JEE Advanced Previous Year Questions with Solutions on Kinematics

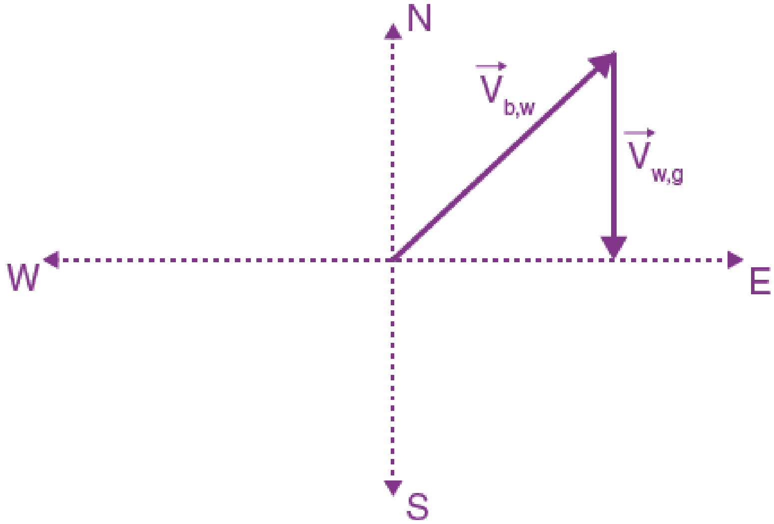
Question 1) Bird is flying in north-east direction with or v = 4√2 m/s with respect to the wind and the wind blowing from north to south with speed 1 m/s. Find the magnitude of the displacement of the bird in 3 sec.

(a) 5 m

(b) 15 m

(c) 10 m

(d) 20 m



Answer: (b) 15 m

Solution:

The velocity of bird w.r.t. wind,

$\vec{v}_{bw} = (4\sqrt{2}\cos 45°\ \hat{i} + 4\sqrt{2}\sin 45°\ \hat{j})\ m/s$

Now velocity of wind w.r.t ground is,

$\vec{v}_{wg} = -1\hat{j}\ m/s$

From relative motion relation, the velocity of bird w.r.t. ground

$\Rightarrow \vec{v}_{bg} = \vec{v}_{bw} + \vec{v}_{wg}$

$\vec{v}_{bg} = 4\hat{i} + 4\hat{j} - 1\hat{j} = 4\hat{i} + 3\hat{j}$

$|\vec{v}_{bg}| = \sqrt{(3)}$

2 + (4)

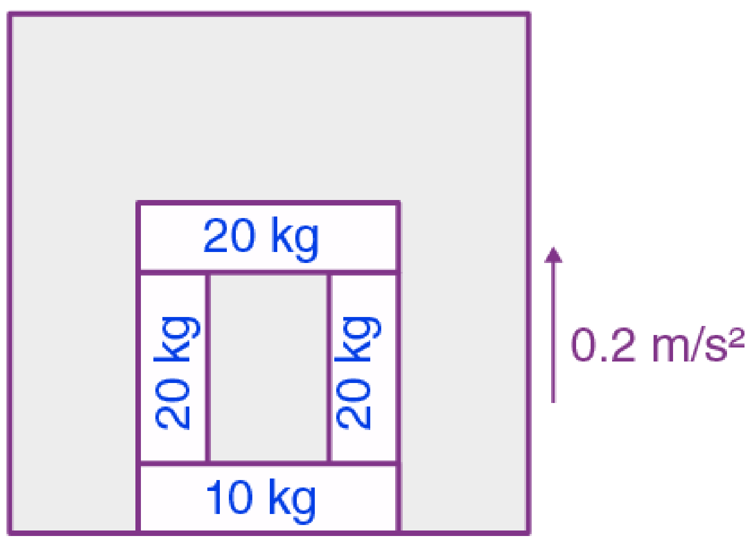
2 = 5 m/s

Then displacement of bird in 3 sec,

$\Rightarrow d = |\vec{v}_{bg}| \times t$

or, $d = 5 \times 3 = 15\ m/s$

Question 2) Four planks are arranged in a lift going upwards with an acceleration of 0.2 m/s^2 as shown in the figure. Find the normal reaction applied by the lift on 10 kg block: (g = 9.8 m/s^2)



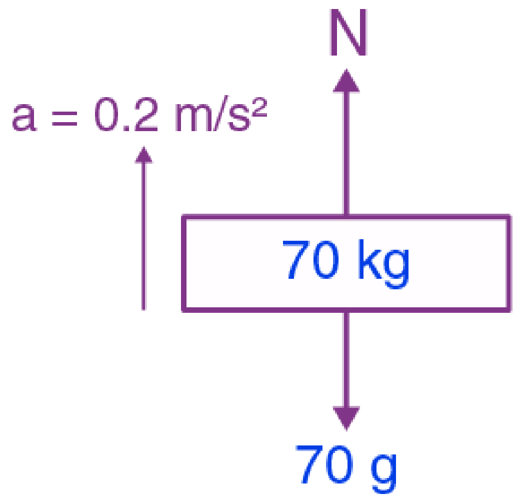
a. 500

b. 700

c. 672

d. 800

Solution: (b) 700



N - 70g = 70 x 0.2

N = 70 (g + 0.2)

N = 700

Question 3) A projectile is thrown from a point O on the ground at an angle 45° from the vertical and with a speed of 5 √2 m/s . The projectile at the highest point of its trajectory splits into two equal parts. One part falls vertically down to the ground, 0.5 s after the splitting. The other part, t seconds after the splitting, falls to the ground at a distance x meters from the point O. The acceleration due to gravity g = 10 m/s^2 . The value of t is ________.

Answer: 0.5

Solution:

H = $u^2\sin^2\theta/2g$

$$= \frac{50}{2 \times 10} \times \frac{1}{2} = \frac{5}{4}$$

$$t = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 5}{4 \times 10}} = (1/2)s = 0.5s$$

Question 4) A projectile is thrown from a point O on the ground at an angle 45° from the vertical and with a speed of 5 √2 m/s . The projectile at the highest point of its trajectory splits into two equal parts. One part falls vertically down to the ground, 0.5 s after the splitting. The other part, t seconds after the splitting, falls to the ground at a distance x meters from the point O. The acceleration due to gravity g = 10 m/s^2 .The value of x is ________.

Answer: 7.5

Solution:

X= 3R/2 as X_{cm} = R

R =$u^2 sin^2θ/g$

= 50/10 = 5

⇒X = 3R/2 = 15/2 = 7.5 m

Question 5) A particle of mass M = 0.2 kg is initially at rest in the xy-plane at a point (x = –l, y = –h), where l = 10 m and h = 1 m. The particle is accelerated at time t = 0 with a constant acceleration a = 10 m/s^2 along the positive x-direction. Its angular momentum and torque with respect to the origin, in SI units, are represented by $\vec{L}$ and $\vec{\tau}$, respectively. $\hat{i}, \hat{j}, \hat{k}$, and are unit vectors along the positive x, y and z-directions respectively. If $\hat{k} = \hat{i} \times \hat{j}$ then which of the following statement(s) is(are) correct?

(A) The particle arrives at the point (x = l, y = –h) at time t = 2s

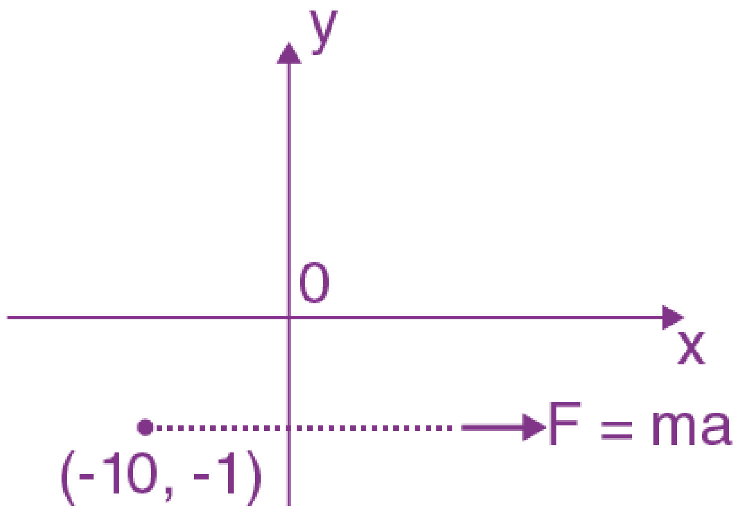
(B) $\vec{\tau} = 2\hat{k}$ when the particle passes through the point (x = l, y = –h)

(C) $\vec{L} = 4\hat{k}$ when the particle passes through the point (x = l, y = –h)

(D) $\vec{\tau} = \hat{k}$ when the particle passes through the point (x = 0, y = –h)

Answer: (A,B,C)

Solution:

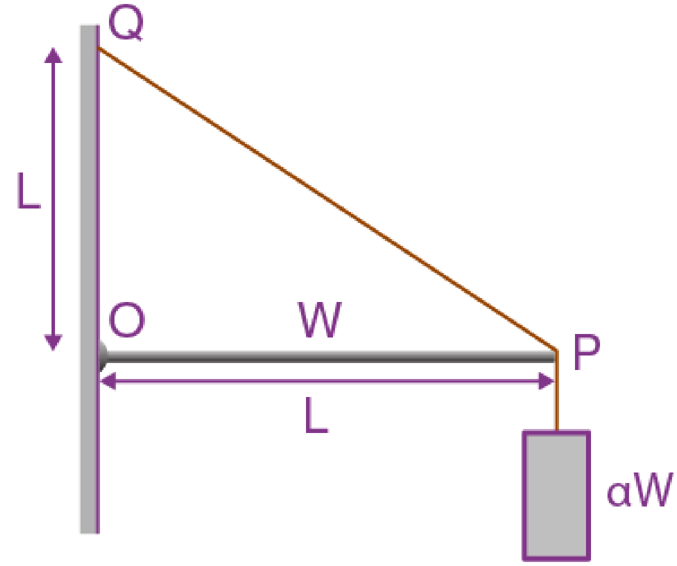


$$t = \sqrt{\frac{2 \times 20}{10}} = 2s$$

$$\vec{\tau} = (0.2 \times 10 \times 1)\hat{k} = 2\hat{k}$$

$$\vec{L} = (0.2 \times (10 \times 2) \times 1)\hat{k} = 4\hat{k}$$

Question 6) One end of a horizontal uniform beam of weight W and length L is hinged on a vertical wall at point O and its other end is supported by a light inextensible rope. The other end of the rope is fixed at point Q, at a height L above the hinge at point O. A block of weight αW is attached at the point P of the beam, as shown in the figure (not to scale). The rope can sustain a maximum tension of (2√2) W Which of the following statement(s) is(are) correct?



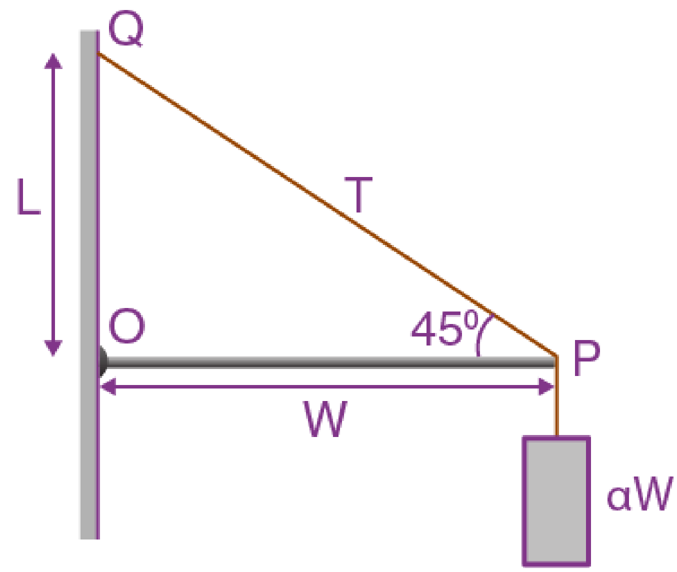
(A) The vertical compenent of reaction force at O does not depend on α

(B) The horizontal component of reaction force at O is equal to W for α = 0.5

(C) The tension in the rope is 2W for α = 0.5

(D) The rope breaks if α > 1.5

Answer: (A,B.D)



Solution:

W x (L/2) + αW x L = T x (1/√2) x L

$$\Rightarrow T = \sqrt{2}\left(\frac{1}{2}+\alpha\right)W$$

$$T \times \frac{1}{\sqrt{2}} + F_v = W + \alpha W$$

$$\frac{W}{2} + \alpha W + F_v = W + \alpha W$$

F_v = W/2

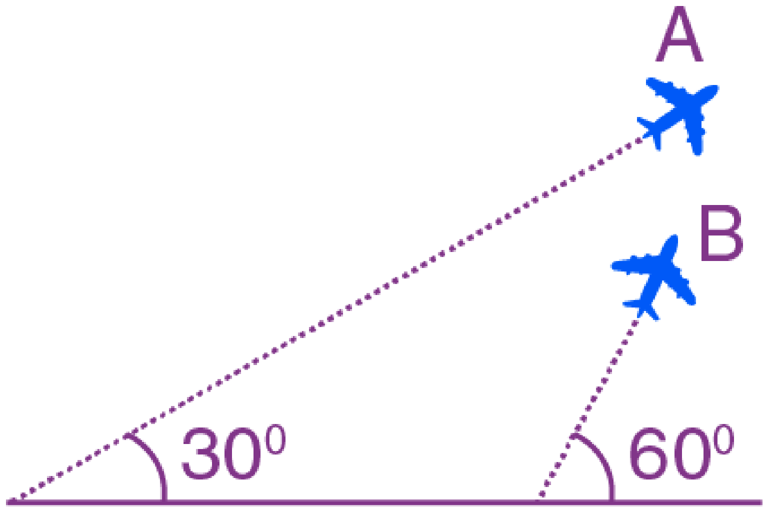
At α = ½ , $T = \sqrt{2}\left(\frac{1}{2}+\frac{1}{2}\right)W$ = √2W

F_H (at α = ½) = √2W x ½ = W

At α = 1.5 , T = √2 x (½ + 3/2) W = 2√2W

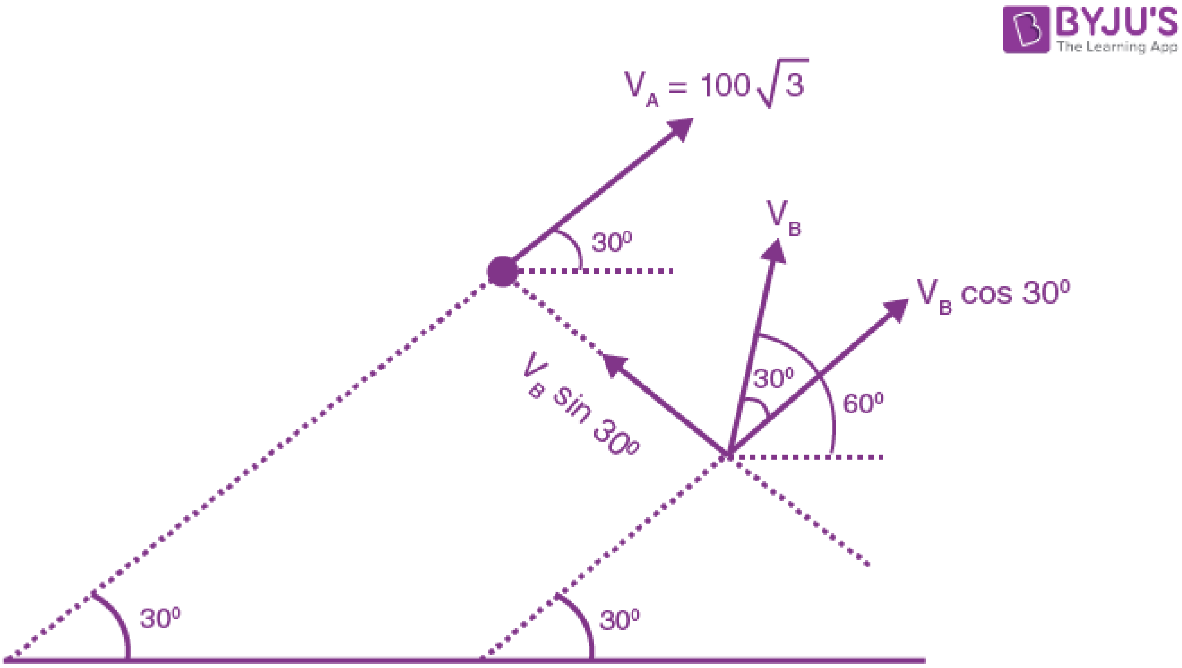
Question 7) Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in the figure. The speed

of A is $100\sqrt{3}$ m/s. At time t = 0 s, an observer in A finds B at a distance of 500 m. This observer sees B moving with a constant velocity perpendicular to the line of motion of A. If at $t = t_0$, A just escapes being hit by B, t_0 in seconds is



Answer: 5 s

Solution:



$v_A = v_B \cos 300$

$\Rightarrow 100\sqrt{3} = v_B \times (\sqrt{3}/2)$

$\Rightarrow v_B = 200$ m/s

$t_0 = d/v_B \sin 30^0$

$= 500/ (200 \times ½)$

= 5 s

Question 8) A bus is moving with a constant velocity v_1 along a horizontal road. A man standing inside the bus throws a ball upward with velocity v_0 and catches the ball. The magnitude of displacement of the ball with respect to the ground is

(A) v_0^2/g

(B) Zero

(C)$2v_0v_1/g$

(D) v_0v_1/g

Answer: (C) $2v_0v_1/g$

Solution:

$T = 2v_0/g$

$X = 2v_0v_1/g$

Question 9) A particle starts sliding down a frictionless inclined plane. If Sn is the distance travelled by it from time t = (n - 1) sec to t = n sec, then the ratio S_n/S_{n+1} is

(A) (2n - 1)/(2n+1)

(B) (2n + 1)/2n

(C) 2n/(2n + 1)

(D) (2n+1)/(2n-1)

Answer: (A) (2n - 1)/(2n+1)

Solution:

$S_n = u + (a/2)(2n - 1)$

$S_n = (g\sin\theta/2)(2n - 1)$ ———-(1)

$S_{n+1} = (g\sin\theta/2)(2n + 1)$ ———-(1)

So, $S_n = (2n - 1)/(2n + 1)$

Question 10) A particle moving in a straight line covers half the distance with speed of 3 m/s. The other half of the distance is covered in two equal time intervals with speed of 4.5 m/s and 7.5 m/s respectively. The average speed of the particle during this motion is

(A) 4.0 m/s

(B) 5.0 m/s

(C)5.5 m/s

(D) 4.8 m/s

Answer: 1) 4 m/s

Solution:

Let the total distance covered by the particle be S. Given that, the particle covers S/2 with a speed of 3m/s.

The time taken to cover this distance is, $(t_1/2)/3$

$t_1=S/6$

Let the time taken to complete the other half distance be $2t_2$. We have,

$(t_2 \times 4.5)+ (t_2 \times 7.5)= S/2$

$12t_2 = S/2$

$t_2 = S/24$

The average speed VA = total distance/total time

$= S /(t_1 + t_2)$

$= S/ \{(S/6)+ (S/24)\}$

$V_A = 4m/s$