BLOOM | BSO Bloom School Olympiad

CLASS 11

# Bloom Physics Olympiad
# Sample Paper

**Maximum Time : 60 Minutes** **Maximum Marks : 60**

## INSTRUCTIONS

1. There are 50 Multiple Choice Questions in this paper divided into two sections :

   **Section A** 40 MCQs; 1 Mark each

   **Section B** 10 MCQs; 2 Marks each

2. Each question has Four Options out of which **ONLY ONE** is correct.
3. All questions are compulsory.
4. There is no negative marking.
5. No electric device capable of storing and displaying visual information such as calculator and mobile is allowed during the course of the exam.

Roll No.

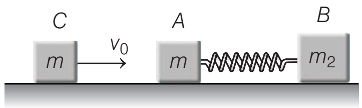
Student's Name

## **Section-A** (1 Mark each)

**1.** A particle of mass $m$ is projected from the surface of earth with velocity $v = 2v_e$, where $v_e$ is the value of escape velocity from the surface of earth. The velocity of the particle on reaching to interstellar space (at infinity) in terms of $v_e$ will be equal to

(a) $\sqrt{3}\ v_e$
(b) $\sqrt{5}\ v_e$
(c) $\sqrt{2.5}\ v_e$
(d) $\sqrt{4.75}\ v_e$

**2.** Two blocks $A$ and $B$ of masses $m$ and $2m$ respectively are placed on a smooth floor. They are connected by a spring. A third block $C$ of mass $m$ moves with a velocity $v_0$ along the line joining $A$ and $B$ and collides elastically with $A$, as shown in figure. At a certain instant of time $t_0$ after collision, it is found that the instantaneous velocities of $A$ and $B$ are the same. Further, at this instant the compression of the spring is found to be $x_0$. The spring constant of the spring is




(a) $\frac{2}{3}\frac{mv_0^2}{x_0^2}$
(b) $\frac{3}{2}\frac{mv_0^2}{x_0^2}$
(c) $\frac{4}{5}\frac{mv_0^2}{x_0^2}$
(d) $\frac{5}{4}\frac{mv_0^2}{x_0^2}$

**3.** 1 g mole of oxygen at 27°C and 1 atmospheric pressure is enclosed in a vessel. Assuming the molecules are moving with $v_{rms}$. Then, the value of $v_{rms}$ is

(a) 483 m/s
(b) 336 m/s
(c) 239 m/s
(d) 537 m/s

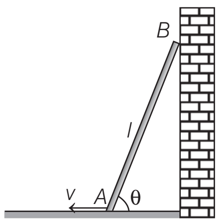
**4.** Two resistance 60.36 Ω and 30.09 Ω are connected in parallel. The equivalent resistance is

(a) $20 \pm 0.08\ \Omega$
(b) $20 \pm 0.06\ \Omega$
(c) $20 \pm 0.03\ \Omega$
(d) $20 \pm 0.10\ \Omega$

**5.** At a distance 20 m from a point source of sound the loudness level is 30 dB. Neglecting the damping. The value of loudness at 10 m from the source will be

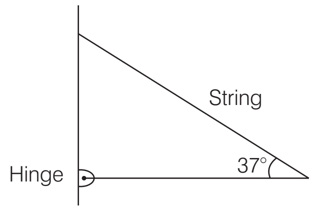
(a) 30 dB
(b) 40 dB
(c) 36 dB
(d) 25 dB

**6.** Figure shows a rod of length $l$ resting on a wall and the floor. Its lower end $A$ is pulled towards left with a constant velocity $v$. The velocity of the other end $B$ downward when the rod makes an angle $\theta$ with the horizontal is




(a) $v_B = v\cot\theta$
(b) $v_B = v\tan\theta$
(c) $v_B = v\cos\theta$
(d) $v_B = v\sin\theta$

**7.** The rod shown in figure has a mass of 2 kg and length 4 m. In equilibrium. The horizontal component of hinge force (or its two components) acting on the rod and tension in the string respectively, is (take, $g = 10\,m/s^2$, $\sin 37^\circ = \frac{3}{5}$ and $\cos 37^\circ = \frac{4}{5}$)




(a) 13.33 N, 16.67 N
(b) 16.67 N, 13.33 N
(c) 17.50 N, 18.50 N
(d) 18.5 N, 17.50 N

**8.** An aeroplane has to go from a point $P$ to another point $Q$, 1000 km away due north. Wind is blowing due east at a speed of 200 km/h. The air speed of plane is 500 km/h. Find the direction in which the pilot should head the plane to reach the point and the time taken by the plane to go from $P$ to $Q$.

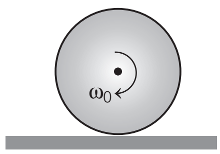
(a) $\theta = \sin^{-1}(0.4)$, west of north, $\frac{10}{\sqrt{21}}$ h

(b) $\theta = \cos^{-1}(0.4)$, west of north, $\frac{10}{\sqrt{22}}$ h

(c) $\theta = \sin^{-1}(0.4)$, north of west, $\frac{10}{\sqrt{22}}$ h

(d) $\theta = \cos^{-1}(0.4)$, north of west, $\frac{10}{\sqrt{21}}$ h

**9.** A solid sphere of radius $r$ is gently placed on a rough horizontal ground with an initial angular speed $\omega_0$ and no linear velocity. If the coefficient of friction is $\mu$, the linear velocity $v$ and angular velocity $\omega$ at the end of slipping are

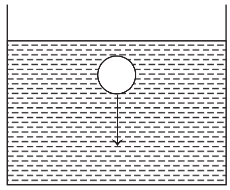



(a) $\frac{2}{7} r\omega_0, \frac{2}{7}\omega_0$
(b) $\frac{2}{5} r\omega_0, \frac{2}{5}\omega_0$
(c) $\frac{3}{4} r\omega_0, \frac{3}{4}\omega_0$
(d) $\frac{5}{6} r\omega_0, \frac{5}{6}\omega_0$

**10.** In Searle's experiment, which is used to find Young's modulus of elasticity, the diameter of experimental wire is $D = 0.05$ cm (measured by a scale of least count 0.001 cm) and length is $L = 110$ cm (measured by a scale of least count 0.1 cm). A weight of 50 N causes an extension of $l = 0.125$ cm (measured by a micrometer of least count 0.001 cm). What is the maximum possible error in the values of Young's modulus. If screw gauge and meter scale are free from error.

(a) 0.0498
(b) 0.0458
(c) 0.0489
(d) 0.0562

**11.** A ball of volume $V$ and density $\rho_1$ is moved downwards by a distance $d$ in liquid of density $\rho_2$. The change in potential energy of the system is equal to



(a) $\Delta U = V(\rho_2 - \rho_1)\frac{gd}{2}$ (b) $\Delta U = V(\rho_2 - \rho_1)\, gd$

(c) $\Delta U = V(\rho_2 - \rho_1)\frac{gd}{3}$ (d) $\Delta U = V(\rho_2 + \rho_1) gd$

**12.** A street car moves rectilinearly from station $A$ to the next station $B$ (from rest to rest) with an acceleration varying according to the law $f = a - bx$, where $a$ and $b$ are constants and $x$ is the distance from station $A$. The distance between the two stations is

(a) $x = \frac{2a}{b}$ (b) $x = \frac{b}{2a}$

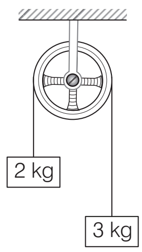
(c) $x = \frac{a}{2b}$ (d) $x = \frac{a}{b}$

**13.** A fighter plane moving in a vertical loop with constant speed of radius $R$. The centre of the loop is at a height $h$ directly overhead of an observer standing on the ground. The observer receives maximum frequency of the sound produced by the plane when it is nearest to him. The value of the speed of the plane is equal to (velocity of sound in air is $v$).

(a) $\frac{R\theta}{\sqrt{h^2 - R^2}} v$, where, $\theta = \cos^{-1}\left(\frac{R}{h}\right)$ (b) $\frac{h\theta}{\sqrt{h^2 - R^2}} v$, where, $\theta = \cos^{-1}\left(\frac{h}{R}\right)$

(c) $\frac{R\theta}{\sqrt{h^2 - R^2}} v$, where, $\theta = \cos^{-1}\left(\frac{h}{R}\right)$ (d) $\frac{h\theta}{\sqrt{h^2 - R^2}} v$, where, $\theta = \cos^{-1}\left(\frac{R}{h}\right)$

**14.** The system of two masses 2 kg and 3 kg as shown in the figure is released from rest. The work done on 3 kg block by the force of gravity during first 2 s of its motion is (take, $g = 10\ \text{ms}^{-2}$)

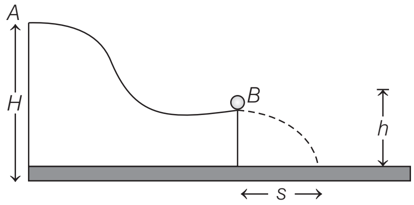



(a) 120 J (b) 80 J (c) 40 J (d) 30 J

**15.** A body is projected from the ground at an angle of $\tan^{-1}\left(\frac{8}{7}\right)$ with the horizontal. The ratio of the maximum height attained by it to its range is

(a) 8 : 7 (b) 4 : 7 (c) 2 : 7 (d) 1 : 7

**16.** A small disc $A$ slides down with initial velocity equal to zero from the top of a smooth hill of height $H$ having a horizontal portion. What must be the height of the horizontal portion $h$ to ensure the maximum distance $s$ covered by the disc?




(a) $\frac{H}{2}$ (b) $\frac{H}{4}$ (c) $\frac{H}{3}$ (d) $\frac{3H}{2}$

**17.** A mono atomic gas performs a thermodynamic process according to the equation, $p = \frac{a}{T}$ (where $a$ is constant).

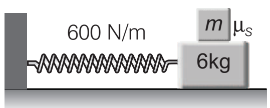
The molar specific heat of the gas in the process is

(a) $\frac{5}{2}R$ (b) $\frac{7}{2}R$ (c) $3R$ (d) $\frac{3}{2}R$

**18.** A spherical body of density $\rho$ is floating half immersed in a liquid of density $d$. If $\sigma$ is the surface tension of the liquid, then the radius of the body is

(a) $\sqrt{\frac{3\sigma}{g(2\rho - d)}}$ (b) $\sqrt{\frac{6\sigma}{g(2\rho - d)}}$ (c) $\sqrt{\frac{4\sigma}{g(2\rho - d)}}$ (d) $\sqrt{\frac{12\sigma}{g(2\rho - d)}}$

**19.** With the assumption of no slipping, determine the mass $m$ of the block which must be placed on the top of a 6 kg cart in order that the system period is 0.75 s. (Take, $g = 9.8 \text{ m/s}^2$)




(a) $m = 4.5$ kg (b) $m = 4.5$ kg (c) $m = 2.55$ kg (d) $m = 2.55$ kg

**20.** An air bubble starts rising from the bottom of a lake. Its diameter is 3.6 mm at the bottom and 4 mm at the surface. The depth of the lake is 250 cm and the temperature at the surface is 40°C. What is the temperature at the bottom of the lake? Give atmospheric pressure = 76 cm of Hg and $g = 980 \text{ cm/s}^2$.

(a) 10.37°C (b) 20.5°C (c) 26.5°C (d) 15.75°C

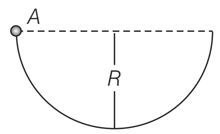
**21.** The temperature of $n$-moles of an ideal gas is increased from $T_0$ to $2T_0$ through a process $p = \frac{\alpha}{T}$. The amount of work done in this process is

(a) $3nRT_0$ (b) $4nRT_0$ (c) $5nRT_0$ (d) $2nRT_0$

**22.** In a system, unit of mass is $A$ kg, length is $B$ m and time is $C$ s, then the value of 10 N in this system is

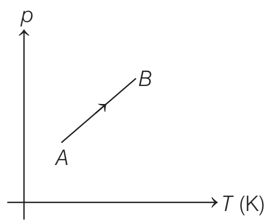
(a) $10\, A^{-1}B^{-1}C^{-2}$ (b) $10\, A^{-1}B^{-1}C^{2}$ (c) $10\, ABC^{-2}$ (d) $5A^{-1}BC^{2}$

**23.** A small solid cylinder of radius $r$ is released coaxially from point $A$ inside the fixed large cylindrical bowl of radius $R$ as shown in figure. If the friction between the small and the large cylinder is sufficient enough to prevent any slipping. What is the normal force exerted by the small cylinder on the larger one when it is at the bottom?



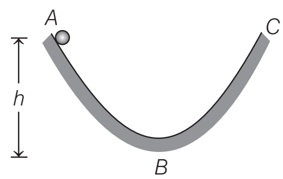

(a) $\frac{4}{3}mg$ (b) $\frac{7}{3}mg$ (c) $\frac{4}{5}mg$ (d) $\frac{5}{4}mg$

**24.** The $p$ - $T$ graph for the given mass of an ideal gas is shown in figure. What inference can be drawn regarding the change in volume (whether it is constant, increasing or decreasing)?



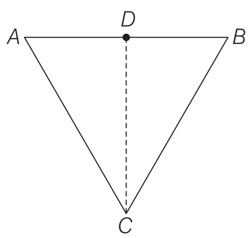

(a) $V_B < V_A$ (b) $V_B > V_A$ (c) $V_A = V_B$ (d) $V_A = \frac{V_B}{2}$

**25.** A solid ball rolls down a parabolic path $ABC$ from a height $h$ as shown in figure. Portion $AB$ of the path is rough while $BC$ is smooth. How high will the ball climb in $BC$?




(a) $\frac{5}{8}h$ (b) $\frac{5}{6}h$ (c) $\frac{5}{7}h$ (d) $\frac{4}{5}h$

**26.** As shown in the figure, an equilateral triangle $ABC$ is formed by joining three rods of equal lengths and $D$ is the midpoint of $AB$. Coefficient of linear expansion of the material of $AB$ is $\alpha_1$ and that of $AC$ and $BC$ is $\alpha_2$. If the length $DC$ remains constant for small changes in temperature, then

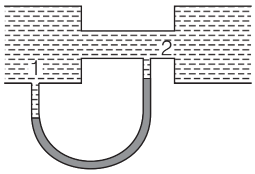



(a) $\alpha_1 = \alpha_2$ (b) $\alpha_1 = 4\alpha_2$ (c) $\alpha_2 = 4\alpha_1$ (d) $\alpha_1 = \frac{\alpha_2}{2}$

**27.** A box is moved along a straight line by a machine delivering constant power. The distance moved by the body in time $t$ is proportional to

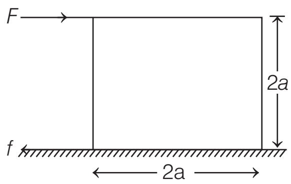
(a) $t^{\frac{1}{2}}$ (b) $t^{\frac{3}{4}}$ (c) $t^{\frac{3}{2}}$ (d) $t^{2}$

**28.** Water flows through the tube as shown in figure. The areas of cross-section of the wide and the narrow portions of the tube are 5 $cm^2$ and 2 $cm^2$, respectively. The rate of flow of water through the tube is 500 $cm^3$/s. What is the difference of mercury levels in the U-tube.




(a) 1.96 cm (b) 1.75 cm (c) 1.52 cm (d) 1.45 cm

**29.** For the given dimensions shown in figure, the critical value of coefficient of friction $\mu$ will be




(a) $\frac{1}{2}$ (b) $\frac{1}{3}$ (c) $\frac{1}{4}$ (d) $\frac{1}{5}$

**30.** A body is projected at an angle of 45° from a point on the ground at a distance of 30 m from the foot of a vertical pole of height 20 m. The body just crosses the top of the pole and strikes the ground at a distance $s$ from the foot of the pole on the other side of the pole. Then, $s$

(a) 20 m (b) 30 m (c) 50 m (d) 60 m

**31.** An explosion blows a stationary rock into three parts. Two parts of masses 1 kg and 2 kg moves at right angles to one another with velocities 12 $ms^{-1}$ and 8 $ms^{-1}$, respectively. If the velocity of third part is 4 $ms^{-1}$, the mass of the rock is

(a) 8 kg (b) 5 kg (c) 17 kg (d) 3 kg

**32.** A sound wave of frequency $f$ travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed $v$. The speed of sound in medium is $c$ then,

(a) the number of waves striking the surface per second is $f\frac{(c+v)}{c}$

(b) the wavelength of reflected wave is $\frac{c(c+v)}{f(c-v)}$

(c) the frequency of the reflected wave is $f\frac{(c-v)}{(c+v)}$

(d) (a), (b), and (c) are correct

**33.** A siren emitting a sound of frequency 1000 Hz moves away from you towards a cliff at a speed of 10 m/s. What is frequency of the sound, you hear coming directly from the siren?

(a) 970.6 Hz (b) 950.5 Hz (c) 850.25 Hz (d) 870.6 Hz

**34.** Carnot engine takes one thousand kilo calories of heat from a reservoir at 827°C and exhausts it to a sink at 27°C. The work done by the Carnot engine and its efficiency, respectively are

(a) $7.28 \times 10^4$ cal, 72.72% (b) $7.28 \times 10^5$ cal, 72.72%

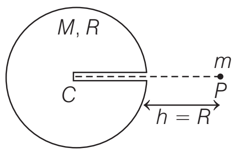
(c) $6.28 \times 10^5$ cal, 75.72% (d) $6.28 \times 10^4$ cal, 75.72%

**35.** A projectile is given an initial velocity of $(\hat{\mathbf{i}} + 2\hat{\mathbf{j}})\ \text{ms}^{-1}$. The equation of its path is (take, $g = 10\ \text{ms}^{-2}$)

(a) $y = 2x - 5x^2$ (b) $y = x - 5x^2$

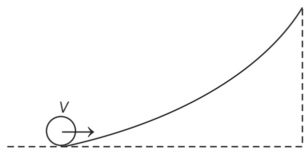
(c) $4y = 2x - 5x^2$ (d) $y = 2x - 25x^2$

**36.** There is a smooth tunnel upto centre $C$ of a solid sphere of mass $M$ and radius $R$. A particle of mass $m(< M)$ is released from point $P$ along the line $CP$. The velocity of $m$ while striking at $C$ will be




(a) $\sqrt{\frac{GM}{R}}$ (b) $\sqrt{\frac{5GM}{R}}$ (c) $\sqrt{\frac{3GM}{R}}$ (d) $\sqrt{\frac{2GM}{R}}$

**37.** A small object of uniform density rolls up a curved surface with an initial velocity $v$. It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is




(a) ring (b) solid sphere

(c) hollow sphere (d) disc

**38.** A closed organ pipe of length $L$ and an open organ pipe contain gases of densities $\rho_1$ and $\rho_2$, respectively. The compressibility of gases are equal in both the pipes. both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is

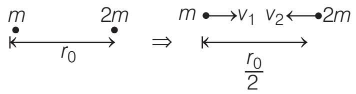
(a) $\frac{L}{3}$ (b) $\frac{4L}{3}$

(c) $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (d) $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

**39.** The temperature of source and sink of a heat engine are 127°C and 27°C, respectively. An inventor claims its efficiency to be 26%, then

(a) it is impossible
(b) it is possible with high probability
(c) it is possible with low probability
(d) Data are insufficient

**40.** In the figure shown in the text, $m_1 = m, m_2 = 2m$ and initial distance between them is $r_0$. What are the velocities of the masses when spearation between them becomes $\frac{r_0}{2}$?




(a) $v_1 = 2\sqrt{\frac{3Gm}{4r_0}}, v_2 = \sqrt{\frac{2Gm}{3r_0}}$
(b) $v_1 = 2\sqrt{\frac{4Gm}{3r_0}}, v_2 = \sqrt{\frac{3Gm}{4r_0}}$
(c) $v_1 = 2\sqrt{\frac{2Gm}{3r_0}}, v_2 = \sqrt{\frac{2Gm}{3r_0}}$
(d) $v_1 = 2\sqrt{\frac{3}{5}\frac{Gm}{r_0}}, v_2 = \sqrt{\frac{3Gm}{5r_0}}$

## Section-B (2 Marks each)

***Directions*** *(Q. Nos. 41-44) These questions consist of two statements each linked as Assertion and Reason. While answering these questions you are required to choose any one of the following responses.*

(a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are true but Reason is not correct explanation of Assertion.
(c) If Assertion is true but Reason is false.
(d) If Assertion is false but Reason is true.

**41.** **Assertion** Young's modulus decreases with the increase of temperature.

**Reason** Interatomic potential energy decrease with the increase in temperature.

**42.** **Assertion** The restoring force $F$ on a stretched string at extension $x$ is related to the potential energy $U$ as $F = -\frac{dU}{dx}$

**Reason** $F = -kx$ and $U = \frac{1}{2}kx^2$, where $k$ is the spring constant.

**43.** **Assertion** The equivalent thermal conductivity of two plates of same thickness in contact is less than the smaller value of thermal conductivity.

**Reason** For two plates of equal thickness in contact, the equivalent thermal conductivity is given by $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2}$

**_44._** **Assertion** When the gas expands adiabatically, its temperature rises.

**Reason** During adiabatic expansion the gas does work at the expense of internal energy.

***Directions*** (Q. Nos. 45-47) *These questions are based on the following situation. Choose the correct options from those given below.*

While visiting friends at cal state chico, Ram pay a visit to the Crazy Horse Saloon. This fine establishment features a 200 kg mechanical bucking bull, that has a mechanism that makes it move vertically in SHM. Whether the bull has a rider or not it moves with same amplitude (0.5 m) and frequency (1.5 Hz). After watching other saloon patrons hold on the bull while riding. Ram (mass 50 kg) decide it to ride the macho way by not holding on. No one is terribly surprised when you come out of the saddle. Later while waiting for your bruises and pride to heal, you pass the time by calculating.

**_45._** If you leave the saddle when it is moving upward. The magnitude of down ward acceleration of the saddle is ______ when you lose contact with it.

(a) $6\ \text{ms}^{-2}$ (b) $7.2\ \text{ms}^{-2}$
(c) $9.8\ \text{ms}^{-2}$ (d) $12.2\ \text{ms}^{-2}$

**_46._** How high is the saddle surface above the equilibrium position when first time Ram become air borne?

(a) 0.5 m (b) 0.25 m
(c) 0.16 m (d) 0.11 m

**_47._** To what time Ram remain air borne (free fall) until Ram return to the saddle?

(a) 0.582 s (b) 1.25 s
(c) 0.483 s (d) 1.92 s

***Directions*** (Q. Nos. 48-49) *In the following questions, a statement I is followed by a corresponding statement II. Of the following statements, choose the correct one.*

These questions consists of two statements I and II. While answering these questions you are required to choose any one of the following four responses.

(a) Both Statement I and Statement II are correct and Statement II is the correct explanation of Statement I.

(b) Both Statement I and Statement II are correct but Statement II is not the correct explanation of Statement I.

(c) Statement I is correct but Statement II is incorrect.

(d) Statement I is incorrect but Statement II is correct.

**_48._** **Statement I** In isobaric process, $\dfrac{\Delta Q}{\Delta W}$ for helium gas is $\dfrac{5}{2}$.

**Statement II** In isobaric process, work done by the gas is $nR\Delta T$.

**_49._** **Statement I** In one dimensional motion of a body, the angle between acceleration and velocity is always zero.

**Statement II** One dimensional motion is along straight line.

***50.*** Match the following columns.

| | Column I | | Column II |
|---|---|---|---|
| A. | Steel | p. | Young's modulus of elasticity |
| B. | Water | q. | Bulk modulus of elasticity |
| C. | Hydrogen gas filled in a chamber | r. | Shear modulus of elasticity |

***Codes***

| | A | B | C |
|---|---|---|---|
| (a) | p | q | r |
| (b) | p | p | q |
| (c) | p | q | q |
| (d) | p | r | r |

# Answers with Hints

**1.** (a) $v_e = \sqrt{\frac{2GM}{R}} \Rightarrow \frac{GM}{R} = \frac{v_e^2}{2}$ ... (i)

Using conservation of mechanical energy at the surface of earth and infinity.

We have, $K_f + U_f = K_i + U_i$

$$\Rightarrow \quad \frac{1}{2}mv_\infty^2 + 0 = \frac{1}{2}m(2v_e)^2 - \frac{GMm}{R} \quad \text{... (ii)}$$

Substituting the value of $\frac{GM}{R} = \frac{v_e^2}{2}$

From Eqs. (i) and (ii), we get

$$v_\infty = \sqrt{3}v_e$$

**2.** (a) Initially, the blocks $A$ and $B$ are at rest and $C$ is moving with velocity $v_0$ to the right. As masses of $C$ and $A$ are same and the collision is elastic hence, the body $C$ transfers its whole momentum $mv_0$ to body $A$ and as a result the body $C$ stops and $A$ starts moving with velocity $v_0$ to the right. At this instant the spring is uncompressed and the body $B$ is still at rest.

The momentum of the system at this instant $= mv_0$

Now, the spring is compressed and the body $B$ comes in motion. After time $t_0$, the compression of the spring is $x_0$ and common velocity of $A$ and $B$ is $v$ (say).

As external force on the system is zero, the law of conservation of linear momentum gives

$$mv_0 = mv + (2m)v \text{ or } v = \frac{v_0}{3}$$

The law of conservation of energy gives

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + \frac{1}{2}(2m)v^2 + \frac{1}{2}kx_0^2$$

or
$$\frac{1}{2}mv_0^2 = \frac{3}{2}mv^2 + \frac{1}{2}kx_0^2$$

$$\frac{1}{2}mv_0^2 = \frac{3}{2}m\left(\frac{v_0}{3}\right)^2 + \frac{1}{2}kx_0^2$$

$\therefore$
$$\frac{1}{2}kx_0^2 = \frac{1}{2}mv_0^2 - \frac{1}{6}mv_0^2$$

or
$$\frac{1}{2}kx_0^2 = \frac{1}{3}mv_0^2$$

$$k = \frac{2}{3}\frac{mv_0^2}{x_0^2}$$

**3.** (a) Mass of one oxygen molecule,

$$m = \frac{M}{N_A} = \frac{32}{6.02 \times 10^{23}} \text{ g}$$

$$= 5.316 \times 10^{-23} \text{ g} = 5.316 \times 10^{-26} \text{ kg}$$

$$v_{\text{rms}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 300}{5.316 \times 10^{-26}}} \quad (\text{as } T = 27 + 273 = 300 \text{ K})$$

$$= 483.35 \text{ m/s} \simeq 483 \text{ m/s}$$

**4.** (a) Parallel resistance is

$$R_{\text{parallel}} = \frac{R_1R_2}{R_1+R_2} = \frac{60 \times 30}{60+30} = 20\Omega$$

and tolerance value is

$$\Rightarrow \qquad \Delta R_P = R_P\left(\frac{\Delta R_1}{R_1} + \frac{\Delta R_2}{R_2} - \frac{\Delta R_1 + \Delta R_2}{R_1 + R_2}\right)$$

$$= 20\left(\frac{0.36}{60} + \frac{0.09}{30} - \frac{0.36+0.09}{90}\right)$$

$$= 20\,(0.006 + 0.003 - 0.005)$$

$$= 0.08\,\Omega$$

So, equivalent resistance, $R_P = 20 \pm 0.08\,\Omega$

**5.** (c) Intensity due to a point source varies with distance $r$ from it as

$$I \propto \frac{1}{r^2} \quad \text{or} \quad \frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$$

Now, $L_1 = 10 \log \dfrac{I_1}{I_0}$

and $L_2 = 10 \log \dfrac{I_2}{I_0}$

$$\therefore \qquad L_1 - L_2 = 10\left[\log \frac{I_1}{I_0} - \log \frac{I_2}{I_0}\right]$$

$$= 10 \log \frac{I_1}{I_2} = 10 \log \left(\frac{r_2}{r_1}\right)^2$$

Substituting, $L_1 = 30$ dB, $r_1 = 20$ m and $r_2 = 10$ m

we have, $30 - L_2 = 10 \log \left(\dfrac{10}{20}\right)^2 = -6.0$

or $\qquad L_2 = 36$ dB

**6.** (a) In such type of problems, when velocity of one part of a body is given and that of other is required, we first the relation between the two displacements, then differentiate them with respect to time. Here, if the distance from the corner to the point $A$ is $x$ and that up to $B$ is $y$. Then,

$$v_A = \frac{dx}{dt}$$

and $v_B = -\dfrac{dy}{dt}$ (– sign denotes that $y$ is decreasing)

Further, $x^2 + y^2 = l^2$

Differentiating with respect to time $t$

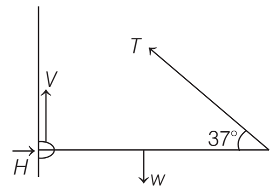
$$2x\frac{dx}{dt} + 2y\frac{dy}{dt} = 0$$

$$xv_A + yv_B = 0$$

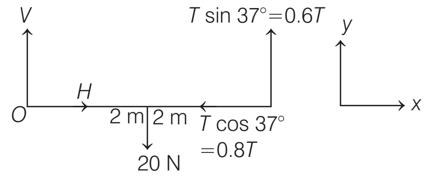
$$v_A = -\frac{y}{x}v_B = -\cot\theta \cdot v$$

$$\therefore \qquad |v_A| = v\cot\theta$$

**7.** (a)




In the figure, only those forces which are acting on the rod has been shown. Here $H$ and $V$ are horizontal and vertical components of the hinge force.




$$\Sigma F_x = 0 \quad \Rightarrow \quad H - 0.8T = 0 \qquad \text{... (i)}$$

$$\Sigma F_y = 0 \quad \Rightarrow \quad V + 0.6T - 20 = 0 \qquad \text{... (ii)}$$

$$\Sigma \tau_0 = 0$$

$\Rightarrow$ Clockwise torque of 20 N = Anti-clockwise torque of 0.6 $T$.

All other forces ($H, V$ and 0.8 $T$ pass through $O$, hence their torques are zero).

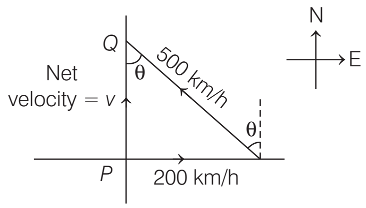
$\therefore$

$$20 \times 2 = 0.6T \times 4 \qquad \text{... (iii)}$$

Solving Eqs. (i), (ii) and (iii), we get

$$T = 16.7 \text{ N}, \; H = 13.33 \text{ N} \; \text{ and } \; V = 10 \text{ N}$$

**8.** (a) $\sin\theta = \dfrac{200}{500} = 0.4$




$\therefore$

$$\theta = \sin^{-1}(0.4), \text{ west of north}$$

$$v = \sqrt{(500)^2 - (200)^2}$$

$$= 100\sqrt{21} \text{ km/h}$$

$\therefore$

$$t = \frac{PQ}{v} = \frac{1000}{100\sqrt{21}} = \frac{10}{\sqrt{21}} \text{ h}$$

**9.** (a) Let $m$ be the mass of the sphere.

Since, it is a case of backward slipping, therefore force of friction is in forward direction. Limiting friction will act in this case.

Linear acceleration $a = \dfrac{f}{m} = \dfrac{\mu m g}{m} = \mu g$

Angular retardation $\alpha = \dfrac{\tau}{I} = \dfrac{f \cdot r}{\frac{2}{5} m r^2} = \dfrac{5}{2} \dfrac{\mu g}{r}$

Slipping is ceased when $v = r\omega$

or

$$(at) = r(\omega_0 - \alpha t)$$

or $$\mu g t = r\left(\omega_0 - \frac{5}{2}\frac{\mu g t}{r}\right) \quad \text{or} \quad \frac{7}{2}\mu g t = r\omega_0$$

$\Rightarrow$ $$t = \frac{2}{7}\frac{r\omega_0}{\mu g}$$

$\therefore$ $$v = at = \mu g t = \frac{2}{7} r\omega_0$$

and $$\omega = \frac{v}{r} = \frac{2}{7}\omega_0$$

**10.** (c) Young's modulus of elasticity is given by

$$Y = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{l/L} = \frac{FL}{lA} = \frac{FL}{l\left(\frac{\pi d^2}{4}\right)}$$

Substituting the values, we get

$$Y = \frac{50 \times 1.1 \times 4}{(1.25 \times 10^{-3}) \times \pi \times (5.0 \times 10^{-4})^2}$$

$$= 2.24 \times 10^{11}\ \text{N/m}^2$$

Now, $\dfrac{\Delta Y}{Y} = \dfrac{\Delta L}{L} + \dfrac{\Delta l}{l} + 2\dfrac{\Delta d}{d}$

$$= \left(\frac{0.1}{110}\right) + \left(\frac{0.001}{0.125}\right) + 2\left(\frac{0.001}{0.05}\right) = 0.0489$$

**11.** (b) Decrease in potential energy of the ball

$$= m_1 g h \qquad (m_1 = \text{mass of ball})$$
$$= (V\rho_1) g d$$

or $$\Delta U_1 = -V\rho_1 g d$$

When $V$ volume of solid comes down, then it is replaced by $V$ volume of liquid.

$\therefore$ Increase in potential energy of liquid

$$= m_2 g h \qquad (m_2 = \text{mass of liquid of volume})$$
$$= (V\rho_2) g d$$

$\therefore$ $$\Delta U_2 = +V\rho_2 g d$$

Total change in potential energy,

$$\Delta U = \Delta U_1 + \Delta U_2 = V(\rho_2 - \rho_1) g d$$

**12.** (a) $f = v \cdot \dfrac{dv}{dx} = a - bx$

or $$\int_0^v v\,dv = \int_0^x (a - bx)\,dx$$

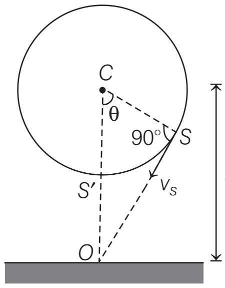
$\therefore$ $$v = \sqrt{2ax - bx^2} \qquad \text{... (i)}$$

At other station, $v = 0$

$\Rightarrow$ $$x = \frac{2a}{b}$$

**13.** (a) Let the speed of the plane (source) be $v_s$. Maximum frequency will be observed by the observer when $v_s$ is along $SO$. The observer receives maximum frequency when the plane is nearest to him.

That is as soon as the wave pulse reaches from $S$ to $O$ with speed $v$ the plane reaches from $S$ to $S'$ with speed $v_s$. Hence,




$$t = \frac{SO}{v} = \frac{SS'}{v_s} \quad \text{or} \quad v_s = \left(\frac{SS'}{SO}\right) v$$

$$= \frac{R\theta}{\sqrt{h^2 - R^2}} v$$

Where, $\theta = \cos^{-1}\left(\frac{R}{h}\right)$

**14.** (a) This is the example of Atwood machine, so acceleration is the system

$$a = \left(\frac{M - m}{M + m}\right) g = \left(\frac{3-2}{3+2}\right) \times 10$$

$$a = \frac{1}{5} \times 10 = 2 \text{ m/s}^2$$

Now, $$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 2\,(2)^2 \qquad (\because\ u = 0)$$

$\Rightarrow$ $$s = 4 \text{ m}$$

Work done on block of 3 kg by gravity

$$W = Mgs = 3 \times 10 \times 4$$

$$W = 120 \text{ J}$$

**15.** (c) For a projectile projected at angle $\theta$,

Maximum height, $H_{max} = \dfrac{u^2 \sin^2 \theta}{2g}$

and range, $R = \dfrac{u^2 \sin 2\theta}{g}$

$\therefore$ $$\text{Ratio} = \frac{H_{max}}{R} = \frac{\left(\frac{u^2 \sin^2 \theta}{2g}\right)}{\left(\frac{u^2 \sin 2\theta}{g}\right)} = \frac{\tan\theta}{4}$$

Here, $$\theta = \tan^{-1}\frac{8}{7} \Rightarrow \tan\theta = \frac{8}{7} = \frac{\frac{8}{7}}{4} = \frac{2}{7}$$

**16.** (a) In order to obtain the velocity at point $B$, we apply the law of conservation of energy.

So, Loss in PE = Gain in KE

or $$mg(H - h) = \frac{1}{2}mv^2$$

$\therefore \quad v = \sqrt{[2g(H-h)]}$

Further $\quad h = \frac{1}{2}gt^2$

$\therefore \quad t = \sqrt{(2h/g)}$

Now, $\quad s = v \times t = \sqrt{[2g(H-h)]} \times \sqrt{(2h/g)}$

or $\quad s = \sqrt{[4h(H-h)]}$

For maximum value of $s = \frac{ds}{dh} = 0$

$\therefore \quad \frac{1}{2\sqrt{[4h(H-h)]}} \times 4(H-2h) = 0 \quad$ or $\quad h = \frac{H}{2}$

**17.** (b) We know that, $dQ = dU + dW$

$$\text{Specific heat, } C = \frac{dQ}{dT} = \frac{dU}{dT} + \frac{dW}{dT} \quad \text{... (i)}$$

Since, $\quad dU = C_V dT \quad$ ... (ii)

$$C = C_V + \frac{dW}{dT}$$

$$= C_V + \frac{pdV}{dT}$$

$$pV = RT$$

$\therefore$ For the given process, $V = \frac{RT}{p} = \frac{RT^2}{a}$

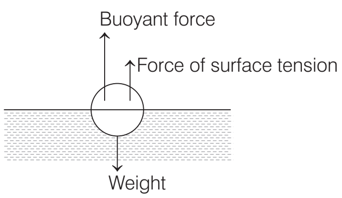
$$\frac{dV}{dT} = \frac{2RT}{a}$$

$$C = C_V + p\left(\frac{2RT}{a}\right)$$

$$= C_V + 2R$$

$$= \frac{3}{2}R + 2R = \frac{7}{2}R$$

**18.** (a)




Weight of body = Buoyant force + Force of surface tension

$$\frac{4}{3}\pi r^3 \rho \times g = \frac{2}{3}\pi r^3 dg + 2\pi r\sigma$$

$$\frac{2}{3}\pi r^3 g(2\rho - d) = 2\pi r\sigma$$

So, $\quad r^2 = \frac{3\sigma}{g(2\rho - d)}$

So, $\quad r = \sqrt{\frac{3\sigma}{g(2\rho - d)}}$

**19.** (c) $T = 2\pi\sqrt{\dfrac{m+6}{600}}$ $\left(T = 2\pi\sqrt{\dfrac{m}{K}}\right)$

or $$0.75 = 2\pi\sqrt{\frac{m+6}{600}}$$

$\therefore$ $$m = \frac{(0.75)^2 \times 600}{(2\pi)^2} - 6 = 2.55 \text{ kg}$$

**20.** (a) At the bottom of the lake, volume of the bubble

$$V_1 = \frac{4}{3}\pi r_1^3 = \frac{4}{3}\pi(0.18)^3 \text{ cm}^3$$

Pressure on the bubble $p_1$ = Atmospheric pressure + Pressure due to a column of 250 cm of water

$$= 76 \times 13.6 \times 980 + 250 \times 1 \times 980$$
$$= (76 \times 13.6 + 250)\ 980 \text{ dyne/cm}^2$$

At the surface of the lake, volume of the bubble

$$V_2 = \frac{4}{3}\pi r_2^3 = \frac{4}{3}\pi(0.2)^3 \text{ cm}^3$$

Pressure on the bubble, $p_2$ = Atmospheric pressure

$$= (76 \times 13.6 \times 980) \text{ dyne/cm}^2$$
$$T_2 = 273 + 40^\circ\text{C}$$
$$= 313^\circ\text{K}$$

Now, $\dfrac{p_1V_1}{T_1} = \dfrac{p_2V_2}{T_2}$

or $$= \frac{(76 \times 13.6 + 250)980 \times \left(\frac{4}{3}\right)\pi(0.18)^3}{T_1}$$

$$= \frac{(76 \times 13.6) \times 980\left(\frac{4}{3}\right)\pi(0.2)^3}{313}$$

or $T_1 = 283.37 \text{ K}$

$\therefore$ $T_1 = 283.37 - 273 = 10.37^\circ\text{C}$

**21.** (d) $pV = nRT$ (ideal gas equation) ...(i)

and $$p = \frac{\alpha}{T} \quad \text{... (ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$V = \frac{nRT^2}{\alpha} \quad \text{or} \quad dV = \frac{2nRT}{\alpha}dT$$

$\therefore$ $$W = \int_{V_i}^{V_f} p\,dV = \int_{T_0}^{2T_0}\left(\frac{\alpha}{T}\right)\left(\frac{2nRT}{\alpha}\right)dT$$

$$= 2nRT_0$$

**22.** (b) Using, $N_1 u_1 = N_2 u_2$

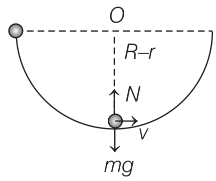
$$10 = N_2 \left( \frac{A \cdot B}{C^2} \right)$$

$$\Rightarrow \quad N_2 = \frac{10 \cdot C^2}{A \cdot B}$$

$$= 10 A^{-1} B^{-1} C^2$$

So, numerical value of 10 N in given system is $10A^{-1}B^{-1}C^2$.

**23.** (b) $K_{\text{trans}} = \frac{1}{2} mv^2$




$$K_{\text{rot}} = \frac{1}{2} I\omega^2 = \frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v}{r}\right)^2 = \frac{1}{4}mv^2$$

$$K = K_{\text{trans}} + K_{\text{rot}} = \frac{3}{4}mv^2$$

$$\therefore \quad \frac{K_{\text{trans}}}{K} = \frac{2}{3} \Rightarrow \frac{K_{\text{rot}}}{K} = \frac{1}{3}$$

From conservation of energy,

$$mg(R - r) = \frac{3}{4}mv^2$$

$$\therefore \quad \frac{mv^2}{R - r} = \frac{4}{3}mg$$

Now, $N - mg = \frac{mv^2}{R - r} = \text{centripetal force} = \frac{4}{3}mg$

$$\therefore \quad N = \frac{7}{3}mg$$

**24.** (b) From the given graph, we can write the $p - T$ equation as

$$p = aT + b \qquad (y = mx + c)$$

Here, $a$ and $b$ are positive constants. Further,

$$\frac{p}{T} = a + \frac{b}{T}$$

Now, $T_B > T_A$

$$\therefore \quad \frac{b}{T_B} < \frac{b}{T_A} \quad \text{or} \quad \left(\frac{p}{T}\right)_B < \left(\frac{p}{T}\right)_A$$

$$\text{or} \quad \left(\frac{T}{p}\right)_B > \left(\frac{p}{T}\right)_A \quad \text{or} \quad V_B > V_A$$

**25.** (c) At $B$, total kinetic energy $= mgh$

Here, $m =$ mass of ball

The ratio of rotational to translational kinetic energy would be, $\frac{K_R}{K_T} = \frac{2}{5}$

$$\therefore \quad K_R = \frac{2}{7}mgh$$

$$\text{and} \quad K_T = \frac{5}{7}mgh$$

In portion $BC$, friction is absent. Therefore, rotational kinetic energy will remain constant and translational kinetic energy will convert into potential energy. Hence, if $H$ be the height to which ball climbs in $BC$, then

$$mgH = K_T \quad \text{or} \quad mgH = \frac{5}{7}mgh \quad \text{or} \quad H = \frac{5}{7}h$$

**26.** (b) For a change of temperature by $t$, change in length $DC$ is $\Delta DC$, then $\Delta DC^2 = \Delta AC^2 - \Delta AD^2$

$$= l(1+\alpha_2 t)^2 - \left[\frac{l}{2}(1+\alpha_2 t)\right]^2$$

$$= l^2(2\alpha_2 t) - \frac{l^2}{4}(2\alpha_1 t)$$

(After neglecting terms $\alpha_2^2 t^2$ and $\alpha_1^2 t^2$, being very small)

As, $\Delta DC = 0 \Rightarrow l^2\, 2\alpha_2 t - \frac{l^2}{4}(2\alpha_1 t) = 0$

$\Rightarrow$ $\alpha_1 = 4\alpha_2$

**27.** (c) We are given that, a box is moved along a straight line by a machine under constant power.

So, we have power, $P = Fv = mav$

$$P = m\frac{dv}{dt}v \quad \text{or} \quad \int v\,dv = \int \frac{P}{m}dt$$

$\Rightarrow$ $\frac{v^2}{2} = \frac{Pt}{m} \Rightarrow v = \sqrt{\frac{2P}{m}t}$

$\Rightarrow$ $\frac{dx}{dt} = \sqrt{\frac{2P}{m}t}$ $\quad \left[\because v = \frac{dx}{dt}\right]$

$\Rightarrow$ $\int dx = \sqrt{\frac{2P}{m}}\int t^{1/2}dt$

$\Rightarrow$ $x = \sqrt{\frac{2P}{m}}\frac{t^{3/2}}{3/2}$

$\Rightarrow$ $x \propto t^{3/2}$

**28.** (a) Applying continuity equation

$$A_1v_1 = A_2v_2 = \text{Rate of flow of water.}$$

$$5v_1 = 2v_2 = 500\ \text{cm}^3/\text{s}$$

$\therefore$ $v_1 = 100\ \text{cm/s} = 1.0\ \text{m/s}$

$v_2 = 250\ \text{cm/s} = 2.5\ \text{m/s}$

Now, applying Bernoulli's equation at 1 and 2

$$p_1 + \frac{1}{2}\rho_w v_1^2 + \rho_w gh_1 = p_2 + \frac{1}{2}\rho_w v_2^2 + \rho_w gh_2 \qquad (h_1 = h_2)$$

$\Rightarrow$ $\frac{1}{2}\rho_w(v_2^2 - v_1^2) = p_1 - p_2 = \rho_{Hg}gh_{Hg}$

or $\frac{1}{2}\rho_w(v_2^2 - v_1^2) = \rho_{Hg}\,gh_{Hg}$

$\therefore$ $h_{Hg} = \frac{\rho_w(v_2^2 - v_1^2)}{2\rho_{Hg}g} = \frac{10^3(6.25-1)}{2\times 13.6\times 10^3\times 9.8}$

$= 0.0196\ \text{m} = 1.96\ \text{cm}$

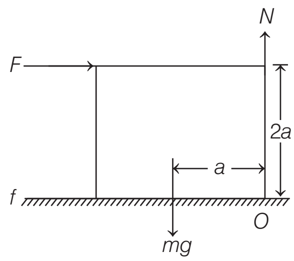
**29.** (a) Condition of sliding

The block will slide if, $F > \mu N$

but $N = mg$ ($m$ = mass of the block)

$\therefore$ $F > \mu mg$ ...(i)

Condition of toppling




Block will topple about an axis passing through $O$ and perpendicular to plane of paper if, clockwise torque of $F >$ anti-clockwise torque of $mg$

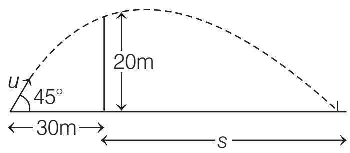
$\therefore$ $$F(2a) > (mg)(a)$$

or $$F > \frac{1}{2}mg \quad \text{...(ii)}$$

From Eqs. (i) and (ii), we can see that,

$$\mu_{cr} = \frac{1}{2}$$

**30.** (d) According to the question, projection of a body shown in the figure below,




Now, from the above figure, let $t$ be the time of crossing of pole,

then, $$30 = t\,u\cos 45° \quad \text{...(i)}$$

and $$20 = u\sin 45°\, t - \frac{10}{2}t^2 \quad \text{...(ii)}$$

Hence, $30\sqrt{2} = ut$ and

$\Rightarrow$ $$20 = \frac{u}{\sqrt{2}}t - 5t^2$$

$\Rightarrow$ $$t = \sqrt{2}\text{ s} \quad \text{and} \quad u = 30\text{ m/s}$$

Hence, $R = \dfrac{u^2 \sin 2\theta}{g} = \dfrac{30 \times 30 \times \sin 90°}{10} = 90$ m

$\therefore$ Distance between pole and the point at which body strike on the ground,

$\Rightarrow$ $$s = (90 - 30) = 60\text{ m}$$

**31.** (a) Given, $m_1 = 1$ kg, $m_2 = 2$ kg, $v_1 = 12\text{ ms}^{-1}$, $v_2 = 8\text{ ms}^{-1}$ and $v_3 = 4\text{ ms}^{-1}$

Since, in the explosion of stationary rock, the momentum is conserved,

so $$\mathbf{p}_i = \mathbf{p}_f$$
$$0 = \mathbf{p}_f = \mathbf{p}_1 + \mathbf{p}_2 + \mathbf{p}_3$$

where, $\mathbf{p}_1 = m_1\mathbf{v}_1, \mathbf{p}_2 = m_2\mathbf{v}_2$ and $\mathbf{p}_3 = m_3\mathbf{v}_3$

$$\mathbf{p}_3 = -(\mathbf{p}_1 + \mathbf{p}_2)$$

$$\mathbf{p}_3 = \sqrt{\mathbf{p}_1^2 + \mathbf{p}_2^2 + 2\mathbf{p}_1 \cdot \mathbf{p}_2 \cos\theta}$$

$$\mathbf{p}_3 = \sqrt{12^2 + 16^2 + 2 \times 12 \times 16 \cos 90^\circ}$$

$$\mathbf{p}_3 = 20$$

$$m_3 v_3 = m_3 \times 4 = 20 \quad \Rightarrow m_3 = 5 \text{ kg}$$

Hence, the mass of the rock is,

$$m = m_1 + m_2 + m_3$$

$$m = 1 + 2 + 5 = 8 \text{ kg}$$

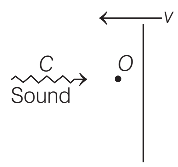
**32.** (a) Moving plane is like a moving observer. Therefore, number of waves encountered by moving plane,

$$f_1 = f\left(\frac{v + v_0}{v}\right) = f\left(\frac{c + v}{c}\right)$$

Frequency of reflected wave,

$$f_2 = f_1\left(\frac{v}{v - v_s}\right) = f\left(\frac{c + v}{c - v}\right)$$

Wavelength of reflected wave, $\lambda_2 = \frac{c}{f_2} = \frac{c}{f}\left(\frac{c - v}{c + v}\right)$




Beat frequency, $f_b = f_2 - f$

$$= f\left(\frac{c + v}{c - v}\right) - f = \frac{2fv}{c - v}$$

Therefore, the only correct option is (a).

**33.** (a) Sound heard directly

$$f_1 = f_0\left(\frac{v}{v + v_s}\right)$$

$\Rightarrow$ $$v_s = 10 \text{ m/s}$$

$\therefore$ $$f_1 = \left(\frac{330}{330 + 10}\right) \times 1000$$

$$= 970.6 \text{ Hz}$$

**34.** (b) Given, $Q_1 = 10^6$ cal

$$T_1 = (827 + 273) = 1100 \text{ K}$$

and $$T_2 = (27 + 273) = 300 \text{ K}$$

as, $$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

$\Rightarrow$ $$Q_2 = \frac{T_2}{T_1} \cdot Q_1 = \left(\frac{300}{1100}\right)(10^6)$$

$$= 2.72 \times 10^5 \text{ cal}$$

$$W = Q_1 - Q_2 = 7.28 \times 10^5 \text{ cal}$$

Efficiency of the cycle,

$$\eta = \left(1 - \frac{T_2}{T_1}\right) \times 100$$

or

$$\eta = \left(1 - \frac{300}{1100}\right) \times 100$$

$$= 72.72\%$$

**35.** (a) Velocity of particle is $(\hat{\mathbf{i}} + 2\hat{\mathbf{j}})\,\text{ms}^{-1}$ initially.

So, $u_x = 1\,\text{ms}^{-1}$ and $u_y = 2\,\text{ms}^{-1}$

Also, $a_x = 0$ and $a_y = -10\,\text{ms}^{-2}$

In time $t$,

Horizontal distance covered by projectile is

$$x = u_x \times t = t \qquad \text{... (i)}$$

And vertical distance covered by projectile is

$$y = u_y t + \frac{1}{2} a_y t^2$$

$$\Rightarrow \quad y = 2t - 5t^2 \qquad \text{... (ii)}$$

Substituting the value of $t$ from Eq (i) in Eq (ii), we get

$$y = 2x - 5x^2$$

**36.** (d) Using mechanical energy conservation equation.

$$E_C = E_P$$

$$\Rightarrow \quad K_C + U_C = K_P + U_P$$

$$\Rightarrow \quad \frac{1}{2} m v_C^2 + m V_C = 0 - \frac{GMm}{(R+R)}$$

Here, $V_C$ = potential at $C$ due to mass $M = -\frac{3}{2}\frac{GM}{R}$

Substituting this value in Eq. (i) and then solving we get,

$$v_C = \sqrt{\frac{2GM}{R}}$$

**37.** (d) $\frac{1}{2} m v^2 + \frac{1}{2} I \left(\frac{v}{R}\right)^2 = mg\left(\frac{3v^2}{4g}\right)$

$$\therefore \quad I = \frac{1}{2} m R^2$$

$\therefore$ Body is disc. The correct option is (d).

**38.** (c) $f_c = f_o$ (both first overtone)

or

$$3\left(\frac{v_c}{4L}\right) = 2\left(\frac{v_o}{2l_0}\right)$$

$$\therefore \quad l_0 = \frac{4}{3}\left(\frac{v_o}{v_c}\right) L = \frac{4}{3} \frac{\sqrt{B/\rho_2}}{3\sqrt{B/\rho_1}} L$$

$$= \frac{4}{3} L \sqrt{\frac{\rho_1}{\rho_2}}$$

**39.** (a) Efficiency of heat engine is

$$\eta = 1 - \frac{T_2}{T_1} \quad \text{or} \quad \eta = \frac{T_1 - T_2}{T_1}$$

Here, $T_1 = 273 + 127 = 400\text{K}$

$T_2 = 273 + 27 = 300 \text{ K}$

$\therefore$ $\eta = \frac{400 - 300}{400}$

$= \frac{100}{400} = 0.25 = 25\%$

Hence, 26% efficiency is impossible for a given heat engine.

**40.** (c) Let their velocities are $v_1$ and $v_2$. From conservation of linear momentum.

$$p_i = p_f$$

$\therefore$ $0 = mv_1 - 2mv_2$ ... (i)

From conservation of mechanical energy,

$$E_i = E_f$$

or $K_i + U_i = K_f + U_f$

or $0 - \frac{G(m)(2m)}{r_0} = \frac{1}{2}mv_1^2 + \frac{1}{2} \times 2m \times v_2^2 - \frac{G(m)(2m)}{(r_2 / 2)}$ ... (ii)

Solving Eqs. (i) and (ii), we get

$$v_1 = 2\sqrt{\frac{2Gm}{3r_0}}, v_2 = \sqrt{\frac{2Gm}{3r_0}}$$

**41.** (a) With the rise in temperature, the atomic grip gets loosened. Due to this, strain increases, hence, value of Young's modulus decreases.

**42.** (a) Work done is stored in the spring as potential energy, $U = \frac{1}{2}kx^2$

**43.** (a) For equivalent thermal conductivity, the relation is

$$\frac{1}{K_R} = \frac{1}{K_1} + \frac{1}{K_2}$$

$\Rightarrow$ $\frac{1}{K_R} = \frac{1}{K} + \frac{1}{K}$ $[\because K_1 = K_2 = K]$

$\Rightarrow$ $K_R = \frac{K}{2}$, which is less than $K$.

If $K_1 > K_2$, suppose $K_1 = K_2 + x$

$\therefore$ $\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2} = \frac{K_2 + K_1}{K_1 K_2}$

$\Rightarrow$ $\frac{1}{K} = \frac{K_2 + K_2 + x}{(K_2 + x)K_2}$

$\Rightarrow$ $K = \frac{K_2^2 + K_2 x}{2K_2 + x}$

Now, $K_2 - K = K_2 - \frac{K_2^2 + K_2 x}{2K_2 + x}$

$$= \frac{2K_2^2 + K_2 x - K_2^2 - K_2 x}{(2K_2 + x)} = \frac{K_2^2}{2K_2 + x} = \text{Positive}$$

So, $K_2 > K$, therefore the value of $K$ is smaller than $K_2$ and $K_1$.

**44.** (d) During adiabatic expansion, the temperature of the system falls while it increases during adiabatic compression. In this work is done by the gas at the expense of its internal energy and hence cooling takes place.

**45.** (c) For a body in SHM, the body has zero acceleration and maximum velocity at the mean position, so the rider has a tendency to leave the saddle at the mean position due to the maximum velocity from where it undergoes decelerating force towards the mean position. So, the inertia makes the rider leave the saddle at the mean position, where acceleration is only due to gravity in the downward direction, i.e. $g = 9.8\ \text{m/s}^2$

**46.** (a) When at the highest point saddle just begins to come down you become air borne.

**47.** (d) The motion of the man is upward with velocity $v = 0.5\,(2\pi \times 1.5)$

$v = 1.5\,\pi\ \text{ms}^{-1}$ and falls with acceleration $g$. Time taken to return to leaving point

$$= \frac{2v}{g} = \frac{2 \times (1.5\,\pi)}{g} = 0.96\ \text{s}$$

In that time saddle has not reached to him. As $T = \frac{1}{1.5} = 0.666$ s. Therefore, man will settle down on, saddle again when the two are at same position. When man is at extreme position during return (0.5 m) saddle is at $y = 0.5 \cos 3\pi\,(0.96) = -\,0.49$ m from mean position.

Therefore, the saddle reaches to him when $a = g$

$$g = y(2\pi f)^2$$

or $$y = \frac{1}{9}\ \text{m};\ y = y_0 \sin \omega t$$

$\Rightarrow$ $t = 0.96$; total time $= 2 \times t = 1.92$ s

**48.** (b) $\frac{\Delta Q}{\Delta W} = \frac{nC_p \Delta T}{nR\Delta T} = \frac{C_p}{R} = \frac{5/2R}{R} = \frac{5}{2}$

**49.** (b) When body is slowing down acceleration and velocity are directed opposite to each other.

Hence, angle between **a** and **v** may be 180° and 0°.

**50.** (c) Young's modulus of elasticity and shear modulus is only defined for solids. Bulk modulus of elasticity is defined for all, i.e. solids, liquid and gases.