Physics

TARGET : JEE 2013

SCORE

JEE (Advanced)

Home Assignment # 04

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ERROR

EXERCISE # (O)

1. In ordinary Vernier calipers, 10^{th} division of the Vernier scale coincides with 9^{th} division of the main scale. In a specially designed Vernier calipers the Vernier scale is so constructed that 10^{th} division on it coincides with 11^{th} division on the main scale. Each division on the main scale equals to 1 mm. The calipers have a zero error as shown in the figure-I. When the Vernier caliper is used to measure a length, the concerned portion of its scale is shown in figure-II.

Figure-I

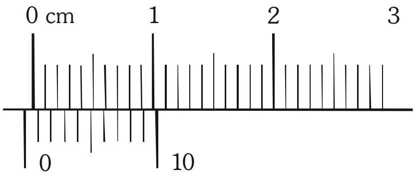
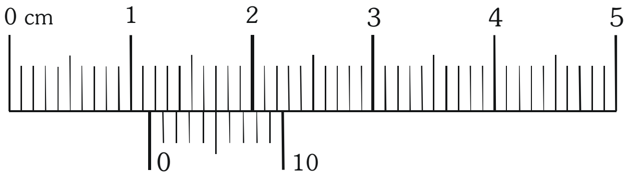


Figure-II



(A) Zero error in the calipers has magnitude 0.7 mm.

(B) The length being measured is 1.08 cm.

(C) The length being measured is 1.22 cm.

(D) Though the given Vernier scale does not follow the principle of Vernier scale, yet can be used satisfactorily.

2. In Post office box experiment, to avoid misleading deflection in galvanometer due to self induced current [back emf/back current] one should press

(A) both the cell key & galvanometer key simultaneously

(B) first cell key & then galvanometer key with delay of 2 to 3 second

(C) first galvanometer key & then cell key with delay of 2 to 3 second

(D) any of the manner mentioned above

3. We can compensate backlash error by

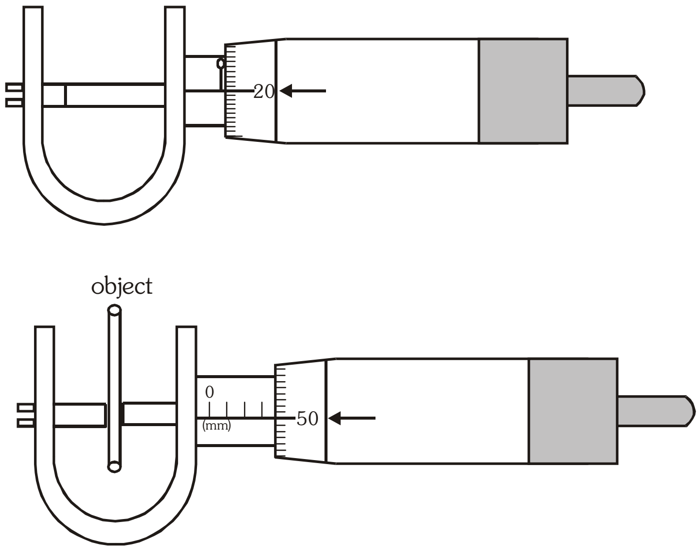
(A) Measuring the objects in ascending order of their sizes.

(B) Measuring the objects in descending order of their sizes.

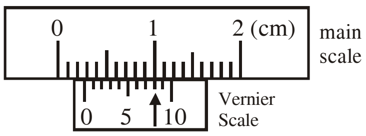
(C) Either (A) or (B)

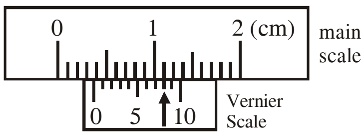
(D) It is not possible as it is random error.

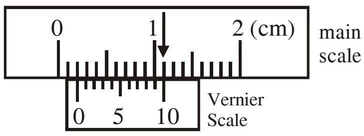
4. When a piece of wire is held diametrically in a screw gauge [pitch = 1mm, number of division on circular scale = 100]. The readings obtained are as shown:

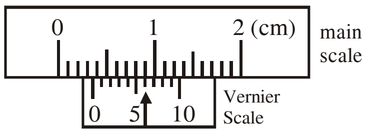


Now if we measure the same with help of vernier callipers [1 MSD = 1mm, 10 divisions of vernier coinciding with 9 divisions of main scale] having a negative zero error of 0.5 mm, then find which of the following figures correctly represents the reading.

(A)


(B)


(C)


(D)


5. Column I shows various practical errors / corrections and column II shows the experimental setups. Choose the correct matching.

1. Radiation correction	(i) Optical bench
2. End correction	(ii) Joule's calorimeter
3. Backlash error	(iii) Searle's apparatus
4. Index error	(iv) Meter bridge

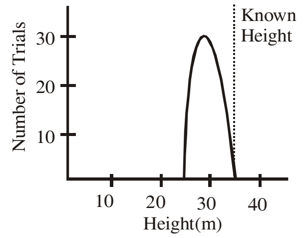
(A) 1 (iii), 2. (i), 3. (iv), 4. (ii) (B) 1. (ii), 2. (iv), 3. (i), 4. (iii)

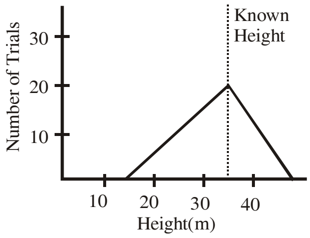
(C) 1. (ii) 2. (iv), 3. (iii), 4. (i) (D) 1. (ii), 2. (iii), 3. (i), 4. (iv)

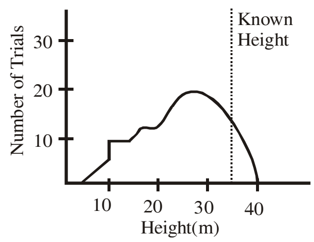
6. If a = 8 ± 0.08 and b = 6 ± 0.06, Let x = a + b, y = a – b, z = a ×b. The correct order of % error in x,y and z is

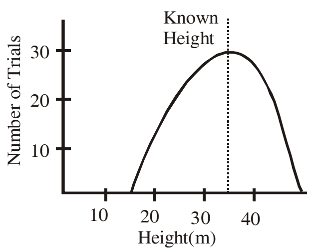
(A) x = y < z (B) x = y > z (C) x < z < y (D) x > z < y

7. Students of four classes measure the height of a building. Each class uses a different method and each measures the height many different times. The data for each class are plotted below. Which class made the most precise measurement?

(A) 

(B) 

(C) 

(D) 

Paragraph for Question Nos. 8 to 10

When applied forced frequency becomes equal to natural frequency of the given object then transfer of energy from source to the given object becomes maximum so it starts vibration at maximum amplitude, this condition is called resonance.

8. In resonance tube the phenomena of resonance can be used to

(i) measure speed of light

(ii) measure speed of sound at 0°C

(iii) Compare the frequency of given tuning forks.

(iv) Measure the speed of sound at room temperature.

(A) (i) & (ii) (B) (ii) & (iii) (C) (ii) & (iv) (D) (ii), (iii) & (iv)

9. In resonance tube, the object to be resonated with tuning fork is

(A) air column above the water level in 1 m tube.

(B) water column below the air column in 1 m tube.

(C) both (A) & (B)

(D) Either (A) or (B)

10. In resonance tube, when water reservoir provided in side in moved downwards then level of liquid in given 1m length tube

(A) also goes down (B) rises

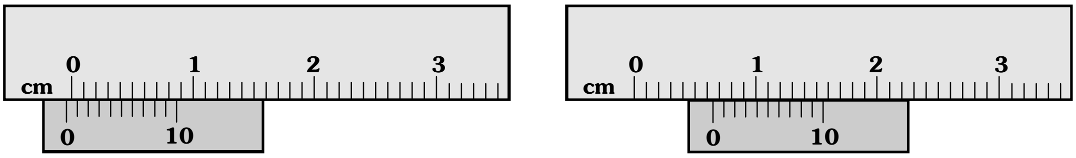
(C) may rise or go down (D) nothing can be predicted

11. **Match the column – I with column – II.**

	Column–I (Number)		Column–II (Number of significant digits)
(A)	1001	(p)	5
(B)	0100.1	(q)	4
(C)	100.100	(r)	6
(D)	0.001001	(s)	3

EXERCISE # (S)

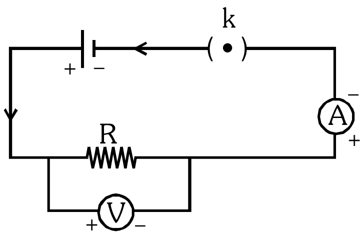
1. The main scale of a vernier callipers reads in millimeter and its vernier is divided into 10 divisions which coincides with 9 divisions of the main scale. The reading for shown situation is found to be $\frac{12x}{10}$ mm. Find the value of x.



2. Time period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{\ell}{g}}$ where ℓ is the length of pendulum and g is acceleration due to gravity. If percentage increase in the length and acceleration due to gravity are 69% and 21% respectively then find out percentage increase in time period.

3. The length of a cylinder is measured with a metre rod having least count 0.1 cm. Its diameter is measured with vernier callipers having least count 0.01 cm. Given the length is 5.0 cm and diameter is 2.00 cm. Find the percentage error in the calculated value of volume.

4. Mr. Vivek Taparia performed an experiment to verify Ohm's law. He connected following circuit to measure voltage and current.



Here R is the unknown resistance, V the voltmeter, A the ammeter and K is the key. The value of R from following readings is given by $\alpha \times 10^{\beta}$ kΩ, then find the value of $\alpha+\beta$.

V(volt)	1	2	3	4	5
I(mA)	1.40	2.83	5.68	7.11	8.54

ANSWER KEY

EXERCISE # (O)

1. Ans. (A,C) **2. Ans. (B)** **3. Ans. (D)** **4. Ans. (A)**

5. Ans. (C) **6. Ans. (C)** **7. Ans. (A)** **8. Ans. (D)**

9. Ans. (A) **10. Ans. (A)** **11. Ans. (A) – q, (B) – q, (C) – r, (D) – q,**

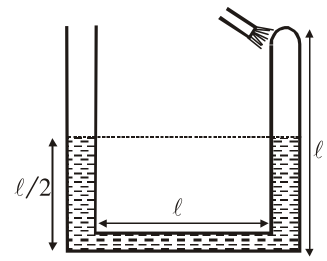
EXERCISE # (S)

1. Ans. 6 **2. Ans. 18.18** **3. Ans. 3** **4. Ans. 6**

FLUID MECHANICS

EXERCISE # (O)

1. A rectangular narrow U-tube has equal arm lengths and base length, each equal to ℓ. The vertical arms are filled with mercury up to $\ell/2$ and then one end is sealed. By heating the enclosed gas all the mercury is expelled. If atmospheric pressure is P_0, the density of mercury is ρ and cross-sectional area is S, then [Neglect thermal expansion of glass and mercury]



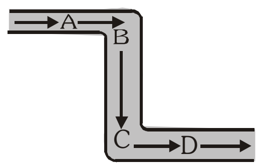
(A) Work done by the gas against the atmospheric pressure is $\frac{5\ell}{2}P_0S$

(B) Work done by the gas against the gravity is $\frac{7}{4}S\rho g\ell^2$

(C) Work done by the gas against the atmospheric pressure is $P_0S\ell$

(D) Word done by the gas against the gravity is $S\rho g\ell^2$

2. The tube shown is of non-uniform cross-section. The cross-section area at A is half of the cross-section area at B,C and D. A liquid is flowing through in steady state. The liquid exerts on the tube-



Statement I : A net force towards right.

Statement II : A net force towards left.

Statement III : A net force in some oblique direction.

Statement IV : Zero net force

Statement V: A net clockwise torque.

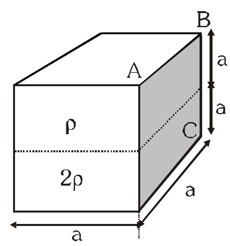
Statement VI: A net counter-clockwise torque.

Out of these

(A) Only statement I and V are correct (B) Only statement II and VI are correct

(C) Only statement IV and VI are correct (D) Only statement III and VI are correct

3. A cuboid (a × a × 2a) is filled with two immiscible liquids of density 2ρ & ρ as shown in the figure. Neglecting atmospheric pressure, ratio of force on base & side wall of the cuboid is



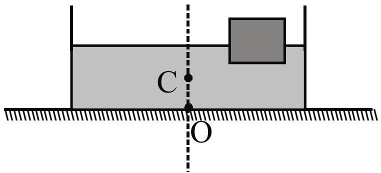
(A) 2 : 3 (B) 1 : 3

(C) 5 : 6 (D) 6 : 5

4. A flat plate moves normally with a speed v_1 towards a horizontal jet of water of uniform area of cross-section. The jet discharges water at the rate of volume V per second at a speed of v_2. The density of water is ρ. Assume that water splashes along the surface of the plate at right angles to the original motion. The magnitude of the force acting on the plate due to jet of water is :–

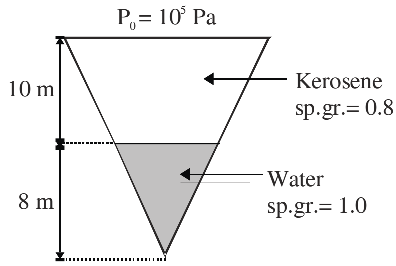
(A) $\rho V v_1$ (B) $\rho\left(\frac{V}{v_2}\right)(v_1+v_2)^2$ (C) $\frac{\rho V}{v_1+v_2}v_1^2$ (D) $\rho V(v_1+v_2)$

5. There is water in container with center of mass at C. Now a small wooden piece is place towards right as shown in the figure. After putting the wooden piece.



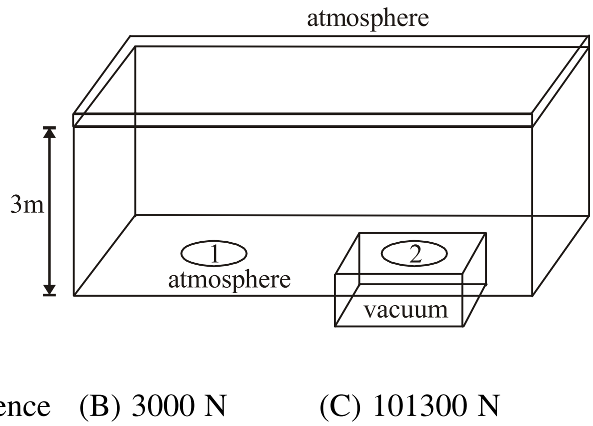
(A) Pressure at base remains same and centre of mass of water and wooden piece will be right of line OC.
(B) Pressure at base remains same and centre of mass of water and wooden piece will be on line OC.
(C) Pressure at base changes and centre of mass of water and wooden piece will be right of line OC.
(D) Pressure at base changes and centre of mass of water and wooden piece will be on line OC.

6. Shown in figure, a conical container of half-apex angle 37° filled with certain quantities of kerosene and water. The force exerted by the water on the kerosene is approximately, (Take atmospheric pressure = 10^5 Pa)



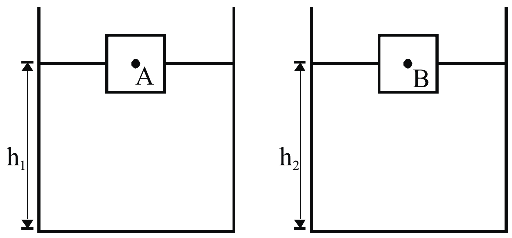
(A) 3×10^7 N (B) 4×10^7 N
(C) 2×10^7 N (D) 5×10^7 N

7. Two identical discs sit at the bottom of a 3m pool of water whose surface is exposed to atmospheric pressure. The first disc acts as a plug to seal the drain as shown. The second disc covers a container containing nearly a perfect vacuum. If each disc has an area of $1m^2$, what is the approximate difference in the force necessary to open the discs ? (**Note** : 1atm = 101300 Pa)



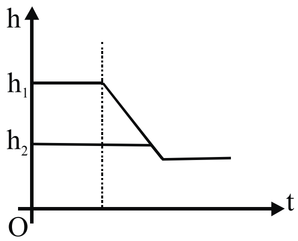
(A) There is no difference (B) 3000 N (C) 101300 N (D) 1013000 N

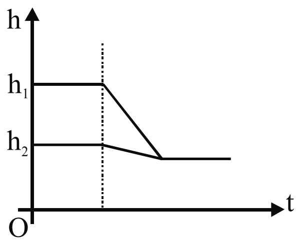
8. Two ice cubes of side 10 cm, having cavity of volume 20 cm^3 at centre of cube but filled with different materials A and B respectively. The specific gravity of material A is 4.9 and specific gravity of material B is 1.9. Now these cubes are placed in two different vessels of same base area as shown in figure. The water level before putting blocks in vessels are same. Assume that ice melts uniformly from all sides and with same constant rate in both the vessels. (specific gravity of ice = 0.9). In (C) and (D) graph showing the variation of heights of water-level in two vessels with time. Choose the correct statement :



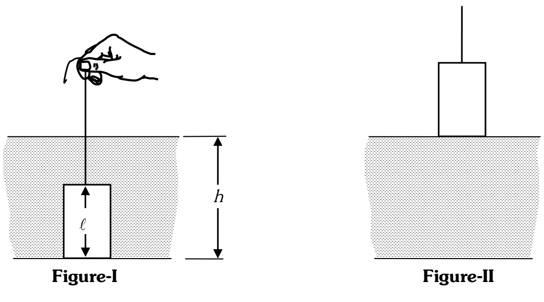
(A) the ratio of initial submerged volumes of the blocks containing A and B is $\frac{49}{46}$

(B) the ratio of initial submerged volumes of the blocks containing A and B is 49/19

(C) 

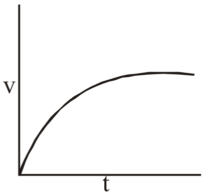
(D) 

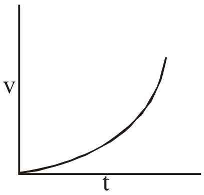
9. A solid right cylinder of length ℓ stands upright at rest on the bottom of a large tub filled with water up to height h as shown in the figure-I. Density of material of the cylinder equals to that of water. Now the cylinder is pulled slowly out of water with the help of a thin light inextensible thread as shown in figure-II. Find the work done by the tension force develop in the thread.

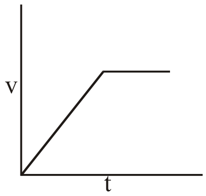


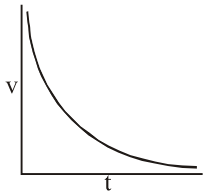
(A) mgh (B) mgℓ (C) 0.5 mgℓ (D) mg(0.5ℓ+h)

10. A piece of cork starts from rest at the bottom of a lake and floats up. Its velocity v is plotted against time t. Which of the following best represents the resulting curve?

(A) 

(B) 

(C) 

(D) 

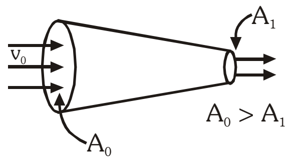
11. A wooden block floats in water in a sealed container. When the container is at rest, 25% of the block is above the water. Consider the following five situation :

(i) the container is lifted up at constant speed.
(ii) the container is lowered at constant speed.
(iii) the container is lifted up at an increasing speed.
(iv) the container is lowered at a decreasing speed.
(v) the air pressure above the water in the container is increased.

What happens in each situation?

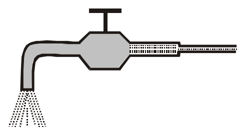
(A) 25% of block is submerged in situation (i) & (ii) and higher fraction is submerged in situations (iii), (iv) & (v)
(B) 25% of block is submerged in situation (i), (ii) & (v) and higher fraction is submerged in situations (iii), (iv).
(C) 25% of block is submerged in situation (i), (ii), (iii) & (iv) and higher fraction is submerged in situations (v).
(D) 25% of block is submerged in all situation.

12. In a tube as shown in figure water coming in per second is equal to water going out per second. Find out the magnitude of the force exerted by water on the tube if inlet velocity is v_0–



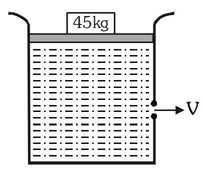
(A) $\rho A v_0^2\left[1-\frac{A_1}{A_0}\right]$ (B) $\frac{\rho A v_0^2 A_1}{A_0}$ (C) $\rho A v_0^2\left[\frac{A_0}{A_1}-1\right]$ (D) None of these

13. The pressure of water in a water pipe when tap is open and closed is respectively 3×10^5 Nm^{-2} and 3.5×10^5 Nm^{-2}. With open tap, the velocity of water flowing is



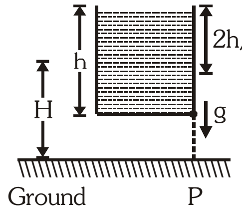
(A) 10 m/s (B) 5 m/s (C) 20 m/s (D) 15 m/s

14. A large cylindrical tank of cross-sectional area $1m^2$ is filled with water. It has a small hole at a height of 1m from the bottom. A movable piston of mass 5 kg is fitted on the top of the tank such that it can slide in the tank freely. A load of 45 kg is applied on the top of water by piston, as shown in figure. The value of v when piston is 7m above the bottom is (g = 10 m/s^2)



(A) $\sqrt{120}$ m/s (B) 10 m/s (C) 1 m/s (D) 11 m/s

15. An open vessel full of water is falling freely under gravity. There is a small hole in one face of the vessel, as shown in the figure. The water which comes out from the hole at the instant when hole is at height H above the ground, strikes the ground at a distance of x from P. Which of the following is correct for the situation described ?



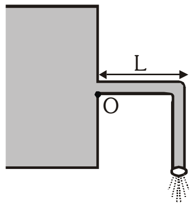
(A) The value of x is $2\sqrt{\frac{2hH}{3}}$

(B) The value of x is $\sqrt{\frac{4hH}{3}}$

(C) The value of x can't be computed from information provided.

(D) The question is irrelevant as no water comes out from the hole.

16. Water flows out of a big tank along a big tube bent at right angles, the inner radius of tube is r. The length of horizontal section of the tube is equal to 'L'. The water flow rate is Q litres/sec. Moment of reaction forces due to water flow acting on tube's wall, w.r.t. point O. Where ρ is the density of water



(A) $\frac{Q^2\rho L}{\pi r^2}$ clockwise (B) $\frac{Q^2\rho L}{\pi r^2}$ anticlockwise (C) $\frac{Q^2\rho L}{2\pi r^2}$ clockwise (D) $\frac{Q^2\rho L}{2\pi r^2}$ anticlockwise

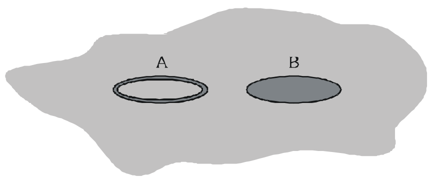
17. A rigid ring A and a rigid thin disk B both made of same material, when gently placed on water, just manage to float due to surface tension as shown in the figure. Both the ring and the disk have same radius. What can you conclude about their masses?

(A) Both have the same mass.

(B) Mass of the ring is half of that of the disk.

(C) Mass of the ring is double to that of the disk.

(D) More information is needed to decide.



18. n drops of a liquid, each with surface energy E, joining to form a single drop

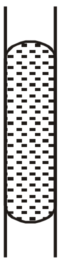
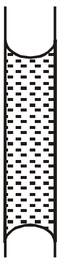
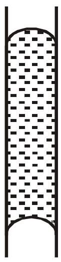
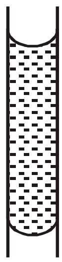
(A) some energy will be released in the process

(B) some energy will be absorbed in the process

(C) the energy released or absorbed will be $E(n-n^{2/3})$

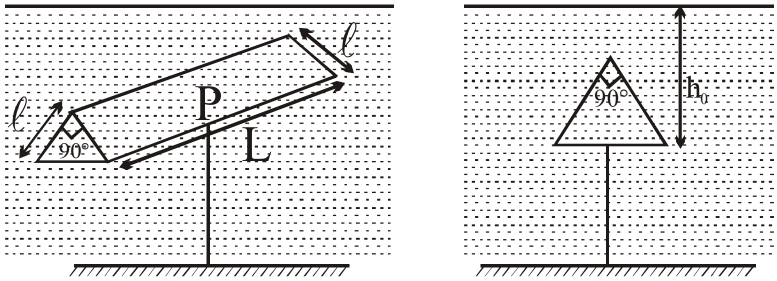
(D) the energy released or absorbed will be $nE(2^{2/3}-1)$

19. A vertical glass capillary tube, open at both ends contains some water. Which of the following shapes may be taken by the water in the tube? Assuming radius of both curved liquid surfaces are same.

(A)  (B)  (C)  (D) 

Paragraph for Question Nos. 20 to 22

A prism shaped styrofoam of density $\rho_{styrofoam} < \rho_{water}$ is held completely submerged in water. It lies with its base horizontal. The base of foam is at a depth h_0 below water surface and atmospheric pressure is P_0. Surface is open to atmosphere. Styrofoam prism is held in equilibrium by the string attached symmetrically. (Take : $\rho_{styrofoam} = \rho_f$; $\rho_{water} = \rho_w$).



20. Net force exerted by water on the styrofoam is

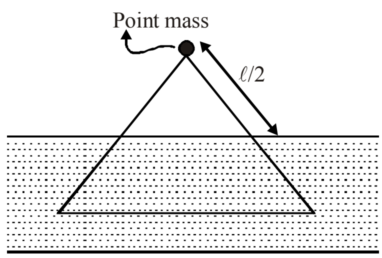
(A) $\sqrt{2}\rho_w g\ell^2 L$ (B) $2\rho_w g\ell^2 L$ (C) $\rho_w g\frac{\ell^2 L}{2}$ (D) $\rho_w g\ell^2 L$

21. Magnitude of force on any one of the slant face of styrofoam is

(A) $(P_0 + \rho_w g(h_0 - \sqrt{2}\ell))L\ell$ (B) $(P_0 + \rho_w g(h_0 - \frac{\ell}{\sqrt{2}}))L\ell$

(C) $(P_0 - \rho_w g(h_0 - \frac{\ell}{\sqrt{2}}))L\ell$ (D) $(P_0 + \rho_w g(h_0 - \frac{\ell}{2\sqrt{2}}))L\ell$

22. Now string is cut and styrofoam is allowed to come to surface. A point mass is to be placed symmetrically on the upper surface of styrofoam such that it is in equilibrium with its base in horizontal plane. In equilibrium position styrofoam has half of its slant length submerged. Surface tension of water is T, contact angle is 0° . Determine mass m to achieve equilibrium.

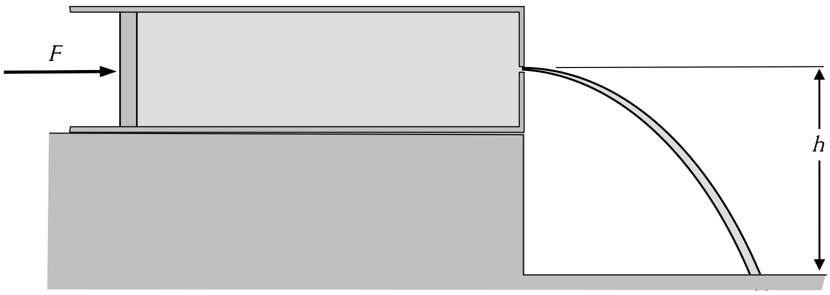


(A) $\frac{\rho_f gL\ell^2}{2} + \frac{3}{4}\rho_w gL\ell^2 - 2T[L+\ell]$ (B) $\frac{-\rho_f gL\ell^2}{2} + \frac{3}{8}\rho_w gL\ell^2 - \sqrt{2}T[L+\ell]$

(C) $\frac{-\rho_f gL\ell^2}{2} + \frac{3}{8}\rho_w gL\ell^2 - \frac{T[L+\ell]}{\sqrt{2}}$ (D) $\frac{-\rho_f gL\ell^2}{2} + \frac{3}{8}\rho_w gL\ell^2 + \sqrt{2}T[L+\ell]$

Paragraph for Question Nos. 23 & 24

An ideal liquid of density ρ is filled in a horizontally fixed syringe fitted with piston. There is no friction between the piston and the inner surface of the syringe. Cross-section area of the syringe is A. At one end of the syringe, an orifice of negligible cross-section area is made. When the piston is pushed into the syringe, the liquid comes out of the orifice following parabolic path and falls on the ground.



23. With what velocity the liquid comes out of the orifice?

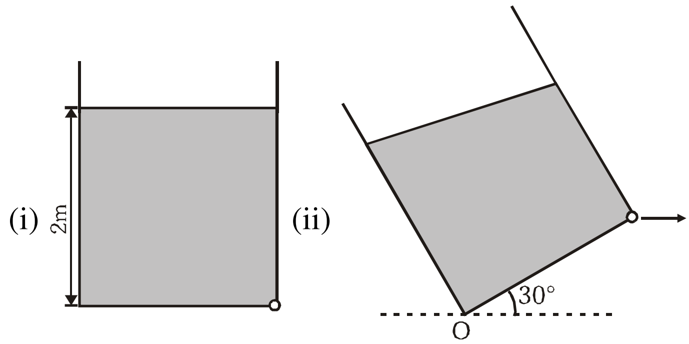
(A) $\sqrt{\frac{F}{\rho A}}$ (B) $\sqrt{\frac{2F}{\rho A}}$ (C) $\sqrt{\frac{F+2\rho ghA}{\rho A}}$ (D) $\sqrt{\frac{F+\rho ghA}{\rho A}}$

24. With what speed the liquid strikes the ground? Neglect the air drag.

(A) $\sqrt{\frac{F+\rho ghA}{\rho A}}$ (B) $\sqrt{\frac{F+2\rho ghA}{\rho A}}$ (C) $\sqrt{\frac{2F+\rho ghA}{\rho A}}$ (D) $\sqrt{\frac{2(F+\rho ghA)}{\rho A}}$

Paragraph for Question Nos. 25 to 27

Velocity of efflux in Torricelli's theorem is given by $v=\sqrt{2gh}$, here h is the height of hole from the top surface, after that, motion of liquid can be treated as projectile motion.



25. Liquid is filled in a vessel of square base (2m × 2m) upto a height of 2m as shown in figure (i). In figure (ii) the vessel is tilted from horizontal at 30°. What is the velocity of efflux in this case. Liquid does not spills out?

(A) 3.29 m/s (B) 4.96 m/s (C) 5.67 cm (D) 2.68 m/s

26. What is its time of fall of liquid on the ground?

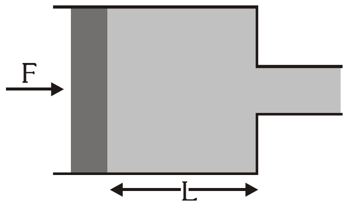
(A) $\frac{1}{\sqrt{2}}$s (B) $\frac{1}{\sqrt{3}}$s (C) $\frac{1}{\sqrt{5}}$s (D) $\sqrt{2}$s

27. At what distance from point O, will be liquid strike on the ground?

(A) 5.24 m (B) 6.27 m (C) 4.93 m (D) 3.95 m

Paragraph for Question Nos. 28 to 30

A container is filled with water as shown. A constant force is applied on the piston slowly to remove the water as shown. The volume of the water inside the container is V. The cross-sectional area of the orifice is 'a' and take the density of water as ρ. Cross-sectional area of the cylinder is A.



28. What is the velocity of water which is coming out ?

(A) $\frac{\sqrt{F}}{A\rho}$ (B) $\frac{\sqrt{2F}}{A\rho}$ (C) $\sqrt{\frac{2F}{A\rho}}$ (D) $\frac{F}{\sqrt{2}\,A\rho}$

29. What is the time taken to completely squeeze the water?

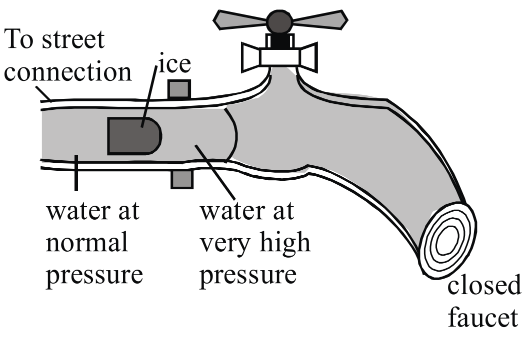
(A) $\frac{V}{a}\sqrt{\frac{A\rho}{2F}}$ (B) $\frac{V}{a}\sqrt{\frac{A\rho}{F}}$ (C) $\frac{V}{a}\sqrt{\frac{2A\rho}{F}}$ (D) $\frac{2V}{a}\sqrt{\frac{a\rho}{F}}$

30. What is the work done by the force F?

(A) $\frac{2V^3\rho}{a^2t^2}$ (B) $\frac{V^3\rho}{2a^2t^2}$ (C) $\frac{V^3\rho}{a^2t^2}$ (D) $\frac{V^3\rho}{3a^2t^2}$

Paragraph for Question Nos. 31 to 33

The fact that the density of ice is smaller than the density of water has an important consequence for home owner, who have to deal with the possibility of bursting water pipes during severe winters. Water often freezes in a section of pipe exposed to unusually cold temperatures. The ice can form an immovable plug that prevents the subsequent flow of water, as figure illustrates. When water (larger density) turns to ice (smaller density), its volume expands by 10%. When ice forms on the right side of the plug, the expanding ice pushes liquid to the right. But it has nowhere to go if the faucet is closed. As ice continues to form and expand, the water pressure between the plug and faucet rises. The bulk modulus of ice is much more than that of the water. So water gets compressed. Even a small increase in the amount of ice produces a large increase in the pressure. Therefore, the pipe can burst at any point where it is structurally weak. There is a simple way to prevent pipes from bursting. Simply open the faucet, so it drips a little. The excessive pressure will be relieved.

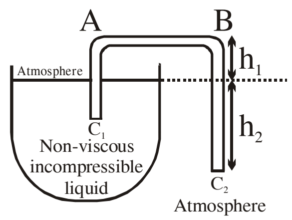


31. Which of the following phenomena can be explained on basis of principles laid in the passage?
(A) Water contracts on heating from 0° C to 4°C.
(B) Conductivity of water is more than that of ice.
(C) Bottle of water bursts when we freeze it.
(D) Temperature near sea coasts are moderate throughout the year.

32. Assume that the plug of ice formed expands only to the right and the mass of ice formed is equal to the mass of water to the right of it. If the bulk modulus of water is $B = 2.2 \times 10^9$ Pa, what is the excess pressure of the water enclosed? (Atmosphere pressure is 1×10^5 Pa)
(A) 2.2×10^7 Pa (B) 2.2×10^8 Pa (C) 2.2×10^9 Pa (D) 2.2×10^{10} Pa

33. Which of the following steps would make the pipe more capable of withstanding the increased pressure?
(A) Increase the radius of pipe and decrease thickness of it's walls.
(B) Increase the radius of pipe and thickness of its walls.
(C) decrease the radius of pipe and thickness of its walls.
(D) decrease the radius of pipe and increase thickness of it's walls.

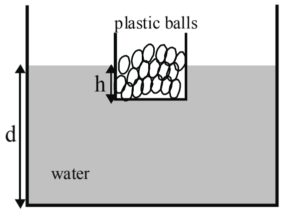
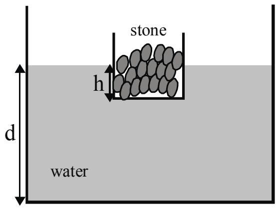
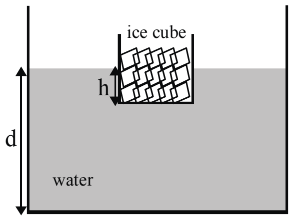
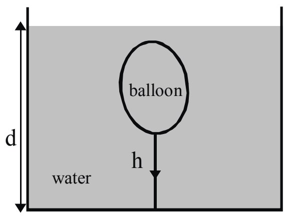
34. An evacuated thin tube has two tight caps C_1 and C_2 at its ends. The tube is adjusted as shown in the figure below



Atmospheric pressure = P and density of the liquid = d, Neglect surface tension of liquid.
Match the entities of columns

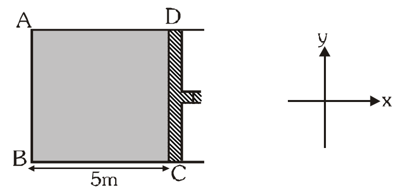
Column-I	**Column-I**
(A) $h_1 > \frac{P}{dg}$, $h_2 = 0$	(P) If C_2 is opened first and then C_1 is opened, liquid level in the left arm of the tube will be on level with liquid in the pot.
(B) $h_1 > \frac{P}{dg}$, $h_2 > 0$	(Q) If C_1 is opened with C_2 closed, liquid will rise in the left arm but tube will not be fully filled.
(C) $h_1 < \frac{P}{dg}$, $h_2 > 0$	(R) If C_1 is opened with C_2 closed, tube will be fully filled with liquid.
(D) $h_1 + h_2 < \frac{P}{dg}$, $h_2 > 0$	(S) If C_1 is opened first and then C_2 is opened, liquid will flow down continuously.
	(T) After any of the above action pressure at the mid point of tube AB is non-zero

35. Column I shows different system as describe, with some parameter while column-II gives the change in the parameter.

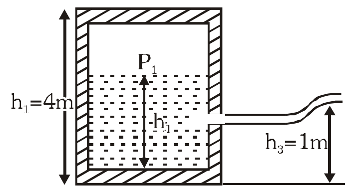
Column-I	Column-II
(A)  Plastic ball is thrown from the container in the water. [d is the height of water level while h is the depth to which the container is submerged]	(P) h decreases
(B)  Stone is thrown from the container in the water. [d is the height of water level while h is the depth to which the container is submerged]	(Q) h remain same
(C)  Ice melts and remain in the container. [d is the height of water level while h is the depth to which the container is submerged]	(R) h increases
(D)  The water is heated slowly. [d is the height of water level while h is the tension in the string. $\gamma_{air} > \gamma_{water}$]	(S) d decreases
	(T) d remain same

EXERCISE # (S)

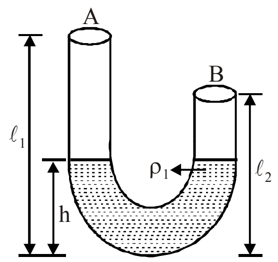
1. A cylinder fitted with piston as shown in figure. The cylinder is filled with water and is taken to a place where there is no gravity. Mass of the piston is 50 kg. The system is accelerated with acceleration 0.5 m/sec^2 in positive x–direction. Find the force exerted by fluid on the surface AB of the cylinder in decanewton. Take area of cross–section of cylinder to be 0.01 m^2 neglect atmospheric pressure (1 decanewton =10N)



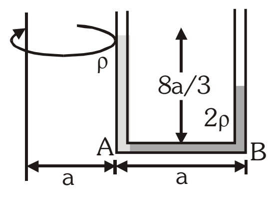
2. A large tank of (height h_1 = 4m) water has a hose connected to it, as shown in figure. The tank is sealed at the top and has compressed air between the water surface & the top. When the water height h_2 is 3m, the gauge pressure of air is P_1=1× 10^{5}N/m^2. Assume that the air above the water surface expands isothermally. What is the velocity of flow out of the hose when h_2 has decreased to 2m? Assume ideal fluid flow. P_{atm} = 10^{5}N/m^2



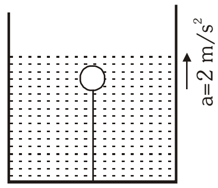
3. A U-tube having uniform cross-section but unequal arm length l_1 = 100 cm and l_2 = 50 cm has same liquid of density ρ_1 filled in it upto a height h = 30 cm as shown in figure. Another liquid of density $\rho_2 = 2\rho_1$ is poured in arm A. Both liquids are immiscible. What length of the second liquid (in cm) should be poured in A so that second overtone of A is in unison with fundamental tone of B. (Neglect end correction)



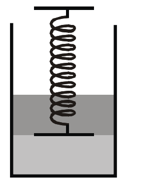
4. The interface of two liquids of densities ρ and 2ρ respectively lies at the point A in a U tube at rest. The height of liquid column above A is 8a/3 where AB = a. The cross sectional area of the tube is S. With what angular velocity the tube must be whirled about a vertical axis at a distance 'a' such that the interface of the liquids shifts to towards B by 2a/3.



5. A solid sphere of mass m = 2 kg and specific gravity S = 0.5 is held stationary relative to tank filled with water. The tank is accelerating upward width acceleration 2 m/s^2. The tension in the string in found to be 8 n. Find the value of n. Given density of water = 1000 kg m^{-3} and g = 10 m/s^2.



6. A thin rod of specific gravity 3 and mass 1 kg is attached to a spring of spring constant $\frac{200}{3}$ N/m and held as shown in the figure. The spring is in its natural length and the rod lies at the interface of water and a liquid of specific gravity 2. The system is released from rest. Find the amplitude (in cm) of the subsequent motion.



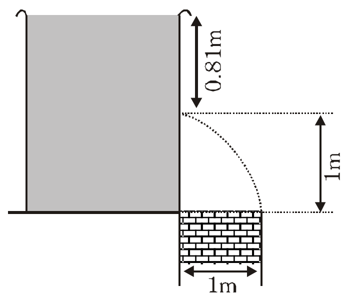
7. A cylindrical wooden float whose base area is 4 m^2 and height 1 m drifts on the water surface in vertical position. Density of wood is 500 kg/m^3 and that of water is 1000 kg/m^3. What minimum work (in kJ) must be performed to take the float out of the water ?

8. A block of wood is floating in water such that $1/3^{rd}$ of it is submerged in water when the same block is floated in alcohol, 1/2 of it's volume is submerged. Now a mixture of water and alcohol is made taking equal volume of both and block is floated in it. What is the % of it's volume that is now submerged.

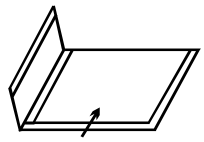
9. A square plate of 1m side moves parallel to a second plate with velocity 4 m/s. A thin layer of water exist between plates. If the viscous force is 2 N and the coeff of viscosity is 0.01 poise then the distance between the plates in mm is.

10. A sphere of diameter 12 cm and density 500 kg/m^3 is under water of density 1000 kg/m^3. The acceleration of the sphere is 9.80 m/s^2 upward. Viscosity of water is 1.0 centipoise. If g = 9.81 m/s^2, the velocity of the sphere is given as 'v' m/s. Find the value of 10v.

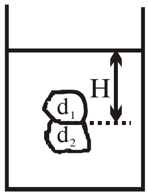
11. For the arrangement shown in the figure. The time interval in seconds after which the water jet ceases to cross the wall is found to be $(A)^3$. Area of the cross section of the tank $A = \sqrt{5}\ m^2$ and area of the orifice a=32 cm^2. [Assume that the container remaining fixed]. Find the value of α. (Take g = 10 m/s^2)



12. A glass plate of area A and mass m is hinged along one of its sides. At what speed the air should be blown parallel to its upper surface to hold the plate horizontal ? The density of air is ρ. Give the answer in term of $\sqrt{\frac{mg}{18\rho A}}$

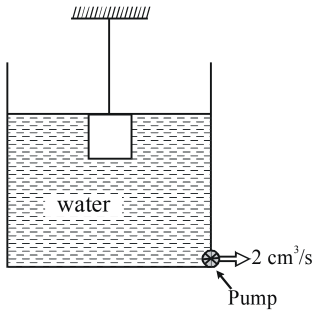


13. Two objects of equal volume $V = 1m^3$ and different densities $d_1 = 500$ kg/m^3 and $d_2 = 1000$ kg/m^3 are glued to each other so that their contact surface is flat and has an area $A = 0.1$ m^2. When the objects are submerged completely in a certain liquid, they float in stable equilibrium, the contact surface being parallel to the surface of the liquid (see the diagram).

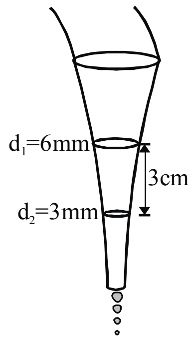


How deep (H in meters) can the contact surface be in the liquid so that the objects are not torn apart? The maximum force that the glue can withstand is F = 250 N. (Neglect atmospheric pressure)

14. Figure shows a cubical block of side 10 cm and relative density 1.5 suspended by a wire of cross sectional area 10^{-6} m^2. The breaking stress of the wire is 7×10^6 N/m^2. The block is placed in a beaker of base area 200 cm^2 and initially i.e. at t = 0, the top surface of water & the block coincide. There is a pump at the bottom corner which ejects 2 cm^3 of water per sec. Find the time (in sec) at which the wire will break.



15. The tap in the garden was closed in appropriately resulting in the water flowing freely out of it which forms a downward narrowing beam. The beam of water has a circular cross-section, the diameter of the circle is 6 mm at one point and 3 cm below it is only 3 mm as shown in figure. If the rate of water wasted is $(x \times \pi)$ mL/minute then find the value of x. (Neglect the effect of viscosity and surface tension of the flowing water.)



ANSWER KEY

EXERCISE # (O)

1. Ans. (A,B)	**2. Ans. (A)**	**3. Ans. (D)**	**4. Ans. (D)**
5. Ans. (D)	**6. Ans. (C)**	**7. Ans. (C)**	**8. Ans. (A,C)**
9. Ans. (C)	**10. Ans. (A)**	**11. Ans. (D)**	**12. Ans. (C)**
13. Ans. (A)	**14. Ans. (D)**	**15. Ans. (D)**	**16. Ans. (B)**
17. Ans. (C)	**18. Ans. (A,C)**	**19. Ans. (D)**	**20. Ans. (C)**
21. Ans. (D)	**22. Ans. (B)**	**23. Ans. (B)**	**24. Ans. (D)**
25. Ans. (B)	**26. Ans. (C)**	**27. Ans. (D)**	**28. Ans. (C)**
29. Ans. (A)	**30. Ans. (B)**	**31. Ans. (C)**	**32. Ans. (B)**
33. Ans. (D)			

34. Ans. (A) $\rightarrow$ (P,Q) ; (B) $\rightarrow$ (P,Q) ; (C) $\rightarrow$ (P,R,S,T) ; (D) $\rightarrow$ (P,R,S,T)

35.Ans. (A) $\rightarrow$ (P,T) ; (B) $\rightarrow$ (P,S) ; (C) $\rightarrow$ (Q,T) ; (D) $\rightarrow$ (R)

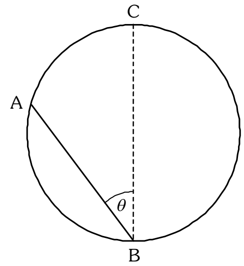
EXERCISE # (S)

1. Ans. 5	**2. Ans. 0**	**3. Ans. 6**	**4. Ans.** $\sqrt{\frac{18g}{19a}}$
5. Ans. 3	**6. Ans. 5**	**7. Ans. 5**	**8. Ans. 040**
9. Ans. 2	**10. Ans. 4**	**11. Ans. 5**	**12. Ans. 6**
13. Ans. 3	**14. Ans. 100**	**15. Ans. 108**	

PARTICLE DYNAMICS

EXERCISE # (O)

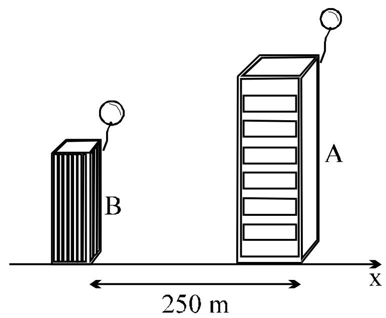
1. A bead slides on a frictionless straight rod fixed between points A and B of a vertical circular loop of radius r as shown in the figure. Line BC is a vertical diameter.
Denoting acceleration due to gravity by g, which of the following is correct expression for the time taken by the bead to slide from A to B.



(A) $\sqrt{\frac{4r}{g}}$ (B) $\sqrt{\frac{4r}{g\cos\theta}}$

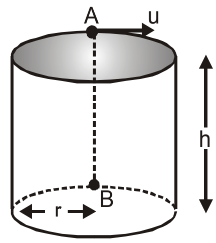
(C) $\sqrt{\frac{4r\tan\theta}{g}}$ (D) $\sqrt{\frac{4r\cot\theta}{g}}$

2. Two balloons are simultaneously released from two buildings A and B. Balloon from A rises with constant velocity 10 ms^{-1}, while the other one rises with constant velocity of 20 ms^{-1}. Due to wind the balloons gather horizontal velocity $V_x = 0.5$ y, where 'y' is the height from the point of release. The buildings are at a distance of 250 m & after some time 't' the balloons collide.



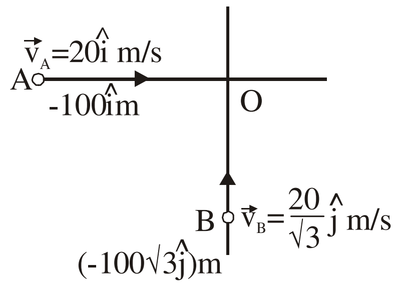
(A) t = 5 sec.
(B) difference in height of buildings is 100 m
(C) difference in height of buildings is 500 m
(D) t = 10 sec

3. A hollow vertical cylinder of radius r and height h has a smooth internal surface. A small particle is placed in contact with the inner side of the upper rim, at point A, and given a horizontal speed u, tangential to the rim. It leaves the lower rim at point B, vertically below A. If n is an integer then



(A) $\frac{u}{2\pi r}\sqrt{\frac{2h}{g}} = n$ (B) $\frac{h}{2\pi r} = n$ (C) $\frac{2\pi r}{h} = n$ (D) $\frac{u}{\sqrt{2gh}} = n$

4. Positions of two vehicles A and B with reference to origin O and their velocities are as shown.



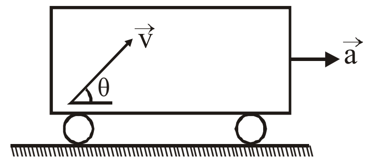
(A) they will collide

(B) distance of closest approach is 100 m.

(C) their relative velocity is $\frac{40}{\sqrt{3}}$ m/s

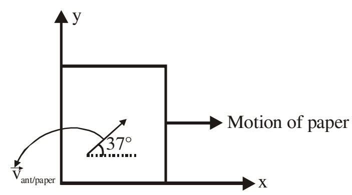
(D) their relative velocity is $\frac{20}{\sqrt{3}}$ m/s

5. A particle is projected with a velocity $\vec{v}$ relative to cart moving with an acceleration $\vec{a}$ towards right. At the instant of projection cart is moving with velocity $\vec{v}_c$. Which of the following remains same in both ground and cart reference frame. Assume that particle does not collide with ceiling and any wall.



(A) Time of flight
(B) Horizontal component of velocity
(C) Horizontal range
(D) Maximum height attained.

6. An ant is scampering on a paper with velocity 10 m/s. Now you begin to pull the paper with velocity 10 m/s along x-axis as shown in figure. Coordinate system has origin fixed to ground as shown in figure. The initially position of ant is (0, 0). Select the correct alternative(s)



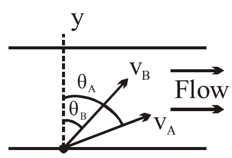
(A) Velocity of ant in ground frame is $(18\hat{i} + 6\hat{j})$ m/s

(B) Position vector of ant with respect to ground after 3 sec. is $(54\hat{i} + 18\hat{j})$ m.

(C) In ground frame, velocity vector of ant is at an angle $\theta < 37°$

(D) In ground frame velocity vector of ant is at an angle $\theta > 37°$.

7. In the figure shown two boats start with different speed relative to water simultaneously. Water flow speed is same for both the boats. Mark the correct statements. θ_A and θ_B are angles from a y-axis at which boats are heading at initial moment :-



(A) If $v_A > v_B$ then for reaching the other bank simultaneously $\theta_A > \theta_B$

(B) In case (A) drift of boat A greater than boat B

(C) If $v_B < v_A$ and $\theta_A > \theta_B$, boat B reaches other bank earlier than boat A

(D) If $v_B = v_A$ and $\theta_A > \theta_B$ drift of A is greater

8. **Statement-1 :** A man can not walk by himself on frictionless floor.

Statement-2 : In the absence of friction we can not push the floor tangentially backward.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

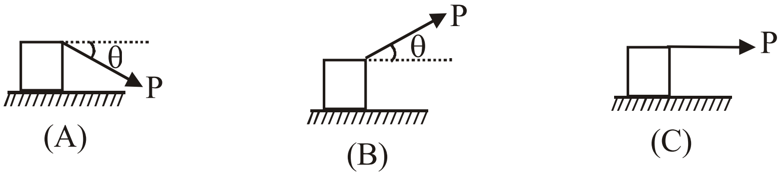
(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

9. The person in the drawing is standing on crutches. Assume that the force exerted on each crutch by the ground is directed along the crutch. If the coefficient of static friction between a crutch and the ground is 0.90, determine the largest angle θ^{MAX} that the crutch can have just before it begins to slip on the floor.

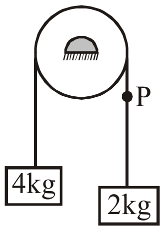
(A) $\tan^{-1}(0.9)$ (B) $\cot^{-1}(0.9)$
(C) $\sin^{-1}(0.9)$ (D) $\cos^{-1}(0.9)$

10. Figure shows three blocks on a rough surface under influence of a force P of same magnitude in all the three cases. Coefficient of friction is same between each block and ground. What possible relation holds between magnitudes of normal reaction and friction forces. [Assume that blocks do not overturn about edge, f_A, f_B & f_C are frictional forces & N_A, N_B & N_C are reactions]



(A) $N_A > N_C > N_B$ (B) $f_A > f_C > f_B$ (C) $f_C > f_A = f_B$ (D) $N_C > N_A = N_B$

11. Point P is on a massless thread in an ideal pulley arrangement as shown.



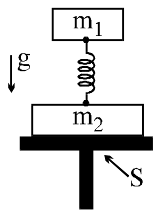
Statement 1 : As point P moves from right side to left side of pulley, the magnitude of it's acceleration remains same throughout.

and

Statement 2 : The tension in massless thread remains uniform in magnitude.

(A) Statement-1 is true, statement -2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement -2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement -2 is false.
(D) Statement-1 is false, statement -2 is true.

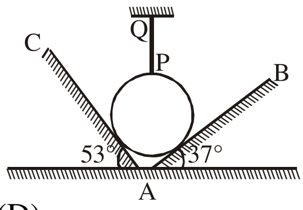
12. The system of two weights with masses m_1 and m_2 are connected with weightless spring as shown. The system is resting on the support S. The support S is quickly removed. The accelerations of each of the weights right after the support S is removed are.



(A) $a_1 = 0,\ a_2 = \dfrac{(m_1+m_2)g}{m_2}$ (B) $a_1 = 0,\ a_2 = \dfrac{(m_1+m_2)g}{m_1}$

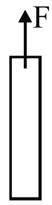
(C) $a_1 = \dfrac{(m_1+m_2)g}{m_1},\ a_2 = 0$ (D) $a_1 = 0,\ a_2 = 0$

13. A cylinder of mass 10 kg is resting between two frictionless inclined surfaces AB and AC, and is attached to a vertical string PQ whose other end Q is fixed to the ceiling as shown in figure. If forces, cylinder applies to surface AC & AB are 30 N and 40 N respectively, the tension in the string is [g = 10 m/s^2]



(A) 100 N (B) 50 N (C) 30 N (D) zero

14. The linear mass density of a rod of length ℓ depends on the distance x from upper end as $\lambda = \lambda_0 e^{2x}$. Rod is moved up by applying a force F. Find the correct statement.



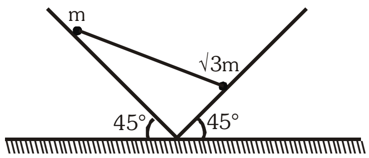
(A) The minimum force required to move the rod up is $\frac{\lambda_0}{2}(e^{2\ell}-1)g$.

(B) The tension at the mid point of the rod is F/2

(C) The acceleration of the rod is g upward if $F = \lambda_0(e^{2\ell}-1)g$

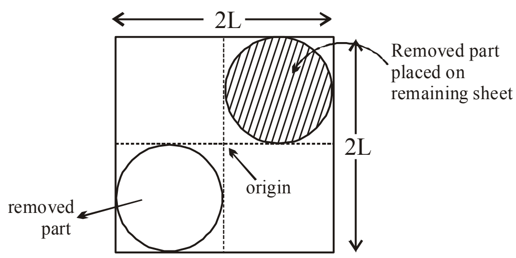
(D) The tension at the mid-point will be less if rod moves on a smooth horizontal surface.

15. Two small balls of mass m and $\sqrt{3}$m, respectively, are connected by a thin and rigid bar with negligible mass, and are free to slide on the 45° smooth inclines, as shown. Find the angle of the bar to the horizontal plane in equilibrium. The angle being negative means that the heavy ball is above the light ball.



(A) 45° (B) 15° (C) – 15° (D) – 45°

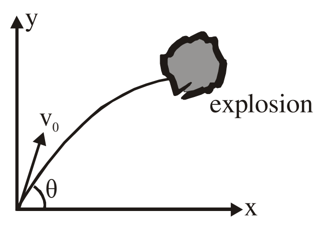
16. Figure shows a square lamina with a disc of radius $\frac{L}{2}$ removed from it which is now placed symmetrically over upper right quarter. What is location of centre of mass of system relative to origin shown in figure.



(A) $\frac{\pi L}{12}(\hat{i}+\hat{j})$ (B) $\frac{\pi L}{8}(\hat{i}+\hat{j})$

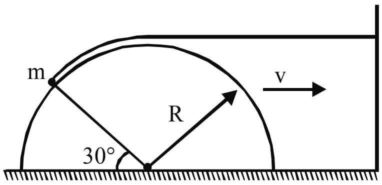
(C) $\frac{\pi L}{4}(\hat{i}+\hat{j})$ (D) $\frac{\pi L}{16}(\hat{i}+\hat{j})$

17. A projectile is projected in x-y plane with velocity v_0. At top most point of its trajectory projectile explodes into two identical fragments. Both the fragments land simultaneously on ground and stick there. Taking point of projection as origin and R as range of projectile if explosion had not taken place. Which of the following can not be position vectors of two pieces, when they land on ground.



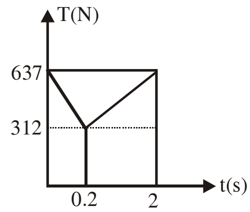
(A) $\frac{R}{2}\hat{i}, \frac{3R}{2}\hat{i}$ (B) $0\hat{i}, 2R\hat{i}$ (C) $R\hat{i}-R\hat{k}, R\hat{i}+R\hat{k}$ (D) $2R\hat{i}+\frac{R}{2}\hat{k}, R\hat{i}-\frac{R}{2}\hat{k}$

18. A point object of mass m is slipping down on a smooth hemispherical body of mass M and radius R. The point object is tied to a wall with an ideal string as shown. At a certain instant, speed of the hemisphere is v and its acceleration is a. Then speed v_p and acceleration a_p of a particle has value (assume all the surfaces in contact are frictionless)



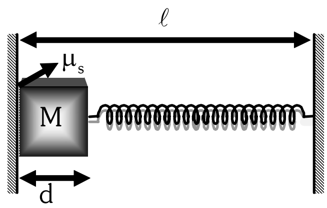
(A) $v_P = v \sin 60°$ (B) $v_P = v$ (C) $a_P = a$ (D) $a_P = \sqrt{\left(\frac{v^2}{R}\right)^2 + a^2}$

19. A mountain climber is sliding down a vertical rope. Her total mass including the equipments is 65 kg. By adjusting the friction on the rope, she controls the tension force on the rope as a function of time is shown in the figure. The speed of the mountaineer at the end of 2 sec if she starts from rest is
[Take g = 9.8 m/s^2]



(A) 2.25 m/s (B) 4.5 m/s (C) 5 m/s (D) 2.5 m/s

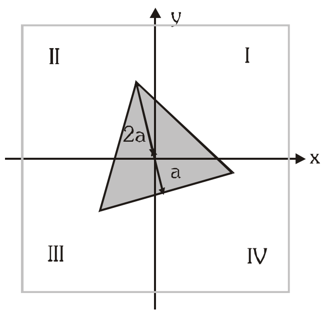
20. A block of mass M is pressed against a vertical surface by a spring of unstretched length ℓ as shown in figure. If the coefficient of static friction between the block and the surface is μ_s, the minimum spring constant k_{min} that will keep M in place is,



(A) $\frac{Mg}{\mu_S d}$ (B) $\frac{2Mg}{\mu_S d}$

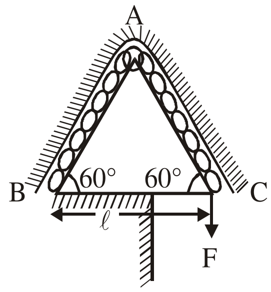
(C) $\frac{Mg}{2\mu_S d}$ (D) $\frac{3}{2}\frac{Mg}{\mu_S d}$

21. An equilateral triangular portion is removed from a uniform square plate as shown in figure. COM of remaining plate will- (Centre of mass of triangular portion concides with the centre of square plate which is at origin)



(A) shifts to quadrant I
(B) shifts to quadrant II
(C) shifts to quadrant III
(D) does not shift

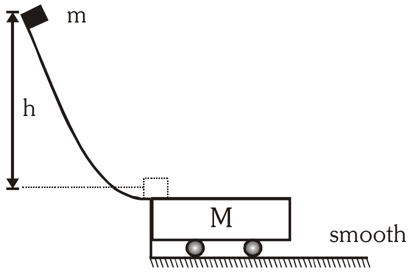
22. A fixed wedge ABC is in the shape of an equilateral triangle of side ℓ. Initially, a chain of length 2ℓ and mass m rests on the wedge inside of a tube as shown. The chain is pulled slightly, as a result it starts sliding out of the tube. Work done by gravity till the time, the chain leaves the wedge will be :-



(A) $\left(\dfrac{(\sqrt{3}+1)mg\ell}{2}\right)$ (B) $\left(\dfrac{(\sqrt{3}+2)mg\ell}{2}\right)$

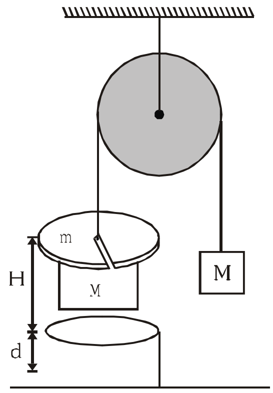
(C) $\left(\dfrac{(\sqrt{3}+2)mg\ell}{4}\right)$ (D) $\left(\dfrac{(\sqrt{3}+4)mg\ell}{4}\right)$

23. A carriage of mass M and length ℓ is joined to the end of a slope as shown in the figure. A block of mass m is released from the slope from height h. It slides till end of the carriage. The friction between the mass and the slope and also friction between carriage and horizontal floor is negligible. Coefficient of friction between block and carriage is μ. Find h in the given terms.



(A) $\mu\left(1+\dfrac{M}{m}\right)\ell$ (B) $2\mu\left(1+\dfrac{M}{m}\right)\ell$ (C) $\mu\left(2+\dfrac{m}{M}\right)\ell$ (D) $\mu\left(1+\dfrac{m}{M}\right)\ell$

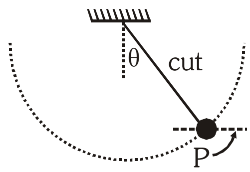
24. Two equal blocks of mass M hangs on either side of pulley as shown in figure. A small square rider of mass m is placed on one block. When the block is released. It accelerates for a distance H till the rider is caught by a ring that allows the block to pass after then it travels a distance 'd'. Then time taken by block to travel the distance 'd' is given by



(A) $t=\sqrt{\dfrac{(2M+m)d^2}{2mHg}}$ (B) $t=\sqrt{\dfrac{(2M+m)d^2}{4mHg}}$

(C) $t=\sqrt{\dfrac{2(2M+m)d^2}{mHg}}$ (D) $t=\sqrt{\dfrac{(2M+m)d^2}{mHg}}$

25. Consider a pendulum, consisting of a massless string with a mass on the end. The mass is held with the string horizontal, and then released. The mass swings down, and then on its way back up, the string is cut at point P when it makes an angle of θ with the vertical. What should θ be, so that the mass travels the largest horizontal distance from P by the time it returns to the height it had when the string was cut?

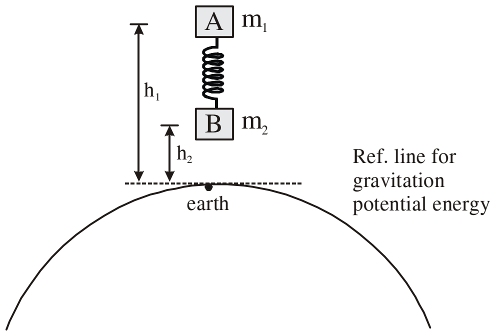


(A) $\tan^{-1}\sqrt{3}$ (B) $\tan^{-1}\left(\dfrac{1}{\sqrt{3}}\right)$ (C) $\tan^{-1}\left(\dfrac{1}{\sqrt{2}}\right)$ (D) $\tan^{-1}(1)$

26. A uniform chain has a mass M and length L. It is placed on a frictionless table with length ℓ_0 hanging over the edge. The chain begins to slide down. The speed V with which the chain slides away from the edge is given by

(A) $V=\sqrt{\frac{g\ell_0}{L}(L+\ell_0)}$ (B) $V=\sqrt{\frac{g\ell_0}{L}(L-\ell_0)}$ (C) $V=\sqrt{\frac{g}{L}(L^2-\ell_0^2)}$ (D) $V=\sqrt{2g(L-\ell_0)}$

27. Figure shows two blocks of masses m_1 and m_2 connected by light spring which at a certain instant, is elongated by 'x'. Heights h_1 and h_2 are very small compared with radius of earth. Take the potential energy of normal spring as zero. Choose the **CORRECT** statement.



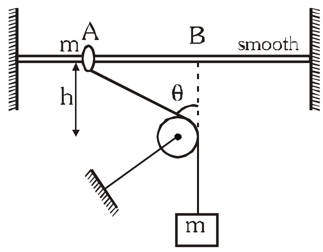
(A) If system = block A, potential energy of system is m_1gh_1

(B) If system = block A + block B + spring, potential energy of the system is $\frac{1}{2}kx^2$

(C) If system = block A + block B + spring, potential energy of the system is $\frac{1}{2}kx^2+m_1gh_1+m_2gh_2$

(D) If system = block A + block B + spring + earth, potential energy of the system is $\frac{1}{2}kx^2+m_1gh_1+m_2gh_2$

28. A ring of mass m slide from rest on the smooth rod as shown in the figure, due to the block of mass m. Pully and string are massless. Then find the speed of ring when the string become straight. (Given $\theta = 60°$)



(A) $4\sqrt{gh}$ (B) $\sqrt{2gh}$

(C) $2\sqrt{2gh}$ (D) $8\sqrt{gh}$

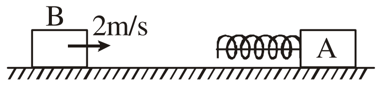
29. Figure shows a block A of mass 5 kg kept at rest on a horizontal smooth surface. A spring (K = 200 N/m) which is compressed by 10 cm and tied with the help of a string to maintain the compression is attached to block A as shown in figure. Block B also of mass 5 kg moving with 2 m/s collides with A, as shown. During the collision the string breaks and after the collision the spring is in its natural state. Assume the bodies to be elastic and let the velocities of A and B be v_1 and v_2 respectively assuming positive direction towards right, after collision. Then

(A) $v_1 + v_2 > 2$

(B) Initial kinetic energy of system = final kinetic energy of system

(C) $v_1^2 + v_2^2 = 4.4\ (m/s)^2$

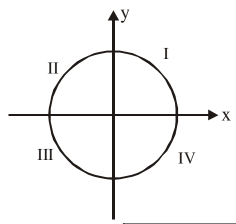
(D) $v_1 - v_2 = 2$



30. A particle is moving along a circular path. The angular velocity $(\vec{\omega})$, angular acceleration $(\vec{\alpha})$, centripetal acceleration $(\vec{a}_c)$ and linear velocity $(\vec{v})$ are related as

(A) $\vec{\omega}\cdot\vec{v} = 0$ (B) $\vec{\omega}\cdot\vec{\alpha} = 0$ (C) $\vec{\omega}\cdot\vec{a}_c = 0$ (D) $\vec{v}.\vec{a}_c = 0$

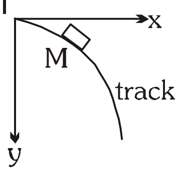
31. A particle is moving along a circular path as shown in figure below. The instantaneous velocity of the particle is $\vec{v} = (4\ \text{m/s})\hat{i} - (3\ \text{m/s})\hat{j}$. The particle may be moving through



(A) first quadrant (B) second quadrant

(C) third quadrant (D) fourth quadrant

32. A man M slides down a curved frictionless track, starting from rest. The curve obeys the equation $y = \frac{x^2}{2}$. The tangential acceleration of man is

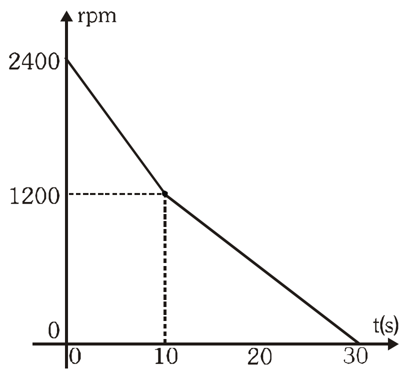


(A) g (B) $\frac{gx}{\sqrt{x^2+4}}$ (C) $\frac{g}{2}$ (D) $\frac{gx}{\sqrt{x^2+1}}$

33. A particle moves in xy plane on a circular path of radius 10m (with centre at origin) with constant speed of 20 m/s. Its velocity vector at point (0, 10m) if it's angular velocity is along z-axis is

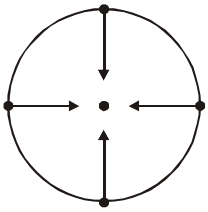
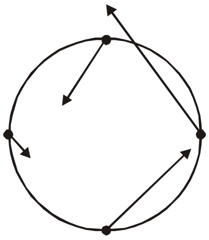
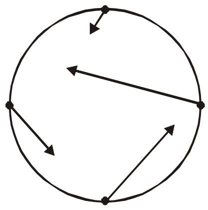
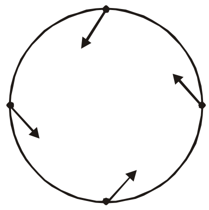
(A) $(20\hat{i})\,m/s$ (B) $(-20\hat{i})\,m/s$ (C) $(10\hat{i})\,m/s$ (D) $(-10\hat{i})\,m/s$

34. A table fan, rotating at a speed of 2400 revolution per minute is switched off and the resulting variation of the rpm with time is shown in the figure. Total number of revolution of the fan before it comes to rest is



(A) 30000 (B) 3000 (C) 300 (D) 500

35. A car speeds up with constant magnitude of tangential acceleration in circular path moving in anticlockwise direction. Which of the following figure represents acceleration of the car?

(A)  (B)  (C)  (D) 

36. Two particles A and B separated by a distance 2R are moving counter clockwise along the same circular path of radius R each with uniform speed v. At time t = 0, A is given a tangential acceleration of magnitude $a = \dfrac{72\, v^2}{25\, \pi R}$.

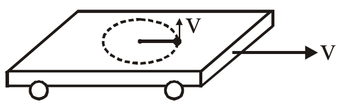
(A) the time lapse for the two bodies to collide is $\dfrac{6\pi R}{5v}$

(B) the angle covered by A after t = 0 and before collision is $\dfrac{11\pi}{6}$

(C) angular velocity of A just before collision is $\dfrac{11v}{5R}$

(D) radial acceleration of A is $\dfrac{289\, v^2}{5R}$

37. On a train moving along east with a constant speed v, a boy revolves a bob with string of length ℓ on smooth surface of a train, with equal constant speed v relative to train. Mark the correct option(s).



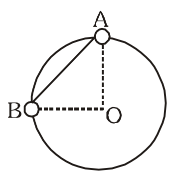
(A) Maximum speed of bob is 2 v in ground frame.

(B) Tension in string connecting bob is $\dfrac{4mv^2}{\ell}$ at an instant.

(C) Tension in string is $\dfrac{mv^2}{\ell}$ at all the moments.

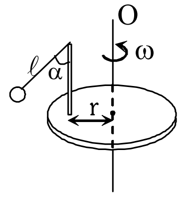
(D) Minimum speed of bob is zero in ground frame.

38. Beads A and B, each of mass m, are connected by a light inextensible cord. They are constrained (restricted) to move on a frictionless ring in a vertical plane as shown. The beads are released from rest at the positions shown. The tension in the cord just after the release is



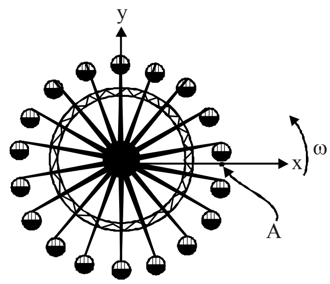
(A) $\sqrt{2}$ mg (B) mg (C) $\dfrac{1}{\sqrt{2}}$ mg (D) 2 mg

39. A ball of mass m is attached to the end of a thread fastened to the top of a vertical rod which is fitted to a horizontally revolving round table as shown. If the thread forms an angle α with the vertical, the angular velocity ω of table is



(A) $\sqrt{\dfrac{g}{l\cos\alpha}}$ (B) $\sqrt{\dfrac{r}{g\tan\alpha}}$ (C) $\sqrt{\dfrac{g\tan\alpha}{r+l\sin\alpha}}$ (D) $\sqrt{\dfrac{g\tan\alpha}{r}}$

40. Consider the setup of a Ferris wheel in an amusement park. The wheel is turning in a counterclockwise manner. Contrary to the illustration, not all seats are aligned horizontally, i.e. parallel to the x-axis. Determine the orientation of the normal to the seat as it passes the point A.



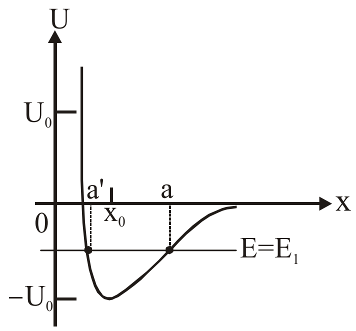
(A) parallel to the x-axis
(B) in the first/third quadrants
(C) parallel to the y-axis
(D) in the second/fourth quadrants.

Paragraph for Question Nos. 41 to 43

In a diatomic molecule the atoms can move relative to one another within certain limits. According to a simple theory of interatomic forces, the potential energy for the motion of each atom is

$$U(x) = U_0\left(e^{-2(x-x_0)/b} - 2e^{-(x-x_0)/b}\right)$$

Here e = 2.718...; U_0, x_0 and b are constants; and x is the distance from the one atom to the midpoint of the molecule.



According to eq. $v^2 = \dfrac{2}{m}\left[E - U(x)\right]$, v^2 is directly proportional to E-U(x); thus, v^2 is large wherever the difference between E and U(x) is large. We can therefore gain some insights into the qualitative features of the motion by drawing a graph of potential energy on which it is possible to display the difference between E and U(x). For example, Figure shows the curve of potential energy for an atom in a diatomic molecule

On this graph, we indicate the value of the energy of the particle by a horizontal line. We will call this horizontal line the energy level of the particle. At any point x, we can then see the difference between E and U(x) at a glance.

41. Mark the incorrect statement.

(A) For the given graph equilibrium of molecule exists where slope of graph is zero.

(B) For $x > x_0$ interatomic force is attractive in nature.

(C) For $x < x_0$ interatomic force is repulsive in nature.

(D) As particle moves away from equilibrium position, magnitude of intermolecular force decreases.

42. For particle of energy level E in the above graph, choose the incorrect option.

(A) Particle has maximum speed at $x = x_0$

(B) Only region $a' \le x \le a$ is permitted for motion of particle.

(C) Speed gradually increases as particle moves towards right from $x= x_0$

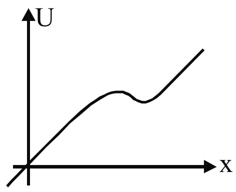
(D) The particle has periodic motion i.e. it repeats again and again whenever the particle returns to its starting point.

43. In the vicinity of equilibrium position $x = x_0$, for a small displacement, force is proportional to the displacement. What is value of proportionality constant k.

(A) $k = \frac{3U_0}{b^2}$ (B) $k = \frac{2U_0}{b^2}$ (C) $k = \frac{6U_0}{b^2}$ (D) $k = \frac{b^2}{3U_0}$

Paragraph for Question Nos. 44 to 46

A particle of mass 1.5 kg moves along x-axis in a conservative force field. Its potential energy is given by $U(x) = 2x^3 - 9x^2 + 12x$, where all quantities are written in SI units. The plot of this potential energy is given below.



It is seen that the particle can be in stable equilibrium at a point on x-axis, x_0. When it is displaced slightly from this equilibrium position, it executes SHM with time period T.

44. What is the range of total mechanical energy of the particle for which its motion can be oscillatory about a point

(A) E < 5J (B) E < 8 J (C) E < 12 J (D) E < 9 J

45. What is the value of x_0?

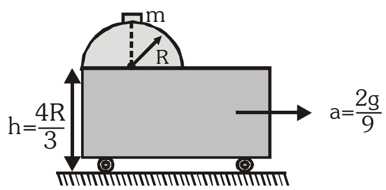
(A) 2m (B) 3m (C) 1 m (D) 1.5 m

46. What is the time period of SHM mentioned in the paragraph?

(A) π sec. (B) 2π sec. (C) $\frac{\pi}{2}$ sec. (D) $\frac{\pi}{4}$ sec.

Paragraph for Question 47 to 49

A vertical frictionless semicircular track of radius R is fixed on the edge of movable trolley. Initially the system is at rest and a mass m is kept at the top of the track. The trolley starts moving to the right with a uniform horizontal acceleration $a = \frac{2g}{9}$. The mass slides down the track, eventually losing contact with it and dropping to the floor h below the trolley.



47. The angle θ with vertical, at which it losses contact with the trolley is

(A) 37° (B) 53° (C) $\cos^{-1}\left(\frac{2}{3}\right)$ (D) $\frac{\pi}{2}-\cos^{-1}\left(\frac{2}{3}\right)$

48. The height at which mass m losing contact is

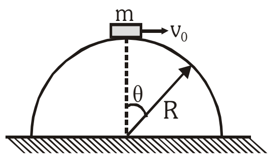
(A) $\frac{4}{5}R$ (B) $\frac{17}{15}R$ (C) R (D) $\frac{32}{15}R$

49. The time taken by the mass to drop on the floor, after losing contact is

(A) $\sqrt{\frac{2R}{3g}}$ (B) $\sqrt{\frac{6R}{3g}}$ (C) $2\sqrt{\frac{2R}{3g}}$ (D) Can't be determined

Paragraph for Question 50 to 52

A point mass m moves horizontally with a velocity of $v_0=\sqrt{\frac{Rg}{2}}$ from the peak of a smooth hemispherical surface of radius R.



50. The angle θ_0 at which the mass m leaves the spherical surface is-

(A) $\cos^{-1}\left(\frac{2}{3}\right)$ (B) $\sin^{-1}\left(\frac{2}{3}\right)$ (C) $\cos^{-1}\left(\frac{5}{6}\right)$ (D) $\sin^{-1}\left(\frac{5}{6}\right)$

51. Radial acceleration at θ_0 is-

(A) g (B) $\frac{5}{6}g$ (C) $\frac{6}{5}g$ (D) $\frac{g}{5}$

52. If there is friction on the spherical surface, then it leaves the surface at an angle θ. Then value of θ -

(A) $>\theta_0$ (B) $<\theta_0$ (C) $=\theta_0$ (D) Can't be determined

Paragraph for Question Nos. 53 to 55

A great basketball player throws a basketball straight upward in the air. It rises and falls back to his hand. During the catch, his hands are displaced downward a few cm as the ball slows down.

53. During the catch while the ball is in hand and is moving downward, the work done by him on the ball is

(A) positive (B) negative (C) zero (D) can't say

54. During the throw work done by gravity is

(A) positive (B) negative (C) zero (D) can't say

55. During the throw while ball is in hand and moving upward then work done by ball on hand

(A) positive (B) negative (C) zero (D) can't say

Paragraph for Question Nos. 56 & 57

A traveler at an airport takes an escalator up one floor. The moving staircase would itself carry him upward with vertical velocity component v between entry and exit points separated by height h. However, while the escalator is moving, the hurried traveler climbs the steps of the escalator at a rate of n steps/s. Assume that the height of each step is h_s.

56. Determine the amount of work done by the traveler during his escalator ride, given that his mass is m.

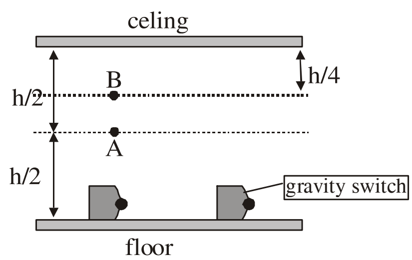
(A) $\frac{2mghnh_s}{(v+nh_s)}$ (B) $\frac{mghnh_s}{2(v+nh_s)}$ (C) $\frac{mghnh_s}{(2v+nh_s)}$ (D) $\frac{mghnh_s}{(v+nh_s)}$

57. Determine the work the escalator motor does on this person.

(A) $\frac{mgvh}{(v+nh_s)}$ (B) $\frac{2mgvh}{(v+nh_s)}$ (C) $\frac{mgvnh_s}{(v+nh_s)}$ (D) $\frac{mgvnh_s}{2(v+nh_s)}$

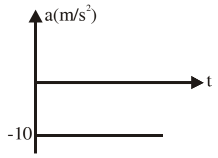
Paragraph for Question Nos. 58 to 60

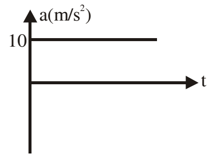
A student tosses a rubber ball vertically upward. When it reaches the top of its trajectory at a point A, another student flips the gravity switch so that acceleration due to gravity now becomes 10 m/s^2 upwards. The ball bounces back down to point B, then it gets back again to the ceiling and sticks there.

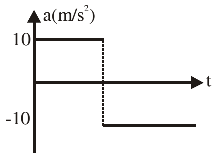


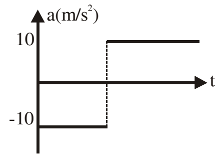
Point A is halfway between the floor and ceiling and point B is 1/4th of the way down from ceiling. Take y =0 at the floor and positive y-axis upward.

58. The a-t graph of ball is

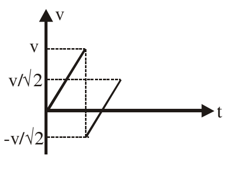
(A) 

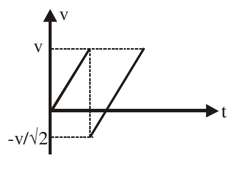
(B) 

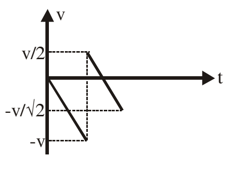
(C) 

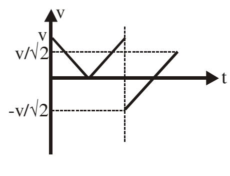
(D) 

59. v-t graph of ball is : (v is initial velocity)

(A) 

(B) 

(C) 

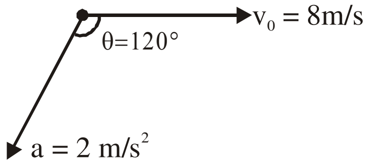
(D) 

60. If h = 40 m, then find the total time taken by ball to stick on ceiling after the flip of gravity switch

(A) $2+2\sqrt{2}$ sec (B) $2+\sqrt{2}$ sec (C) 2 sec (D) None of these

Paragraph for Question Nos. 61 to 63

The figure shows the velocity and acceleration of a particle at the initial moment t =0 of its motion. The acceleration vector of the particle remains constant.



61. The instant of time after t =0 at which the speed of the particle is 8 m/s again is

(A) 2 s (B) 8 s (C) 16 s (D) 4 s

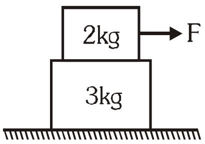
62. The instant of time at which the acceleration and velocity vector of the particle are mutually perpendicular is

(A) 4 s (B) 8 s (C) 2 s (D) 16 s

63. The magnitude of displacement of the particle in time interval t =0 to t =4 seconds is

(A) $16\sqrt{3}$ m (B) 32 m (C) 30 m (D) $32\sqrt{3}$ m

Paragraph for Question Nos. 64 to 66



The slipping starts between the blocks when the force of 25 N acts on 2kg block.

64. Acceleration of both the blocks when 40 N force acts on 2 kg block is

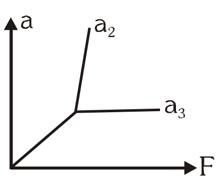
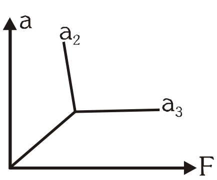
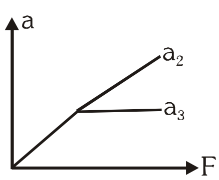
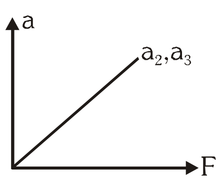
(A) $a_2 = 7.5\ m/s^2$, $a_3 = 5\ m/s^2$ (B) $a_2 = 12.5\ m/s^2$, $a_3 = 5\ m/s^2$

(C) $a_2 = 7.5\ m/s^2$, $a_3 = 25/3\ m/s^2$ (D) $a_2 = 12.5\ m/s^2$, $a_3 = 25/3\ m/s^2$

65. The force applied on 3 kg block so that slipping start between 2 kg & 3 kg blocks

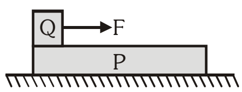
(A) 25 N (B) 37.5 N (C) 50 N (D) 62.5 N

66. Select the correct graph of acceleration of blocks with force F is

(A)  (B)  (C)  (D) 

Paragraph for Question Nos. 67 to 69

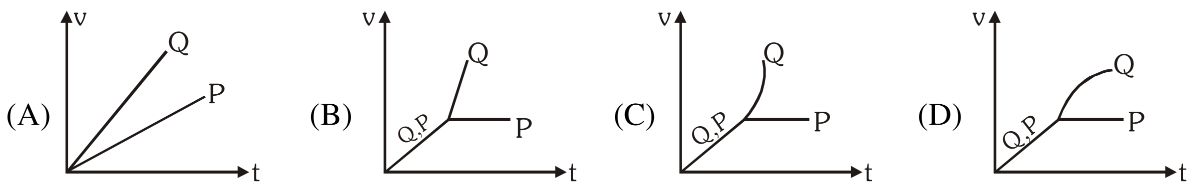
A block Q of mass 2 kg is placed on top of a long plank P of mass 8 kg. The coefficient of friction between block and plank is 0.8 and friction is absent between plank and horizontal surface. A time varying force F is applied to Q. F depends on time t (taken in seconds) as F=5t N.



67. The force of friction acting on P after time 2 seconds is

(A) 16 N backwards (B) 8N forwards (C) zero (D) 16N forwards

68. The variation of velocity of 'P' and 'Q' at any subsequent time follows the graph :–



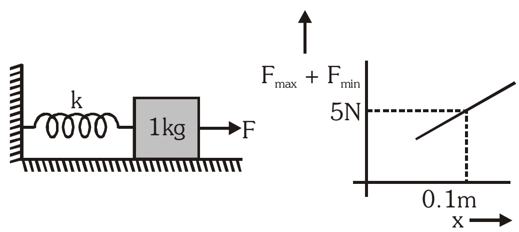
69. The velocity of 'P' and 'Q' respectively after 6 seconds from start will be :–

(A) 8 m/s, 13 m/s (B) 12 m/s, 16 m/s

(C) 12 m/s, 24 m/s (D) 0 m/s, 16 m/s

Paragraph for Question Nos. 70 to 72

A block of mass 1 kg is placed on a rough horizontal surface. A spring is attached to the block whose other end is joined to a rigid wall, as shown in the figure. A horizontal force is applied on the block so that it remains at rest while the spring is elongated by x. $\left(x \geq \frac{\mu mg}{k}\right)$. Let F_{max} and F_{min} be the maximum and minimum values of force F for which the block remains in equilibrium. For a particular x, $F_{max} - F_{min} = 2N$. Also shown is the variation of $F_{max} + F_{min}$ versus x, the elongation of the spring.



70. The coefficient of friction between the block and the horizontal surface is :

(A) 0.1 (B) 0.2 (C) 0.3 (D) 0.4

71. The spring constant of the spring is :

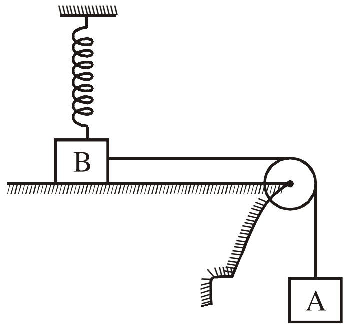
(A) 25 N/m (B) 20 N/m (C) 2.5 N/m (D) 50 N/m

72. The value of F_{min}, if x = 3 cm is :

(A) 0 (B) 0.2 N (C) 5 N (D) 1N

Paragraph for Question Nos. 73 to 75

In the figure is shown a situation where A and B are blocks of mass 1 kg and 4 kg respectively and the spring is compressed by 3 cm and is vertical, where its natural length is 15 cm. The surface on which B is placed is frictionless and horizontal. The spring is attached at one end to B and other end is attached to fixed support. The blocks are released from rest. ($g = 10\ m/s^2$)



73. If the normal force between B and surface is 46 N, when spring is vertical, the spring constant of spring will be

(A) 600 N/m (B) 400 N/m (C) 300 N/m (D) 200 N/m

74. The acceleration of the blocks when normal force between surface and B becomes 40 N, is

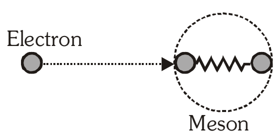
(A) $a_A = a_B = 2\ m/s^2$ (B) $a_A = a_B < 2$ (C) $a_A = a_B > 2$ (D) $a_A = 10, a_B = 0$

75. If the blocks are released from that position shown at t=0, the time when normal force between surface and block B becomes 40 N, is

(A) t = 0.3 s (B) t < 0.3 s (C) t > 0.3 s (D) not enough information is given

Paragraph for Question Nos. 76 to 78

Meson is composed of two quarks and the interaction between the quarks is complicated. Research of meson can be done by studying the inelastic collisions between the meson and high energy electrons. As the collision is quite complicated, scientists invented a simplified model called "parton model" to grasp the main content during collision. In the model, the electron first collides with part of meson (e.g. one of the quarks) elastically. Then the energy and momentum are transferred to the other quark and thus the whole meson during subsequent interaction. This simplified model is described by the following :



An electron of mass M and energy E collides with a quark of mass m_1 in a meson. The other quark in the meson has mass m_2. The quarks are connected by a massless spring of natural length L which is at equilibrium before collision. All movements are on a straight line and neglect the effect of relativity. Find, after collision,

76. The energy gain of the quark m_1

(A) $\frac{4Mm_1}{(M+m_1)^2}E$ (B) $\frac{2Mm_1}{(M+m_1)^2}E$ (C) $\frac{Mm_1}{(M+m_1)^2}E$ (D) $\frac{3Mm_1}{2(M+m_1)^2}E$

77. The minimum kinetic energy of the meson as a whole system

(A) $\dfrac{4Mm_1^2}{(M+m_1)^2(m_1+m_2)}E$ (B) $\dfrac{4Mm_1^2}{(M+m_2)^2(m_1+m_2)}E$

(C) $\dfrac{2Mm_1^2}{(M+m_2)^2(m_1+m_2)}E$ (D) $\dfrac{2Mm_1^2}{3(M+m_2)^2(m_1+m_2)}E$

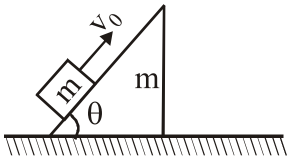
78. The internal energy of the meson which is expressed by the oscillation of the spring.

(A) $\dfrac{4Mm_1m_2}{(M+m_1)^2(m_1+m_2)}E$ (B) $\dfrac{4Mm_1m_2}{(M+m_2)^2(m_1+m_2)}E$

(C) $\dfrac{2Mm_1m_2}{(M+m_2)^2(m_1+m_2)}E$ (D) $\dfrac{3Mm_1m_2}{(M+m_2)^2(m_1+m_2)}E$

Paragraph for question nos. 79 to 81

A wedge is kept on a smooth ground and it's inclined surface is also smooth. A block is projected on it as shown, assume that the block does not fall off to the other side. Both the block and wedge have equal mass.



79. To find the maximum height attained by the block, we have written few equations. Which of the following equations is correct?

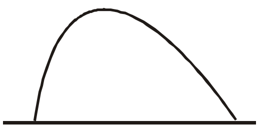
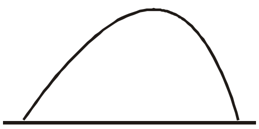
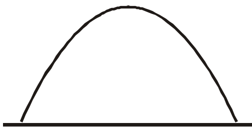
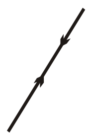
(A) $mgh = \frac{1}{2}mv_0^2$ (by conservation of energy) where h is maximum height of the block.

(B) $0^2 = v_0^2 - 2g\sin\theta \times s$ where s is maximum displacement along the inclined surface

(C) $mv_0 = mv + mv$ (by conservation of momentum) and $\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + mgh$

(D) None of these

80. How does the path of block look like as seen from ground?

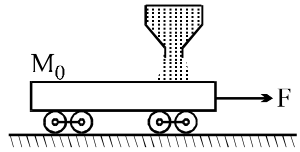
(A)  (B)  (C)  (D) 

81. What is the radius of curvature of it's path at the highest point ?

(A) 0 (B) $\dfrac{v_0^2\cos^2\theta}{g(\sin\theta\cos\theta+\sin^2\theta)}$ (C) $\dfrac{v_0^2\cos^2\theta}{2g(1+\sin^2\theta)}$ (D) None of these

Paragraph for Question Nos. 82 to 84 (3 questions)

In the figure shown a long cart moves on a smooth horizontal surface due to an external constant force of magnitude F. Initial mass of the cart is M_0 and velocity is zero. At t = 0 sand starts falling from a stationary hopper on to the cart with negligible velocity at constant rate μ kg/s and sticks to the cart.



82. The velocity of the cart at time t ($<t_0$)

(A) $\frac{Ft}{M_0+\mu t}e^{\mu t}$ (B) $\frac{Ft}{M_0}e^{\mu t}$ (C) $\frac{Ft}{M_0}$ (D) $\frac{Ft}{M_0+\mu t}$

83. In the same model of the above question if the cart is to be moved with constant velocity v, then the power supplied by external agent applying that force is

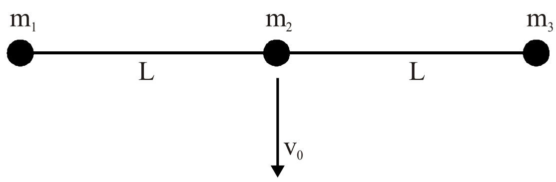
(A) $2\mu v$ (B) μv (C) μv^2 (D) $\frac{1}{2}\mu v^2$

84. In the above question the rate of increase of the kinetic energy of the cart (with sand) is

(A) $2\mu v^2$ (B) μv (C) μv^2 (D) $\frac{1}{2}\mu v^2$

Paragraph for Question Nos. 85 to 87

There are three small elastic disks with masses $m_1 = m_3 = 0.2$ kg, $m_2 = 0.3$ kg connected with two inelastic strings of equal length having negligible mass, on a horizontal frictionless table. At the beginning the three disks are at rest and reside in one line (according to the figure). Then we impart the middle disk m_2 a velocity of $v_0 = 6$ m/s so that it moves horizontally perpendicular to line joining m_1 & m_3.



85. What is velocity of m_2 at the moment m_1 and m_3 undergo elastic collision :

(A) $\frac{9}{2}$ m/s (B) $\frac{18}{7}$ m/s (C) 6 m/s (D) None of these

86. What is the speed of the side disks at the moment when the disk of mass m_2 stops instantaneously after the elastic collision of m_1 and m_3 :

(A) $3\sqrt{3}$ m/s (B) 3 m/s (C) $2\sqrt{3}$ m/s (D) None of these

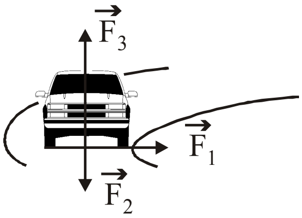
87. In reference of above question, what is the angle formed by the two strings in this position :

(A) 30° (B) 60° (C) 90° (D) 120°

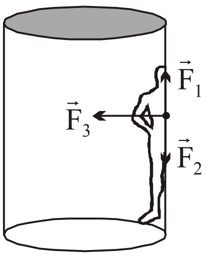
88. Column-I shows certain situations and column-2 shows information about forces.

Column - I | **Column - II**

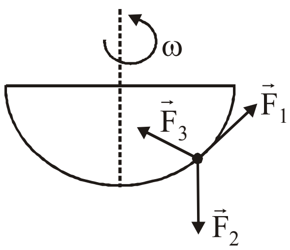
Situation

(A) 

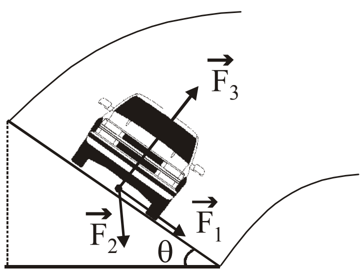
Front view of a car rounding a curve with constant speed.

(B) 

Passengers in a rotor not sliding relative to rotor wall cylindrical rotor is rotating with constant angular velocity about its symmetry axis.

(C) 

Particle kept on rough surface of a bowl, no relative motion of particle in bowl, bowl has constant angular velocity

(D) 

Car moving on a banked road with constant speed, no sideways skidding

(P) $\vec{F}_1 + \vec{F}_2 + \vec{F}_3$ is centripetal force.

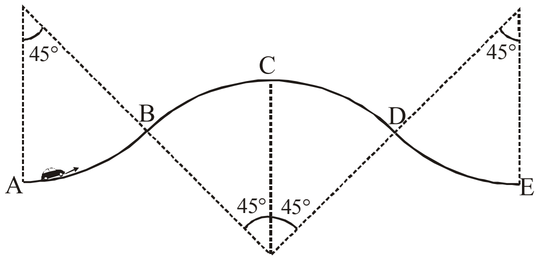
(Q) $\vec{F}_1$ is static friction.

(R) $\vec{F}_1$ can be in direction opposite to that shown in figure.

(S) $\vec{F}_1 + \vec{F}_2 = \vec{0}$

(T) $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{0}$

89. A car moves with constant speed on a track consisting of four circular segements AB, BC, CD and DE, all in vertical plane. Size of car is negligible as compared to the radius of the tracks.

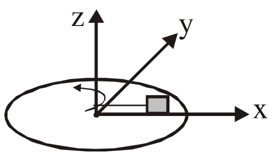


	Column I		Column II
(A)	Segement AB	(P)	Friction up the slope
(B)	Segement BC	(Q)	Friction down the slope
(C)	Segement CD	(R)	Car can not leave the track
(D)	Segement DE	(S)	Friction force is maximum at any one end of the segement.
		(T)	Normal reaction is minimum at any one end of the segement.

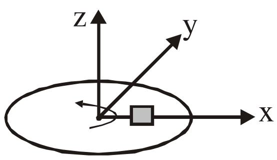
90. Mark the matching options for situations shown in respective figures of column-I at the instant, when particle / car is located on the x-axis as shown :

Column I

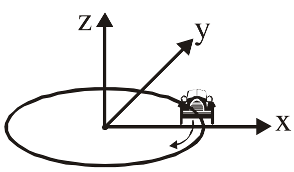
(A) Block attached to string is moving along a circle on rough surface



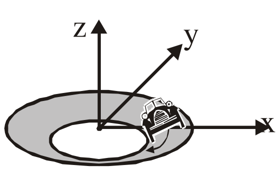
(B) Block is placed on a disc rotating with non-uniform angular velocity as shown below. There is no slipping between block & disc.



(C) Car moving on ground along a circular horizontal track at a constant speed



(D) Car moving on ground at constant speed along a circular banked track.



Column II

(P) Force due to friction may have non-zero x-component

(Q) Force due to friction may have non-zero y-component.

(R) Force due to friction may have non-zero z-component.

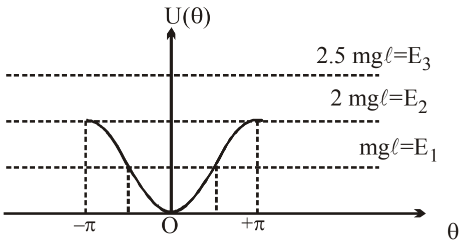
(S) Force due to friction may be zero.

(T) Centripetal force is only due to friction.

91. Column-I represents potential energy graph for certain system. Column-II gives statements related to graphs.

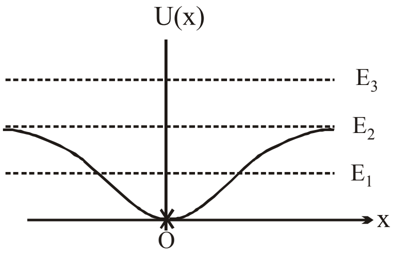
Column I

(A)



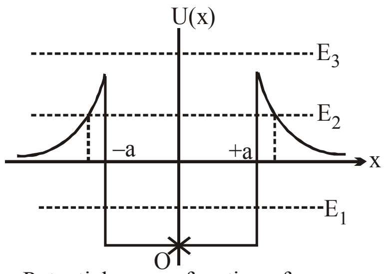
U vs θ graph for a bob hanging vertically from a string with its lowest position as reference level and θ is angle of string from vertical line

(B)



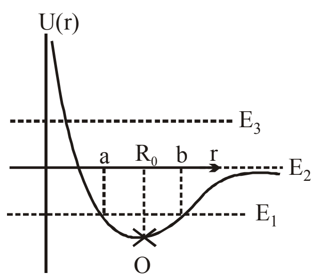
A particle moving along x axis with potential energy function as $U(x) = [1 - e^{-x^2}]$

(C)



Potential energy function of a particle in an arbitrary force field

(D)



Graph represents potential energy for a particle

Column II

(P) If total energy is E_3, it is not possible for the body to have any turning point in its motion.

(Q) For a small displacement about point O potential energy function is quadratic in variable plotted on x-axis.

(R) For a small displacement about position O motion is simple harmonic.

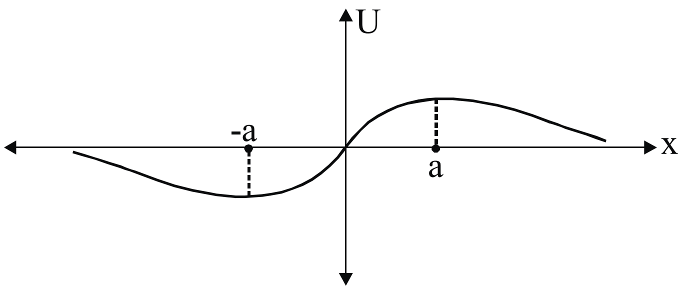
(S) If total energy is $E_{total} < E_2$ particle executes periodic and oscillatory motion for all energy values greater than energy at O.

(T) Point O is position of stable equilibrium

92. A particle of mass m kg is displaced from one given point to another given point under the action of several conservative and non-conservative forces (Neglect relativistic considerations). Now match the following.

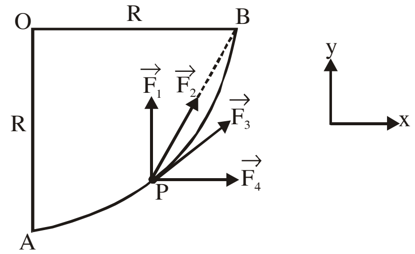
	Column -I		**Column-II**
(A)	Displacement of particle	(P)	Path dependent
(B)	Work done by conservative force	(Q)	Path independent
(C)	Work done by non-conservative force	(R)	Frame dependent
(D)	Angular displacement	(S)	Frame independent
		(T)	Dependent on location of observer in a given frame

93. A particle of mass 'm' moves under a conservative force with potential energy $U(x) = \frac{cx}{x^2 + a^2}$ where c & a are positive constants. Assume that initially particle is on mean position (where equilibrium is stable). For the given function potential energy v/s position graph is shown below.



	Column I		**Column II**
(A)	position of unstable equilibrium is	(P)	Less than $\sqrt{\frac{c}{ma}}$
(B)	for the particle to be confined in the region the velocity of particle must be	(Q)	More than $\sqrt{\frac{c}{ma}}$
(C)	for particle to reach x = + ∞, velocity of particle must be	(R)	More than $\sqrt{\frac{2c}{ma}}$
(D)	For the particle to reach x = – ∞, velocity of particle must be	(S)	$x = -a$
		(T)	x = +a

94. AB is a quarter of a smooth horizontal circular track of radius R. A particle P of mass m moves along the track from A to B under the action of following forces :



$\vec{F}_1$ = F (always towards y-axis)

$\vec{F}_2$ = F (always towards point B)

$\vec{F}_3$ = F (always along the tangent to path AB)

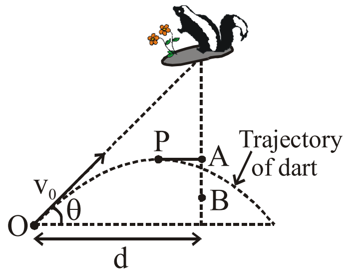
$\vec{F}_4$ =F (always towards x-axis)

	Column I		**Column II**
(A)	Work done by $\vec{F}_1$	(P)	$\sqrt{2}FR$
(B)	Work done by $\vec{F}_2$	(Q)	$\frac{1}{\sqrt{2}}FR$
(C)	Work done by $\vec{F}_3$	(R)	FR
(D)	Work done by $\vec{F}_4$	(S)	$\frac{\pi FR}{2}$
		(T)	$\frac{2FR}{\pi}$

95. A block is projected with an initial velocity v_{Block} on a long conveyor belt moving with velocity v_{Belt} (at that instant) having constant acceleration a_{Belt} . Mark the correct option regarding friction **after long time** (friction coefficient between block and belt = μ). If :

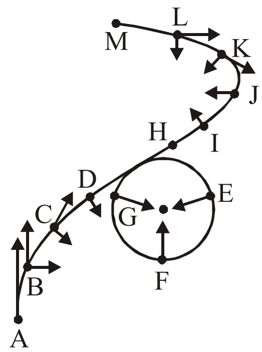
	Column-I		**Column-II**
(A)	$v_{Block} = 2v_{Belt}$ and $a_{Belt} = 0$	(P)	zero
(B)	$v_{Block} = 2v_{Belt}$ and $a_{Belt} > \mu g$	(Q)	f_s static friction ($0 < f_s < f_L$)
(C)	$v_{Block} = 2v_{Belt}$ and $a_{Belt} = \mu g$	(R)	f_L limiting friction
(D)	$v_{Block} = 2v_{Belt}$ and $a_{Belt} < \mu g$	(S)	f_K kinetic friction

96. A dart gun is fired towards a squirrel hanging from a tree. Dart gun was initially directed towards squirrel. P is maximum height attained by dart in its flight. Three different events can occur. (Assume squirrel to be a particle and there is no air resistance).



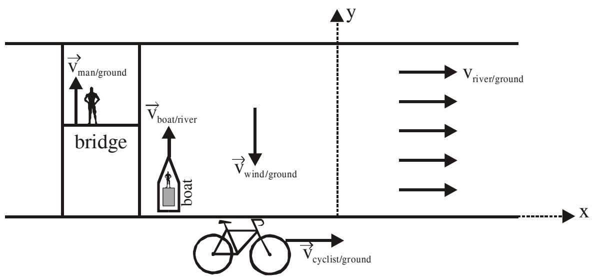
Column-I	Column-II
(A) Event -1 :Squirrel drops itself before the gun is fired.	(P) When dart is at P Squirrel may be at A
(B) Event - 2 : Squirrel drops itself at same time when the gun is fired.	(Q) When dart is at P Squirrel may be at B
(C) Event - 3 : A strong wind imparts same constant horizontal acceleration to squirrel and dart in addition to gravitational acceleration. Squirrel drops itself at the same instant as the gun is fired	(R) In gravity free space dart will hit Squirrel.
	(S) Dart cannot hit Squirrel in presence of gravity

97. Figure shows the path of an ice skater beginning from rest at A to rest at M. The heavy dots along the path indicate the position of the skater every 2 s. On the curved path are shown approximate directions and magnitudes for the tangential and centripetal acceleration of several points by arrows. Column-II gives comparison of first quantity with second quantity in given order



Column - I	Column - II
(A) Greater	(P) Segment length ABCD and DEFG
(B) Smaller	(Q) If radius of curvature in segment ABCD and JKLM is equal, magnitude of average tangential acceleration in segment ABCD and JKLM
(C) Equal	(R) Speed at points H and J
(D) Cannot be compared	(S) Radius of curvature at points D and E
	(T) Acceleration at points F and G

98. Figure shows a river flowing towards right, there is a bridge over river perpendicular to flow. A boat starts perpendicular to flow with velocity $\vec{v}_{B/W}$ Column II shows required relative velocity and column I gives the possible directions.



	Column I		Column II
(A)	→	(P)	Direction of velocity boat relative to a person moving on bridge in y > 0 direction.
(B)	↙	(Q)	Direction of flutter of flag relative to an observer on boat if wind is flowing towards y < 0 direction.
(C)	↖	(R)	Direction of velocity boat as seen by a cyclist moving on river bank along x > 0 direction.
(D)	↘	(S)	Direction of velocity of man on bridge relative to person on boat
		(T)	Direction of velocity of cyclist relative to person on boat

99. Column II shows some small objects that are our system. The forces acting are expressed by vectors $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$. In all the cases $\vec{F}_3$ represents force of gravity. Match the situations given in column I within their appropriate discriptions in column I. All the bodies are in equilibrium initially.

Column I

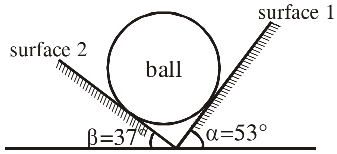
(A) $\vec{F}_1 + \vec{F}_2 = -\vec{F}_3$

(B) $F_1^2 + F_2^2 = F_3^2$

(C) If suddenly $\vec{F}_3$ is removed then instantaneous acceleration of system is zero.

(D) If force of gravity $\vec{F}_3$ is reversed in direction then the instantaneous acceleration of the system is upward.

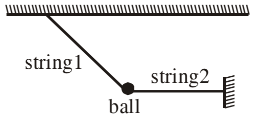
Column II

(P) 

Ball is system

$\vec{F}_1$ normal reaction of surface 1

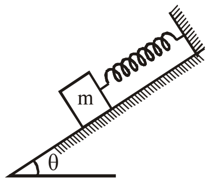
$\vec{F}_2$ normal reaction of surface 2

(Q) 

Ball is system

$\vec{F}_1$ tension in string 1

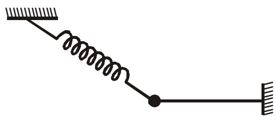
$\vec{F}_2$ tension in string 2

(R) 

Block is system

$\vec{F}_1$ normal reaction

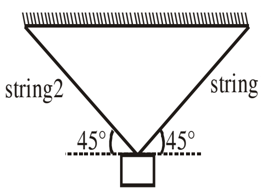
$\vec{F}_2$ spring force

(S) 

Ball is system

$\vec{F}_1$ force of spring

$\vec{F}_2$ force of string

(T) 

y

Block is system

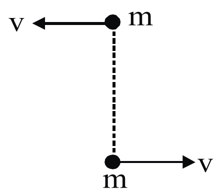
$\vec{F}_1$ tension in string 1

$\vec{F}_2$ tension in string 2

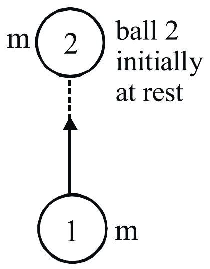
100. Column I describes the system and initial motion of its particles and column II gives characteristics associated with subsequent motion.

Column I	**Column II**
(A) Two identical particles under influence of mutual gravitational force only. Particles are given initial velocity perpendicular to line joining as shown.	(P) Centre of mass of system does not accelerate.
(B) Two identical balls on a smooth table. Elastic head on collision takes place.	(Q) In centre of mass frame momentum of system is zero.
(C) Two identical balls on a smooth table. Oblique elastic collision takes place.	(R) Momentum of system is conserved.
(D) Block is released on a wedge as shown in figure. All the surfaces are smooth.	(S) Mechanical energy of system is conserved
	(T) Total kinetic energy is constant

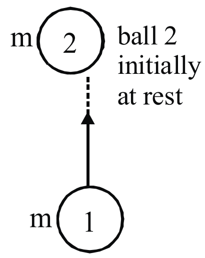
(A)



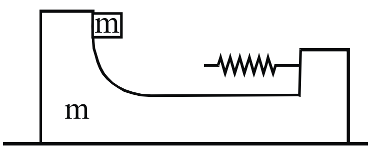
(B)



(C)

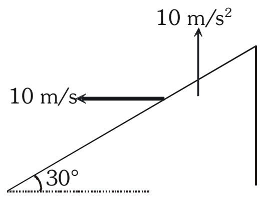


(D)

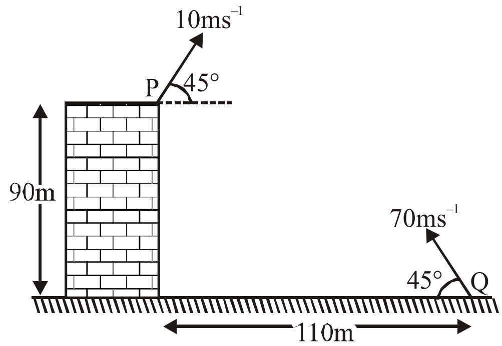


EXERCISE # (S)

1. A particle is projected horizontally with velocity 10 m/s from an inclined plane. Incline plane starts moving with acceleration 10 m/s^2 vertically upward as shown. The time (in second) after which particle will land on the plane is given by $\frac{1}{\sqrt{n}}$s. Find the value of n. (g = 10 m/s^2)

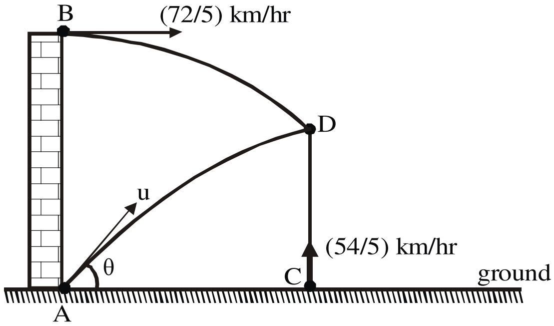


2. Two particles P and Q are launched simultaneously as shown in figure. Find the minimum distance between particles in meters.

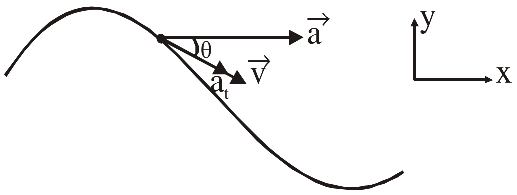


3. A particle is projected from ground towards a vertical wall 80 m away at an angle of 37° with horizontal with initial velocity of 50 m/s. After its collision with wall & then once with ground find at what distance in meter from wall will it strike the ground. The component of velocity normal to the surface becomes half after collision with each surface.

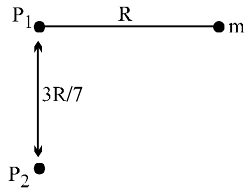
4. In the given figure points A and C are on the horizontal ground & A and B are in same vertical plane. Simultaneously bullets are fired from A, B and C and they collide at D. The bullet at B is fired horizontally with speed of $\frac{72}{5}$ km/hr and the bullet at C is projected vertically upward at velocity of $\frac{54}{5}$ km/hr. Find velocity of the bullet projected from A in m/s.



5. A particle moves with a tangential acceleration $a_t = \vec{a}.\hat{v}$ where $\vec{a} = (5\hat{i})$ m/s². If the speed of the particle is zero at x=0, then find v (in m/s) at x = 4.9 m.

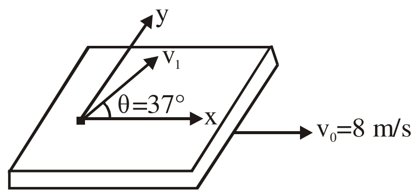


6. A simple pendulum consists of a bob of mass m and a string of length R suspended from a peg P_1 on the wall. A second peg P_2 is fixed vertically below the first one at a distance $3R/7$ from it. The pendulum is drawn aside such that the string is horizontal and released. Calculate the maximum height (with respect to the lowest point) to which it rises

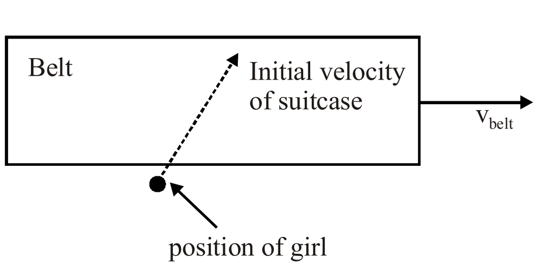


7. A transparent lift A is going upwards with velocity 20 ms^{-1} and retarding at the rate of 8 ms^{-2}. Second transparent lift B is located in front of it and is going down at 10 ms^{-1} with retardation of 2 ms^{-2}. At the same instant a bolt from the ceiling of lift A drops inside lift A. If height of car of lift A is 16 m then find the distance travelled by bolt as observed by a person in lift B till the time it collides with floor of lift A.

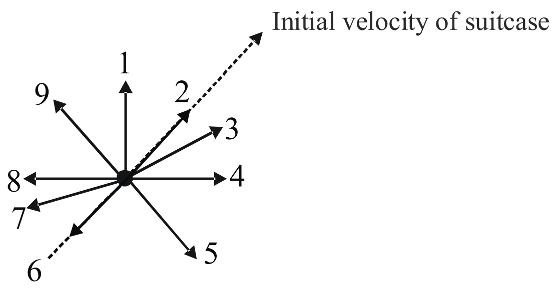
8. A board is being moved with a cosntant velocity v_0 on a smooth horizontal plane. A small block is projected on the rough boards. Coefficient of friction between board and block is μ=0.3. Block is projected with velocity v_1 = 25 m/s at an angle of θ= 37° relative to ground. What is the velocity of block (in m/s) relative to ground after time t= 10 sec.



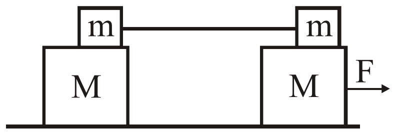
9. A girl is standing on ground near a horizontally moving conveyor belt. She throws her suitcase horizontally. Such that the initial velocity of suitcase relative to stationary girl is along dotted line shown in top view of conveyor belt.



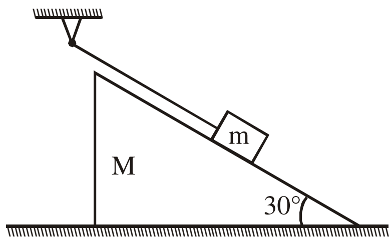
Which of the following arrows (1 to 9) best represents direction of friction at initial moment.



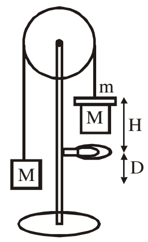
10. Four blocks are arranged on a smooth horizontal surface as shown. The masses of the blocks are given (see the diagram). The coefficient of static friction between the top and the bottom blocks is μ_s. What is the maximum value of the horizontal force F, applied to one of the bottom blocks as shown, that makes all four blocks move with the same acceleration?



11. A block of mass m = 1 kg is connected with an ideal string as shown in figure. If the string is parallel to incline at the instant of release, find the ratio of acceleration of m to that of M = 2kg instanteously. Consider all the surface to be smooth.

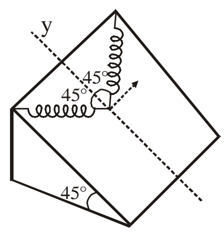


12. Atwood's machine was an apparatus that allowed a direct verification of Newton's second law. It could also be used to measure g. Two equal blocks of mass M hang at either side of a pulley; see figure. A small square rider of mass m is placed on one block. When the block is released, it accelerates for a distance H till the rider is caught by a ring that allows the block to pass. From then on the system moves at constant speed which is measured by timing the fall through a distance D. t is the time moved at constant speed. Find the value of g. [Given : M = 4 kg, m = 1 kg, D = 2m, H = 2m, t = 1 s]

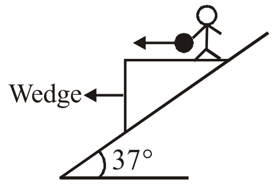


13. In the figure shown a plank of length L = 16 m, mass m_2 = 5 kg rests on a smooth surface. Upper surface of plank is rough with coefficient of kinetic friction μ_k = 0.5 and static friction μ_s = 0.6. A small block of mass m_1 = 2 kg is placed over it. A force F of magnitude 30 N is applied on block m_1. What is displacement of plank (in m) till the small block falls over from plank ?

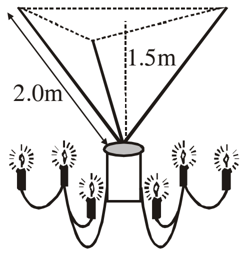
14. Figure shows a ball of mass m connected with two ideal springs of force constant k, kept in equilibrium on a smooth incline, suddenly right spring is cut. What is magnitude of instantaneous acceleration (in m/s^2) of ball.



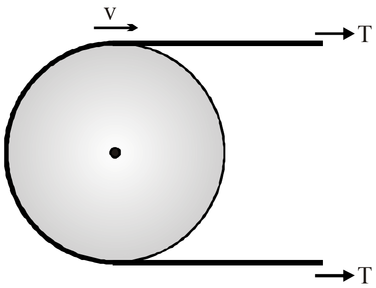
15. A wedge can slide frictionlessly on a fixed incline of angle 37°. A girl who is strapped on the wedge [no relative motion between wedge and girl] pushes a small ball of negligible mass on the horizontal smooth upper surface of wedge as shown in figure. Ball is pushed at the same instant as the motion of wedge starts. Initial velocity of ball is 12 m/s relative to wedge. Find the time (in sec) after which ball returns to girl. Assume that horizontal surface of wedge is very long.



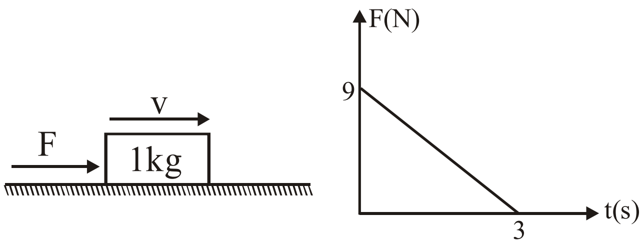
16. A 45 kg chandelier is suspended 1.5 m below a ceiling by three identical wires, each of which has the same tension and the same length of 2.0 m (see the drawing). Find the tension in each wire.



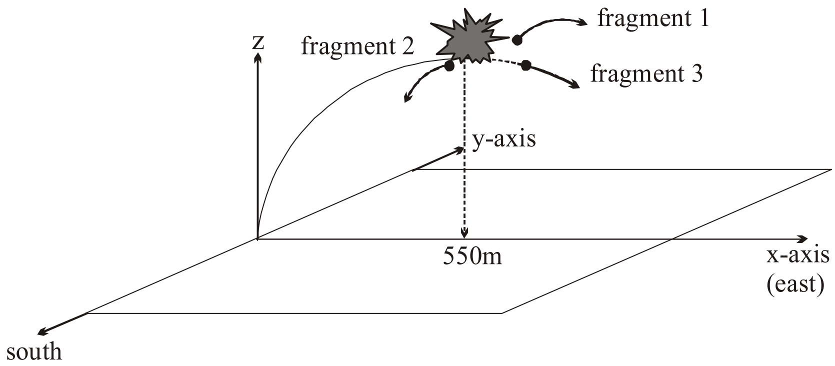
17. A flexible drive belt runs over a frictionless flywheel (see Figure). The mass per unit length of the drive belt is 1 kg/m, and the tension in the drive belt is 10N. The speed of the drive belt is 2m/s. The whole system is located on a horizontal plane. Find the normal force (in N) exerted by the belt on the flywheel.



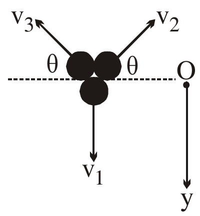
18. A 1 kg block moving on horizontal rough surface of friction coefficient 0.6 is pushed with a force varying with time t in seconds as shown in figure. If initial velocity of block was 4.5 m/s. Find the velocity (in m/s) at t = 3 s.



19. A Diwali rocket going vertically up, explodes at the topmost point of its trajectory, at horizontal distance 550 m from the point of projection see figure. When the fragments strike the ground one of the fragments is found at a location 550 m east and 120m north of the launch point. Second fragment is found at a location 550m east and 60 m south of the launch point. First two fragments are of equal mass m and third fragment has mass 2m. All the three fragments struck the ground simultaneously. Take x-axis as east and y-axis as north, point of projection as origin. The location of the third fragment with respect to origin when it strikes ground is $x\hat{i}+y\hat{j}$ (in m). Fill $\left|\frac{x}{11y}\right|$ in your answer sheet.



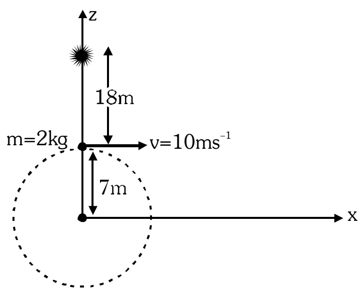
20. A rocket is projected straight up and explodes into three equally massive fragments just as it reaches the top of its flight (refer figure). One of the fragments is observed to come straight down in 2 sec, while the other two take 4 sec to come to ground, after the burst. Find the height h (in m) at which the fragmentation occurred.



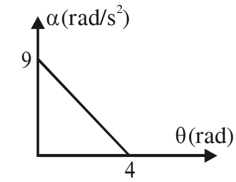
21. A projectile is projected from horizontal ground with velocity 18 km/hr at an angle of 60° from horizontal. Find angular speed (in rad/s) as observed from the point of projection at the time of landing. [$g = 10\ m/s^2$]

22. A particle is moving in a circle of radius R in such a way that at any instant the normal and the tangential component of its acceleration are equal. If its speed at t=0 is v_0 then the time it takes to complete the first revolution is $\frac{R}{\alpha v_0}\left(1-e^{-\beta\pi}\right)$. Find the value of $(\alpha+\beta)^6$.

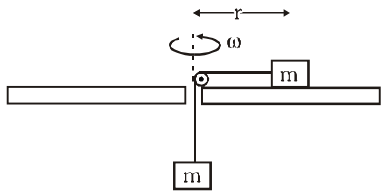
23. A particle of mass m is moving with constant speed in a vertical circle in X–Z plane. There is a small bulb at some distance on Z–axis. The maximum distance of the shadow of the particle on X–axis is found $\alpha\left(\frac{25}{24}\right)$. Find the value of α.



24. A particle starts moving in a non-uniform circular motion, has angular acceleration as shown in figure. The angular velocity at the end of 4 radian is given by ω rad/s then find the value of ω.



25. Two equal masses m are attached by a string. One mass lies at radial distance r from the center of a horizontal turntable which rotates with constant angular velocity ω, while the second hangs from the strings inside the turntable's hollow spindle (see figure). The coefficient of static friction between the turntable and the mass lying on it is $\mu_s = 0.5$. The maximum and minimum values r_{max}, r_{min} of r such that the mass lying on the turntable does not slide. Find the ratio of r_{max} / r_{min} ?



26. There are three blocks of masses $m_1 = m$, $m_2 = 4m$ and $m_3 = m$. If two block system is kept over a smooth hemisphere with two different arrangement one by one as shown in figure (i) & (ii) respectively are connected with massless & inextensible string. In arrangement figure (i), after releasing the system from rest acceleration of blocks is found to be $\left(a = \frac{5\sqrt{3}}{2}\right) m/s^2$. In second arrangement block m_1 & m_2 are kept symmetrically. Find the acceleration of block (in m/s²) after releasing the system from rest according to figure (ii).

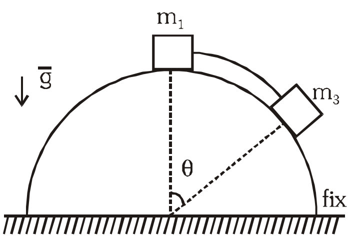


fig. (i)

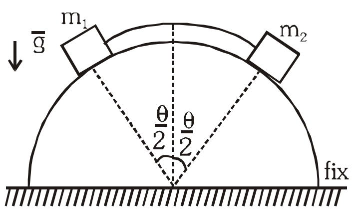
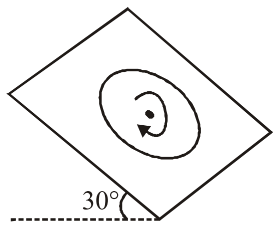
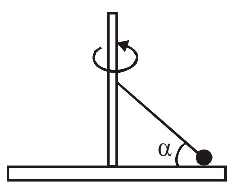


fig. (ii)

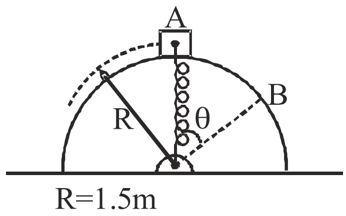
27. An old record player of 10 cm radius turns at 10 rad/s while mounted on a 30° incline as shown in the figure. A particle of mass m can be placed any where on the rotating record. If the least possible coefficient of friction μ that must exist for no slipping to occur is μ, find $2\sqrt{3}\,\mu$.



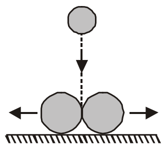
28. A circular platform rotates around a vertical axis with angular velocity ω = 10 rad/s. On the platform is a ball of mass 1 kg, attached to the long axis of the platform by a thin rod of length 10 cm (α = 30°). Find normal force exerted by the ball on the platform (in newton). Friction is absent.



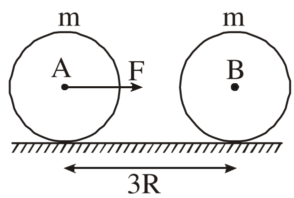
29. A 2 kg block is gently pushed from rest at A and it slides down along the fixed smooth circular surface as shown in figure. If the attached spring has a force constant k = 20 N/m. What is unstretched length of spring (in m) so that it does not allow the block to leave the surface until angle with the vertical is $\theta = 60°$.



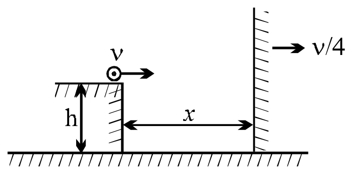
30. Two identical balls of mass M and radius R are placed in contact with each other on a frictionless horizontal surface as shown. The third ball of mass M and radius R/2 moves vertically downward and hits the two balls symmetrically with speed $\sqrt{5}$ m/s and comes to rest. Find the speed of any one of the bigger balls after collision if bigger balls are moving horizontally after collision.



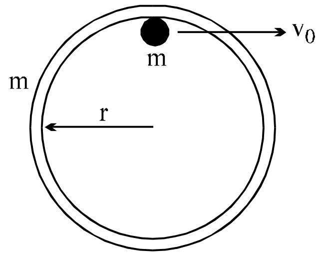
31. Two identical spheres A & B of mass 50 kg and radius 1 m each lie on a smooth horizontal surface as shown in figure. The initial distance between their centres is 3 m. Starting from t = 0 a constant force F = 100 N acts on the sphere A towards right. The coefficient of restitution is e = 0.5. Find the time interval (in sec) between the first collision and the instant after which collision between both the spheres cease.



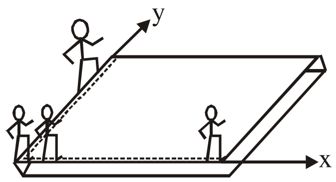
32. A particle is thrown from a height h horizontally towards a vertical wall moving away with a speed v as shown in the figure. If the particle returns to the point of projection after suffering two elastic collisions, one with the wall and another with the ground, find the total time of flight and initial separation x between the particle and the wall.



33. A small body of mass m is at rest inside a thin, narrow tyre of mass m and radius r which is lying on a horizontal table with its plane horizontal. How does the centre of mass of the system move if the small body is given a tangential initial velocity v_0 at t = 0, as shown in figure? If after time T the velocity of tyre becomes zero, then find T. Find magnitude of velocity of ball at t = T/6. (Neglect friction everywhere)

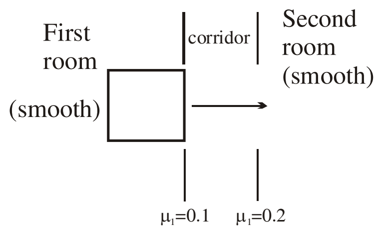


34. A square plank of mass m_1 = 100 kg and edge length L = $20\sqrt{2}$ m is placed on a smooth surface. Two person each of mass $m_2 = m_3 = 50$ kg are at corner of a plank as shown in figure. Two person begin to walk on the plank along two different paths as shown in figure and reach nearest corners. What is magnitude of displacement of plank (in m) in the process.



35. A block of mass $m = \frac{1}{3}$ kg is kept on a rough horizontal plane. Friction coefficient is $\mu = 0.75$. The work done by minimum force required to drag the block along the plane by a distance 5 m, is W joule, then find the value of W.

36. A square carpet of a mass of 20 kg is dragged from one room into another as shown in the figure. The width of the corridor and the carpet is the same, 2m. The friction coefficient is 0.1 at the end of the first room and 0.2 at the other end, in the corridor it changes linearly from 0.1 to 0.2. The carpet presses the floor uniformly. If the amount of work that must be done to drag the carpet slowly from the first room to the other is x Joules. Find the value of x.



37. A particle of mass 2kg moves on a smooth horizontal plane under the action of a single force $\vec{F} = (30\hat{i} + 40\hat{j})$N. Under this force it is displaced from (0,0) to (100m,100m). If the initial speed of the particle is $\sqrt{3000}$ m/s then find out its final speed in m/s.

ANSWER KEY

EXERCISE # (O)

1. Ans. (A)	2. Ans. (B, D)	3. Ans. (A)	4. Ans. (B,C,D)
5. Ans. (A,D)	6. Ans. (A, B, C)	7. Ans. (A, B, D)	8. Ans. (A)
9. Ans. (A)	10. Ans. (A,B,C)	11. Ans. (B)	12. Ans. (A)
13. Ans. (B)	14. Ans. (A,C,D)	15. Ans. (C)	16. Ans. (B)
17. Ans. (D)	18. Ans. (B,D)	19. Ans. (C)	20. Ans. (A)
21. Ans. (D)	22. Ans. (D)	23. Ans. (D)	24. Ans. (A)
25. Ans. (C)	26. Ans. (C)	27. Ans. (B,D)	28. Ans. B
29. Ans. (C)	30. Ans. (A,C,D)	31. Ans. (A,C)	32. Ans. (D)
33. Ans. (B)	34. Ans. (D)	35. Ans. (C)	36. Ans. (B)
37. Ans. (A,C,D)	38. Ans. (C)	39. Ans. (C)	40. Ans. (D)
41. Ans. (D)	42. Ans. (C)	43. Ans. (C)	44. Ans. (B)
45. Ans. (A)	46. Ans. (A)	47. Ans. (A)	48. Ans. (D)
49. Ans. (C)	50. Ans. (C)	51. Ans. (B)	52. Ans. (A)
53. Ans. B	54. Ans. B	55. Ans. B	56. Ans. (D)
57. Ans. (A)	58. Ans. (D)	59. Ans. (D)	60. Ans. (A)
61. Ans. (D)	62. Ans. (C)	63. Ans. (A)	64. Ans. (A)
65. Ans. (B)	66. Ans. (B)	67. Ans. (A)	68. Ans. (C)
69. Ans. (A)	70. Ans. A	71. Ans. A	72. Ans.A
73. Ans. (D)	74. Ans. (A)	75. Ans. (B)	76. Ans. (A)
77. Ans. (A)	78. Ans. (A)	79. Ans. (D)	80. Ans. (B)
81. Ans. (D)	82. Ans. (D)	83. Ans. (C)	84. Ans. (D)
85. Ans. (B)	86. Ans. (A)	87. Ans. (D)	

88. Ans. (A) → (P,Q) ; (B) → (P,Q,S) ; (C) → (P,Q,R) ; (D) → (P,Q,R)

89. Ans. (A) → (P,S,T) ; (B) → (P,R) ; (C) → (P,R,S,T) ; (D) → (P)

90. Ans. (A) → (Q) ; (B) → (P,Q,T) ; (C) → (P,T) ; (D) → (P,R,S)

91. Ans. (A) → (P,Q,R,T) ; (B) → (P,Q,R,S,T) ; (C) → (P) ; (D) → (Q,R, S,T)

92. Ans. (A) → (Q,R) ; (B) → (Q,R) ; (C) → (P,R) ; (D) → (Q,R,T)

93. Ans. (A) → (T) ; (B) → (P) ; (C) → (R) ; (D) → (Q)

94. Ans. (A) → (R); (B) → (Q) ; (C) → (S) ; (D) → (R)

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

96. Ans. (A) → (R,Q,S) ; (B) → (P,R) ; (C) → (P,R)

97. Ans. (A) → (S) ; (B) → (P) ; (C) → (Q, R) ; (D) → (T)

98. Ans. (A) → (P) ; (B) → (Q,S,T) ; (C) → (R,S) ; (D) → (P,T)

99. Ans. (A) → (P,Q,R,S,T) ; (B) → (P,R,T) ; (C) → (P,Q,T) ; (D) → (P,Q,S,T)

100. Ans. (A) → (P,Q,R,S) ; (B) → (P,Q,R,S) ; (C) → (P,Q,R,S) ; (D) → (Q,S)

ANSWER KEY

EXERCISE # (S)

1. Ans. 3	**2. Ans. 6**	**3. Ans. 140**	**4. Ans. 5**
5. Ans. 7	**6. Ans: 27R/28**	**7. Ans. 51 m**	**8. Ans. 8**
9. Ans. 5	**10. Ans.** $F = 2\mu_s mg\left(\frac{m+M}{2m+M}\right)$		**11. Ans. 2**
12. Ans. 9	**13. Ans. 4**	**14. Ans. 5**	**15. Ans. 5**
16. Ans. 200 N	**17. Ans. 12 N**	**18. Ans. 0**	**19. Ans. 5**
20. Ans. 50	**21. Ans. 2**	**22. Ans. 729**	**23. Ans. 9**
24. Ans. 6	**25. Ans. 3**	**26. Ans. 3**	**27. Ans. 6**
28. Ans. 5	**29. Ans. 1**	**30. Ans. 1**	**31. Ans. 2**
32. Ans. $T = 2\sqrt{\frac{2h}{g}}$, $x = v\sqrt{\frac{h}{2g}}$		**33. Ans. straight line,** $\frac{2\pi r}{v_0}$, $\frac{\sqrt{3}v_0}{2}$	
34. Ans. 10	**35. Ans. 8**	**36. Ans. 60**	**37. Ans. 100**