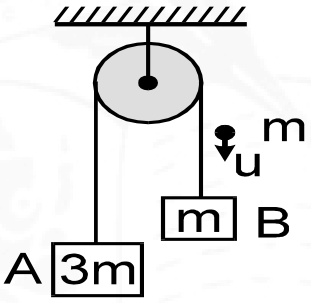
PHYSICS **Max Marks: 80**

SECTION – I
(SINGLE CORRECT CHOICE TYPE)

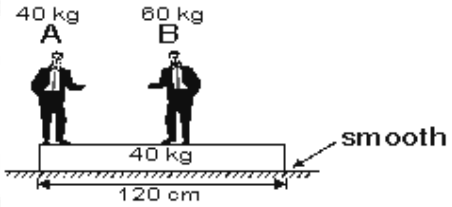
This section contains ***7* multiple choice questions.** Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct

24. A system of two blocks A and B are connected by an inextensible massless strings as shown. The pulley is massless and frictionless. Initially the system is at rest when, a bullet of mass 'm' moving with a velocity 'u' as shown hits the block 'B' and gets embedded into it. The impulse imparted by tension force to the block of mass 3m is :



A) $\frac{5mu}{4}$ B) $\frac{4mu}{5}$ C) $\frac{2mu}{5}$ D) $\frac{3mu}{5}$

25. Two men 'A' and 'B' are standing on a plank. 'B' is at the middle of the plank and 'A' is at the left end of the plank. Surface of the plank is smooth. System is initially at rest and masses are as shown in figure. 'A' and 'B' starts moving such that the position of 'B' remains fixed with respect to ground. Then the point where A meets B is located at :



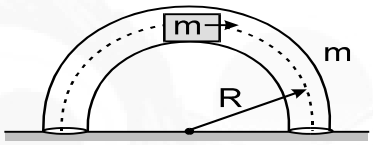
A) the middle of the plank B) 30 cm from the left end of the plank

C) the right end of the plank D) None of these

26. A balloon having mass ' m ' is filled with gas and is held in hands of a boy. Then suddenly it get released and gas starts coming out of it with a constant rate. The velocities of the ejected gases is also constant 2 m/s with respect to the balloon. Find out the velocity of the balloon when the mass of gas is reduced to half.

A) $\ell n\, 2$ B) $2\ell n\, 4$ C) $2\ell n\, 2$ D) none of these

27. In a vertical plane inside a smooth hollow thin tube a block of same mass as that of tube is released as shown in figure. When it is slightly disturbed it moves towards right. By the time the block reaches the right end of the tube then the displacement of the tube will be (where 'R' is mean radius of tube). Assume that the tube remains in vertical plane.



A) $\frac{2R}{\pi}$ B) $\frac{4R}{\pi}$ C) $\frac{R}{2}$ (D) R

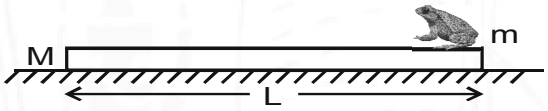
28. At time t = 0, the velocities of two particles A and B of equal masses and both lying at origin are $\vec{u}_A = 10\hat{i}\, m/s$ and $\vec{u}_B = 10\sqrt{3}\hat{j}\, m/s$ respectively. The acceleration of both particles is always constant such that acceleration of A has magnitude $a_A = 10 m/s^2$ and acceleration of B $\vec{a}_B = 10\hat{j}\, m/s^2$. If the centre of mass of system of two particle system moves along a straight line with increasing speed, then the acceleration vector of particle A in m/s^2 is :

A) $5\sqrt{3}i + 5\hat{j}$ B) $5\hat{i} + 5\sqrt{3}\,\hat{j}$ C) $10\hat{i} + 5\sqrt{3}\,\hat{j}$ D) $5\sqrt{3}\,\hat{i} + 10\,\hat{j}$

29. A plate, of uniform thickness and uniform density, has shape in the x-y plane defined by the lines x = 0, y = 2, and curve $y=\frac{1}{2}x^2$. The plate lies in first quadrant of x-y plane. Then the x-coordinate of centre of mass of this plate is:

A) $\frac{1}{2}$ B) $\frac{3}{2}$ C) $\frac{4}{3}$ D) $\frac{3}{4}$

30. A plank of mass M and length L is at rest on smooth horizontal ground. At the right end of plank there is a frog of mass m. The frog jumps with an initial velocity $\vec{u}$ relative to ground making an angle 45° with horizontal. If the frog just lands on left end of plank, then the value of length of plank is :(where $u=|\vec{u}|$, g is acceleration due to gravity. Neglect air resistance)



A) L = $\frac{u^2}{g}\left[1+\frac{m}{M}\right]$ B) L = $\frac{u^2}{g}\left[1+\frac{\sqrt{2}m}{M}\right]$

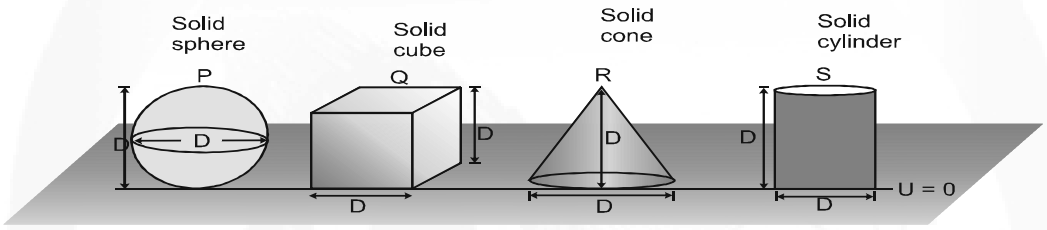
C) L = $\frac{u^2}{g}\left[1+\frac{m}{\sqrt{2}M}\right]$ D) L = $\frac{u^2}{g}\left[1+\frac{m}{2M}\right]$

SECTION – II

(MULTIPLE CORRECT CHOICE TYPE)

This section contains **4 multiple choice questions.** Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/ are correct

31. Assuming potential energy 'U' at ground level to be zero.



All objects are made up of same material.

U_P = Potential energy of solid sphere

U_Q = Potential energy of solid cube

U_R = Potential energy of solid cone

U_S = Potential energy of solid cylinder

A) $U_S > U_P$ B) $U_Q > U_S$ C) $U_P > U_Q$ D) $U_S > U_R$

32. A bag of mass M hangs by a long thread and a bullet (mass m) comes horizontally with velocity v and gets caught in the bag. Then for the combined system (bag + bullet) :

A) Momentum is $mMv/(M+m)$

B) KE is $(1/2)Mv^2$

C) Momentum is mv

D) KE is $m^2v^2/2(M+m)$

33. A ball moving with a velocity v hits a massive wall normally moving towards the ball with a velocity u. An elastic impact lasts for a time Δt.

A) The average elastic force acting on the ball is $\frac{m(u+v)}{\Delta t}$

B) The average elastic force acting on the ball is $\frac{2m(u+v)}{\Delta t}$

C) The kinetic energy of the ball increases by 2mu (u + v)

D) The kinetic energy of the ball remains the same after the collision.

34. A particle strikes a horizontal smooth floor with a velocity u making an angle θ with the floor and rebounds with velocity v making an angle ϕ with the floor. If the coefficient of restitution between the particle and the floor is e, then :

A) the impulse delivered by the floor to the body is $mu(1+e)\sin\theta$.

B) $\tan\phi = e\tan\theta$.

C) $v = u\sqrt{1-(1-e^2)\sin^2\theta}$

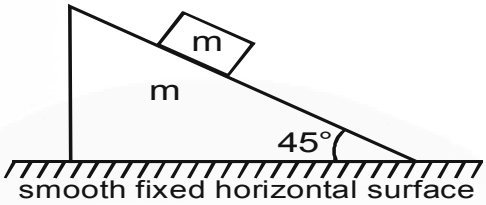
D) the ratio of the final kinetic energy to the initial kinetic energy is $(\cos^2\theta + e^2\sin^2\theta)$

SECTION – III
(COMPREHENSION TYPE)

This section contains 2 groups of questions. Each group has 2&3 multiple choice questions based on a paragraph. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

PASSAGE-1

A wedge of mass m is placed on a smooth fixed horizontal surface and a block of mass m is placed on smooth inclined surface of wedge as shown. The system is then released from rest. (g is acceleration due to gravity)



35. At the shown instant, the magnitude of vertical component of acceleration of block is :

A) $\frac{g}{2}$ B) $\frac{g}{3}$ C) $\frac{2g}{3}$ D) $\frac{3g}{4}$

36. At the shown instant, the magnitude of acceleration of centre of mass of system comprising wedge and block is :

A) $\frac{g}{2}$ B) $\frac{g}{3}$ C) $\frac{2g}{3}$ D) $\frac{3g}{4}$

PASSAGE-2

A smooth rope of mass m and length L lies in a heap on a smooth horizontal floor, with one end attached to a block of mass M. The block is given a sudden kick and instantaneously acquires a horizontal velocity of magnitude V_0 as shown in figure 1. As the block moves to right pulling the rope from heap, the rope being smooth, the heap remains at rest. At the instant block is at a distance x from point P as

shown in figure-2 (P is a point on the rope which has just started to move at the given instant) , choose correct options for next three question.

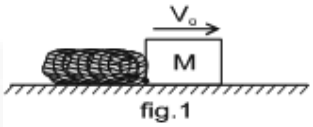


fig.1

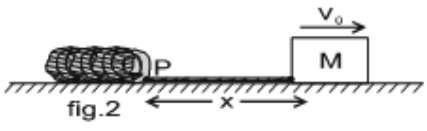


fig.2

37. The speed of block of mass M is

A) $\frac{mV_0}{(M+\frac{m}{L}x)}$ B) $\frac{MV_0}{(M+\frac{m}{L}x)}$ C) $\frac{m^2V_0}{M(M+\frac{m}{L}x)}$ D) $\frac{M^2V_0}{m(M+\frac{m}{L}x)}$

38. The magnitude of acceleration of block of mass M is

A) $\frac{m^3}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^3}$ B) $\frac{mM^2}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^3}$ C) $\frac{m^4}{ML}\frac{V_0^2}{(M+\frac{m}{L}x)^3}$ D) $\frac{M^2}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^3}$

39. The tension in rope at point P is

A) $\frac{mM^2}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^2}$ B) $\frac{m^2M}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^2}$

C) $\frac{m^3}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^2}$ D) $\frac{M^3}{L}\frac{V_0^2}{(M+\frac{m}{L}x)^2}$

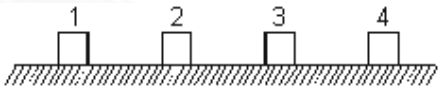
SECTION –IV
(INTEGER ANSWER TYPE)

This section contains 7 questions . The answer to each of the questions is a single digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened.

40. A spaceship of mass m_0 moves in the absence of external forces with a constant velocity v_0. To change the motion direction a jet engine is switched on. It starts ejecting a gas jet with velocity relative to space ship being u such that u is constant and always directed at right angles to the spaceship motion. The engine is shut down when the mass of the spaceship decreases to $\frac{m_o}{7.4}$. Find the angle in radians by which the motion direction of the spaceship will deviate due to the jet engine operation. Use the value $\frac{u}{v_o}=1$.

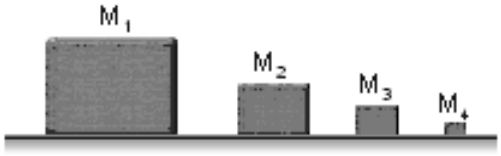
41. A cannon shell moving along a straight line bursts into two parts. Just after the burst one part moves with momentum 4 Ns making an angle 30º with the original line of motion. Find minimum momentum of the other part of shell just after the burst in Ns.

42. Four small blocks are placed on smooth horizontal surface and lie on same horizontal straight line. The blocks have masses $m_1 = m_2 = m_4 = m$ and $m_3 = 2m$. Blocks 1, 3, and 4 are initially stationary, while block 2 is initially moving towards block 3 at speed $v = 9m/s$. Assuming that collisions involving block 1 or block 4 are perfectly inelastic, while collision between blocks 2 and 3 is perfectly elastic, then find the final speed of block 4 in m/s.:



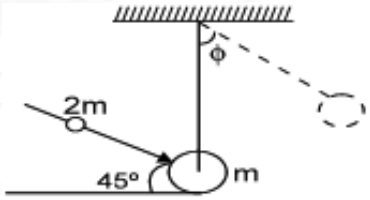
43. A train of mass M =6.28 kg is moving on a circular track of radius 'R = 3 metres' with constant speed $V = 1m/s$. The length of the train is half of the perimeter of the track. Find the magnitude of linear momentum of the train in Ns.

44. Four blocks of masses M_1, M_2, M_3 and M_4 are placed on a smooth horizontal surface along a straight line as shown. It is given that $M_1 >> M_2 >> M_3 >> M_4$. All the blocks are initially at rest. M_1 is given initial velocity $v_0 = 1m/s$ towards right such that it will collide with M_2. Consider all collisions to be perfectly elastic. Find the speed of M_4 in m/s after all collision are over .



45. A stationary pulley carries a rope whose one end supports a ladder with a man and the other end the counterweight of mass M = 10 kg. The man of mass m =5 kg climbs up a distance $\ell' = 12$ metres with respect to the ladder and then stops. Neglecting the mass of the rope and the friction in the pulley axle, find the displacement ℓ of the centre of inertia of this system in metres.

46. A ball of mass 'm' is suspended by a massless string of length $'\ell' = 10cm$ from a fixed point. A ball of mass 2m strikes in the direction of $\theta = 45°$ from horizontal & sticks to it. (take $g = 10 m/s^2$)



What should be the initial velocity of 2m in m/s so that system deflects by $\phi = \frac{\pi}{2}$