\circ - \frac{x\cos 70^\circ}{2\cos 35^\circ} = P$$

$$x = 2P\cos 35^\circ$$

36. Answer (1)

$$\vec{v} = (0.5t^2\hat{i} + 3t\hat{j} + 9\hat{k}) \text{ m/s}$$

At $t = 2 \text{ s}$

$$\vec{v} = (2\hat{i} + 6\hat{j} + 9\hat{k})$$

$$\cos\theta = \frac{(\vec{v} \cdot \hat{j})}{\sqrt{9^2 + 6^2 + 2^2}} = \frac{6}{\sqrt{121}} = \frac{6}{11}$$

$$\sin\theta = \frac{\sqrt{85}}{11}$$

$$\tan\theta = \frac{\sqrt{85}}{6}$$

37. Answer (4)

$$v = \sqrt{\frac{1}{k\rho}}$$

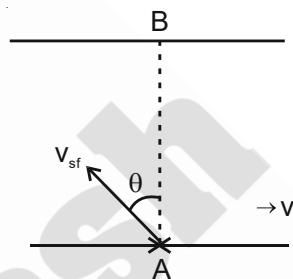
$$\frac{3v_1}{4L} = \frac{2v_2}{2L_2}$$

$$\Rightarrow L_2 = \frac{4}{3}L \left(\frac{v_2}{v_1} \right)$$

$$= \frac{4}{3}L \sqrt{\frac{\rho_1}{\rho_2}}$$

$$x = 4$$

38. Answer (5)



$$\sin\theta = \frac{v_f}{v_{sf}}$$

$$\sin 30^\circ = \frac{x}{10}$$

$$x = 5$$

39. Answer (2)

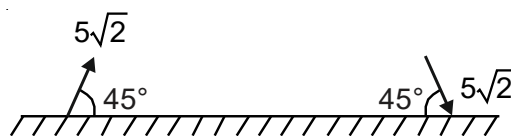
$$F_r = -\frac{dU}{dr}$$

$$= -\frac{d}{dr} \left(-\frac{C}{r} \right) = -\frac{C}{r^2}$$

$$\Rightarrow \frac{mv^2}{r} = \frac{C}{r^2}$$

$$\Rightarrow v^2 = \frac{C}{mr}$$

40. Answer (5)



$$|\Delta\vec{P}| = 2 \times (5 \times 10^{-3}) (5)$$

$$= 5 \times 10^{-2} \text{ kg ms}^{-1}$$

41. Answer (2)

$$\begin{aligned}\vec{A} \cdot \vec{B} &= |\vec{A} \times \vec{B}| \\ \Rightarrow AB \cos \theta &= AB \sin \theta \\ \Rightarrow \cos \theta &= \sin \theta \quad \Rightarrow \theta = 45^\circ \\ \therefore |\vec{A} - \vec{B}| &= \sqrt{A^2 + B^2 - 2AB \cos \theta} \\ &= \sqrt{A^2 + B^2 - \sqrt{2}AB}\end{aligned}$$

42. Answer (1)

$$\begin{aligned}|\vec{P} + \vec{Q}|^2 &= n^2 |\vec{P} - \vec{Q}|^2 \\ \Rightarrow P^2 + Q^2 + 2PQ \cos \theta &= n^2 (P^2 + Q^2 - 2PQ \cos \theta) \\ \Rightarrow 1 + 1 + 2 \cos \theta &= n^2 (1 + 1 - 2 \cos \theta) \\ \Rightarrow 1 + \cos \theta &= n^2 (1 - \cos \theta) \\ \Rightarrow \frac{1 + \cos \theta}{1 - \cos \theta} &= \frac{n^2}{1} \\ \Rightarrow \frac{1}{\cos \theta} &= \frac{n^2 + 1}{n^2 - 1} \\ \Rightarrow \theta &= \cos^{-1} \left(\frac{n^2 - 1}{n^2 + 1} \right)\end{aligned}$$

43. Answer (200)

$$\begin{aligned}4\pi^2 \frac{(18^2 - 6^2)10^4}{60^2} &= \frac{2 \times 1200}{10} \times \frac{\pi 2 \times \theta}{60} \\ \theta &= \frac{\pi \times 24 \times 12 \times 10^4}{120 \times 60} = \frac{\pi 24 \times 10^3}{60} \\ \theta &= \frac{(12000)(2\pi)}{60} \\ &= (200)2\pi\end{aligned}$$

44. Answer (2)

$$\begin{aligned}\text{Projection} &= \frac{\vec{A} \cdot \vec{B}}{|\vec{B}|} (\hat{B}) \\ &= \frac{(\hat{i} + \hat{j} + \hat{k}) \cdot (\hat{i} + \hat{j})}{\sqrt{2}} \frac{(\hat{i} + \hat{j})}{\sqrt{2}} \\ &= \frac{2(\hat{i} + \hat{j})}{\sqrt{2} \sqrt{2}} \\ &= (\hat{i} + \hat{j})\end{aligned}$$

45. Answer (4)

- (a) $\vec{C} = \vec{A} + \vec{B} \Rightarrow$ (iv)
 (b) $\vec{A} = \vec{B} + \vec{C} \Rightarrow$ (iii)
 (c) $\vec{B} = \vec{A} + \vec{C} \Rightarrow$ (i)
 (d) $-\vec{C} = \vec{A} + \vec{B} \Rightarrow$ (ii)

46. Answer (4)

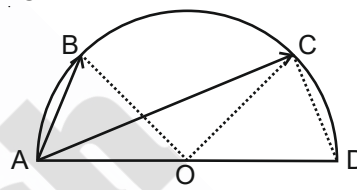
$$\begin{aligned}|\vec{X} + \vec{Y}|^2 &= X^2 + Y^2 + 2XY \cos \theta \\ |\vec{X} - \vec{Y}|^2 &= X^2 + Y^2 - 2XY \cos \theta \\ n^2 &= \frac{2 - 2 \cos \theta}{2 + 2 \cos \theta} \\ n^2 &= \frac{1 - \cos \theta}{1 + \cos \theta}\end{aligned}$$

$$n^2 + n^2 \cos \theta = 1 - \cos \theta$$

$$\cos \theta = -\left(\frac{n^2 - 1}{n^2 + 1} \right)$$

47. Answer (4)

$$\vec{AB} + \vec{AC} + \vec{AD}$$



$$\begin{aligned}&= (\vec{AO} + \vec{OB}) + (\vec{AO} + \vec{OC}) + 2\vec{AO} \\ &= 4\vec{AO} + \vec{OB} + \vec{OC}\end{aligned}$$

48. Answer (4)

$$\begin{aligned}\text{Sum of } x \text{ component,} \\ R_x &= a \cos 30^\circ + a \cos 60^\circ + a \cos 45^\circ \\ &= a \left(\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{1}{\sqrt{2}} \right) \\ &= a \frac{\sqrt{3} + 1 + \sqrt{2}}{2}\end{aligned}$$

Sum of y component,

$$\begin{aligned}R_y &= a \sin 30^\circ - a \sin 60^\circ - a \sin 45^\circ \\ &= \frac{a}{2} - \frac{a\sqrt{3}}{2} + \frac{a}{\sqrt{2}} = a \frac{1 - \sqrt{3} - \sqrt{2}}{2}\end{aligned}$$

$$\text{Now, } \tan \theta = \frac{R_y}{R_x} = \frac{1 - \sqrt{3} - \sqrt{2}}{\sqrt{3} + 1 + \sqrt{2}}$$

$$\theta = \tan^{-1} \left(\frac{1 - \sqrt{3} - \sqrt{2}}{1 + \sqrt{3} + \sqrt{2}} \right)$$

49. Answer (2)

 Angle between $\vec{A}$ and $\vec{B} = 60^\circ$

 So angle between $\vec{A}$ and $-\vec{B} = 120^\circ$

If angle between $\vec{A}$ and $\vec{A} - \vec{B}$ is θ

$$\begin{aligned}\text{then } \tan \theta &= \frac{|\vec{B}| \sin \theta}{\vec{A} + |\vec{B}| \cos \theta} \\ &= \frac{B \sin 120^\circ}{A + B \cos 120^\circ} = \frac{B \frac{\sqrt{3}}{2}}{A - \frac{B}{2}} \\ &= \frac{\sqrt{3} B}{2A - B}\end{aligned}$$

$$\theta = \tan^{-1} \left(\frac{B\sqrt{3}}{2A - B} \right)$$

50. Answer (1)

Relative velocity of bomb w.r.t. observer in plane = 0
Bomb will fall down vertically. So, it will move in straight line w.r.t. observer.

51. Answer (1)

$$\begin{aligned}\sum F_x &= 10 \times \frac{\sqrt{3}}{2} + 20 \times \frac{1}{2} - 15 \times \frac{\sqrt{3}}{2} - 15 \times \frac{1}{\sqrt{2}} + 20 \times \frac{1}{\sqrt{2}} \\ &= 8.5 + 10 - 12.75 - 10.71 + 14.28 = 9.32\end{aligned}$$

$$\begin{aligned}\sum F_y &= 10 \times \frac{1}{2} + 20 \times \frac{\sqrt{3}}{2} + 15 \times \frac{1}{2} - 15 \times \frac{1}{\sqrt{2}} - 20 \times \frac{1}{\sqrt{2}} \\ &= 5 + 17 + 7.5 - 10.71 - 14.28 = 4.54\end{aligned}$$

$$\vec{F}_{net} = 9.32\hat{i} + 4.54\hat{j}$$

52. Answer (2)

$$h_{\max} = \frac{u^2 \sin^2 \theta}{2g} = \frac{25^2 \times \frac{1}{2}}{2 \times 10} = 15.625 \text{ m}$$

$$T = \frac{u \sin \theta}{g} = \frac{25 \times \frac{1}{\sqrt{2}}}{10} = 1.77 \text{ s}$$

53. Answer (3)

$$\text{Time of flight} = \sqrt{\frac{2h}{g}}$$

$$\text{Now displacement in horizontal direction} = \sqrt{\frac{2h}{g}} v$$

So, distance of man from helicopter

$$= \sqrt{h^2 + \left(\sqrt{\frac{2h}{g}} v \right)^2}$$

$$= \sqrt{h^2 + \frac{2v^2 h}{g}}$$

54. Answer (3)

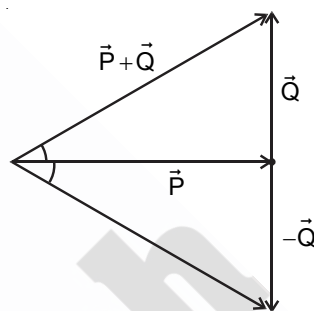
$$\text{As, } \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$$

So three forces are concurrent and object is in equilibrium.

$$\text{Also if } \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$$

then $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$ lie along sides of triangle taken in order

55. Answer (1)



$$|\vec{P} + \vec{Q} + \vec{P} - \vec{Q}| = \sqrt{3} \sqrt{P^2 + Q^2}$$

$$4P^2 = 3(P^2 + Q^2)$$

$$P^2 = 3Q^2$$

$$\theta_1 = 2 \tan^{-1} \left(\frac{Q}{P} \right)$$

$$= 60^\circ$$

For case-II

$$4P^2 = 2(P^2 + Q^2)$$

$$P = Q$$

$$\theta_2 = 2 \tan^{-1} \left(\frac{Q}{P} \right) = 90^\circ$$

56. Answer (3)

$$R = \frac{U^2 \sin 2\theta}{g}$$

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

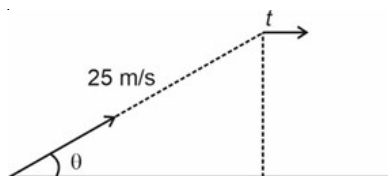
$$\theta_1 + \theta_2 = 90$$

$$\Rightarrow R_1 = R_2$$

$$\theta_1 < \theta_2$$

$$\Rightarrow H_1 < H_2$$

57. Answer (4)



$$t = \frac{25 \sin \theta}{g}$$

$$\text{and, } R = \frac{(25)^2 (2 \sin \theta \cos \theta)}{g}$$

$$\Rightarrow R = \frac{25 \times 25 \times 2}{g} \times \frac{gt}{25} \times \cos \theta$$

$$\Rightarrow R = 50t \cos \theta$$

$$\therefore \tan \theta = \frac{gt}{25} \times \frac{50t}{R}$$

$$= \frac{20t^2}{R}$$

$$\Rightarrow \theta = \cot^{-1} \left(\frac{R}{20t^2} \right)$$

58. Answer (1)

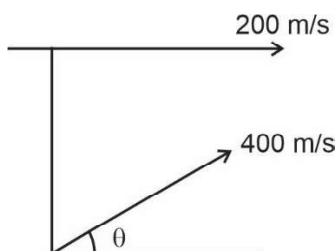
$$h_1 = \frac{u^2 \sin^2 \theta}{2g}$$

$$h_2 = \frac{u^2 \cos^2 \theta}{2g}$$

$$\therefore \sqrt{h_1 h_2} = \frac{u^2 \sin \theta \cos \theta}{2g} = \frac{R}{4}$$

$$\Rightarrow R = 4\sqrt{h_1 h_2}$$

59. Answer (60)



To hit the jet

$$400 \cos \theta = 200$$

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

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

60. Answer (2)

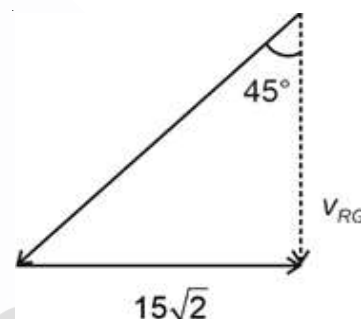
$$v_y = 20 \times \sin \alpha - 10 \times 10$$

$$v_x = 20 \cos \alpha$$

$$\therefore \tan \beta = \frac{v_y}{v_x} = \frac{20 \sin \alpha - 100}{20 \cos \alpha}$$

$$= \tan \alpha - 5 \sec \alpha$$

61. Answer (3)



From graph,

$$v_{RG} = 15\sqrt{2} \tan 45^\circ$$

$$= 15\sqrt{2}$$

$$= \frac{30}{\sqrt{2}}$$

62. Answer (1)

$$x = 4 \sin \left(\frac{\pi}{2} - \omega t \right)$$

$$= 4 \cos(\omega t)$$

$$y = 4 \sin(\omega t)$$

$$\Rightarrow x^2 + y^2 = 4^2$$

$\Rightarrow$ The particle is moving in a circular motion with radius of 4 m.

63. Answer (2)

$$\alpha = \frac{d\omega}{dt} = 6t^2 - 2t$$

$$\int_0^\omega d\omega = \int_0^t (6t^2 - 2t) dt$$

$$\text{so } \omega = 2t^3 - t^2 + 10$$

$$\text{and } \frac{d\theta}{dt} = 2t^3 - t^2 + 10$$

$$\text{so } \int_4^0 d\theta = \int_0^t (2t^3 - t^2 + 10) dt$$

$$\theta = \frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$$

64. Answer (2)

$$R_{\max} = \frac{u^2}{g} = 100 \text{ m}$$

$$\text{So, } H_{\max} = \frac{u^2}{2g} = 50 \text{ m}$$

65. Answer (2)

Distance travelled = 60 m

$\Rightarrow$ Angle covered = 135°

$$\text{Displacement} = 2R \sin\left(\frac{135^\circ}{2}\right)$$

$$= 2 \left(\frac{60}{135} \times \frac{180}{\pi} \right) \left[\frac{1 - \cos(135^\circ)}{2} \right]^{1/2}$$

$$= 2 \left(\frac{80}{\pi} \right) (0.85)^{1/2}$$

$$\approx 47 \text{ m}$$

66. Answer (4)

$$\therefore \tan \theta = \frac{4H}{R}$$

$$\Rightarrow \tan \theta = 4 \times 1$$

$$\Rightarrow \tan \theta = 4$$

67. Answer (3)

$$\therefore t_a = \frac{u \sin \theta}{g}$$

$$\Rightarrow \frac{u_1 \sin(30^\circ)}{g} = \frac{u_2 \sin(45^\circ)}{g}$$

$$\Rightarrow \frac{u_1}{u_2} = \frac{\frac{1}{2}}{\frac{1}{\sqrt{2}}} = \frac{\sqrt{2}}{1}$$

68. Answer (5)

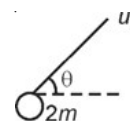
$$y = 5x - 5x^2$$

$$y = x \tan \theta - \frac{1}{2} \frac{gx^2}{v^2}$$

$$\tan \theta = 5 = \frac{u_y}{u_x}$$

$$\Rightarrow u_y = 5$$

69. Answer (1)



$$T_1 = \frac{2u_1}{g}$$

$$T_2 = \frac{2u_2 \sin \theta}{g}$$

$$\therefore u_1 = u_2 \sin \theta$$

$$\begin{aligned} \frac{H_1}{H_2} &= \frac{\frac{u_1^2}{2g}}{\frac{u_2^2 \sin^2 \theta}{2g}} \\ &= \left(\frac{u_1}{u_2 \sin \theta} \right)^2 \\ &= 1 \end{aligned}$$

70. Answer (2)

$$x = 3t \Rightarrow a_x = 0$$

$$y = 5t^3 \Rightarrow a_y = 30t$$

$$\vec{a}(t=1) = 30\hat{y}$$

71. Answer (3)

$$K \cdot E = E = \frac{1}{2} mv^2$$

at highest point

$$K \cdot E' = \frac{1}{2} mv^2 \cos^2 \theta$$

$$= \frac{1}{2} mv^2 \left(\frac{1}{4} \right)$$

$$= \frac{E}{4}$$

72. Answer (15)

$$\theta = 45^\circ$$

$$R_1 = \frac{R}{2}$$

$$\frac{u^2 \sin 2\theta_1}{g} = \frac{u^2 \sin(90^\circ)}{2g}$$

$$\Rightarrow 2\theta_1 = 90^\circ$$

$$\theta_1 = 45^\circ$$

73. Answer (2)

$$A \cos \theta = \frac{\vec{A} \cdot \vec{B}}{|\vec{B}|} = \frac{2+6-2}{3} = \frac{6}{3} = 2$$

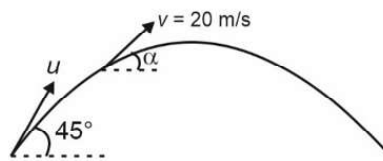
74. Answer (2)

$$\theta_1 = \frac{1}{2} \alpha (2 \times 1 - 1) = 5 \text{ rad}$$

$$\Rightarrow \alpha = 10 \text{ rad/sec}^2$$

$$\text{So } \theta_2 = \frac{1}{2} \times \alpha (2 \times 2 - 1) = 15 \text{ rad}$$

75. Answer (20)



$$\Rightarrow v \cos \alpha = u \cos 45^\circ \quad \dots(i)$$

$$\& v \sin \alpha = u \sin 45^\circ - gt \quad \dots(ii)$$

Solve for u we get

$$u = 20\sqrt{2} \text{ m/s}$$

$$\Rightarrow H = \frac{u^2 \sin^2 45^\circ}{2g} = 20 \text{ m}$$

76. Answer (3)

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

$$\Rightarrow \frac{R_1}{R_2} = \frac{\sin 2\theta_1}{\sin 2\theta_2} = \frac{1}{\frac{\sqrt{3}}{2}} = \frac{2}{\sqrt{3}}$$

□ □ □

Q1 - 24 January - Shift 1

The maximum vertical height to which a man can throw a ball is 136 m. The maximum horizontal distance upto which he can throw the same ball is

- (1) 192 m (2) 136 m
(3) 272 m (4) 68 m

Space for your notes:

Q2 - 25 January - Shift 2

Two objects are projected with same velocity 'u' however at different angles α and β with the horizontal. If $\alpha + \beta = 90^\circ$, the ratio of horizontal range of the first object to the 2nd object will be :

- (1) 4 : 1 (2) 2 : 1
(3) 1 : 2 (4) 1 : 1

Space for your notes:

Q3 - 29 January - Shift 1

A stone is projected at angle 30° to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of flight will be :

- (1) 1 : 2 (2) 1 : 4
(3) 4 : 1 (4) 4 : 3

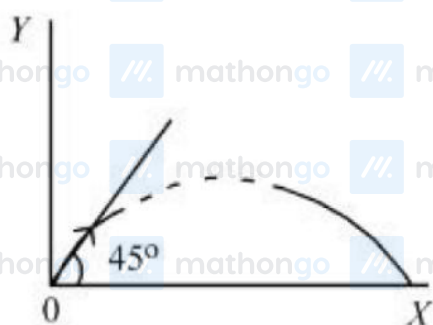
Space for your notes:

Q4 - 29 January - Shift 2

A particle of mass 100 g is projected at time $t = 0$ with a speed 20 ms^{-1} at an angle 45° to the horizontal as given in the figure. The magnitude of the angular momentum of the particle about the starting point at time $t = 2\text{s}$ is found to be

$\sqrt{K} \text{ kg m}^2 / \text{s}$. The value of K is _____.

(Take $g = 10 \text{ ms}^{-2}$)



Space for your notes:

Q5 - 31 January - Shift 1

The initial speed of a projectile fired from ground is u . At the highest point during its motion, the

speed of projectile is $\frac{\sqrt{3}}{2}u$. The time of flight of

the projectile is:

(1) $\frac{u}{2g}$

(2) $\frac{u}{g}$

(3) $\frac{2u}{g}$

(4) $\frac{\sqrt{3}u}{g}$

Space for your notes:

Q6 - 31 January - Shift 1

The speed of a swimmer is 4 km h^{-1} in still water.

If the swimmer makes his strokes normal to the flow of river of width 1 km , he reaches a point 750 m down the stream on the opposite bank.

The speed of the river water is _____ km h^{-1} .

Space for your notes:

Q7 - 31 January - Shift 2

Two bodies are projected from ground with same speeds 40 ms^{-1} at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60° , with horizontal then sum of the maximum heights, attained by the two projectiles, is _____ m . (Given $g=10\text{ms}^{-2}$)

Space for your notes:

Q8 - 01 February - Shift 1

A child stands on the edge of the cliff 10 m above the ground and throws a stone horizontally with an initial speed of 5 ms^{-1} . Neglecting the air resistance, the speed with which the stone hits the ground will be _____ ms^{-1} (given, $g = 10 \text{ ms}^{-2}$).

Space for your notes:

(1) 20

(2) 15

(3) 30

(4) 25

Answer Key

(As per Official NTA Key released on 2 Feb)

Q1 (3)

Q2 (4)

Q3 (4)

Q4 (800)

Q5 (2)

Q6 (3)

Q7 (80)

Q8 (2)

#MathBoleTohMathonGo

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Q1 (3)

$$H_{\max} = \frac{v^2}{2g} = 136\text{m}$$

$$R_{\max} = \frac{v^2}{g} = 2H_{\max}$$

$$= 2(136)$$

$$= 272 \text{ m}$$

Q2 (4)

#MathBoleTohMathonGo

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

Range for projection angle “ α ”

$$R_1 = \frac{u^2 \sin 2\alpha}{g}$$

Range for projection angle “ β ”

$$R_2 = \frac{u^2 \sin 2\beta}{g}$$

$$\alpha + \beta = 90^\circ \text{ (Given)}$$

$$\Rightarrow \boxed{\beta = 90^\circ - \alpha}$$

$$R_2 = \frac{u^2 \sin 2(90^\circ - \alpha)}{g}$$

$$R_2 = \frac{u^2 \sin(180^\circ - 2\alpha)}{g}$$

$$R_2 = \frac{u^2 \sin 2\alpha}{g}$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{\left(\frac{u^2 \sin 2\alpha}{g} \right)}{\left(\frac{u^2 \sin 2\alpha}{g} \right)} = \frac{1}{1}$$

#MathBoleTohMathonGo

Q3 (4)

$$\frac{KE_{\text{POP}}}{KE_{\text{top}}} = \frac{\frac{1}{2} M (u)^2}{\frac{1}{2} M (u \cos 30^\circ)^2} = \frac{4}{3}$$

Q4 (800)

$$\text{Use } \Delta L = \int_0^t \tau dt$$

$$L_0 = \int_0^2 mg(v_x t) dt$$

$$= mg v_x \frac{t^2}{2} = (0.1)(10)(10\sqrt{2}) \frac{2^2}{2}$$

$$= 20\sqrt{2}$$

$$= \sqrt{800} \text{ kg m}^2 / \text{s}$$

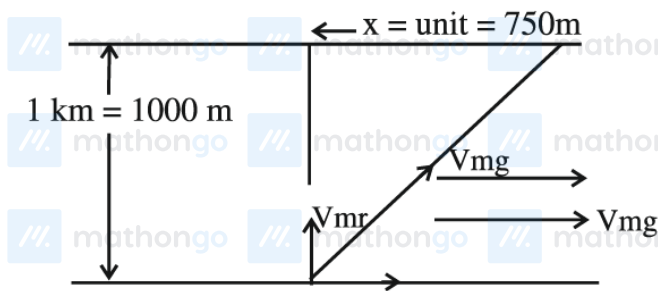
Q5 (2)

$$u \cos \theta = \frac{\sqrt{3}u}{2} \Rightarrow \cos \theta = \frac{\sqrt{3}}{2}$$

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

$$T = \frac{2u \sin 30^\circ}{g} = \frac{u}{g}$$

Q6 (3)



time to cross the River width $t = 1000 \text{ m}$

$$t = \frac{1 \text{ km}}{4 \text{ km/h}}$$

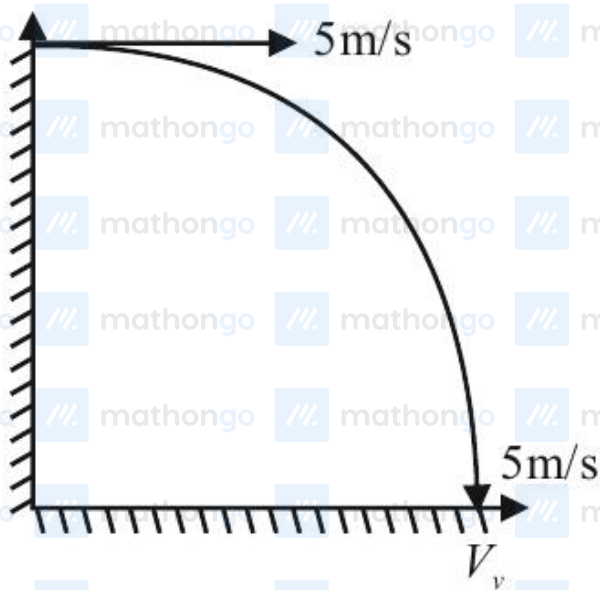
$$\text{Drift } x = V_{m/g} \times t$$

Where $V_{m/g}$ is velocity of River w.r. to ground.

Q7 (80)

No Solution

Q8 (2)



$$v_y = \sqrt{2gh} = \sqrt{200}$$

$$v_{net} = \sqrt{25 + 200} = 15 \text{ m/s}$$

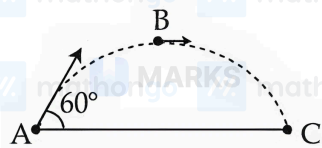
Q1. JEE Main 2026 (21 January Shift 2)

A river of width 200 m is flowing from west to east with a speed of 18 km/h. A boat, moving with speed of 36 km/h in still water, is made to travel one-round trip (bank to bank of the river). Minimum time taken by the boat for this journey and also the displacement along the river bank are _____ and _____ respectively.

- (1) 20 s and 100 m (2) 40 s and 0 m
(3) 40 s and 200 m (4) 40 s and 100 m

Q2. JEE Main 2026 (23 January Shift 1)

An object is projected with kinetic energy K from a point A at an angle 60° with the horizontal. The ratio of the difference in kinetic energies at points B and C to that at point A (see figure), in the absence of air friction is :



- (1) 1 : 4 (2) 2 : 3 (3) 3 : 4 (4) 1 : 2

Q3. JEE Main 2026 (22 January Shift 1)

A projectile is thrown upward at an angle 60° with the horizontal. The speed of the projectile is 20 m/s when its direction of motion is 45° with the horizontal. The initial speed of the projectile is _____ m/s.

- (1) $20\sqrt{2}$ (2) 40 (3) $40\sqrt{2}$ (4) $20\sqrt{3}$

Q4. JEE Main 2026 (24 January Shift 1)

A boy throws a ball into air at 45° from the horizontal to land it on a roof of a building of height H . If the ball attains maximum height in 2 s and lands on the building in 3 s after launch, then value of H is _____ m.

($g = 10 \text{ m/s}^2$)

- (1) 15 (2) 20 (3) 25 (4) 10

ANSWERS AND SOLUTIONS

1. (3)

2. (3)

3. (1)

4. (1)

1. (3) Width of the river $d = 200$ m.

Speed of river $v_r = 18$ km/h $= 18 \times \frac{5}{18} = 5$ m/s.

Speed of boat in still water $v_b = 36$ km/h $= 36 \times \frac{5}{18} = 10$ m/s.

For minimum time to cross the river, the boat must head perpendicular to the river flow (at 90° to the bank).

Time taken to cross once $t = \frac{d}{v_b} = \frac{200}{10} = 20$ s.

For a round trip (bank to bank and back), the total minimum time is $T = 2t = 2 \times 20 = 40$ s.

During the first crossing, the drift (displacement along the bank) is $x_1 = v_r \times t = 5 \times 20 = 100$ m.

During the return trip, to minimize time, the boat again heads perpendicular to the flow relative to the water. The river continues to flow in the same direction, so the drift is again in the same direction as the first trip.

Return drift $x_2 = v_r \times t = 5 \times 20 = 100$ m.

Total displacement along the river bank $= x_1 + x_2 = 100 + 100 = 200$ m.

Thus, minimum time is 40 s and displacement is 200 m.

2. (3) At A: $KE_A = K$, $v_A = v$, angle $= 60^\circ$.

At B (highest point): $v_B = v \cos 60^\circ = v/2$, so $KE_B = K/4$.

At C (same level as A): by energy conservation, $KE_C = K$.

$|KE_B - KE_C| = |K/4 - K| = 3K/4$.

Ratio $= \frac{3K/4}{K} = \frac{3}{4}$, i.e., 3 : 4.

3. (1) Horizontal velocity is constant: $v_x = u \cos 60^\circ = \frac{u}{2}$.

When direction is 45° with horizontal and speed is 20 m/s:

$v_x = 20 \cos 45^\circ = \frac{20}{\sqrt{2}}$.

$\frac{u}{2} = \frac{20}{\sqrt{2}} \Rightarrow u = \frac{40}{\sqrt{2}} = 20\sqrt{2}$ m/s.

4. (1) For projectile motion at 45° , vertical component of initial velocity:

$v_{0y} = v_0 \sin 45^\circ = \frac{v_0}{\sqrt{2}}$

Maximum height occurs at $t = 2$ s when $v_y = 0$:

$0 = v_{0y} - gt$

$\Rightarrow v_{0y} = 10 \times 2 = 20$ m/s

Thus $\frac{v_0}{\sqrt{2}} = 20$, so $v_0 = 20\sqrt{2}$ m/s

Height at landing time $t = 3$ s:

$H = v_{0y}t - \frac{1}{2}gt^2 = 20 \times 3 - \frac{1}{2} \times 10 \times 9$

$= 60 - 45 = 15$ m

Questions

MathonGo

Q1 - 2024 (04 Apr Shift 1)

The co-ordinates of a particle moving in $x - y$ plane are given by : $x = 2 + 4t, y = 3t + 8t^2$.

The motion of the particle is :

- (1) uniformly accelerated having motion along a parabolic path.
- (2) uniform motion along a straight line.
- (3) uniformly accelerated having motion along a straight line.
- (4) non-uniformly accelerated.

Q2 - 2024 (05 Apr Shift 2)

A man carrying a monkey on his shoulder does cycling smoothly on a circular track of radius 9 m and completes 120 revolutions in 3 minutes. The magnitude of centripetal acceleration of monkey is (in m/s^2) :

- (1) $57600\pi^2 \text{ ms}^{-2}$
- (2) Zero
- (3) $4\pi^2 \text{ ms}^{-2}$
- (4) $16\pi^2 \text{ ms}^{-2}$

Q3 - 2024 (05 Apr Shift 2)

The maximum height reached by a projectile is 64 m. If the initial velocity is halved, the new maximum height of the projectile is _____ m.

Q4 - 2024 (08 Apr Shift 2)

The angle of projection for a projectile to have same horizontal range and maximum height is :

- (1) $\tan^{-1}(4)$
- (2) $\tan^{-1}\left(\frac{1}{4}\right)$
- (3) $\tan^{-1}\left(\frac{1}{2}\right)$
- (4) $\tan^{-1}(2)$

Questions

MathonGo

Q5 - 2024 (08 Apr Shift 2)

A body of mass M thrown horizontally with velocity v from the top of the tower of height H touches the ground at a distance of 100 m from the foot of the tower. A body of mass $2M$ thrown at a velocity $\frac{v}{2}$ from the top of the tower of height $4H$ will touch the ground at a distance of _____ m.

Questions

MathonGo

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Answer Key

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Q1 (1) MathonGo Q2 (4) MathonGo Q3 (16) MathonGo Q4 (1) MathonGo

Q5 (100) MathonGo MathonGo MathonGo MathonGo MathonGo MathonGo

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#MathBoleTohMathonGo

Solutions

MathonGo

Q1

$$x = 2 + 4t$$

$$\frac{dx}{dt} = v_x = 4$$

$$\frac{dv_x}{dt} = a_x = 0$$

$$y = 3t + 8t^2$$

$$\frac{dy}{dt} = v_y = 3 + 16t$$

$$\frac{dv_y}{dt} = a_y = 16$$

the motion will be uniformly accelerated motion.

For path

$$x = 2 + 4t$$

$$\frac{(x-2)}{4} = t$$

Put this value of t is equation of y

$$y = 3\left(\frac{x-2}{4}\right) + 8\left(\frac{x-2}{4}\right)^2$$

this is a quadratic equation so path will be parabola.

Q2

Given : $R = 9 \text{ m}$,

120 revolution in 3 min

$$\omega = \frac{120 \text{ Rev.}}{3 \text{ min.}} = \frac{120 \times 2\pi \text{ rad}}{3 \times 60 \text{ sec}} = \frac{4\pi}{3} \text{ rad/s}$$

$$a_{\text{centripetal}} = \omega^2 R = \left(\frac{4\pi}{3}\right)^2 \times 9 = 16\pi^2 \text{ m/s}^2$$

Q3

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

$$\frac{H_{1\max}}{H_{2\max}} = \frac{u_1^2}{u_2^2}$$

$$\frac{64}{H_{2\max}} = \frac{u^2}{(u/2)^2}$$

$$H_{2\max} = 16 \text{ m}$$

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Solutions

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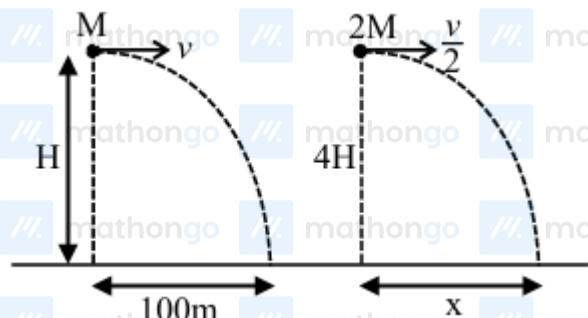
Q4

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

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

$$4 = \tan \theta$$

Q5



$$100 = v \sqrt{\frac{2H}{g}}; \quad x = \frac{v}{2} \sqrt{\frac{2(4H)}{g}} = v \sqrt{\frac{2H}{g}}$$

$$\Rightarrow x = 100$$

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Questions with Answer Keys

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Q1 - 2024 (01 Feb Shift 1)

A particle moving in a circle of radius R with uniform speed takes time T to complete one revolution. If this particle is projected with the same speed at an angle θ to the horizontal, the maximum height attained by it is equal to $4R$. The angle of projection θ is then given by :

(1) $\sin^{-1} \left[\frac{2gT^2}{\pi^2 R} \right]^{\frac{1}{2}}$

(2) $\sin^{-1} \left[\frac{\pi^2 R}{2gT^2} \right]^{\frac{1}{2}}$

(3) $\cos^{-1} \left[\frac{2gT^2}{\pi^2 R} \right]^{\frac{1}{2}}$

(4) $\cos^{-1} \left[\frac{\pi R}{2gT^2} \right]^{\frac{1}{2}}$

Q2 - 2024 (29 Jan Shift 1)

If the radius of curvature of the path of two particles of same mass are in the ratio 3:4, then in order to have constant centripetal force, their velocities will be in the ratio of:

(1) $\sqrt{3} : 2$

(2) $1 : \sqrt{3}$

(3) $\sqrt{3} : 1$

(4) $2 : \sqrt{3}$

Q3 - 2024 (29 Jan Shift 1)

A ball rolls off the top of a stairway with horizontal velocity u . The steps are 0.1 m high and 0.1 m wide. The minimum velocity u with which that ball just hits the step 5 of the stairway will be $\sqrt{x} \text{ ms}^{-1}$ where $x =$ _____ [use $g = 10 \text{ m/s}^2$].

Q4 - 2024 (30 Jan Shift 1)

A particle of mass m projected with a velocity ' u ' 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 :

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Questions with Answer Keys

MathonGo

- (1) $\frac{\sqrt{3}}{16} \frac{mu^3}{g}$
- (2) $\frac{\sqrt{3}}{2} \frac{mu^2}{g}$
- (3) $\frac{mu^3}{\sqrt{2}g}$
- (4) zero

Q5 - 2024 (30 Jan Shift 2)

Projectiles A and B are thrown at angles of 45° and 60° with vertical respectively from top of a 400 m high tower. If their ranges and times of flight are same, the ratio of their speeds of projection $v_A : v_B$ is :

[We changed options. In official NTA paper no option was correct.]

- (1) $1 : \sqrt{3}$
- (2) $\sqrt{2} : 1$
- (3) $1 : 2$
- (4) $1 : 1$

Q6 - 2024 (31 Jan Shift 1)

A body starts falling freely from height H hits an inclined plane in its path at height h. As a result of this perfectly elastic impact, the direction of the velocity of the body becomes horizontal. The value of $\frac{H}{h}$ for which the body will take the maximum time to reach the ground is _____

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Questions with Answer Keys

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Answer Key

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Q5 (4) mathongo /// math Q6 (2) /// math math math math math math

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Solutions

MathonGo

Q1

$$\frac{2\pi R}{T} = V$$

$$\text{Maximum height } H = \frac{v^2 \sin^2 \theta}{2g}$$

$$4R = \frac{4\pi^2 R^2}{T^2 2g} \sin^2 \theta$$

$$\sin \theta = \sqrt{\frac{2gT^2}{\pi^2 R}}$$

$$\theta = \sin^{-1} \left(\frac{2gT^2}{\pi^2 R} \right)^{\frac{1}{2}}$$

Q2

$$\text{Given } m_1 = m_2 \text{ and } \frac{r_1}{r_2} = \frac{3}{4}$$

$$\text{As centripetal force } F = \frac{mv^2}{r}$$

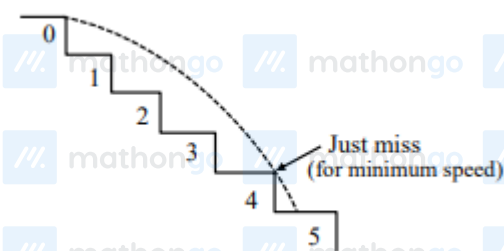
In order to have constant (same in this question) centripetal force

$$F_1 = F_2$$

$$\frac{m_1 v_1^2}{r_1} = \frac{m_2 v_2^2}{r_2}$$

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

Q3



The ball needs to just cross 4 steps to just hit 5th step

Therefore, horizontal range (R) = 0.4 m

$$R = u \cdot t$$

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Solutions

MathonGo

Similarly, in vertical direction

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

$$0.4 = \frac{1}{2}gt^2$$

$$0.4 = \frac{1}{2}g\left(\frac{0.4}{u}\right)^2$$

$$u^2 = 2$$

$$u = \sqrt{2} \text{ m/s}$$

Therefore, $x = 2$

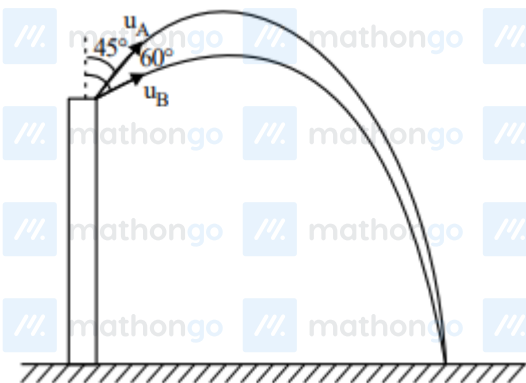
Q4

$$L = mu \cos \theta H$$

$$= mu \cos \theta \times \frac{u^2 \sin^2 \theta}{2g}$$

$$= \frac{mu^3}{2g} \times \frac{\sqrt{3}}{2} \times \left(\frac{1}{2}\right)^2 = \frac{\sqrt{3}mu^3}{16g}$$

Q5



For u_A & u_B time of flight and range can not be same. So above options are incorrect.

Q6

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Solutions

MathonGo

Total time of flight = T

$$T = \sqrt{\frac{2h}{g}} + \sqrt{\frac{2(H-h)}{g}}$$

For max. time = $\frac{dT}{dh} = 0$

$$\sqrt{\frac{2}{g}} \left(\frac{-1}{2\sqrt{H-h}} + \frac{1}{2\sqrt{h}} \right) = 0$$

$$\sqrt{H-h} = \sqrt{h}$$

$$h = \frac{H}{2} \Rightarrow \frac{H}{h} = 2$$

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1. A particle is moving with constant speed in a circular path. When the particle turns by an angle 90° , the ratio of instantaneous velocity to its average velocity is $\pi : x\sqrt{2}$. The value of x will be

[2023 (06 Apr Shift 1)]

- (1) 2
(2) 5
(3) 1
(4) 7

2. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R .

Assertion A: When a body is projected at an angle 45° , its range is maximum.

Reason R: For maximum range, the value of $\sin 2\theta$ should be equal to one.

In the light of the above statements, choose the correct answer from the options given below:

[2023 (06 Apr Shift 1)]

- (1) A is false but R is true
(2) A is true but R is false
(3) Both A and R are correct and R is the correct explanation of A
(4) Both A and R are correct but R is NOT the correct explanation of A

3. A child of mass 5 kg is going round a merry-go-round that makes 1 rotation in 3.14 s. The radius of the merry-go-round is 2 m. The centrifugal force on the child will be

[2023 (06 Apr Shift 2)]

- (1) 80 N
(2) 40 N
(3) 100 N
(4) 50 N

4. Two projectiles A and B are thrown with initial velocities of 40 m s^{-1} and 60 m s^{-1} at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is ($g = 10 \text{ m s}^{-2}$)

[2023 (08 Apr Shift 1)]

- (1) 4 : 9
(2) 2 : $\sqrt{3}$
(3) $\sqrt{3}$: 2
(4) 1 : 1

5. The trajectory of projectile, projected from the ground is given by $y = x - \frac{x^2}{20}$. Where x and y are measured in meter. The maximum height attained by the projectile will be.

[2023 (08 Apr Shift 2)]

- (1) 200 m
(2) 10 m
(3) 5 m
(4) $10\sqrt{2}$ m

6. The range of the projectile projected at an angle of 15° with horizontal is 50 m. If the projectile is projected with same velocity at an angle of 45° with horizontal, then its range will be

[2023 (10 Apr Shift 1)]

- (1) 100 m
(2) $100\sqrt{2}$ m
(3) $50\sqrt{2}$ m
(4) 50 m

7. Two projectiles are projected at 30° and 60° with the horizontal with the same speed. The ratio of the maximum height attained by the two projectiles respectively is:

[2023 (10 Apr Shift 2)]

- (1) $\sqrt{3} : 1$
(2) $1 : \sqrt{3}$
(3) $2 : \sqrt{3}$
(4) $1 : 3$

8. A projectile fired at 30° to the ground is observed to be at same height at time 3 s and 5 s after projection, during its flight. The speed of projection of the projectile is m s^{-1} .

(Given $g = 10 \text{ m s}^{-2}$)

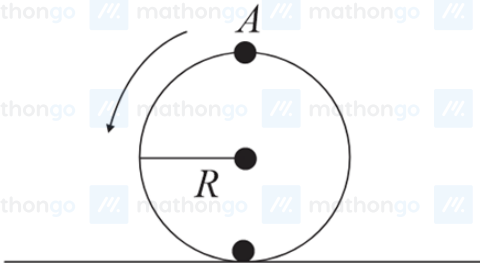
[2023 (11 Apr Shift 1)]

9. A projectile is projected at 30° from horizontal with initial velocity 40 m s^{-1} . The velocity of the projectile at $t = 2 \text{ s}$ from the start will be:

[2023 (11 Apr Shift 2)]

- (1) $40\sqrt{3} \text{ m s}^{-1}$
- (2) Zero
- (3) 20 m s^{-1}
- (4) $20\sqrt{3} \text{ m s}^{-1}$

10. A disc is rolling without slipping on a surface. The radius of the disc is R . At $t = 0$, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is



[2023 (13 Apr Shift 1)]

- (1) $2R$
- (2) $R\sqrt{(\pi^2 + 4)}$
- (3) $R\sqrt{(\pi^2 + 1)}$
- (4) $2R\sqrt{(1 + 4\pi^2)}$

11. A vehicle of mass 200 kg is moving along a levelled curved road of radius 70 m with angular velocity of 0.2 rad s^{-1} . The centripetal force acting on the vehicle is:

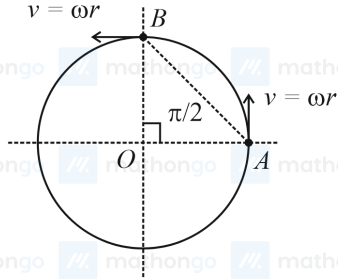
[2023 (13 Apr Shift 2)]

- (1) 560 N
- (2) 2800 N
- (3) 2240 N
- (4) 14 N

ANSWER KEYS

1. (1) 2. (3) 3. (2) 4. (1) 5. (3) 6. (1) 7. (4) 8. (80)
9. (4) 10. (2) 11. (1)

1. (1)



In circular motion with constant speed, magnitude of instantaneous velocity, $v_{ins} = \omega r$.

Time taken to turn by 90° will be $= \frac{\pi}{\omega} = \frac{\pi}{2\omega}$.

Displacement will be equal to the length of $AB = \sqrt{r^2 + r^2} = r\sqrt{2}$

Average velocity

$$v_{avg} = \frac{\text{displacement}}{\text{time}}$$

$$= \frac{r\sqrt{2} \times 2\omega}{\pi} = \frac{2\sqrt{2}}{\pi} \omega r$$

Hence, required ratio $\frac{v_{ins}}{v_{avg}} = \frac{\omega r \pi}{2\sqrt{2}\omega r} = \frac{\pi}{2\sqrt{2}}$

Therefore, $x = 2$.

2. (3)

Horizontal range of a projectile from a horizontal plane is given by, $R = \frac{u^2 \sin 2\theta}{g}$.

Clearly for maximum range, $\sin 2\theta = 1$.

Therefore, $\theta = 45^\circ$.

3. (2)

The angular speed (ω) of the child can be calculated as follows:

$$\omega = \frac{2\pi}{3.14}$$

$$= 2 \text{ rad s}^{-1}$$

The formula to calculate the centrifugal force on the child is given by

$$F_r = m\omega^2 r \dots (1)$$

Substitute the values of the known parameters into equation (1) to calculate the required centrifugal force.

$$F_r = 5 \text{ kg} \times (2 \text{ rad s}^{-1})^2 \times 2 \text{ m}$$

$$= 40 \text{ N}$$

4. (1)

The range (R_1) of the first projectile is given by

$$R_1 = \frac{u_1^2 \sin 2\theta_1}{g} \dots (1)$$

The range (R_2) of the second projectile is given by

$$R_2 = \frac{u_2^2 \sin 2\theta_2}{g} \dots (2)$$

Divide equation (1) by equation (2) and simplify to obtain the ratio of the ranges.

$$\begin{aligned} \frac{R_1}{R_2} &= \frac{\frac{u_1^2 \sin 2\theta_1}{g}}{\frac{u_2^2 \sin 2\theta_2}{g}} \\ &= \frac{u_1^2 \sin 2\theta_1}{u_2^2 \sin 2\theta_2} \dots (3) \end{aligned}$$

Substitute the values of the known parameters into equation (3) to calculate the required ratio.

$$\begin{aligned} \frac{R_1}{R_2} &= \frac{40^2 \times \sin 60^\circ}{60^2 \times \sin 120^\circ} \\ &= \frac{4}{9} \end{aligned}$$

5. (3)

The trajectory of a projectile is parabolic in nature. At maximum height, it can be written that

$$\frac{dy}{dx} = 0 \dots (1)$$

Substitute the expression for trajectory into equation (1) and solve to calculate the horizontal distance, for which the projectile attains the maximum height.

$$\frac{d}{dx} \left[x - \frac{x^2}{20} \right] = 0$$

$$\begin{aligned} \Rightarrow 1 - \frac{x}{10} &= 0 \\ \Rightarrow x &= 10 \text{ m} \end{aligned}$$

Substitute the value of x in the given expression for the trajectory to obtain the maximum height.

$$\begin{aligned} y &= \left(10 - \frac{10^2}{20} \right) \text{ m} \\ &= 5 \text{ m} \end{aligned}$$

6. (1)

The data given is

$$\theta_1 = 15^\circ$$

$$\theta_2 = 45^\circ$$

$$R_1 = 50 \text{ m}$$

The formula for range of a projectile is given by

$$R = \frac{u^2 \sin 2\theta}{g} \dots (i)$$

Substituting the values in equation (i)

$$\begin{aligned} R_1 &= \frac{u^2 \sin 2\theta_1}{g} \\ \Rightarrow 50 &= \frac{u^2 \sin 30^\circ}{g} \end{aligned}$$

$$\Rightarrow \frac{u^2}{g} = 100$$

Let the new range be R_2 . The magnitude of the range is

$$R_2 = \frac{u^2 \sin 2\theta_2}{g}$$

$$\Rightarrow R_2 = \left(\frac{u^2}{g} \right) \sin 90^\circ$$

$$\Rightarrow R_2 = 100 \text{ m}$$

7. (4)

The maximum height is given by, $H = \frac{u^2 \sin^2 \theta}{2g}$.

The given data is

$$\theta_1 = 30^\circ$$

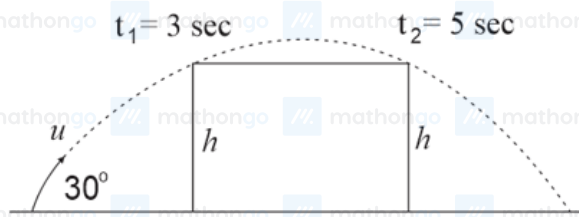
$$\theta_2 = 60^\circ$$

$$u_1 = u_2$$

Therefore,

$$\begin{aligned} \frac{(H_1)_{\max}}{(H_2)_{\max}} &= \frac{u_1^2 \sin^2 \theta_1}{u_2^2 \sin^2 \theta_2} \\ &= \left(\frac{\sin 30^\circ}{\sin 60^\circ} \right)^2 \\ &= \left(\frac{\frac{1}{2}}{\frac{\sqrt{3}}{2}} \right)^2 \\ &= \frac{1}{3} \end{aligned}$$

8. (80)



The time taken to reach maximum height is

$$T^* = \frac{u \sin \theta}{g}$$

The total time of flight is $T = (3 + 5) \text{ s} = 8 \text{ s}$.

Hence,

$$\begin{aligned} T^* &= \left(\frac{T}{2} \right) = \left(\frac{3+5}{2} \right) = \left(\frac{u \sin \theta}{g} \right) \\ \Rightarrow 4 &= \frac{(u) \times \frac{1}{2}}{10} \end{aligned}$$

$$\Rightarrow u = 80 \text{ m s}^{-1}$$

9. (4)

It is given that $v = 40 \text{ m s}^{-1}$.

The components of the velocity will be

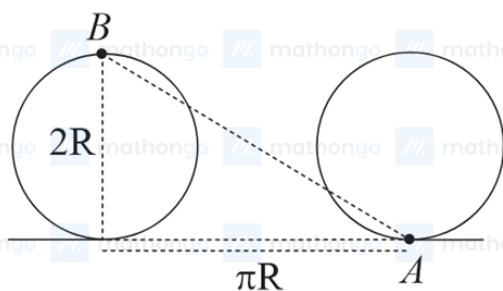
$$v_y = v \sin 30^\circ = \frac{40 \text{ m s}^{-1}}{2} = 20 \text{ m s}^{-1}$$

$$v_x = v \cos 30^\circ = \frac{40\sqrt{3}}{2} \text{ m s}^{-1} = 20\sqrt{3} \text{ m s}^{-1}$$

The time taken to reach maximum height is $T = \frac{u \sin 30^\circ}{g} = \frac{20 \text{ m s}^{-1}}{10 \text{ m s}^{-2}} = 2 \text{ s}$

Hence, at $T = 2 \text{ s}$, as $v_y = 0 \text{ m s}^{-1}$ therefore $v_{\text{net}} = v_x = 20\sqrt{3} \text{ m s}^{-1}$.

10. (2)



The displacement is the hypotenuse of the diameter and the distance travelled for half the rotation πR .

By using Pythagoras theorem,

$$\begin{aligned}\text{Displacement of } A &= \sqrt{(2R)^2 + (\pi R)^2} \\ &= R\sqrt{\pi^2 + 4}\end{aligned}$$

11. (1)

The centripetal force is given by

$$F = \frac{Mv^2}{R} = MR\omega^2$$

The given data is

$$M = 200 \text{ kg}$$

$$R = 70 \text{ m}$$

$$\omega = 0.2 \text{ rad s}^{-1}$$

The magnitude of the force is

$$F = 200 \times 70 \times 0.2^2 \text{ N}$$

$$\Rightarrow F = 560 \text{ N}$$