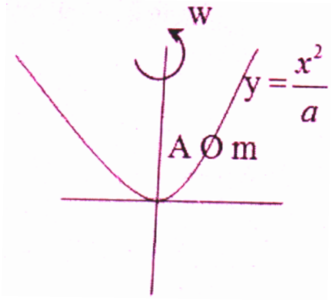
PART (A) : PHYSICS

SECTION-I : (SINGLE CHOICE QUESTIONS)

This section contains **05 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

1. In the given figure, a smooth parabolic track lies in the vertical plane (x-y) the shape of track is defined by equation $y = \frac{x^2}{a}$ where a is a constant. A ring of mass m which can slide freely on wire track, is placed at the position (a, a). The track is rotated with constant angular speed ω such that there is no relative slipping between the ring and the track then ω is equal to



(A) $\sqrt{\frac{2g}{a}}$ (B) $\sqrt{\frac{g}{a}}$

(C) $\sqrt{\frac{g}{2a}}$ (D) None of these

1. **(A)**

$\frac{dy}{dx} = \frac{2x}{a} = 2$ ....(1)

$N\cos\theta = mg$ ....(2)

$N\sin\theta = mr\omega^2 = ma\omega^2$ ....(3)

$(2)/(3)$,

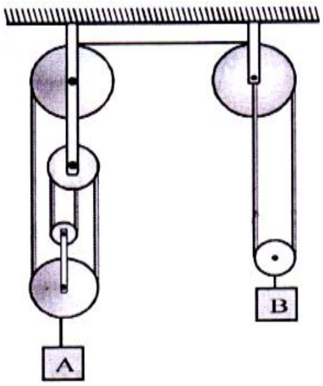
$\tan\theta = \frac{a\omega^2}{g}$ ....(4)

(1) and (4),

$2 = \frac{a\omega^2}{g}$

$\omega = \sqrt{\frac{2g}{a}}$

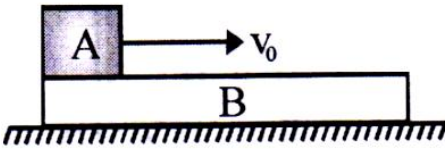
2. Block B has a downward velocity in m/s and given by $v_B = \frac{t^2}{2} + \frac{t^3}{6}$, where t is in s. Acceleration of A at t = 2 second is



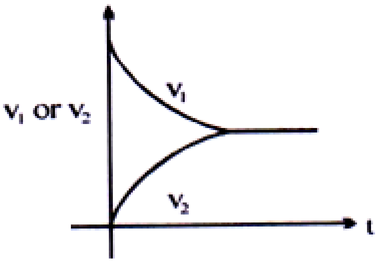
(A) 2 m/s^2
(B) 4m/s^2
(C) 6m/s^2
(D) none of these

2 **(A)**

3. A block A is placed over a long uniform rough plank B of same mass as shown in figure. The plank is placed over a smooth horizontal surface. At time t = 0, block A is given a velocity v_0 in horizontal direction. Let v_1 and v_2 be the velocities of A and B at time t. Then choose the correct graph between v_1 or v_2 and t.



(A)



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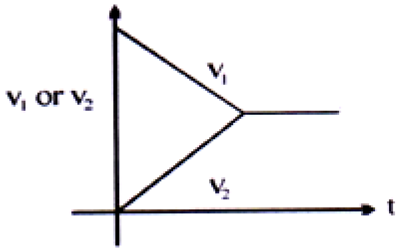

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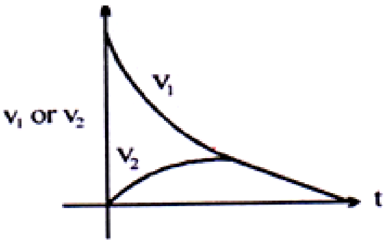
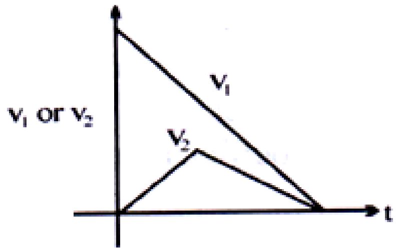
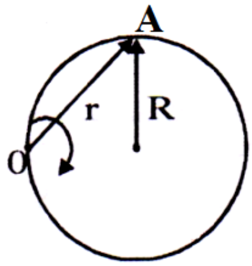


(D)



3. **(B)**

4. A particle A moves along a circle of radius R = 50 cm so that its radius vector r relative to the point O (figure) rotates with the constant angular velocity $\omega = 0.40\,rad/s$. Then modulus of the velocity of the particle, and the modulus of its total acceleration will be



(A) $v = 0.4\,m/s,\ a = 0.4\,m/s^2$ (B) $v = 0.32\,m/s,\ a = 0.32\,m/s^2$

(C) $v = 0.32\,m/s,\ a = 0.4\,m/s^2$ (D) $v = 0.4\,m/s,\ a = 0.32\,m/s^2$

4. **(D)**

$V = R\omega^{1} = R \times 2\omega = 0.4 m/s$

$a = R\omega^{1^2} = 0.5 \times (2\omega)^2 = 0.32 m/s^2$

5. A particle is moving in a plane with velocity given by $\vec{u} = u_0\hat{i} + (a\omega\cos\omega t)\hat{j}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axes respectively. If particle is at the origin at $t = 0$. Calculate the trajectory of the particle:

(A) $y = a\sin\left(\frac{u_0}{\omega x}\right)$ (B) $y = a\sin\left(\frac{\omega x}{u_0}\right)$

(C) $y = \frac{1}{a}\sin\left(\frac{u_0}{\omega x}\right)$ (D) $y = \frac{1}{a}\sin\left(\frac{\omega x}{u_0}\right)$

5. **(B)**

$\vec{u} = u_0\hat{i} + a\omega\cos\omega t\,\hat{j}$

$\frac{dx}{dt} = u_0, \frac{dy}{dt} = a\omega \cos \omega t$

on intergrating both and eliminating 't',

$y = a \sin\left(\frac{\omega x}{u_0}\right)$

SECTION-II : (MULTIPLE CHOICE QUESTIONS)

This section contains **08 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE than one is/are correct.**

6. In the two cases shown, the coefficient of kinetic friction between the block and the surface is the same, and both the identical blocks are moving with the same uniform speed. If $\sin\theta = \frac{mg}{4F_2}$, then

(A) $F_1 = F_2$ (B) $F_1 < F_2$ (C) $F_1 > F_2$ (D) $F_1 = 2F_2$

6. **(CD)**

If θ is the angle made by the direction of force with the horizontal, we have

$F_1 \cos\theta = \mu(mg + F_1 \sin\theta)$ and

$F_2 \cos\theta = \mu(mg - F_2 \sin\theta)$.

Clearly $F_1 > F_2$ so that option (C) is correct.

If $\sin\theta = \frac{mg}{4F_2}$, two relations written above become

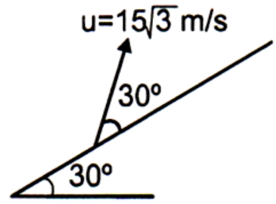
$F_1 \cos\theta = \mu\left[mg + \frac{mgF_1}{(4F_2)}\right]$ and

$F_2 \cos\theta = \mu\left[mg - \frac{mgF_2}{(4F_2)}\right]$.

From this we get $\frac{F_1}{F_2} = \frac{1+\left(\frac{F_1}{4F_2}\right)}{\left(\frac{3}{4}\right)}$

Solving this we get $F_1 = 2F_2$, so that (D) is correct.

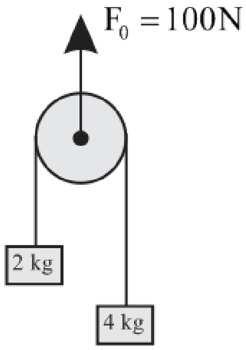
7. A particle is projected up an incline (inclination angle = 30°) with $15\sqrt{3}\,m/s$ at an angle of 30° with the incline (as shown in figure) $(g = 10\,m/s^2)$



(A) 1.5 sec later, angle between acceleration & velocity is 120º
(B) 1.5 sec later, angle between acceleration & velocity is 60º
(C) Range on the incline is 45 m
(D) Time of flight on the incline is 3 sec

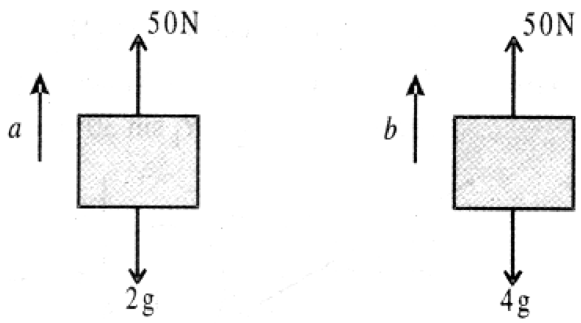
7. **(ACD)**

8. Two blocks of masses $m_1 = 2kg$ and $m_2 = 4kg$ over a massless pulley as shown in the figure. The string connecting both the blocks is light and inextensible. A force $F_0 = 100N$ acting at the axis of the pulley accelerates the system upwards. Then (Take $g = 10\,m/s^2$)



(A) acceleration of both the masses is same
(B) magnitude of acceleration of 2 kg mass is 15 m/sec^2
(C) magnitude of acceleration of 4 kg mass is 2.5 m/sec^2
(D) acceleration of both the masses is upward

8. **(BCD)**



$50 - 2g = 2a$ and also $50 - 4g = 4b$

$\frac{50-20}{2} = a$ $\frac{50-4\times10}{4} = b$

$a = 15\,m/sec^2$ upwards $b = 2.5\,m/sec^2$ upwards

The acceleration of both the masses is upward.

9. Two particles A and B are located in $x-y$ plane at points $(0,0)$ and $(0,4m)$. They simultaneously start moving with velocities. $\vec{v}_A = 2\hat{j}\,m/s$ and $\vec{v}_B = 2\hat{i}\,m/s$. Select the correct alternative(s).
(A) The distance between them is constant

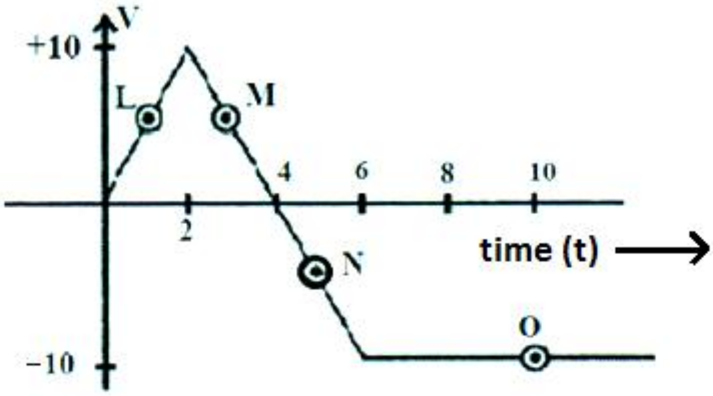
(B) The distance between them first decreases and then increases
(C) The shortest distance between them is $2\sqrt{2}$m
(D) Time after which they are at minimum distance is 1s

9. **(BCD)**

10. A particle starts from rest and moves with acceleration a which varies with time t as a = kt , where k is a constant. The displacement s of the particle at time t is
(A) $1/2\ kt^3$ (B) $1/2at^3$ (C) $1/6\ kt^3$ (D) $at^2/6$

10. **(CD)**

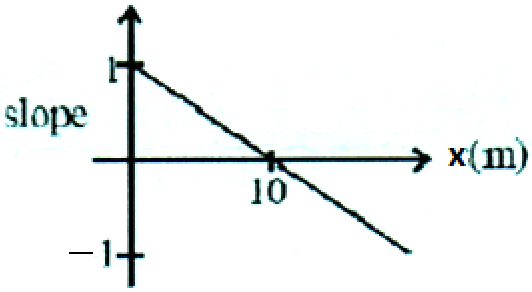
11. A particle starts from origin and moving along x-axis, whose v – t graph is as shown. Choose the CORRECT statement(s)



(A) At point L particle is speeding up
(B) At point M particle is moving in positive x – direction
(C) At point N particle is slowing down
(D) At point O particle is rest

11. **(AB)**
Slope of $\bar{v}-t$ graph is acc^n.

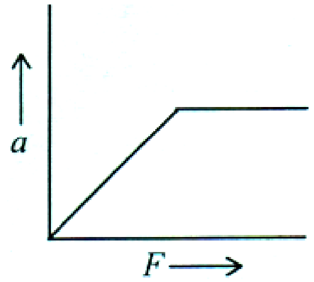
12. A projectile is fired on a horizontal ground. Variation of slope of its trajectory with horizontal displacement is shown (g = 10 m/s^2). Choose the CORRECT statement(s):

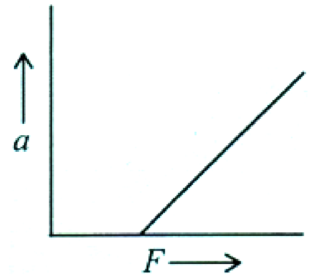


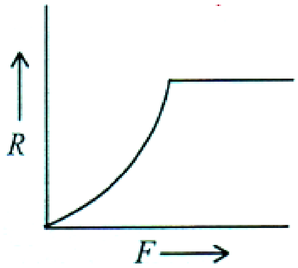
(A) Angle of projection of projectile is 60^o
(B) Horizontal range of projectile is 20 m
(C) Time of flight of projectile is 2 sec
(D) Area under curve gives vertical displacement of projectile

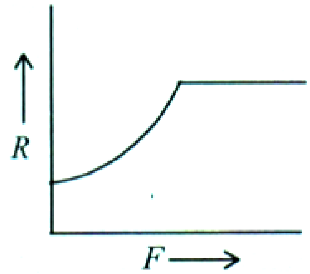
12. **(BCD)**

13. A block rests on a rough horizontal surface. A linearly increasing horizontal force *F* is applied to the block at $t = 0$. If 'R' denotes the net force by the block on the ground and 'a' denotes the acceleration of the block, which of the following graph(s) is/are correct?

(A)


(B)


(C)


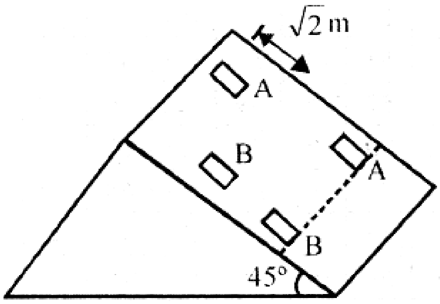
(D)


13. **(BD)**

SECTION-III : (INTEGER CORRECT TYPE)

This section contains **05 Questions.** The answer to each question is a **Single digit integer**, ranging from 0 to 9 (both inclusive)

14. Two blocks A and B of equal masses are placed on rough inclined plane as shown in figure. When will the two blocks come on the same line on the inclined plane if they are released simultaneously? Initially the block A is behind B and $\mu_A = 0.1, \mu_B = 0.2, g = 10\ \text{m/sec}^2$. (Initially the blocks are at rest)



14. **(2)**

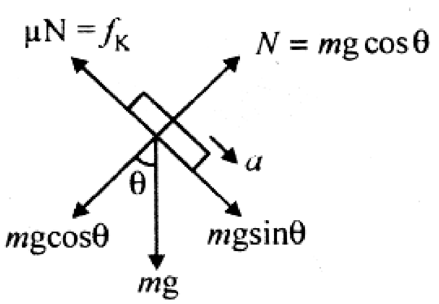
$$a = \frac{mg\sin\theta - \mu_k mg\cos\theta}{m}$$

$\therefore \quad a_A = g\sin\theta - \mu_{k,A} g\cos\theta \qquad ...(i)$

and $\quad a_B = g\sin\theta - \mu_{k,B}\, g\cos\theta \qquad ...(ii)$

$$a_{AB} = g(\mu_B - \mu_A)\cos\theta$$

$$= \frac{1}{\sqrt{2}}$$



a_{AB} is relative acceleration of A w.r.t. B

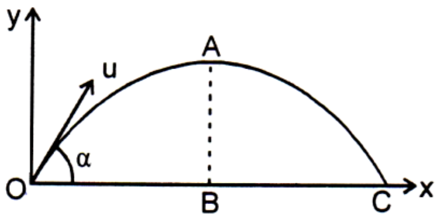
$$\vec{a}_{AB} = \vec{a}_A - \vec{a}_B$$

$L = \sqrt{2}m \Rightarrow L = \frac{1}{2}a_{AB}t^2$ [where L is the relative distance between A and B]

Or $t^2 = \frac{2L}{a_{AB}} = \frac{2L}{a_A - a_B}$

Putting values we get, $t^2 = 4$ or $t = 2s$.

15. A is highest point of a projectile. If the average velocity of the projectile between O and A is $8\hat{i}+3\hat{j}$ then (8 tan α) is :



15. **(6)**

Along *y*-direction, average velocity,

$$v_{ov} = \frac{u\sin\alpha + 0}{2} = 3$$

$u\sin\alpha = 6$ …(1)

Along *x*-direction, average velocity,

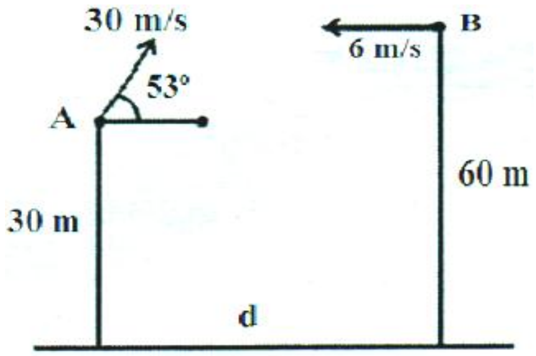
$u\cot\alpha = 8$ …(2)

$(1)/(2)$,

$\tan\alpha = \frac{6}{8}$

So, $8\tan\alpha = 6$

16. Ball A is projected from tower of height 30 m & B is projected horizontally at 6m/s. A & B collide in air if separation between the tower d = 10x. Find x



16. **(3)**

w.r.t. A,

$V_{BA_x} = 24,\ V_{BA_y} = 24$

Along y, $s_y = u_y t$

$30 = 24 \times t$

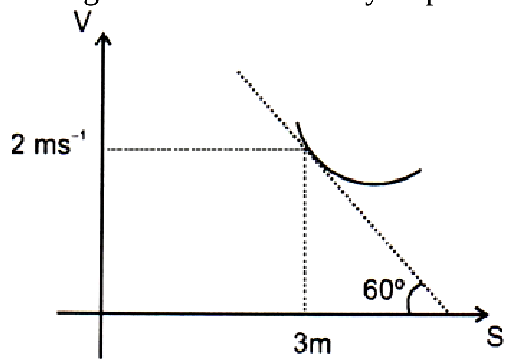
$t = \frac{5}{4}\,\text{sec}$

$5x = ux\,t$

$d = 24 \times \frac{5}{4} = 30$

$d = 10x = 30 \Rightarrow x = 3$

17. A particle is moving along a straight line whose velocity displacement curve is as shown in figure



If the acceleration of particle when its displacement is 3m is $-2\sqrt{x}\ \text{ms}^{-2}$, then x is :

17. **(3)**

$a = \frac{dv}{ds} = 2(-\tan 60^\circ) = -2\sqrt{3}$

$x = 3$

18. A projectile is fired with a speed 6.25 m/s at an angle $\theta = 53^\circ$ above horizontal. This planet is strange one, in that acceleration due to gravity increases linearly with time starting with a value zero, when projectile is fired. In other words $g = \beta t$ where β is a constant. If horizontal range of projectile remains same as obtained if $g = 10\,m/s^2$ (under same initial velocity), then find value of $\beta/6$ in (m/s^2)

18. **(5)**