SAMPLE PAPER - 7

Class 11 - Physics

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

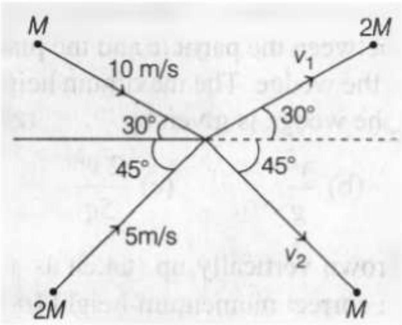
Section A

1. If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be: **[1]**

   a) $[EV^{-2}T^{-1}]$ b) $[E^2V^{-1}T^{-2}]$

   c) $[EV^{-1}T^{-2}]$ d) $[EV^{-2}T^{-2}]$

2. Two particles of masses M and 2M moving as shown, with speeds of 10 m/s and 5 m/s, collide elastically at the origin. After the collision, they move along the indicated directions with speed v_1 and v_2 are nearly **[1]**



   a) 6.5 m/s and 3.2 m/s b) 3.2 m/s and 12.6 m/s

   c) 6.5 m/s and 6.3 m/s d) 3.2 m/s and 6.3 m/s

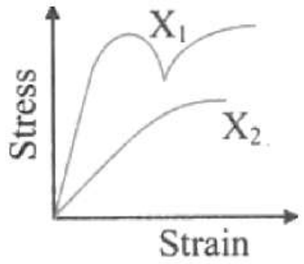
3. A body A of mass M while falling vertically downwards under gravity breaks into two parts; a body B of mass $\frac{M}{3}$ and a body C of mass $\frac{2}{3}$ M. The centre of mass of bodies B and C taken together shifts compared to that of body A: **[1]**

   a) towards body C b) does not shift

c) depends on height of breaking

d) towards body B

4. The diagram shows stress v/s strain curve for the materials X_1 and X_2. From the curves, we infer that **[1]**



a) X_1 is brittle but X_2 is ductile

b) Both X_1 and X_2 are ductile

c) Both X_1 and X_2 are brittle

d) X_1 is ductile and X_2 is brittle

5. A satellite of mass m is orbiting the earth (of radius R) at a height h from its surface. The total energy of the satellite in terms of g_0? the value of acceleration due to gravity at the earth's surface is: **[1]**

a) $\frac{2mg_0R^2}{R, + h}$

b) $-\frac{2mg_0R^2}{R+h}$

c) $\frac{mg_0R^2}{2(R+h)}$

d) $-\frac{mg_0R^2}{2(R+h)}$

6. On colliding in a closed container the gas molecules: **[1]**

a) momentum becomes zero

b) transfer momentum to the balls

c) move in opposite directions

d) perform brownian motion

7. One mole of an ideal monoatomic gas is heated at a constant pressure from 0^oC to 100^oC. Then the change in the internal energy of the gas is: (Given R = 8.32 J mol^{-1} K^{-1}) **[1]**

a) 4.6×10^3 J

b) 0.83×10^3 J

c) 1.25×10^3 J

d) 2.08×10^3 J

8. An open pipe is suddenly closed with the result that the second overtone of the closed pipe is found to be higher in frequency by 100 Hz than the first overtone of the original pipe. The fundamental frequency of open pipe will be: **[1]**

a) 150 Hz

b) 200 Hz

c) 100 Hz

d) 300 Hz

9. Three liquids of densities ρ_1, ρ_2 and ρ_3 with $\rho_1 > \rho_2 > \rho_3$, having the same value of surface tension T, rise to the same height in three identical capillaries. The angles of contact θ_1, θ_2 and θ_3 obey: **[1]**

a) $\frac{\pi}{2} > \theta_1 > \theta_2 > \theta_3 \geq 0$

b) $\frac{\pi}{2} < \theta_1 < \theta_2 < \theta_3 < \pi$

c) $\pi > \theta_1 > \theta_2 > \theta_3 > \frac{\pi}{2}$

d) $0 \leq \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$

10. A satellite is launched into a circular orbit of radius R around the earth. A second satellite is launched into an orbit of radius 1.01R. The time period of the second satellite is larger than that of the first one by approximately: **[1]**

a) 0.5%

b) 3.0%

c) 1%

d) 1.5%

11. The density of a non-uniform rod of length 1m is given by $\rho(x) = a(1 + bx^2)$ where a and b are constants and 0 **[1]**

$\leq x \leq 1$. The centre of mass of the rod will be at

a) $\frac{4(3+b)}{3(2+b)}$

b) $\frac{4(2+b)}{3(3+b)}$

c) $\frac{3(2+b)}{4(3+b)}$

d) $\frac{3(3+b)}{4(2+b)}$

12. The mean free path for air at STP is of the order of: **[1]**

a) 2.9×10^{-4} m

b) 2.9×10^{-7} m

c) 2.9×10^{-2} m

d) 2.9×10^{-10} m

13. Consider the three waves z_1, z_2 and z_3 as **[1]**

$z_1 = A \sin (kx - \omega t)$

$z_2 = A \sin (kx + \omega t)$

$z_3 = A \sin (ky - \omega t)$

Which of the following represents a standing wave?

a) z_1, z_2 and z_3

b) z_2 and z_3

c) z_1 and z_2

d) z_1 and z_3

14. Molar specific heat at constant volume Cv for a monoatomic gas is: **[1]**

a) $\frac{6}{2}$R

b) $\frac{3}{2}$R

c) $\frac{4}{2}$R

d) $\frac{5}{2}$R

15. Derive an expression for the work required to move an Earth satellite of mass m from a circular orbit of radius 2 R_E to one of radius 3 R_E. **[1]**

a) $\frac{GM_E}{12R_E}$

b) $\frac{GM_Em}{12R_E}$

c) $\frac{GM_Em}{24R_E}$

d) $\frac{Gm}{24R_E}$

16. **Assertion (A):** The projectile hits the ground with the same speed with which it was thrown. **[1]**

Reason (R): The projectile hits the ground with the same velocity with which it was thrown.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

17. **Assertion (A):** Identical springs of steel and copper are equally stretched. More work will be done on the steel spring. **[1]**

Reason (R): Steel is more elastic than copper.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

18. **Assertion (A):** If the units of force and length are doubled, the unit of energy will be 4 times. **[1]**

Reason (R): The unit of energy is independent of the unit of force and length.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

Section B

19. State the number of significant figures in the following : **[2]**

i. 0.007 m^2

ii. 2.64×10^{24} kg

iii. 0.2370 g cm^{-3}

iv. 6.320 J

v. 6.032 N m^{-2}

vi. 0.0006032 m^2

20. A man stands in a lift going downward with uniform velocity. He experiences a loss of weight at the start but not when lift is in uniform motion. Explain why? **[2]**

21. An astronaut inside a small space ship orbiting around the earth cannot detect gravity. If the space station orbiting around the earth has a large size, can he hope to detect gravity? **[2]**

OR

The radius of the earth's orbit around the sun is 1.5×10^{11} m. Calculate the angular and linear velocity of the earth. Through how much angle does the earth revolve in 2 days?

22. If a wire of length 4 m and cross-sectional area of $2m^2$ is stretched by a force of 3 kN, then determine the change in length of the wire due to the applied force. Given Young's modulus of material of the wire is110×10^9 N/m. **[2]**

23. a. When a molecule (or an elastic ball) hits a (massive) wall, it rebounds at the same speed. When a ball hits a massive bat held firmly, the same thing happens. However, when the bat is moving towards the ball, the ball rebounds at a different speed. Does the ball move faster or slower? **[2]**

b. When the gas in a cylinder is compressed by pushing in a piston, its temperature rises. Guess at an explanation of this in terms of kinetic theory using (a) above.

c. What happens when a compressed gas pushes a piston out and expands. What would you observe?

d. Sachin Tendulkar used a heavy cricket bat while playing. Did it help him in any way?

OR

The specific heat of argon at constant volume is 0.075 kcal kg^{-1} K^{-1}, then what will be its atomic weight? [Given, R =2 cal $mol^{-1}K^{-1}$]

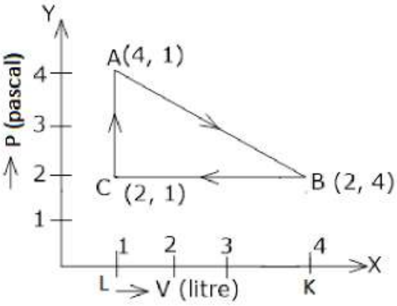
24. A balloon is ascending at the rate of 4.9m/s. A pocket is dropped from the balloon when situated at a height of 24.5m. How long does it take the packet to reach the ground? What is its final velocity? **[2]**

25. A passenger of mass 72.2 kg is standing on a weighing scale in an elevator. What does the scale read when the elevator cab is **[2]**

1. descending with constant velocity?
2. ascending with constant acceleration, 3.5 m /s^2?

Section C

26. Deduce the work done in the following complete cycle. **[3]**



27. A body weighing 0.4 kg is whirled in a vertical circle making 2 revolutions per second. If the radius of the circle is 1.2 m, find the tension in the string, when body is **[3]**

i. at the bottom of the circle,

ii. at the top of the circle.

28. The flow of blood in a large artery of an anesthetised dog is diverted through a Venturi meter. The wider part of the meter has a cross-sectional area equal to that of the artery. A = 8 mm^2. The narrower part has an area a = 4 mm^2. The pressure drop in the artery is 24 Pa. What is the speed of the blood in the artery? **[3]**

OR

In deriving Bernoulli's equation, we equated the work done on the fluid in the tube due to its change in the potential and kinetic energy.

a. What is the largest average velocity of blood flow in an artery of diameter 2×10^{-3} m if the flow must remain laminar?(Given, $\eta_{blood} = 2.084 \times 10^{-3} PaS$ and $\rho_{blood} = 1.06 \times 10^3 Kg/m^3$)

b. Do the dissipative forces become more important as the fluid velocity increases? Discuss qualitatively.

29. From the equation y - A sin $\frac{2\pi}{\lambda}(vt - x)$, establish the relation between particle velocity and wave velocity. **[3]**

OR

Briefly explain propagation of sound waves in air.

30. What is calorimetry? Briefly explain its principle. **[3]**

Section D

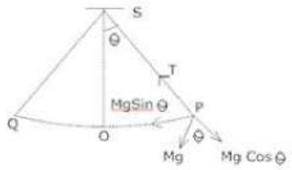
31. A cylindrical log of wood of height h and area of cross-section A floats in a liquid. It is pressed and then released. Show that the log would execute S.H.M. with a time period. **[5]**

$T = 2\pi\sqrt{\frac{m}{A\rho g}}$

Where m is mass of the body and ρ is the density of the liquid.

OR

What is Simple pendulum? Find an expression for the time period and frequency of a simple pendulum?



32. Establish the following vector inequalities: **[5]**

i. $|\vec{a} + \vec{b}| \leq |\vec{a}| + |\vec{b}|$

ii. $|\vec{a} - \vec{b}| \leq |\vec{a}| + |\vec{b}|$

When does the equality sign apply?

OR

An airline passenger who is late for a flight walks on an airport sidewalk at a speed of 5.00 km /h relative to the sidewalk, in the direction of its motion. The sidewalk is moving at 3.00 km /h relative to the ground and has a total length of 135 m.

i. What is the passenger's speed relative to the ground?

ii. How long does it take him to reach the end of the sidewalk?

iii. How much of the sidewalk has he covered by the time he reaches the end?

33. Find the centre of mass of a uniform **[5]**

i. half-disc,

ii. quarter-disc.

OR

A man stands on a rotating platform, with his arms stretched horizontally holding a 5 kg weight in each hand. The angular speed of the platform is 30 revolutions per minute. The man then brings his arms close to his body with the distance of each weight from the axis changing from 90cm to 20cm. The moment of inertia of the man together with the platform may be taken to be constant and equal to 7.6 kg m^2.

a. What is his new angular speed? (Neglect friction.)

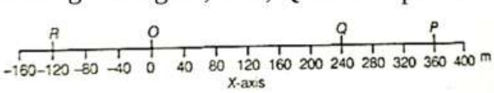
b. Is kinetic energy conserved in the process? If not, from where does the change come about?

Section E

34. **Read the text carefully and answer the questions:** **[4]**

If the position of an object is continuously changing w.r.t. its surrounding, then it is said to be in the state of motion. Thus, motion can be defined as a change in position of an object with time. It is common to everything in the universe.

In the given figure, let P, Q and R represent the position of a car at different instants of time.



(i) With reference to the given figure, What are the position coordinates of points P and R?

(ii) Give any 2 differences between distance and displacement.

(iii) From the given figure, find the displacement of a car in moving from O to P and then to Q?

OR

If the car goes from O to P and returns back O, what will be the displacement of the car for whole journey?

35. **Read the text carefully and answer the questions:** **[4]**

Power is defined as the time rate at which work is done or energy is transferred. The average power of a force is defined as the ratio of the work, W, to the total time t taken

$P_{av} = \frac{W}{t}$

The instantaneous power is defined as the limiting value of the average power as time interval approaches zero.

$P = \frac{dw}{dt}$

The work dW done by a force F for a displacement dr is dW = F·dr. The instantaneous power can also be expressed as

$P = \frac{F.dr}{dt}$

P = F·v

Where v is the instantaneous velocity when the force is F. Power, like work and energy, is a scalar quantity. Its dimensions are $[ML^2 T^{-3}]$. In the SI, its unit is called a watt (W). The watt is 1 J s^{-1}. The unit of power is named after James Watt, one of the innovators of the steam engine in the eighteenth century. There is another unit of power, namely the horse-power (hp)

1 hp = 746 W

This unit is still used to describe the output of automobiles, motorbikes.

(i) What is the term used for the time rate at which work is done or energy is transferred?

(ii) What is the term used for the limiting value of power as the time interval approaches zero?

(iii) Define instantaneous power. Give its SI unit and dimensions.

OR

1 horse power is equal to how many watt?

Solution

SAMPLE PAPER - 7

Class 11 - Physics

Section A

1. **(d)** $[EV^{-2}T^{-2}]$

Explanation: Suppose surface tension depends on fundamental quantities E, V, and T as follows: $\sigma = E^a V^b T^c$

Equating the dimensions on both sides of above equation, we get:

$\frac{[M^1L^1T^{-2}]}{[L]} = [M^1L^2T^{-2}]^a \left[\frac{L}{T}\right]^b [T]^c$

$[M^1L^0T^{-2}] = [M^a L^{2a+b} T^{-2a-b+c}]$

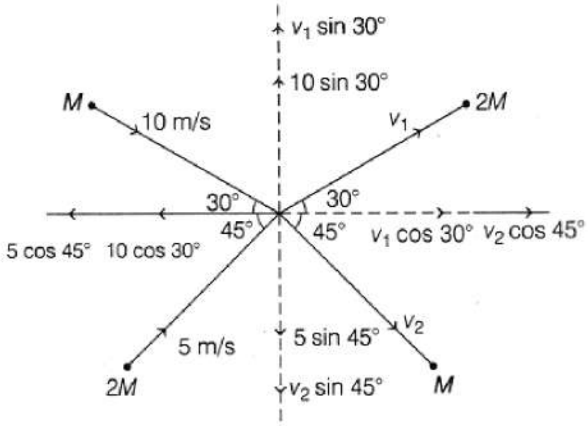
Hence, a = 1, 2a + b = 0 and -2a - b + c = -2

Solving above equations, we get: a = 1, b = -2, c = -2

Hence, dimension of surface tension will be $[EV^{-2}T^{-2}]$

2. **(c)** 6.5 m/s and 6.3 m/s

Explanation: The given condition can be drawn as shown below



Applying linear momentum conservation law in the x-direction, we get

Initial momentum = Final momentum

$(M \times 10\cos 30°) + (2M \times 5\cos 45°) = (M \times v_2 \cos 45°) + (2M \times v_1 \cos 30°)$

$\Rightarrow \left(M \times 10 \times \frac{\sqrt{3}}{2}\right) + \left(2M \times 5 \times \frac{1}{\sqrt{2}}\right)$

$= \left(M \times v_2 \times \frac{1}{\sqrt{2}}\right) + \left(2M \times v_1 \times \frac{\sqrt{3}}{2}\right)$

$\Rightarrow 5\sqrt{3} + 5\sqrt{2} = \frac{v_2}{\sqrt{2}} + v_1\sqrt{3}$ ...(i)

Similarly, applying linear momentum conservation law in the y-direction, we get

$(M \times 10 \sin 30°) - (2M \times 5 \sin 45°)$

$= (M \times v_2 \sin 45°) - (2M \times v_1 \sin 30°)$

$\Rightarrow \left(M \times 10 \times \frac{1}{2}\right) - \left(2M \times v_1 \times \frac{1}{2}\right)$

$\Rightarrow 5 - 5\sqrt{2} = \frac{v_2}{\sqrt{2}} - v_1$ ....(ii)

Subtracting Eq. (ii) from Eq. (i), we get

$(5\sqrt{3} + 5\sqrt{2}) - (5 - 5\sqrt{2})$

$= \left(\frac{v_2}{\sqrt{2}} + v_1\sqrt{3}\right) - \left(\frac{v_2}{\sqrt{2}} - v_1\right)$

$\Rightarrow 5\sqrt{3} + 10\sqrt{2} - 5 = v_1\sqrt{3} + v_1$

$\Rightarrow v_1 = \left(\frac{5\sqrt{3}+10\sqrt{2}-5}{1+\sqrt{3}}\right) = \frac{8.66+14.142-5}{1+1.732}$

$= \frac{17.802}{2732} \Rightarrow v_1 = 6.516 m/s \approx 6.5$ m/s ....(iii)

Substituting the value from Eq. (iii) in Eq. (i), we get

$5\sqrt{3} + 5\sqrt{2} = \frac{v_2}{\sqrt{2}} + 6.51 \times \sqrt{3}$

$\Rightarrow v_2 = (5\sqrt{3} + 5\sqrt{2} - 6.51 \times \sqrt{3})\sqrt{2}$

$v_2 = (8.66 + 7.071 - 11.215)\ 1.414$

$\Rightarrow v_2 = 4.456 \times 1.414$

$\Rightarrow v_2 \approx 6.3$m/s

3. **(b)** does not shift

   Explanation: Does not shift as no external force acts. The centre of mass of the system continues its original path. It is only the internal forces that come into play while breaking.

4. **(d)** X_1 is ductile and X_2 is brittle

   Explanation: In ductile materials, yield point exists while in brittle materials, failure would occur without yielding.

5. **(d)** $-\frac{mg_0R^2}{2(R+h)}$

   Explanation: Total energy of satellite at a height h above the earth's surface,

   TE = $-\frac{GMm}{2(R+h)} = -\frac{GMmR^2}{2(R+h)R^2} = -\frac{g_0mR^2}{2(R+h)}$

6. **(b)** transfer momentum to the balls

   Explanation: transfer momentum to the balls

7. **(c)** 1.25×10^3 J

   Explanation: Here, R = 8.32 J mol^{-1} K^{-1}

   $\Delta T = 100^oC - 0^oC = 100^oC$, n = 1

   At constant pressure,

   $\Delta Q = nC_p\Delta T$ and $\Delta W = nR\Delta T$

   According to first law of thermodynamics

   $\Delta Q = \Delta U + \Delta W$

   $\Delta U = \Delta Q - \Delta W - nC_p\Delta T - nR\Delta T$

   $= n\Delta T(C_P - R)$

   $= nC_v\Delta T$ ($\because C_p - C_V = R$)

   For monoatomic gas, $C_V = \frac{3}{2}R$

   $\therefore \Delta U = 1 \times \frac{3}{2} \times 8.32 \times 100$

   $= 12.5 \times 10^2$ J $= 1.25 \times 10^3$ J

8. **(b)** 200 Hz

   Explanation: Frequency of mth harmonic in an open organ pipe $v_m = \frac{mv}{2L}$

   Fundamental frequency in an open organ pipe i.e m = 1, $v_1 = \frac{v}{2L}$

   Frequency of nth harmonic in a closed organ pipe $\nu'_n = \frac{nv}{4L}$

   Frequency of 3rd harmonic in a closed organ pipe $\nu'_3 = \frac{3v}{4L}$

   Now, $\nu'_3 - v_1 = 100$

   $\frac{3v}{4L} - \frac{v}{2L} = 100 \Rightarrow \frac{v}{L} = 400$

   Thus fundamental frequency in an open organ pipe

   $v_1 = \frac{v}{2L} = \frac{400}{2} = 200$ Hz

9. **(d)** $0 \leq \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$

   Explanation: $h = \frac{2\sigma \cos\theta}{\rho rg}$

   But h, σ, r and g are same for the three liquids

   $\therefore \frac{\cos\theta}{\rho}$ = constant

   $\Rightarrow \frac{\cos\theta_1}{\rho_1} = \frac{\cos\theta_2}{\rho_2} = \frac{\cos\theta_3}{\rho_3}$

   Given: $\rho_1 > \rho_2 > \rho_3$

   $\Rightarrow \cos\theta_1 > \cos\theta_2 > \cos\theta_3$

   $\Rightarrow \theta_1 < \theta_2 < \theta_3$

   Also, θ is acute for liquid which rise in a capillary

   $\therefore 0 \leq \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$

10. **(d)** 1.5%

Explanation: $T = 2\pi\sqrt{\frac{(R+h)^3}{GM}}$

$T_1 = 2\pi\sqrt{\frac{R^3}{GM}}$, $T_2 = 2\pi\sqrt{\frac{(1.01R)^3}{GM}}$

$\frac{T_2 - T_1}{T_1} \times 100 = 1.5\ \%$

11. **(c)** $\frac{3(2+b)}{4(3+b)}$

Explanation: Given: $p(x) = a(1 + bx^2)$

$\frac{\text{mass}}{\text{length}}$ = density of rod

$dm = p(x)\,dx$

$= a(1 + bx^2)\,dx$

As we know that

Centre of mass = $\frac{\int x\mathrm{dm}}{\int \mathrm{dm}} = \frac{\int \mathrm{ax}(1+\mathrm{x}^2)\mathrm{dx}}{\int \mathrm{a}(1+\mathrm{x}^2)\mathrm{dx}}$

$= \frac{\frac{a}{2}+\frac{ab}{4}}{a+\frac{ab}{3}} = \frac{3(2+b)}{4(3+b)}$

12. **(b)** 2.9×10^{-7} m

Explanation: 2.9×10^{-7} m

13. **(c)** z_1 and z_2

Explanation: z_1 travels along +ve x-direction

z_2 travels along -ve x-direction

z_3 travels along +ve y-direction.

$\therefore z_1 + z_2$ represents a standing wave i.e., wave obtained by the superposition of two waves travelling along opposite directions.

14. **(b)** $\frac{3}{2}$R

Explanation: For monoatomic gas, f = 3

$\therefore \quad \gamma = 1 + \frac{2}{f} = 1 + \frac{2}{3} = \frac{5}{3}$

Now, $C_v = \frac{R}{\gamma-1} = \frac{R}{\frac{5}{3}-1} = \frac{3R}{2}$

15. **(b)** $\frac{GM_Em}{12R_E}$

Explanation: The energy of a satellite in low orbit:

$E_L = \frac{-GMm}{2r} = \frac{-GM_Em}{2(2R_E)} = \frac{-GM_Em}{4R_E}$

The energy of a satellite in high orbit:

$E_H = \frac{-GMm}{2r} = \frac{-GM_Em}{2(3R_E)} = \frac{-GM_Em}{6R_E}$

Energy required to move a satellite from the orbit of radius $2R_E$ to orbit of radius $3R_E$:

$= \Delta E = E_H - E_L = \frac{-GM_Em}{6R_E} - \left(\frac{-GM_Em}{4R_E}\right) \Rightarrow \Delta E = \frac{GM_Em}{12R_E}$

16. **(c)** A is true but R is false.

Explanation: A is true but R is false.

17. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation: Work done = $\frac{1}{2} \times$ stress $\times$ strain

$= \frac{1}{2} \times \gamma \times (\text{ strain })^2$

Since, elasticity of steel is more than copper, hence more work has to be done in order to stretch the steel.

18. **(c)** A is true but R is false.

Explanation: Energy = force $\times$ distance; so when the units of force and length or distance are doubled the unit of energy will become 4 times that of its initial value.

Section B

19. i. 1. If the number is less than one, then all zeros on the right of the decimal point are insignificant. This means that here, two zeros after the decimal are not significant. Hence, only 7 is a significant figure in this quantity.

ii. 3. For the determination of significant values, we do not consider the power of 10 (Number is not less than 1). The digits 2, 6, and 4 are significant figures. Hence, It has 3 significant digits.
iii. 4. Explanation: Significant figure- 2, 3, 7, 0. Trailing 0's is significant. These 0's increase the accuracy of the answer.
iv. 4. From the condition of a significant figure, the zero after the decimal point comes after a non-zero number so it significant figure. The number of significant figures is 4.
v. 4. Explanation: Significant figure- 6, 0, 3, 2. 0's between 2 non-zero digits are significant.
vi. 4. Explanation: Significant figure- 6, 0, 3, 2. Since **the number is less than 1.**

20. The apparent weight is given by
R = W - ma = mg - ma or R = m(g - a)
Since lift is in acceleration in the start, $a \neq 0$, so R < mg. When lift comes in uniform motion, acceleration ceases (a = 0) and man experiences his own weight.
21. Yes,
If the spaceship is large enough then the astronaut will definitely detect the Earth's gravity as Gravitational Force on the spaceship is directly proportional to the mass of spaceship so as a mass of bigger spaceship will be large and hence it will experience a noticeable amount of force which can be detected, we know gravitational force on a body is given as
$F = \frac{Gm_1m_2}{r^2}$
Where, F is the gravitational force
G is the universal gravitational Constant
m_1 is mass of first body which in this case is earth
m_2 is the mass of second body which is the spaceship
and r is the distance between earth and spaceship
so as the mass of spaceship m_2 increases the gravitational force experienced by it increases and hence can be detected i.e. Gravity can be detected.

OR

Here $r = 1.5 \times 10^{11}$m,
Period of revolution of the earth,
T = 365 days = $365 \times 24 \times 60 \times 60$ s
$\therefore$ Angular velocity,
$\omega = \frac{2\pi}{T} = \frac{2 \times 3.14}{365 \times 24 \times 60 \times 60}$
$= 1.99 \times 10^{-7}$ rad s^{-1}
Linear velocity,
$v = r\omega = 1.5 \times 10^{11} \times 1.99 \times 10^{-7} = 2.99 \times 10^4$ ms^{-1}
In 365 days, the earth revolves through an angle of 2π radians.
$\therefore$ The angle through which the earth revolves in 2 days
$= \frac{2\pi}{365} \times 2 = \frac{2 \times 3.14 \times 2}{365} = 0.0344$ rad
22. Given, area of cross-section of the wire, A = 2 m^2
Force applied, F = 3 kN = 3000 N
Length of the wire, L = 4 m
Young's modulus, $Y = 110 \times 10^9$ N/m^2
To find: Change in length, $\triangle L$ = ?
We know that, $Y = \frac{Stress}{Strain}, Y = \frac{FL}{A\Delta L}$
$\Rightarrow \quad \Delta L = \frac{FL}{AY} = \frac{3 \times 10^3 \times 4}{2 \times 110 \times 10^9} = 0.0545 \times 10^{-6}$m
$\Delta L = 54.5 \times 10^{-3}$mm = 54.5 μ
23. a. Let the speed of the ball be u relative to the wicket behind the bat. If the bat is moving towards the ball with a speed V relative to the wicket, then the relative speed of the ball to bat is V + u towards the bat. When the ball rebounds (after hitting the massive bat) its speed, relative to bat, is V + u moving away from the bat. So relative to the wicket the speed of the rebounding ball is V + (V + u) = 2V + u, moving away from the wicket. So the ball speeds up after the collision with the bat. The rebound speed will be less than u if the bat is not massive. For a molecule, this would imply an increase in temperature.
b. When the gas in a cylinder is compressed by pushing in a piston, bat hits the ball, it moves faster, and hence the temperature of the gas increases.

c. When a compressed gas pushes a piston out and expands, the velocity of the ball decrease, hence the temperature of the gas decreases.

d. Sachin Tendulkar uses a heavy cricket bat. Therefore, on hitting with such a bat, the velocity of the ball increases further. He is able to score better.

OR

Argon is a monoatomic gas, so

$c_V = \frac{3}{2}R = \frac{3}{2} \times 2$ = 3 cal mol^{-1}K^{-1}. Molar specific heat, $C_V = Mc_V$ = 0.075(given) M being molecular mass.

$\Rightarrow M = \frac{C_V}{c_V} = \frac{3}{0.075} = 40$

24. Here, u = 4.9 m/s (upward), h = 24.5 m and a = g = 9.8m/s^2 (downwards)

$s = ut + \frac{1}{2}at^2$

$24.5 = -4.9 \times t + \frac{1}{2}(9.8) \times t^2$

4.9 t^2 - 4.9t = 24.5

After solving the equation we get

t = 7.6 s or -5.6 s

Since time cannot be negative, we have

t = 7.6s

Now, $v = u + at$

$v = -4.9 + (9.8)(7.6)$

$v = 69.6 m/s$

25. Given, mass of the man, m = 72.2 kg

Acceleration due to gravity, g = 9.8 m /s^2

To find : Scale reading = apparent weight = Reaction force = R in the following two cases,

i. While descending with constant velocity, a = 0

R = mg

R = 72.2 × 9.8

⇒ R = 707.56 N

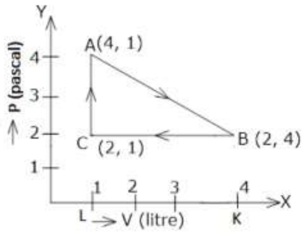
ii. While ascending with a = 3.2 m / s^2

R = m (g + a)

R =72.2 (9.8+ 3.2) = 938.6 N

Section C

26.



BC = KL = 4 - 1 = 3 $litre$ = 3 × 10^{-3}m^3 ($\because 1m^3 = 1000 litre$)

AC = 4 - 2 = 2 pa

LC = 2 - 0 = 2 pa

i. Let W_{AB} is the work done during the process from A to B

Now, Work done = Area under the P - V curve

W_{AB} = area (ABKLA)

= area of ΔABC + area of rectangle BKLC

$= \left(\frac{1}{2} \times BC \times AC\right) + (KL \times LC)$

$W_{AB} = \left(\frac{1}{2} \times 3 \times 10^{-3} \times 2\right) + \left(3 \times 10^{-3} \times 2\right)$

$= 3 \times 10^{-3} + 6 \times 10^{-3}$

$W_{AB} = 9 \times 10^{-3} J$

Since gas expands during this process, hence, W_{AB} is positive

ii. Let work done during process(compression) B to C is W_{BC}

W_{BC} = - area of rectangle BCLK

(Negative because gas compresses during BC)

= - KL × LC

$W_{BC} = -3 \times 10^{-3} \times 2$

$= -6 \times 10^{-3} J$

iii. Let W_{CA} be the work done during the process from C to A:-

As there is no change in volume of gas in this process, W_{CA} = O

So, net work done during the complete cycle = $W_{AB} + W_{BC} + W_{CA}$

$= 9 \times 10^{-3} - 6 \times 10^{-3} + 0$

Net work done $= 3 \times 10^{-3} J$

27. Here m = 0.4 kg, r = 1.2 m, ν = 2 rps

Angular speed, $\omega = 2\pi v = 2\pi \times 2 = 4\pi$ rad s^{-1}

i. When body is at bottom of the circle. Let T_1 be tension in the string. Then

T_1 - mg = Centripetal force $= mr\omega^2$

or $T_1 = m(r\omega^2 + g) = 0.4 [1.2 \times (4\pi)^2 + 9.8]$

= 0.4 [1.2 × 16 × 9.87 + 9.8]

= 0.4 [189.5 + 9.8] = 79.32 N

ii. When the body is at the top of the circle. Let T_2 be the tension in the string. Then

T_2 + mg = Centripetal force $= mr\omega^2$

or $T_2 = m(r\omega^2 - g) = 0.4 [1.2 \times (4\pi)^2 - 9.8]$

= 0.4 [189.5 - 9.8] = 71.88 N

28. We take the density of blood from table to be 1.06 × 10^3 g m^{-3}. The ratio of the area is $\left(\frac{A}{a}\right) = 2$.

FLuid	**ρ(kg m^{-3})**
Water	1.00×10^3
Sea water	1.03×10^3
Mercury	13.6×10^3
Ethyl alcohol	0.806×10^3
Whole blood	1.06×10^3
Air	1.29
oxygen	1.43
Hydrogen	9.0×10^{-2}
Interstellar space	$\approx 10^{-2}$

Using eq. speed of fluid through wide neck is given by $v_1 = \sqrt{\left(\frac{2\rho_m gh}{\rho}\right)}\left(\left(\frac{A}{a}\right)^2 - 1\right)^{-1/2}$ we obtain

$v_1 = \sqrt{\frac{2 \times 24\text{Pa}}{1060\text{kgm}^{-3} \times (2^2 - 1)}} = 0.123\text{ms}^{-1}$

OR

a. Diameter of the artery, $d = 2 \times 10^{-3} m$

Viscosity of blood, $\eta = 2.084 \times 10^{-3}$Pas

Density of blood, $\rho = 1.06 \times 10^3 \text{kg/m}^3$

Reynolds' number for laminar flow, N_R = 2000

The largest average velocity of blood is given as:

$(V_{\text{avg}})_{max} = \frac{N_R \times \eta}{\rho \times d}$

$= \frac{2000 \times 2.084 \times 10^{-3}}{1.06 \times 10^3 \times 2 \times 10^{-3}}$

= 1.966 m/s

Therefore, the largest average velocity of blood is 1.966 m/s.

b. Yes, As the fluid velocity increases, the dissipative forces become more important. From Newton's law of viscous drag, we know that $F = -\eta A \frac{dv}{dx}$ .This is because of the rise of turbulence. From this equation it can be explained that, as v increases, velocity gradient $\frac{dv}{dx}$ also increases, causing more viscous drag i.e. the dissipative force also increases because of turbulence.

29. The velocity with which the wave travels in space is called the wave velocity , whereas particle velocity is the velocity with which the particles are vibrating to transfer the energy in form of a wave. The relation between wave velocity and particle velocity is given as:

The given wave equation is y = A sin $\frac{2\pi}{\lambda}(vt - x)$ = A sin $\left(\frac{2\pi v}{\lambda}t - \frac{2\pi}{\lambda}x\right)$

or y = A sin (ωt - kx),

because $2\pi\frac{v}{\lambda} = 2\pi v = \omega$ = angular frequency

and $\frac{2\pi}{\lambda}$ = k = propogation constant.

$\therefore$ particle velocity $\frac{dy}{dt} = \frac{dA\sin(wt-kx)}{dt}$ =A ω cos (ωt - kx)

and $\frac{dy}{dx} = \frac{dA\sin(wt-kx)}{dx}$ = -AK cos (ωt - kx)

$\therefore$ wave velocity v = $\frac{dx}{dt}$ = $\left(\frac{dy}{dt}.\frac{-dx}{dy}\right) = \frac{\omega}{k}$

Hence we conclude that particle velocity $\frac{dy}{dt}$ = ($-\frac{dy}{dx}$) $\times$ wave velocity

Here $\frac{dy}{dx}$ is the slope of displacement position graph for given wave motion.

$\therefore$ Particle velocity = - (slope of displacement - position graph) $\times$ wave velocity.

OR

Sound waves in air are propagated as longitudinal waves. Longitudinal waves are the types of waves in which displacement of the particles in the propagation medium take place horizontally with the direction of the wave. When the vibration of the sound source applies pressure at a frequency of its own vibration then this situation begins. During their propagation, waves can be reflected, refracted or attenuated by the medium. As the sound wave passes through the air, it compresses or expands a small region of the air. It causes a change in the density of that air region, which in turn induces a change in pressure in that region. As pressure is force per unit area, so there is a restoring force whose magnitude is directly proportional to the disturbance which causes compression. If a particular air region is compressed, the molecules in that region are packed together and they tend to move out to the adjoining region. Consequently, the density of the adjoining region is also increased, and compression is created there . As a result, the air in the first region undergoes rarefaction. If a region is comparatively rarefied then the surrounding air will rush in making the rarefaction move the adjoining region. In this way, compression or rarefaction moves from one region to another, making the propagation of a disturbance possible in the air. Such a wave which travels in the form of compression and rarefaction is called a longitudinal wave. Thus, it is clear that sound waves in air are longitudinal waves.

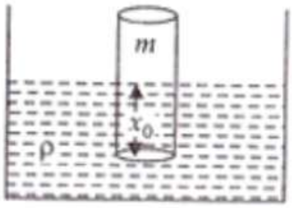
30. Calorimetry is a branch of physics that deals with the measurement of the quantity of heat being transferred from one substance to another.

The principle of calorimetry follows the law of conservation of energy. According to the principle of calorimetry, if two chemically non-reactive substances maintained at different temperatures are brought in thermal contact so as to share heat, the hotter substance transfers heat to the colder substance and the heat exchange continues till the temperature of both the substances become same. In such a situation if there is no heat energy dissipated due to radiation loss etc., then, we have

Total heat transferred from the hotter body = Total heat transferred to the colder body.

Section D

31. When the block is pressed downward into the liquid then an upward Buoyant force (B.F.) acts on it which moves the block upward and it moves upward from its mean position due to inertia and then again come down due to gravity. So the net restoring force on the block is given by = Buoyant force on the log by the liquid – weight of the log of wood



Say, V is = the volume of liquid displaced by the block

When the block floats then,

Weight of the block is given by, mg = buoyant force by the liquid or $mg = V\rho g$, [$V\rho g$ is the weight of the displaced liquid by the block]

$mg = Ax_0\rho g$ ...(i) [x_0 = is the depth of the block into the liquid just before the block is pressed and volume displaced by the liquid, V = Ax_0]

A is the area of cross-section

$x_0 =$ is the depth of the block into the liquid due to its own weight

Let x height again dip in liquid when pressed into it. Hence total height of block into the liquid $= (x + x_0)$

So net force acting upward on the block is given by $= [A(x + x_0)]\rho \cdot g - mg$

$F_{\text{net}} = Ax_0\rho g + Ax\rho g - Ax_0\rho g$

$F_{\text{restoring}} = -F_{net} = -Ax\rho g$

(as Buoyant force is upward and displacement of the block, x is directed downwards)

$\therefore F_{restoring} \propto -x$

So motion is SHM with proportional constant k = $A\rho g$

Again from SHM equation, $a = -\omega^2 x$ ....(i)

$F_{\text{restoring}} = -A\rho g x$

$\Rightarrow ma = -A\rho g x$

$\Rightarrow a = \frac{-A\rho g x}{m} \Rightarrow -\omega^2 x = \frac{-A\rho g x}{m}$ [putting the value of a from equation (i)]

$\therefore \omega^2 = \frac{A\rho g}{m}$

with $k = A\rho g$ and $\omega = \frac{2\pi}{T}$

Hence, $\left(\frac{2\pi}{T}\right)^2 = \frac{A\rho g}{m} \Rightarrow \frac{T}{2\pi} = \sqrt{\frac{m}{A\rho g}} \Rightarrow T = 2\pi\sqrt{\frac{m}{A\rho g}}$

OR

A simple pendulum is the most common example of the body executing S.H.M, it consists of heavy point mass body suspended by a weightless inextensible and perfectly flexible string from rigid support, which is free to oscillate. When a pendulum is displaced sideways from its resting, equilibrium position, it is subject to a restoring force due to gravity that will accelerate it back toward the equilibrium position. When released, the restoring force acting on the pendulum's mass causes it to oscillate about the equilibrium position, swinging back and forth. The time for one complete cycle, a left swing and a right swing, is called the period.

Let m = mass of bob

l = length of a pendulum

Let O is the equilibrium position, OP = X

Let θ = small angle through which the bob is displaced.

The forces acting on the bob are:-

i. The weight = Mg acting vertically downwards.
ii. The tension = T in string acting along Ps.

Resolving Mg into 2 components as Mg Cos θ and Mg Sin θ,

Now, T = Mg Cos θ

Restoring force F = - Mg Sin θ

- ve sign shows force is directed towards mean position.

Let θ = Small, so Sin $\theta \approx \theta = \frac{\text{Arc(op)}}{1} = \frac{\text{x}}{1}$

Hence F = - mg θ

$\Rightarrow$F = - mg $\frac{x}{l} \rightarrow 3)$

Now, In S.H.M, F = k x $\rightarrow$ 4)

where,k = Spring constant

Equating equation 3) & 4) for F

$\Rightarrow$- k x = - m g $\frac{x}{l}$

$\Rightarrow$Spring factor = $k = \frac{mg}{l}$

Inertia factor = Mass of bob = m

Now, Time period = T

$= 2\pi\sqrt{\frac{\text{Inertia factor}}{\text{Spring factor}}}$

$\Rightarrow T = 2\pi\sqrt{\frac{l}{g}}$

32. i. If θ be the angle between $\vec{a}$ and $\vec{b}$, then

$|\vec{a}+\vec{b}| = \sqrt{|\vec{a}|^2 + |\vec{b}|^2 + 2|\vec{a}||\vec{b}|\cos\theta}$

Now $|\vec{a}+\vec{b}|$ will be maximum when

$\cos\theta = 1$ or $\theta = 0$

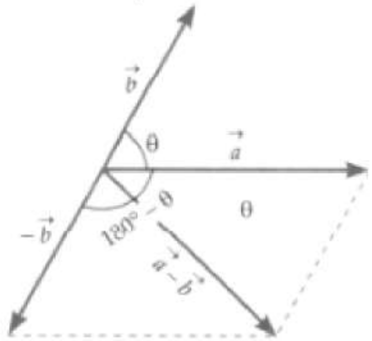
$\therefore |\vec{a}+\vec{b}|_{\max} = \sqrt{|\vec{a}|^2 + |\vec{b}|^2 + 2|\vec{a}||\vec{b}|\cos 0^\circ}$

$= \sqrt{(|\vec{a}| + |\vec{b}|)^2} = |\vec{a}| + |\vec{b}|$

Hence $|\vec{a}+\vec{b}| \leq |\vec{a}| + |\vec{b}|$

The equality sign in applicable when $\theta = 0^o$ i.e., when $\vec{a}$ and $\vec{b}$ are in the same direction.

ii. If θ is the angle between $\vec{a}$ and $\vec{b}$, then the angle between $\vec{a}$ and $-\vec{b}$ will be $(180^o - \theta)$, as shown in figure.



$\therefore \quad |\vec{a}-\vec{b}| = |\vec{a}+(-\vec{b})|$

$= \sqrt{|\vec{a}|^2 + |-\vec{b}|^2 + 2|\vec{a}||-\vec{b}|\cos(180^\circ - \theta)}$

$= \sqrt{|\vec{a}|^2 + |\vec{b}|^2 - 2|\vec{a}||\vec{b}|\cos\theta}$

$\left[\because |-\vec{b}| = |\vec{b}|, \cos(180^\circ - \theta) = -\cos\theta\right]$

$|\vec{a}-\vec{b}|$ will be maximum when $\cos\theta = -1$ or $\theta = 180^o$

$\therefore |\vec{a}-\vec{b}|_{\max} = \sqrt{|\vec{a}|^2 + |\vec{b}|^2 - 2|\vec{a}||\vec{b}|\cos 180^\circ}$

$= \sqrt{(|\vec{a}| + |\vec{b}|)^2} = |\vec{a}| + |\vec{b}|$

Hence $|\vec{a}-\vec{b}| \leq |\vec{a}| + |\vec{b}|$

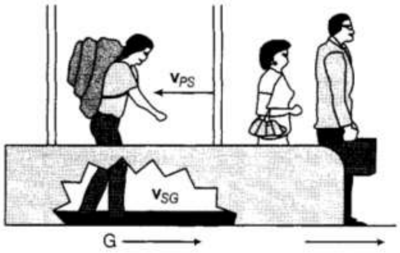
The equality sign is applicable when $\theta = 180°$

OR

The situation is sketched in figure. We assign a letter to each body in relative motion, P passenger, S sidewalk, G ground. The relative velocities v_{PS} and v_{SG} are given

v_{PS} = 5.00 km/h, towards right

v_{SG} = 3.00 km/h, towards right



i. Velocity of the passenger with respect to the ground v_{PG}, is given by the relation of relative velocity

$V_{PG} = V_{PS} + V_{SG}$

= 5.00 km / h + 3.00 km/h

= 8.00 km/h

ii. Given length of the sidewalk is 135 m, and so this is the distance Δx_G the passenger travels relative to the ground. The rate at which this distance along the ground is covered by the passenger is v_{PG}, where

$v_{PG} = \frac{\Delta x_G}{\Delta t}$

Therefore, to find the time required we will use the relation,

$\Delta t=\frac{\Delta x_G}{v_{PG}}=\frac{135}{8.00\left(\frac{1000}{3600}\right)}$ = 60.8 s ~ 1 min 1 s

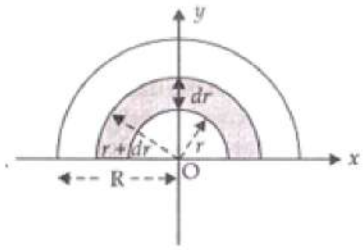
iii. The problem here is to determine how much of the sidewalk's surface the passenger moves over. If he was standing still and not walking along the surface, he would cover none of it. Because he is moving relative to the surface at velocity v_{PS}, he does move some distance Δx_s relative to the surface. The problem is to find Δx_s in time Δt = 60.8 s, since we found in part (b) that this is the time interval during which he is on the moving sidewalk. His velocity relative to the sidewalk is $v_{ps} = \Delta x_s/\Delta t$, and so

$\Delta x_s=v_{PS}\Delta t$

$=(5.00)\left(\frac{1000}{3600}\right)(60.8)$

= 84.4 m

33. Let mass of half disc is M.



i. Area of element $=\frac{\pi}{2}\left[(r+dr)^2-r^2\right]$

$=\frac{\pi}{2}\left[r^2+dr^2+2rdr-r^2\right]$

$=\pi rdr$

$\therefore$ Mass of elementary Ring $dm=\frac{2M}{\pi R^2}.\pi rdr$

dm $=\frac{2M}{R^2}r.dr$

Let (x,y) are the co-ordinates of c.m. of this strip $(x,y)=\left(0,\frac{2r}{\pi}\right)$

$x=x_{cm}=\frac{1}{M}\int_0^R xdm=\int_0^R 0dm=0$

$y_{cm}=\frac{1}{M}\int_0^R ydm=\frac{1}{M}\int_0^R\frac{2r}{\pi}\times\frac{2M}{R^2}rdr$

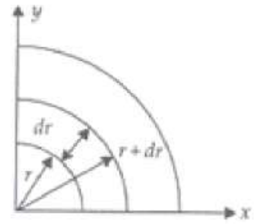
$=\frac{1}{m}\cdot\frac{4M}{\pi R^2}\int_0^R r^2dr=\frac{4}{\pi R^2}\left[\frac{r^3}{3}\right]_0^R=\frac{4}{3\pi R^2}\cdot R^3$

$y_{cm}=\frac{4R}{3\pi}$

So centre of mass of circular half disc $=\left(0,\frac{4R}{3\pi}\right)$

ii. Mass per unit area of quarter disc

$\sigma=\frac{M}{\frac{\pi R^2}{4}}=\frac{4M}{\pi R^2}$.



Area of element = $\frac{1}{2}$

dm = $\frac{1}{2}\pi rdr\times\sigma=\frac{2Mr}{R^2}dr$

X_{cm} = $\int_0^R xdm=\frac{4R}{3\pi}$

Similarly $Y_{cm}=\frac{4R}{3\pi}$

center of mass = $(\frac{4R}{3\pi},\frac{4R}{3\pi})$

OR

THE **LAW OF CONSERVATION OF ANGULAR MOMENTUM** STATES THAT: "When the net external torque acting on a system about a given axis is. zero , the total **angular momentum** of the system about that axis remains constant." Mathematically, If then Iw= constant.

In this problem,as all the forces are conservative in nature and external torque on the system is zero so angular momentum of the system will remain conserved although energy of the system may not remain constant if external forces are acting on the system.

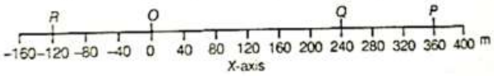
a. Moment of inertia of the man-platform system I= 7.6 kg m^2
   Moment of inertia when the man stretches his hands to a distance of 90 cm:
   $2 \times mr^2$
   $= 2 \times 5 \times (0.9)^2$
   = 8.1 kg m^2
   Initial moment of inertia of the system, $I_i = 7.6 + 8.1 = 15.7 \text{kgm}^2$
   Angular speed, $\omega_1 = 300$ rev /min
   Angular momentum, $L_i = I_i\omega_i = 15.7 \times 30$ ......(i)
   Moment of inertia when the man folds his hands to a distance of 20 cm:
   $2 \times m^2$
   $= 2 \times 5(0.2)^2 = 0.4 \text{kgm}^2$
   Final moment of inertia, $I_f = 7.6 + 0.4 = 8kgm^2$
   Final angular speed = ω_f
   Final angular momentum, $L_f = I_f\omega_f = 0.79\omega_f$ ... *(ii)*
   From the conservation of angular momentum, we have:
   $I_i\omega_i = I_f\omega_f$
   $\therefore \omega_f = \frac{15.7 \times 30}{8} = 58.88 rev/\text{min}$
b. Kinetic energy is not conserved in the given process. In fact, with the decrease in the moment of inertia, kinetic energy increases. The additional kinetic energy comes from the work done by the man to fold his hands toward himself.(muscular work done by the man will be converted into kinetic energy)

Section E

34. **Read the text carefully and answer the questions:**

If the position of an object is continuously changing w.r.t. its surrounding, then it is said to be in the state of motion. Thus, motion can be defined as a change in position of an object with time. It is common to everything in the universe.

In the given figure, let P, Q and R represent the position of a car at different instants of time.



(i) The position coordinates of point P = (+360, 0, 0) and point R = (-120, 0, 0)
(ii) Distance can not be negative while displacement of a body can be negative or zero.
Distance is a scalar quantity while displacement is a vector quantity.
(iii)Displacement from O to P = 240 m
Displacement from P to Q = 240-300 = -60 m
Total displacement = 240-60 = 180 m

OR

As the initial and final position are same, so displacement will be 0 m.

35. **Read the text carefully and answer the questions:**

Power is defined as the time rate at which work is done or energy is transferred. The average power of a force is defined as the ratio of the work, W, to the total time t taken

$P_{av} = \frac{W}{t}$

The instantaneous power is defined as the limiting value of the average power as time interval approaches zero.

$P = \frac{dw}{dt}$

The work dW done by a force F for a displacement dr is dW = F·dr. The instantaneous power can also be expressed as

$P = \frac{F.dr}{dt}$

P = F·v

Where v is the instantaneous velocity when the force is F. Power, like work and energy, is a scalar quantity. Its dimensions are [$ML^2 T^{-3}$]. In the SI, its unit is called a watt (W). The watt is 1 J s^{-1}. The unit of power is named after James Watt, one of the innovators of the steam engine in the eighteenth century. There is another unit of power, namely the horse-power (hp)

1 hp = 746 W

This unit is still used to describe the output of automobiles, motorbikes.

(i) Power

(ii) Instantaneous power

(iii) The instantaneous power is defined as the limiting value of the average power as time interval approaches zero.

P = $\frac{dw}{dt}$

The work dW done by a force F for a displacement dr is dW = F·dr. The instantaneous power can also be expressed as

P = $\frac{F \cdot dr}{dt}$

P = F·v

Where v is the instantaneous velocity when the force is F. Power, like work and energy, is a scalar quantity. Its dimensions are $[ML^2 T^{-3}]$. In the SI, its unit is called a watt (W).

OR

1 horse power is equal to 746 watt.