NEET

KATTAR NEET 2026

Physics by MR Sir

Motion in a plane

Q1 A particle is moving along curve $x^2 = 4y$ with constant speed of 4 m/s. Acceleration of particle at origin is

(A) 8 m/s^2 (B) 16 m/s^2

(C) 6 m/s^2 (D) 12 m/s^2

Q2 A particle P moves along a circle of radius R so that its radius vector , relative to the point O at the circumference rotates with constant angular velocity ω. Find the magnitude of the velocity of the particle

(A) $\frac{3R\omega}{2}$ (B) $3R\omega$

(C) $\frac{R\omega}{2}$ (D) $2R\omega$

Q3 The equation of a projectile is $y = \sqrt{3}x - \frac{gx^2}{4}$. The horizontal component of initial velocity of the projectile will be;

(A) $\frac{1}{\sqrt{2}}\ \mathrm{m/s}$ (B) $\frac{1}{\sqrt{3}}\ \mathrm{m/s}$

(C) $\sqrt{3}\ \mathrm{m/s}$ (D) $\sqrt{2}\ \mathrm{m/s}$

Q4 Rain is falling vertically with a speed of 35 m/s. Winds start blowing after some time with a speed of 12 m/s in east to west direction. At what angle with the vertical should a boy waiting at a bus stop should hold his umbrella to protect himself from rain?

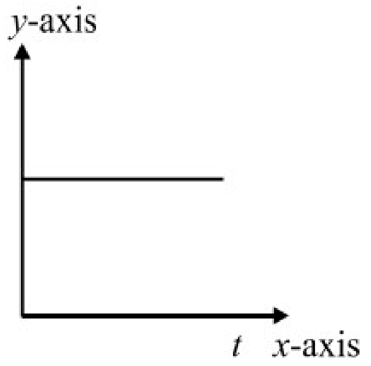
(A) $\sin^{-1}\left(\frac{12}{35}\right)$

(B) $\cos^{-1}\left(\frac{12}{35}\right)$

(C) $\tan^{-1}\left(\frac{12}{35}\right)$

(D) $\cot^{-1}\left(\frac{12}{35}\right)$

Q5 In the graph shown in figure, which quantity associated with projectile motion is plotted along the y-axis? (t is the time along x-axis)



(A) Vertical component of velocity

(B) Angle made by velocity vector with horizontal

(C) Horizontal component of velocity

(D) Speed

Q6 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 m/sec. Neglecting the air resistance, the speed with which the stone hits the ground will be

(A) 15 m/s (B) 20 m/s

(C) 25 m/s (D) 30 m/s

Q7 A football player throws a ball with a velocity of 50 metre / sec at an angle 30 degrees from the horizontal. The ball remains in the air for: ($g = 10\ \mathrm{m/s^2}$)

(A) 2.5 sec (B) 1.25 sec

(C) 5 sec (D) 0.625 sec

Q8 If a particle is projected from ground with initial speed u at angle θ with horizontal then magnitude of its mean velocity between its point of projection and at highest point of trajectory is;

(A) $0.5u\sqrt{1+\cos^2\theta}$

(B) $0.5u\sqrt{1+2\cos^2\theta}$

(C) $0.5u\sqrt{1+3\cos^2\theta}$

(D) $u\cos\theta$

Q9

The position vector of a particle is expressed as $\overrightarrow{r} = \left(3t^2\hat{i} + 4t\hat{j}\right)$ m, where t is in seconds. The acceleration of the particle at any time t is;

(A) $3\hat{i}\ \mathrm{m/s^2}$ (B) $6\hat{i}\ \mathrm{m/s^2}$

(C) $3\hat{j}\ \mathrm{m/s^2}$ (D) $6\hat{j}\ \mathrm{m/s^2}$

Q10 A particle moves in the xy -plane with an acceleration given by $\overrightarrow{a} = \left(3\hat{i} + 4\hat{j}\right) m/s^2$. What is the displacement (in m) after 2 seconds if the initial velocity is $\overrightarrow{v_0} = \left(5\hat{i} + 6\hat{j}\right) m/s$ and initial position is the origin?

(A) 25 (B) 5

(C) $\sqrt{656}$ (D) $\sqrt{200}$

Q11 A ball is projected with a velocity of $50\ \mathrm{m/s}$ at an angle of 60° with the vertical direction. The maximum height attained by ball during its motion is: $(g = 10\ \mathrm{m/s^2})$

(A) $31.25\ \mathrm{m}$ (B) $93.75\ \mathrm{m}$

(C) $100.25\ \mathrm{m}$ (D) $50.75\ \mathrm{m}$

Q12 A ball is kicked with a velocity of 10 ms^{-1} at an angle 60° with the horizontal. Then match the lists for required quantities (Take g = 10 ms^{-2})

	List-I		**List-II**
(A)	Time taken by the ball to strike the ground (in sec)	(I)	$5\sqrt{3}$
(B)	Vertical component of velocity (in ms^{-1})	(II)	$\sqrt{3}$
(C)	Half of horizontal range (in m)	(III)	$\frac{5\sqrt{3}}{2}$

(A) A-II, B-III, C-I

(B) A-I, B-II, C-III

(C) A-II, B-I, C-III

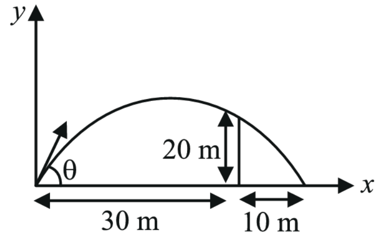
(D) A-III, B-II, C-I

Q13 A projectile is fired from the horizontal ground at $t = 0$ and is found at same height at two instants $3\ \mathrm{s}$ and $7\ \mathrm{s}$. The time of flight is;

(A) $10\ \mathrm{s}$ (B) $11\ \mathrm{s}$

(C) $9\ \mathrm{s}$ (D) $8\ \mathrm{s}$

Q14 In the given diagram shown for a projectile, what is the angle of projection?

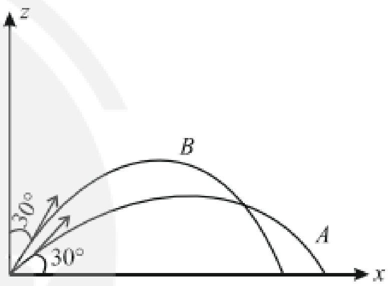


(A) $\tan^{-1}(1)$ (B) $\tan^{-1}\left(\frac{8}{3}\right)$

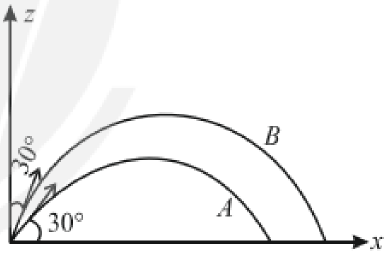
(C) $\tan^{-1}\left(\frac{4}{3}\right)$ (D) $\tan^{-1}\left(\frac{5}{3}\right)$

Q15 Two projectiles A and B are thrown from the same point on ground with same initial speed at an angle of 30° and 60° with horizontal respectively. The correct trajectory of two projectiles in $x - z$ plane is; (neglect air resistance)

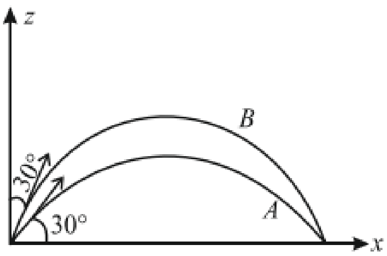
(A)



(B)



(C)



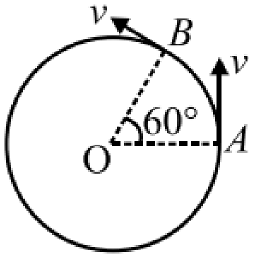
(D) Can not be predicted

Q16 A particle is projected from origin of a coordinate system. A target is fixed at point $(40m\ ,\ 30\ m)$ Find the minimum velocity of projectile to hit the target? (g = 10 m/s^2)

(A) 10 m/s (B) 17 m/s

(C) $20\sqrt{2}$ m /s (D) $10\sqrt{5}$ m/s

Q17 A particle is moving in a circle of radius r having centre at O, with a constant speed v as shown. The magnitude of change in velocity in moving from A to B is;



(A) $2v$ (B) 0
(C) $\sqrt{3}v$ (D) v

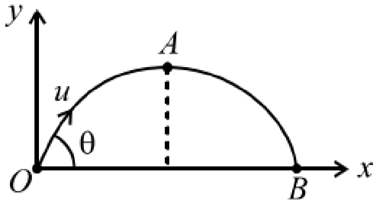
Q18 A boat moves relative to water with a velocity which is n times the river flow velocity. At what angle to the stream direction must the boat move to minimize drifting?
(A) $\frac{\pi}{2}$
(B) $\sin^{-1}\left(\frac{1}{n}\right)$
(C) $\frac{\pi}{2}+\sin^{-1}\left(\frac{1}{n}\right)$
(D) $\frac{\pi}{2}-\sin^{-1}\left(\frac{1}{n}\right)$

Q19 A projectile is projected from ground with a speed $10\sqrt{3}$ m/s at an angle 30° with horizontal. Average velocity over its entire journey just before hitting the ground is
(A) 5 m/s (B) 10 m/s
(C) 15 m/s (D) 20 m/s

Q20 A man is running up a hill with a velocity $\left(2\hat{i}+4\hat{j}\right)$ m/s w.r.t ground. He feels that the rain drops are falling vertically with velocity 3 m/s, then the velocity of the rain w.r.t ground is:
(A) $\left(2\hat{i}-3\hat{j}\right)$m/s
(B) $\left(2\hat{i}+\hat{j}\right)$m/s
(C) $\left(-2\hat{i}+3\hat{j}\right)$m/s
(D) $\left(-2\hat{i}-\hat{j}\right)$m/s

Q21 The horizontal range of a projectile is $4\sqrt{3}$ times its maximum height. Its angle of projection will be
(A) 45° (B) 60°
(C) 90° (D) 30°

Q22 Match column I with column II. In projectile motion shown in figure: (A is the point at highest point of projectile)



	Column-I		Column-II
A	Magnitude of change in velocity between O and A	P	$u \cos \theta$
B	Magnitude of average acceleration between O and A	Q	$u \sin \theta$
C	Magnitude of change in velocity between O and B	R	$2u \sin \theta$
D	Magnitude of average velocity between O and B	S	g

(A) A→Q; B→S; C→R; D→P
(B) A→Q; B→P; C→R; D→Q
(C) A→P; B→Q; C→S; D→S
(D) A→S; B→Q; C→P; D→Q

Q23 A particle projected from the ground at an angle 30° with the horizontal has maximum height H_0 and range R_0. If the particle was projected with half the initial velocity at an angle 45° with the horizontal, its maximum height and range respectively would be:

(A) $\frac{H_0}{4}, \frac{R_0}{2}$
(B) $\frac{H_0}{2}, \frac{R_0}{2\sqrt{3}}$
(C) $\frac{H_0}{2}, \frac{R_0}{\sqrt{3}}$
(D) $\frac{H_0}{4}, \frac{2R_0}{\sqrt{3}}$

Q24 A water sprinkler is throwing water with same speed in every possible direction in a plane. The locus of outer tangent curve touching all parabolic trajectories will be
(A) Circle (B) Parabola

(C) Straight line (D) None

Q25 An arrow is projected into air. Its time of flight is 5 s and range 200 m. What is the maximum height reached by it? (Take $g = 10$ ms^{-2})

(A) 31.25 m (B) 24.5 m
(C) 18.25 m (D) 46.75 m

Q26 If T_1 and T_2 are the time of flight for two complementary angles, then the range of projectile R is given by

(A) $R = 4gT_1T_2$ (B) $R = 2gT_1T_2$
(C) $R = \frac{1}{4}gT_1T_2$ (D) $R = \frac{1}{2}gT_1T_2$

Q27 A projectile is launched from origin with velocity $u\hat{i} + v\hat{j}$. Find the range of the projectile (g is acceleration due to gravity)

(A) $\frac{2uv}{g}$ (B) $\frac{2uv}{g} + \frac{u^2}{g}$
(C) $\frac{2uv}{g} - \frac{v^2}{g}$ (D) $\frac{v^2}{2g}$

Q28 Two bullets are fired horizontally with different velocities from the same height. Which one will reach the ground first?

(A) Slower one
(B) Faster one
(C) Both will reach simultaneously
(D) Cannot be predicted

Q29 A particle is moving along a circular path with a constant speed. The acceleration of the particle is constant in

(A) Magnitude
(B) Direction
(C) Both magnitude and direction
(D) Neither magnitude nor direction

Q30 A ball is thrown at an angle θ with the horizontal. Its initial kinetic energy is 100 J and it becomes 30 J at the highest point. The angle of projection is

(A) 45°
(B) 30°
(C) $\cos^{-1}$ (3/10)
(D) $\cos^{-1}\left(\sqrt{3/10}\right)$

Q31 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 on the ground fired by the two guns is:

(A) 1 : 4 (B) 1 : 16
(C) 1 : 8 (D) 1 : 2

Q32 The position vector of a particle changes with time according to the relation $r(t) = 15t^2\hat{i} + (4 - 20t^2)\hat{j}$ in metre. What is the magnitude of the acceleration (in ms^{-2}) at t = 1s ?

(A) 50 (B) 100
(C) 25 (D) 40

Q33 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 (Take, $g = 10$ms^{-2})

(A) $\theta_0 = \sin^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3}\ ms^{-1}$
(B) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}\ ms^{-1}$
(C) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3}\ ms^{-1}$
(D) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}\ ms^{-1}$

Q34 A projectile moving in x-y plane is given an initial velocity of $\hat{i} + \hat{j}$ m/s. The equation of its path is; ($g = 10$ m/s^2)

(A) $y = 2x - 5x^2$
(B) $y = x - 5x^2$
(C) $4y = 2x - 5x^2$
(D) $y = 2x - 25x^2$

Q35 A man can swim with speed 5 m/s in still water. He wants to cross a 100 m wide river flowing at 3 m/s to reach the point directly opposite to his starting point. In which direction he should try to swim?

(A) 120° with flow of river
(B) 153° with flow of river
(C) 90° with flow of river
(D) 127° with flow of river

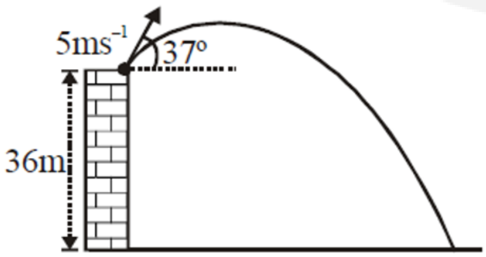
Q36 A particle is moving along a circular path of radius 5 m with uniform speed 5 m/s. The average acceleration of the particle in quarter revolution is;

(A) Zero
(B) $\frac{10\sqrt{2}}{\pi}\ \mathrm{m/s^2}$
(C) $10\pi\ \mathrm{m/s^2}$
(D) $\frac{10}{\pi}\mathrm{m/s^2}$

Q37 A batsman (B) hits a ball at an angle of 37° with horizontal at a speed 50 m/s. A fielder (F), in the same vertical plane of the ball, starts running horizontally with constant speed (v) at the instant the ball is hit by the batsman. Refer the figure below and find out the speed v at which the fielder should run to catch the ball just before hitting the ground. (Ignore the height of Batsman and fielder and R is the range of the projectile in m)

(A) $\frac{R}{4}\ \mathrm{m/s}$
(B) $\frac{R}{2}\ \mathrm{m/s}$
(C) R m/s
(D) $2R$ m/s

Q38 A ball is thrown from the top of 36 m high tower with velocity 5 m/s at an angle 37° above the horizontal as shown. Its horizontal distance on the ground is closest to [g = 10 m/s^2]



(A) 12 m
(B) 18 m
(C) 24 m
(D) 30 m

Q39 A vector $\vec{S}$ having magnitude of $5\sqrt{2}$ units is along +x-axis. Another vector $\vec{R}$ has magnitude of 5 units lies on the line $y = x$. The magnitude of resultant of $\vec{S}$ and $\vec{R}$ can be;

(A) $5\sqrt{5}$ units
(B) $5\sqrt{2}$ units
(C) 10 units
(D) $3\sqrt{2}$ units

Q40 If the velocity of projection is increased by 1% (other things remains constant) the horizontal range will increase by:

(A) 1%
(B) 2%
(C) 4%
(D) 8%

Q41 A person P can complete one round of a circular track in 30 s. Another person R can complete one round of the same circular track in 40 s. Both P and R start from a common point and start moving simultaneously in opposite sense on the circular track. After how much time both of them will meet?

(A) $\frac{120}{7}$ s
(B) $\frac{60}{7}$ s
(C) $\frac{240}{7}$ s
(D) $\frac{150}{7}$ s

Q42 A projectile is given an initial velocity of $\left(\hat{i} + 2\hat{j}\right)\ \mathrm{m/s}$. The equation of its path is: (g = 10m/s^2):

(A) $y = 2x - 5x^2$
(B) $y = x - 5x^2$
(C) $4y = 2x - 5x^2$
(D) $y = 2x - 25x^2$

Q43 A body moves in x-y plane, such that the displacement along the x and y axis at any time t are given by $x = 2t^3$ m and $y = 4t^2$ m. The speed of body at $t = 1$ s is;

(A) 14 m/s
(B) 10 m/s
(C) 24 m/s
(D) 12 m/s

Q44 A boy aims at a bird, at same horizontal level and at a distance of 100 m. The gun can impart a velocity of 500 m/s to the bullet. At what height above the bird must he aim his gun in order to hit the bird:

(A) 20 cm
(B) 40 cm
(C) 50 cm
(D) 100 cm

Q45 A ball is projected from ground with a speed of 20 m/s at an angle of 45° with horizontal. There is a wall of 25 m height at a distance of 10 m from the projection point. The ball will hit the wall at a height of:

(A) 5 m
(B) 7.5 m
(C) 10 m
(D) 12.5 m

Q46 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**?

(A) $R^2 = 4h_1h_2$
(B) $R^2 = 16h_1h_2$
(C) $R^2 = 2h_1h_2$
(D) $R^2 = h_1h_2$

Q47 A river is flowing from West to East at a speed of 5 m/min. A man on the South bank of the river, capable of swimming at 10 m/min in still water, wants to swim across the river in the shortest time. He should swim in a direction

(A) due North
(B) 30° East of North
(C) 30° West of North
(D) 60° East of North

Q48 Ship A is sailing towards north-east with velocity $v = \left(30\hat{i} + 50\hat{j}\right)$ km/h, 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/h. A will be at minimum distance from B in:

(A) 4.2 h
(B) 2.6 h
(C) 3.2 h
(D) 2.2 h

Q49 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, then speed of the plane is

(A) $\frac{\sqrt{3}}{2}v$
(B) v
(C) $\frac{2v}{\sqrt{3}}$
(D) $\frac{v}{2}$

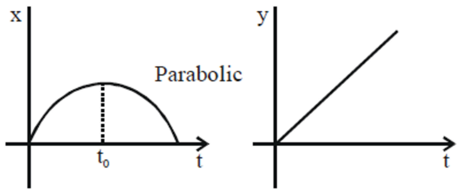
Q50 Rain is falling with a velocity $\left(-4\hat{i} + 8\hat{j} - 10\hat{k}\right)$ m/s. A person is moving with a velocity $\left(6\hat{i} + 8\hat{j}\right)$ m/s on the ground. The speed with which the rain drops hit the person is:

(A) 10 m/s
(B) $10\sqrt{2}$ m/s
(C) $\sqrt{180}$ m/s
(D) $\sqrt{360}$ m/s

Q51 A person is sitting facing the engine in a moving train. He tosses a coin. The coin falls behind him. This shows that the train is:

(A) moving forward with a finite acceleration
(B) moving forward with a finite retardation
(C) moving backward with a uniform speed
(D) moving forward with a uniform speed

Q52 An object is moving in x-y plane and its position-time graphs are given. Select the **correct** statement:



(A) motion of object is non-uniformly accelerated
(B) x co-ordinate is continuously increasing
(C) speed is maximum at time t_0
(D) at time t_0 velocity and acceleration are perpendicular

Q53 A ball is thrown from a point with a speed v_0 at angle of projection θ. From the same point and at the same instant, a person starts running with a constant speed $\frac{v_0}{2}$ to catch the ball. If he catches the ball, what should be the angle of projection?

(A) 60°
(B) 30°
(C) 75°
(D) 45°

Q54 An arrow is shot in air, its time of flight is 5 sec and horizontal range is 200 m. The inclination of the arrow with the horizontal is:

(A) $\tan^{-1}\frac{5}{8}$
(B) $\tan^{-1}\frac{8}{5}$
(C) $\tan^{-1}\frac{1}{8}$
(D) 45°

Q55 Three balls of same mass are thrown with equal speeds at angle 15°, 45°, 75° and their ranges are respectively R_{15}, R_{45} and R_{75}, then:

(A) $R_{15} > R_{45} > R_{75}$
(B) $R_{15} < R_{45} < R_{75}$
(C) $R_{15} = R_{45} = R_{75}$
(D) $R_{15} = R_{75} < R_{45}$

Q56

During a rainstorm, raindrops are observed to be striking the ground at an angle θ with the vertical. A wind is blowing horizontally at the speed of 5.0 m/s. The speed of raindrops is:

(A) $5 \sin \theta$

(B) $\frac{5}{\sin \theta}$

(C) $5 \cos \theta$

(D) $\frac{5}{\cos \theta}$

Q57 What is the ratio of vertical distance and horizontal distance covered when the body reaches the top most point of the projectile motion: ($\theta \rightarrow$ angle of projection)

(A) $\tan\theta$ (B) $\tan^2\theta$

(C) $\frac{\tan \theta}{2}$ (D) $2\cot\theta$

Q58 A projectile thrown with velocity v making angle θ with vertical gains maximum height H in the time for which the projectile remains in air. The time period is:

(A) $\sqrt{H \cos \theta / g}$ (B) $\sqrt{2H \cos \theta / g}$

(C) $\sqrt{4H/g}$ (D) $\sqrt{8H/g}$

Q59 The coordinates of a moving particle at any time are given by $x = at^2$ and $y = bt^2$. The speed of the particle at any moment is:

(A) $2t(a+b)$ (B) $2t\sqrt{a^2 - b^2}$

(C) $t\sqrt{a^2 + b^2}$ (D) $2t\sqrt{a^2 + b^2}$

Q60 A bomb is dropped from an aeroplane moving horizontally at constant speed. When air resistance is taken into consideration , the bomb

(A) Falls on earth exactly below the aeroplane

(B) Fall on earth behind the aeroplane

(C) Falls on earth ahead of the aeroplane

(D) Flies with the aeroplane

Answer Key

Q1	(A)
Q2	(D)
Q3	(D)
Q4	(C)
Q5	(C)
Q6	(A)
Q7	(C)
Q8	(C)
Q9	(B)
Q10	(C)
Q11	(A)
Q12	(C)
Q13	(A)
Q14	(B)
Q15	(C)
Q16	(C)
Q17	(D)
Q18	(C)
Q19	(C)
Q20	(B)
Q21	(D)
Q22	(A)
Q23	(B)
Q24	(B)
Q25	(A)
Q26	(D)
Q27	(A)
Q28	(C)
Q29	(A)
Q30	(D)
Q31	(B)
Q32	(A)
Q33	(C)
Q34	(B)
Q35	(D)
Q36	(B)
Q37	(B)
Q38	(A)
Q39	(A)
Q40	(B)
Q41	(A)
Q42	(A)
Q43	(B)
Q44	(A)
Q45	(B)
Q46	(B)
Q47	(A)
Q48	(B)
Q49	(D)
Q50	(B)
Q51	(A)
Q52	(D)
Q53	(A)
Q54	(A)
Q55	(D)
Q56	(B)
Q57	(C)
Q58	(D)
Q59	(D)
Q60	(B)

Hints & Solutions

Q1 Text Solution:

$x^2 = 4y$

$2xv_x = 4v_y$

$v_x^2 + xa_x = 2a_y$

At (0, 0)

$a_x = 0$

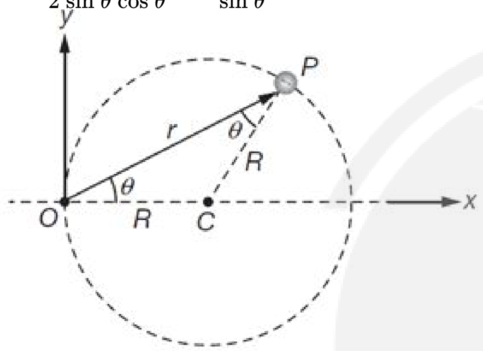
$a_y = \frac{v_x^2}{2}$

Q2 Text Solution:

In triangle *OPC*, we get from Lami's Theorem

$\frac{r}{\sin(\pi - 2\theta)} = \frac{R}{\sin\theta}$

$\Rightarrow \frac{r}{2\sin\theta\cos\theta} = \frac{R}{\sin\theta}$



$\Rightarrow r = 2R\cos\theta$ ... (1)

Further we observe that

$\vec{r} = (r\cos\theta)\hat{i} + (r\sin\theta)\hat{j}$

$\Rightarrow \vec{r} = \left(2R\cos^2\theta\right)\hat{i} + (2R\sin\theta\cos\theta)\hat{j}$

Since $\vec{v} = \frac{d\vec{r}}{dt}$

$\Rightarrow \vec{v} = -\left(4R\cos\theta\sin\theta\frac{d\theta}{dt}\right)\hat{i}$

$+ \left(2R\cos(2\theta)\frac{d\theta}{dt}\right)\hat{j}$

Since $\frac{d\theta}{dt} = \omega$

$\Rightarrow \vec{v} = -2R\omega\left[-\sin(2\theta)\hat{i} + \cos(2\theta)\hat{j}\right]$....

(2)

$\Rightarrow \left|\vec{v}\right| = 2R\omega$

Q3 Text Solution:

General equation of projectile motion,

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

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

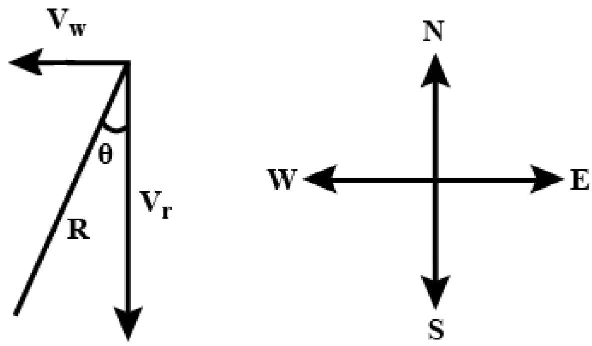
$y = \sqrt{3}x - \frac{gx^2}{4}$

Comparing (1) and (2)

$2u_x^2 = 4$

$u_x = \sqrt{2}\ \mathrm{m/s}$

Q4 Text Solution:

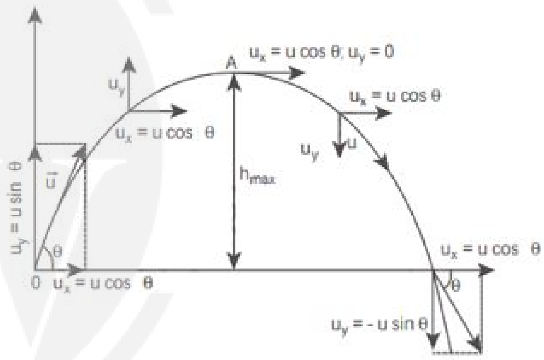


Direction of resultant velocity

$= \tan^{-1}\left(\frac{v_x}{v_y}\right) = \tan^{-1}\left(\frac{12}{35}\right)$

Option (C) is correct.

Q5 Text Solution:



Horizontal component of velocity remains constant.

Q6 Text Solution:

(1)

$$\text{Height} = 10\,\mathrm{m}, \quad \text{Initial horizontal speed} = 5\,\mathrm{m/s}.$$

Time to fall $10\,\mathrm{m}$:

$$10 = \frac{1}{2}gt^2 \implies t = \sqrt{\frac{2\times10}{10}} = \sqrt{2}\,\mathrm{s}.$$

Vertical speed on impact:

$$v_y = gt = 10\left(\sqrt{2}\right)\mathrm{m/s}.$$

Resultant speed:

$$v=\sqrt{v_x^2+v_y^2}=\sqrt{5^2+(10\sqrt{2})^2}$$
$$=\sqrt{25+200}=\sqrt{225}=15\,\mathrm{m/s}.$$

Q7 Text Solution:

(3)

Time of flight of projectile, $T=\frac{2u\sin\theta}{g}$

$T=\frac{2\times50\times0.5}{10}=5\ \sec$

Q8 Text Solution:

$$\text{Average velocity } = \frac{\text{displacement}}{\text{time}}$$

$$V_{av}=\frac{\sqrt{H^2+\frac{R^2}{4}}}{T/2}$$

Here, H=max height $=\frac{u^2\sin^2\theta}{2g}$

$R=$ range $=\frac{u^2\sin2\theta}{g}$ and $T=$ time of flight $=\frac{2u\sin\theta}{g}$

$V_{av}=\frac{u}{2}\sqrt{1+3\cos^2\theta}$

Q9 Text Solution:

$$\vec{r}=\left(3t^2\hat{i}+4t\hat{j}\right)\ \mathrm{m}$$

$$\vec{v}=\frac{dr}{dt}=\frac{d}{dt}\left(3t^2\hat{i}+4t\hat{j}\right)=\left(6t\hat{i}+4\hat{j}\right)\ \mathrm{m/s}$$

$$\vec{a}=\frac{d\vec{v}}{dt}=\frac{d}{dt}\left(6t\hat{i}+4\hat{j}\right)=6\hat{i}\ \mathrm{m/s^2}$$

Q10 Text Solution:

$$\text{Acceleration: } \vec{a}=3\,\hat{i}+4\,\hat{j},$$
$$\text{Initial velocity: } \vec{v}_0=5\,\hat{i}+6\,\hat{j},$$
$$\text{Initial position: } \vec{r}_0=0.$$

$$\text{Position after time } t:\ \vec{r}(t)=\vec{r}_0+\vec{v}_0\,t+\tfrac{1}{2}\,\vec{a}\,t^2.$$

At $t=2$:

$$\vec{r}(2)=(5\hat{i}+6\hat{j})\times2+\tfrac{1}{2}(3\hat{i}+4\hat{j})(2^2)$$
$$=10\hat{i}+12\hat{j}+2(3\hat{i}+4\hat{j})=16\hat{i}+20\hat{j}.$$

Its magnitude is

$$|\vec{r}(2)|=\sqrt{16^2+20^2}=\sqrt{256+400}=\sqrt{656}.$$

Hence the correct choice is the one with $\sqrt{656}$.

Q11 Text Solution:

$\theta=90-60=30^\circ$

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

$=\frac{(50)^2\times\frac{1}{4}}{20}=31.25\ \mathrm{m}$

Q12 Text Solution:

Given,

u = 10 ms^{-1}

$\theta=60^\circ$

(a) time of flight = $\frac{2\,u\ \sin\theta}{g}$

$=\frac{2\times10\times\sin60^\circ}{10}$

$=2\times\frac{\sqrt{3}}{2}=\sqrt{3}\ s$

(b) Vertical component of velocity

$=u\sin\theta$

$=10\times\sin60^\circ=10\times\frac{\sqrt{3}}{2}$

$=5\sqrt{3}\ ms^{-1}$

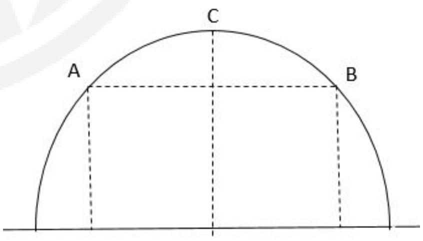
(c)Half of horizontal Range

$=\frac{u^2\sin2\theta}{2g}$

$=\frac{10^2\times\sin\ 120^\circ}{2\ X\ 10}=\frac{10}{2}\times\cos30^\circ=5\times\frac{\sqrt{3}}{2}=\frac{5}{2}\sqrt{3}$

m

Q13 Text Solution:



Time to reach A be $t_1=3$ s and to reach B be $t_2=7$ s

So, time taken for going from A to B will be

$t_2-t_1=4$ s

By symmetry time taken from A to C will be 2 s

Therefore, time of ascent will be

$t_a=3+2=5$ s

And, time of flight will be $T=2t_a=10$ s

Q14 Text Solution:

$Y = x\tan\theta\left(1 - \frac{x}{R}\right)$

$20 = 30\tan\theta\left(1 - \frac{30}{40}\right)$

$\frac{2}{3} = \tan\theta\left(\frac{1}{4}\right)$

$\theta = \tan^{-1}\left(\frac{8}{3}\right)$

Q15 Text Solution:

30° and 60° are complimentary angles,

So, $R_A = R_B$

Q16 Text Solution:

Using the standard projectile equations from the origin:

$$x = v\cos\theta\, t,\quad y = v\sin\theta\, t \;-\; \tfrac{1}{2}\, g t^2.$$

For the target $(40\,\mathrm{m},\ 30\,\mathrm{m})$

$$t \;=\; \frac{40}{v\cos\theta},$$

then substitute into the y-equation and simplify. The resulting expression requires a minimum v for the projectile to pass through $(40,\ 30)$. Solving yields

$\boxed{V_{MIN}} \;=\; 20\,\sqrt{2}\,\mathrm{m/s}.$

Hence, $20\sqrt{2}\,\mathrm{m/s}$ is the least launch speed to hit the target.

Q17 Text Solution:

$\left|\Delta\vec{v}\right| = 2v\sin\frac{\theta}{2} = 2v\sin 30^\circ = v$

Q18 Text Solution:

$\cos\theta = -\frac{\text{velocity of river}}{\text{velocity of boat w.r.t. river}}$

$= -\frac{v}{nv} = -\frac{1}{n}$

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

Q19 Text Solution:

Average velocity = Horizontal component of velocity

$= u\cos\theta$

$= 10\sqrt{3} \times \frac{\sqrt{3}}{2}$

= 15 m/s

Q20 Text Solution:

(2)

$\vec{v}_{m/g} = \left(2\hat{i} + 4\hat{j}\right)\ \mathrm{m/s}$

$\vec{v}_{r/m} = -3\hat{j}$ m/s

$\vec{v}_{r/g} = \vec{v}_{r/m} + \vec{v}_{m/g}$

$= \left(-3\hat{j}\right) + \left(2\hat{i} + 4\hat{j}\right)$

$= \left(2\hat{i} + \hat{j}\right)$ m/s

Q21 Text Solution:

Let u be initial velocity of projection at angle θ with the horizontal. Then, horizontal range,

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

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

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

$\therefore\ \frac{u^2\sin 2\theta}{g} = 4\sqrt{3}\cdot\frac{u^2\sin^2\theta}{2g}$

$\therefore\ 2\sin\theta\cos\theta = 2\sqrt{3}\,\sin^2\theta$ or $\frac{\cos\theta}{\sin\theta} = \sqrt{3}$

or $\cot\theta = \sqrt{3} = \cot 30^\circ$

Q22 Text Solution:

A. $\vec{a}_{av} = \vec{a} = \left(-g\hat{j}\right) = \frac{\Delta\vec{v}}{\Delta t}$

$\therefore\ \overrightarrow{\Delta v} = \left(-g\hat{j}\right)\Delta t$

$= \left(-g\hat{j}\right)\left(\frac{T}{2}\right) = \left(-g\hat{j}\right)\left(\frac{u\sin\theta}{g}\right)$

$= \left(-u\sin\theta\right)\hat{j}$

$\left|\underset{0\to A}{\Delta\vec{v}}\right| = u\sin\theta$

B. $a_{avg} = -g\hat{j}$

$\left|\vec{a}_{avg}\right| = g$

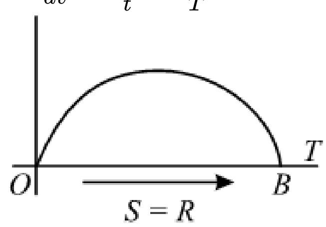
C. $\Delta v = \left(-g\hat{j}\right)\left(\Delta t\right)$

$= \left(-g\hat{j}\right)T = \left(-g\hat{j}\right)\left(\frac{2u\sin\theta}{g}\right)$

$= \left(-2u\sin\theta\right)\hat{j}$

$\left|\underset{0\to B}{\Delta\vec{v}}\right| = 2u\ \sin\theta$

D. $v_{av} = \frac{S}{t} = \frac{R}{T}$



$= \frac{u_x T}{T} = u_x = u\cos\theta$

Q23 Text Solution:

We know that $H = \frac{u^2\sin^2\theta}{2g}$ and $R = \frac{u^2\sin 2\theta}{g}$

Therefore, for projection speed u and projection angle 30°,

$$H_0 = \frac{u^2}{8g} \quad \text{and} \quad R_0 = \frac{\sqrt{3}u^2}{2g}$$

And, for projection speed $\frac{u}{2}$ and projection angle 45°,

$$H = \frac{u^2}{16g} \quad \text{and} \quad R = \frac{u^2}{4g}$$

So, $H = \frac{H_0}{2}$ and $R = \frac{R_0}{2\sqrt{3}}$

Q24 Text Solution:

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

$\Rightarrow gx^2\sec^2\theta - 2u^2x\tan\theta + 2u^2y = 0$

$\Rightarrow gx^2\tan^2\theta - 2u^2x\tan\theta + 2u^2y + gx^2 = 0$

For real roots of $\tan\theta$

$4u^4x^2 - 4\left(2u^2y + gx^2\right)\left(gx^2\right) \geq 0$

$\Rightarrow y \leq \frac{u^4 - g^2x^2}{2u^2g}$, it shows trajectory as parabola.

Q25 Text Solution:

Given, $5 = \frac{2u\sin\theta}{g}$ or $\frac{u\sin\theta}{g} = \frac{5}{2}$

Maximum height $= \frac{u^2\sin^2\theta}{2g} = \frac{g}{2}\left(\frac{u^2\sin^2\theta}{g^2}\right)$

$= \frac{g}{2} \times \left(\frac{5}{2}\right)^2 = \frac{10}{2} \times \frac{25}{4} = 31.25\text{ m}$

Q26 Text Solution:

$T_1 = \frac{2u\sin\theta}{g}$

$\therefore T_2 = \frac{2u\sin(90^\circ - \theta)}{g}$

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

$T_1T_1 = \frac{2}{g}\frac{2u^2\sin\theta\cos\theta}{g}$

Thus,

$T_1T_2 = \frac{2R}{g}$

Or

$\Rightarrow R = \frac{1}{2}gT_1T_2$

Q27 Text Solution:

$T = \frac{2v}{g}, R = uT = \frac{2uv}{g}$

Q28 Text Solution:

The time taken to reach the ground depends on the height from which the bullets are fired when the bullets are fired horizontally. Here height is same for both the bullets, and hence the bullets will reach the ground simultaneously

Q29 Text Solution:

Only magnitude remains constant and direction changes

Q30 Text Solution:

KE at highest point $K' = K\cos^2\theta$

$30 = 100\cos^2\theta \Rightarrow \cos^2\theta = \frac{3}{10} \Rightarrow \theta = \cos^{-1}\left(\sqrt{\frac{3}{10}}\right)$

Q31 Text Solution:

Bullets from guns can reach upto a distance of maximum range which occurs when projection is made at angle of 45°

$R_1 = \frac{u_1^2}{g}$ (at 45°)

$R_2 = \frac{u_2^2}{g}$

So, ratio of covered areas = $\frac{\pi(R_1)^2}{\pi(R_2)^2} = \frac{u_1^4}{u_2^4}$

Here, $u_1 = 1$ km/s and $u_2 = 2$ km/ s

So, ratio of areas = $\frac{1^4}{2^4} = \frac{1}{16} = 1:16$

Q32 Text Solution:

$r = 15t^2\hat{i} + \left(4 - 20t^2\right)\hat{j}$

Velocity of particle is

$v = \frac{dr}{dt} = 30t\hat{i} - 40t\hat{j}$

Acceleration of particle is

$a = \frac{d}{dt}\left(v\right) = 30\hat{i} - 40\hat{j}$

So, magnitude of acceleration at $t = 1$s is :

$|a| = \sqrt{30^2 + 40^2}$

$= 50\text{ ms}^{-2}$

Q33 Text Solution:

Given, $g = 10\ m/s^2$

Equation of trajectory of the projectile,

$y = 2x - 9x^2$

In projectile motion, equation of trajectory is given by

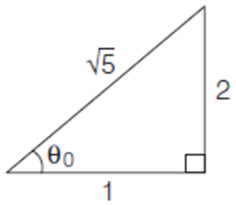
$y = x\tan\theta_0 - \frac{gx^2}{2v_0^2\cos^2\theta_0}$

Comparing these equations, we get

$\tan\theta_0 = 2$

and $\frac{g}{2v_0^2\cos^2\theta_0} = 9$

or $v_0^2 = \frac{g}{9\times 2\cos^2\theta_0}$



$\therefore v_0^2 = \frac{10\times(\sqrt{5})^2}{2\times(1)^2\times 9} = \frac{10\times 5}{2\times 9}$

$\Rightarrow \quad v_0^2 = \frac{25}{9} \text{ or } v_0 = \frac{5}{3} \text{ m/s}$

and $\quad \theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$

Q34 Text Solution:

$u_x = 1 = \frac{x}{t}$

$\Rightarrow x = t \qquad$ ...(1)

$u_y = 1$

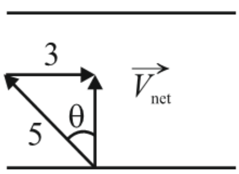
$y = u_y t - 5t^2$

$y = t - 5t^2 \qquad$ ...(2)

From (1) and (2)

$y = x - 5x^2$

Q35 Text Solution:



$\theta = 37^\circ$

Angle with the flow is 127°.

Q36 Text Solution:

$a_{avg} = \frac{|\Delta\vec{v}|}{\Delta t} = \frac{2\sqrt{2}v^2}{\pi r} = \frac{2\sqrt{2}\times 25}{\pi\times 5}$

$a_{avg} = \frac{10\sqrt{2}}{\pi}\text{m/s}^2$

Q37 Text Solution:

$T = \frac{2u\sin\theta}{g} = \frac{2\times 50\times 3}{10\times 5} = 6\text{s}$

In 6 s fielder has to cover a distance 3*R*

$v = \frac{3R}{6} = \frac{R}{2}$

Q38 Text Solution:

Initial horizontal velocity (v_x)

= 5 × cos37° ≈ 5 × 0.8 = 4 m/s.

Initial vertical velocity (v_y)

= 5 × sin37° ≈ 5 × 0.6= 3 m/s.

To find the time of flight (t), use vertical motion:

$-36 = 3t + \frac{1}{2}(-10)t^2$

Solving the quadratic equation

$5t^2 - 3t - 36 = 0$ gives $t = 3$ seconds.

Horizontal distance

= $v_x \times t$ = 4 m/s × 3 s = 12 m.

Q39 Text Solution:

Angle between the two vectors is 45°

Resultant $= \sqrt{25 + 50 + 2\times 5\times 5\sqrt{2}\times\frac{1}{\sqrt{2}}}$

$= \sqrt{75 + 50} = \sqrt{125} = 5\sqrt{5}$ units

Q40 Text Solution:

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

$R \propto u^2$

$\frac{\Delta R}{R} = \frac{2\Delta u}{4}\left(\text{Error formula}\right)$

= 2%

Q41 Text Solution:

Let radius is R and speed are v_P and v_R

$\Rightarrow v_P = \frac{2\pi R}{30}$ and $v_R = \frac{2\pi R}{40}$

Using $S_{rel} = v_{rel}\, t$

$t = \frac{2\pi R}{v_P + v_R} = \frac{120}{7}$ s

Q42 Text Solution:

Using the equation of projectile path:

$y = x\tan\theta - \frac{gx^2}{2v_0^2\cos^2\theta}$

Alternatively, using the components:

$x = v_{0_x} t \Rightarrow t = \frac{x}{v_{0x}}$

$y = v_{0_y} t - \frac{1}{2}gt^2$

Substitute t:

$y = v_{0_y}\left(\frac{x}{v_{0x}}\right) - \frac{1}{2}g\left(\frac{x}{v_{0x}}\right)^2$

$y = 2\left(\frac{x}{1}\right) - \frac{1}{2}\left(10\right)\left(\frac{x}{1}\right)^2$

$y = 2x - 5x^2$

Q43 Text Solution:

$v_x = \frac{dx}{dt} = 6t^2 = 6$ m/s

$v_y = \frac{dy}{dt} = 8t = 8$ m/s

$v = \sqrt{{v_x}^2 + {v_y}^2} = 10$ m/s

Q44 Text Solution:

First, calculate the time it takes for the bullet to travel the horizontal distance:

$t = \frac{\text{distance}}{\text{speed}} = \frac{100\,\text{m}}{600\,\text{m/s}} = 0.2\,\text{s}.$

Next, calculate the vertical distance the bullet will drop due to gravity during this time:

$h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10\,\text{m/s}^2 \times 0.2\,\text{s}^2$

$= 5\,\text{m/s}^2 \times 0.04\text{s}^2 = 0.2\,\text{m}$

Finally, convert this height to centimeters:

h = 0.2 m × 100 cm/m = 20 cm.

Q45 Text Solution:

u_x = 20 cos 45°

= 20 × $\frac{1}{\sqrt{2}} = 10\sqrt{2}\,\text{m/s}$

u_y = 20 sin 45°

$= 20 \times \frac{1}{\sqrt{2}} = 10\sqrt{2}\,\text{m/s}$

Time to reach wall (t):

t = horizontal distance

$u_x = 10\,\text{m}/10\sqrt{2}\,\text{m/s} = 1\sqrt{2}\,\text{s}.$

Height at wall (y):

$y = u_y t - \frac{1}{2}gt^2$

$10\sqrt{2} \times \frac{1}{\sqrt{2}} - \frac{1}{2} \times 10 \times \frac{1}{\sqrt{2}}$

$= 10 - \frac{1}{2} \times 10 \times \frac{1}{2}$

$= 10 - 2.5 = 7.5\,\text{m}$

Q46 Text Solution:

As maximum range occurs at θ = 45°:

$R_1 = R_2$

$\theta_1 = 45^\circ + \theta, \theta_2 = 45^\circ - \theta$

$R = \frac{u^2 \sin 2(45^\circ + \theta)}{g}$

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

Maximum heights achieved in two cases are

$h_1 = \frac{u^2 \sin^2(45^\circ + \theta)}{2g}$

and $h_2 = \frac{u^2 \sin^2(45^\circ - \theta)}{2g}$

After simplifying we can show that,

$R^2 = 16h_1h_2$

Q47 Text Solution:

To cross the river in shortest time, one has to swim perpendicular to the river current.

Q48 Text Solution:

Considering the initial position of ship A as origin. After time t, coordinates of ships A and B are $(80 - 10t, 150)$ and $(30t, 50t)$

So, distance between A and B after time t is

$d = \sqrt{(80 - 10t - 30t)^2 + (150 - 50t)^2}$

$d^2 = (80 - 40t)^2 + (150 - 50t)^2$

Distance is minimum when $\frac{d}{dt}(d^2) = 0$

$\frac{d}{dt}\left[(80 - 40t)^2 + (150 - 50t)^2\right] = 0$

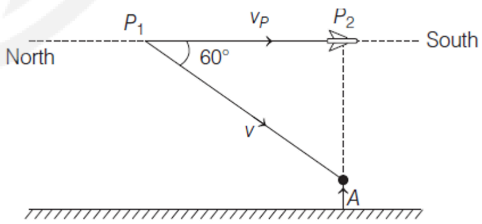
$\Rightarrow\ 2(80 - 40t)(-40) + 2(150 - 50t)(-50) = 0$

After solving, we get

t = 2.6 h

Q49 Text Solution:

Let P_1 be the position of plane at t = 0, when sound waves started towards person A and P_2 is the position of plane observed at time instant t as shown in the figure below.



$\cos 60^\circ = \frac{P_1P_2}{P_1A} = \frac{v_P \times t}{v \times t}$

$\frac{1}{2} = \frac{v_P}{v} \Rightarrow v_P = \frac{v}{2}$

Q50 Text Solution:

The relative velocity of rain with respect to the person is $V_{RP} = V_R - V_P$

Given $V_R = \left(-4\hat{i} + 8\hat{j} - 10\hat{k}\right)$

and $V_P = \left(6\hat{i} + 8\hat{j}\right)$.

$$V_{RP} = \left(-4\hat{i} + 8\hat{j} - 10\hat{k}\right) - \left(6\hat{i} + 8\hat{j}\right)$$
$$= \left(-4 - 6\right)\hat{i} + \left(8 - 8\right)\hat{j} - 10\hat{k}$$
$$= 10\hat{i} - 10\hat{k}$$

The speed is the magnitude of this relative velocity:

$$\left|V_{RP}\right| = \sqrt{(-10)^2 + (-10)^2}$$
$$= \sqrt{100 + 100} = \sqrt{200} = 10\sqrt{2}\,\mathrm{m/s}$$

Q51 Text Solution:

When the coin is tossed, it initially shares the train's horizontal velocity. If the coin falls behind the person, it means the train's forward speed increased after the coin was tossed, while the coin maintained its initial horizontal speed. This indicates the train is moving forward with a finite acceleration.

The final answer is moving forward with a finite acceleration.

Q52 Text Solution:

From graphs: a_x = constant (<0)

$v_x(t_0) = 0. a_y = 0$, v_y = constant (>0)

At t_0: v = $v_y\hat{j}$ and $a = a_x\hat{i}$.

Since v is in y-direction and a is in x-direction, they are perpendicular.

Q53 Text Solution:

Man will catch the ball if the horizontal component of velocity becomes equal to the constant speed of man i.e.

$v_0 \cos\theta = \frac{v_0}{2}$

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

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

$\therefore\ \theta = 60^\circ$

Q54 Text Solution:

$T = 5 = \frac{2u\sin\theta}{g}$

$u\sin\theta = 25$

$R = \frac{2(u\sin\theta)(u\cos\theta)}{g} = 200$

$\frac{2}{10}(25)\left(u\cos\theta\right) = 200$

$u\cos\theta = \frac{200\times10}{50} = 40$

$\tan\theta = \frac{25}{40} = \frac{5}{8} \qquad \theta = \tan^{-1}\left(\frac{5}{8}\right)$

Q55 Text Solution:

The range formula is $R = = \frac{u^2\sin(2\theta)}{g}$.

Since u and g are constant

$R \propto \sin(2\theta)$.

For $15^\circ: 2\theta = 30^\circ, \sin(30^\circ) = 0.5$

For $45^\circ: 2\theta = 90^\circ, \sin(90^\circ) = 1$

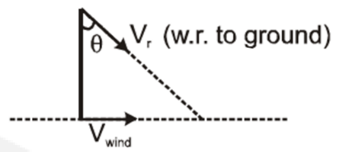
For $75^\circ: 2\theta = 150^\circ, \sin(150^\circ)$

= sin(180° – 30°) = sin(30°) = 0.5

Comparing the sin(2θ) values : 0.5 < 1.

Thus, $R_{15} = R_{75} < R_{45}$.

Q56 Text Solution:



$\left|V_r\sin\theta\right| = \left|V_{wind}\right|$

$V_r = \frac{5.0}{\sin\theta} = \frac{5}{\sin\theta}$

Q57 Text Solution:

At top most point, $y = h_{max}$

and $x = \frac{R}{2}$

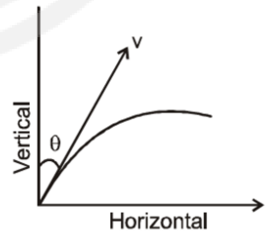
So, required ratio $= \frac{u^2\sin^2\theta}{2g} \times \frac{2g}{u^2\sin 2\theta}$

$= \frac{\tan\theta}{2}$

Q58 Text Solution:

Max. height $= H = \frac{v^2\sin^2(90-\theta)}{2g}$ ..... (i)

Time of flight $= T = \frac{2v\sin(90-\theta)}{g}$ .... (ii)



From (i) and (ii) $\frac{v\cos\theta}{g}\sqrt{\frac{2H}{g}}$.

Q59 Text Solution:

Given $x = at^2$ and $y = bt^2$.

Velocity components are

$v_x = \frac{dx}{dt} = 2at$ and

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

Speed is the magnitude of the velocity:

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(2at)^2 + (2bt)^2}$$
$$= \sqrt{4a^2t^2 + 4b^2t^2}$$
$$= \sqrt{4t^2(a^2 + b^2)}$$
$$= 2t\sqrt{a^2 + b^2}$$

Q60 Text Solution:

When the bomb is dropped, it initially has the same horizontal velocity as the aeroplane. However, air resistance will act against the bomb's horizontal motion, causing its horizontal speed to decrease. The aeroplane, meanwhile, maintains its constant horizontal speed. Therefore, the bomb's horizontal distance covered will be less than that of the aeroplane, causing it to fall behind the aeroplane.