
Sample Paper-03
Physics (Theory)
Class – XI

Time allowed: 3 hours

Maximum Marks: 70

General Instructions:

- a) All the questions are compulsory.
- b) There are **26** questions in total.
- c) Questions **1 to 5** are very short answer type questions and carry **one** mark each.
- d) Questions **6 to 10** carry **two** marks each.
- e) Questions **11 to 22** carry **three** marks each.
- f) Questions **23** is value based questions carry **four** marks.
- g) Questions **24 to 26** carry **five** marks each.
- h) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions in five marks each. You have to attempt only one of the choices in such questions.
- i) Use of calculators is **not** permitted. However, you may use log tables if necessary.
- j) You may use the following values of physical constants wherever necessary:
- k)

$$c = 3 \times 10^8 \text{ m/s}$$

$$h = 6.63 \times 10^{-34} \text{ Js}$$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ TmA}^{-1}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$$

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

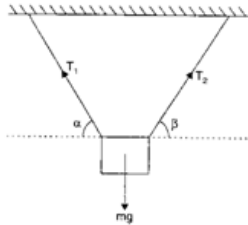
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- 1. If one mass of one electron is $9.11 \times 10^{-31} \text{ kg}$, then how many electrons would weigh in 1 kg?
 - 2. What do you understand by the term conservative force?
 - 3. Give reason: "Liquid set in rotation comes to rest after some time".
 - 4. What is the number of degree of freedom of a molecule of a diatomic gas at room temperature?
 - 5. What is the slope of stress-strain body within the elastic limit?
 - 6. Give the limitations of the first law of Thermodynamics?

Or

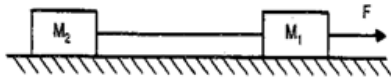
If work required blowing a soap bubble of radius r is W , then what additional work is required to be done below it to a radius $3r$?

- 7. The measured quantities a , b , c and x is calculated by using the relation $x = \frac{ab^2}{c^3}$. If the percentage errors in measurements of a , b , and c are $\pm 1\%$, $\pm 2\%$ and $\pm 1.5\%$, then calculate the maximum percentage error in value of x obtained.
 - 8. What would be the velocity of the top end at the time of touching the ground if a rod of length l and mass M held vertically is let go down, without slipping at the point of contact?
 - 9. State the laws of limiting friction.
 - 10. If $1\text{Å} = 10^{-10} \text{ m}$ and the size of a hydrogen atom is about 0.5Å , then what is the total atomic volume in m^3 of a mole of hydrogen atoms?
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11. What is the average speed during the whole journey, if a body covers half of its journey with a speed of 40 m/s and other half with a speed of 60 m/s.
 12. Find the height to which it rises above the earth's surface if a particle is projected vertically upwards from the surface of earth of radius R with kinetic energy equal to half of the minimum value needed for it to escape.
 13. If the density of hydrogen at S.T.P is 0.09 kg m^{-3} , then calculate
 - (i) RMS velocity
 - (ii) Mean kinetic energy E of one gram molecule of hydrogen at S.T.P.
 14. The planet Mars has two moons, A and B
 - (i) How would you calculate the mass of Mars, A has a period 7 hours, 39 minutes and an orbital radius of $9.4 \times 10^3 \text{ km}$
 - (ii) Assuming that Earth and Mars move in circular orbits around the sun with the Martian orbit being 1.52 times the orbital radius of the earth, then what is the length of the Martian year in days?
 15. Deduce the height at which the value of g is the same as at a depth of $\frac{R}{2}$?
 16. A body of mass m is suspended by two strings making angles α and β with the horizontal. Calculate the tensions in the two strings.



17. (i) Calculate the angular momentum and rotational kinetic energy of earth about its own axis.
- (ii) How long could this amount of energy supply one KW power to each of the 3.5×10^9 persons on earth?
18. A diagram below is a light inextensible string. If a force F as shown acts upon M_1 , find the acceleration of the system and tension in string.



19. (i) State ideal gas equation.
 - (ii) Draw graph to check whether a real gas obeys this equation.
 - (iii) What is the conclusion drawn?
 20. A uniform disc of radius R and mass M is mounted on an axis supported in fixed frictionless bearing. A light chord is wrapped around the rim of the wheel and suppose that we hang a body of mass m from the chord. Find the angular of the disc and tangential acceleration of point on the rim.
 21. The following equation represents standing wave set up in medium $y = 4 \cos \frac{\pi x}{5} \sin 40 \pi t$, where x and y are in cm and t in seconds. Find out the amplitude and the velocity of the two component waves and calculate the distance between adjacent nodes. What is the velocity of a medium particle at $x = 3 \text{ cm}$ at time $\frac{1}{8}$ second?
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22. Uniform spring whose unstretched length is l has a force constant k . The spring is cut into two pieces of unstretched lengths, l_1 and l_2 , where $l_1 = n l_2$ and n is an integer. What are the corresponding force constants k_1 and k_2 in terms of n and k ?

Or

If a steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length, then calculate [Given $Y = 2.0 \times 10^{11} \text{ N/m}^2$]

- (a) Stress
(b) Elongation
(c) Strain of the rod
23. Radha was 70 kg at the age of 16 years. She then decided to lose weight. She started walking daily for 30 minutes and started taking only milk and fruits. Her parents advised her not to cut off her meal so drastically. She showed the result of losing 30 kg but she was feeling weak. So her parents took her to doctor who advised her to take proper balanced diet and exercise regularly.
- (a) Is taking crash diet advisable? Why?
(b) Give the relation between SI and CGS unit of heat.
(c) What would be her rise in temperature, if Radha weighing 40 kg now was advised to take 4000 kcal diet in a day and this energy was to be used in heating her without any losses?
[Given: Sp. Heat of human body = $0.83 \text{ cal g}^{-1} \text{ } ^\circ\text{C}^{-1}$]
24. Tunnel is dug through the earth from one side to the other side along with a diameter. The motion of a particle into the tunnel is simple harmonic motion. Find the time period, neglect all the frictional forces and assume that the earth has a uniform density. Assume that $G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$; density of the earth = $5.51 \times 10^3 \text{ kg m}^{-3}$.

Or

Explain the following:

- (a) In a sound wave, the displacement node is a pressure antinode and vice versa
(b) Bats can ascertain distance, direction, nature and sizes of the obstacles without any eyes.
(c) Solids can support both longitudinal and transverse waves, but only longitudinal waves can propagate in gases
(d) The shape of a pulse gets distorted during propagation in a dispersive medium
25. An artificial diamond crystal has been manufactured by subjecting carbon in the form of graphite to a pressure of $1.55 \times 10^{10} \text{ Nm}^{-2}$ at a high temperature. What must have been the original volume of the diamond, whose mass before cutting was about 175g? Assuming that natural diamonds were formed at similar high pressure within the earth, the density of the diamond = 3.5 g cm^{-3} and its bulk modulus = $62 \times 10^{10} \text{ Nm}^{-2}$.

Or

Derive the expression for excess pressure inside:

- (a) A liquid drop.
(b) A liquid bubble.
(c) An air bubble.
26. A SHM is expressed by the equation $x = A \cos(\omega t + \phi)$ and the phase angle $\phi = 0$. Draw graphs to show variation of displacement, velocity and acceleration for one complete cycle in SHM.

Or

If two tuning forks A and B give 9 beats in 3 seconds and a sound with a closed column of air 15 cm long and B with an open column 30.5 cm long, then calculate their frequencies

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Answers

1. $9.11 \times 10^{-31} \times n = 1 \text{ kgp}$
 Therefore, $n = 1.1 \times 10^{30}$
2. Any force is called conservative force if,
 (a) Work done against is independent of path.
 (b) Work done in a closed path is zero
3. The liquid comes to rest due to the viscous force, due to internal fluid friction between its different layers.
4. A molecule of diatomic gas possesses five degrees of freedom at room temperature which is due to translational motion and rotational motion.
5. Within elastic limit, the slope of stress-strain curve gives the value of modulus of elasticity of the given material.
6. (i) It does not tell us about the direction of flow of heat
 (ii) It fails to explain why heat cannot be spontaneously converted into work.

Or

$$\text{Increase in surface area} = 2[4\pi (3r)^2 - 4\pi r^2]$$

$$\text{Increase in surface energy} = \sigma \times 2 \times 4\pi \times 8r^2 = 8W$$

$$\text{Additional work done} = 8W$$

$$7. \quad x = \frac{ab^2}{c^3}$$

$$\left(\frac{\Delta x}{x} \right)_{\max} = \frac{\Delta a}{a} + 2 \frac{\Delta b}{b} + 3 \frac{\Delta c}{c}$$

$$\frac{\Delta a}{a} = \pm 1\%, \quad \frac{\Delta b}{b} = \pm 2\%, \quad \frac{\Delta c}{c} = \pm 3\%$$

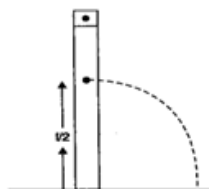
$$\left(\frac{\Delta x}{x} \right)_{\max} = 1\% + 2 \times 2\% + 3 \times 1.5\%$$

$$= (1 + 4 + 4.5)\%$$

$$= 9.5\%$$

8. Loss in potential energy = Gain in rotational Kinetic energy

$$mg \frac{l}{2} = \frac{1}{2} \frac{Ml^2}{3} \cdot \omega^2$$



$$\omega = \sqrt{\frac{3gl}{l^2}} = \sqrt{\frac{3g}{l}}$$

$$v = l\omega$$

$$= \sqrt{3gl}$$

9. The laws of limiting friction are as follows:

- (a) The value of limiting friction depends on the nature of the two surfaces in contact and on the state of their smoothness.
- (b) The force of friction acts tangential to the surfaces in contact in a direction opposite to the direction of relative motion.
- (c) The value of limiting friction is directly proportional to the normal reaction between the two given surfaces.
- (d) For any two given surface and for a given value of normal reaction the force of limiting friction is independent of the shape and surface area of surfaces in contact. Coefficient of limiting friction for two given surfaces in contact is defined as the ratio of the force of normal reaction N.

$$\mu_r = \frac{f_1}{N}$$

10. Volume of the one hydrogen atom = $\frac{4}{3} \pi r^3 = \frac{4}{3} \times 3.14 \times (0.5 \times 10^{-10})^3 \text{ m}^3$

$$= 5.23 \times 10^{-31} \text{ m}^3$$

According to Avogadro's hypothesis, one mole of hydrogen contains 6.023×10^{23} atoms.

Atomic volume of 1 mole of hydrogen atom = $6.023 \times 10^{23} \times 5.23 \times 10^{-31}$

$$= 3.15 \times 10^{-7} \text{ m}^3.$$

11. Average speed = $\frac{\text{Total Distance}}{\text{Time taken}}$

Let x be the distance to be covered,

$$\text{Average speed} = \frac{x}{\frac{x}{2v_1} + \frac{x}{2v_2}}$$

Where $\frac{x}{2v_1}$ = time taken to cover first half of the distance, $\frac{x}{2v_2}$ = time taken to cover the second half of the distance,

$$\text{Average speed} = \frac{x}{\frac{x(v_1 + v_2)}{2v_1 v_2}}$$

$$= \frac{x (x) 2v_1 v_2}{x (v_1 v_2)} = \frac{2v_1 v_2}{v_1 + v_2}$$

$$V_{av} = \frac{2 \times 40 \text{ m/s} \times 60 \text{ m/s}}{100 \text{ m/s}}$$

$$= 48 \text{ ms}^{-1}$$

12. Escape velocity from the surface of earth is

$$v_{es} = \sqrt{\frac{2GM}{R}}$$

$$\text{K.E of a body } K_{es} = \frac{1}{2} m v_{es}^2 = \frac{GMm}{R}$$

The body is projected from the surface of earth with a K.E half of that needed to escape from earth surface hence

$$\text{Initial K.E. of body } K = \frac{K_{es}}{2} = \frac{GMm}{2R}$$

And its potential energy $\mu = -\frac{GMm}{R}$

Total initial energy of body $-\frac{GMm}{2R}$

The body goes up to a maximum height h from surface of earth, where the final K.E. = 0 and P.E = $-\frac{GMm}{(R+h)}$

Total energy = $-\frac{GMm}{(R+h)}$

From conservation law of mechanical energy,

$$-\frac{GMm}{2R} = -\frac{GMm}{(R+h)}$$

On simplifying, $h = R$.

13. Hence $\rho = 0.09 \text{ kg m}^{-3}$

S.T.P pressure $P = 101 \times 10^5 \text{ Pa}$.

According to K.E of gases

$$P = \frac{1}{3}\rho C^2 \text{ or } C = \sqrt{\frac{3P}{\rho}}$$

$$\sqrt{\frac{3 \times 1.01 \times 10^5}{0.09}} = 1837.5 \text{ ms}^{-1}$$

Volume occupied by one mole of hydrogen at S.T.P = 22.4 litres = $22.4 \times 10^{-3} \text{ m}^3$

Mass of hydrogen $M = \text{volume} \times \text{density}$

$$= 22.4 \times 10^{-3} \times 0.09$$

$$= 2.016 \times 10^{-3} \text{ kg}$$

Average K.E / mole = $\frac{1}{2} MC^2$

$$= \frac{1}{2} \times (2.016 \times 10^{-3}) \times (1837.5)^2$$

$$= 3403.4 \text{ J}$$

14. (i) The Sun's Mass replaced by the Martian mass M_m

$$T^2 = \frac{4\pi^2}{GMm} R^3$$

$$Mm = \frac{4\pi^2}{G} \times \frac{R^3}{T^2}$$

$$Mm = \frac{4 \times (3.14)^2 \times (9.4)^3 \times 10^{18}}{6.67 \times 10^{-11} \times (459 \times 60)^2}$$

$$= \frac{4 \times (3.14)^2 \times (9.4)^3 \times 10^{18}}{6.67 \times (4.59 \times 6)^2 \times 10^{-5}}$$

$$= 6.48 \times 10^{23} \text{ kg}$$

(ii) Using Kepler's third law

$$\frac{T_M^2}{T_E^2} = \frac{R_{MS}^3}{R_{ES}^3}$$

Where R_{MS} is the Mars (Earth) – Sun distance

$$T_M = \left(\frac{R_{MS}}{R_{ES}} \right)^{3/2} T_E$$

$$= (1.52)^{3/2} \times 365 = 684 \text{ days}$$

15. At depth = $\frac{R}{2}$, value of acceleration due to gravity

$$g' = g \left(1 - \frac{R}{2R} \right) = \frac{g}{2}$$

At height x,

$$g' = g \left(1 - \frac{2x}{R} \right)$$

$$g \left(1 - \frac{2x}{R} \right) = \frac{g}{2}$$

$$\frac{1}{2} = \frac{2x}{R} \Rightarrow x = \frac{R}{4}$$

16. Consider components of tensions T_1 and T_2 along the horizontal and vertical directions

$$-T_1 \cos \alpha + T_2 \cos \beta = 0 \dots\dots\dots (i)$$

$$T_1 \cos \alpha = T_2 \cos \beta \dots\dots\dots (ii)$$

$$T_1 \sin \alpha + T_2 \sin \beta = mg$$

From (i)

$$T_2 = \frac{T_1 \cos \alpha}{\cos \beta} \text{ And substituting in (ii) we get}$$

$$T_1 \sin \alpha + \left(\frac{T_1 \cos \alpha}{\cos \beta} \right) \sin \beta = mg$$

$$T_1 \frac{\sin(\alpha + \beta)}{\cos \beta} = mg$$

$$T_1 = \frac{mg \cos \beta}{\sin(\alpha + \beta)}$$

Hence,

$$T_2 = \frac{T_1 \cos \alpha}{\cos \beta} = \frac{mg \cos \beta}{\sin(\alpha + \beta)} \cdot \frac{\cos \alpha}{\cos \beta}$$

$$T_2 = \frac{mg \cos \alpha}{\sin(\alpha + \beta)}$$

17. Assume that earth to be a solid sphere. We know that the moment of inertia of a solid sphere about its axis is

$$I = \frac{2}{5} MR^2 = \frac{2}{5} \times (6.0 \times 10^{24} \text{ kg}) \times (6.4 \times 10^6 \text{ m})^2$$
$$= 9.8 \times 10^{37} \text{ kg m}^2$$

In one day the earth completes one revolution. Hence the angular velocity is given by

$$\omega = \frac{2\pi}{24 \times 60 \times 60} = 7.27 \times 10^{-5} \text{ rad/sec}$$

$$\text{Angular momentum } I\omega = (9.8 \times 10^{37} \text{ kg m}^2) (7.27 \times 10^{-5} \text{ s}^{-1})$$
$$= 7.1 \times 10^{33} \text{ kg m}^2 / \text{sec.}$$

The rotational energy

$$\frac{1}{2} I\omega^2 = \frac{1}{2} (9.8 \times 10^{37} \text{ kg m}^2) (7.27 \times 10^{-5} \text{ s}^{-1})^2$$
$$= 2.6 \times 10^{29} \text{ J}$$

Power supplied by this energy

$$P = \frac{\text{Energy}}{\text{Time}} = \frac{2.6 \times 10^{29}}{t} \text{ watt}$$

$$= \frac{2.6 \times 10^{29}}{10^3 t} \text{ KW}$$

Power required by 3.5×10^9 persons = $3.5 \times 10^9 \times 1$ kilowatt

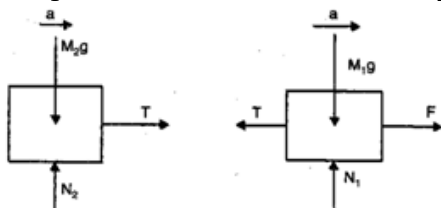
$$\frac{2.6 \times 10^{29}}{10^3 t} = 3.5 \times 10^9$$

$$t = \frac{2.6 \times 10^{29}}{10^3 \times 3.5 \times 10^9} \text{ sec}$$

$$= 2.35 \times 10^9 \text{ years}$$

18. As the string is inextensible acceleration of two blocks will be same. Also string is massless so tension throughout the string will be same. Contact force will be normal force only.

Acceleration of each block is a , tension in string is T and contact force between M_1 and surface is N_1 and contact force between M_2 and surface is N_2



Applying Newton's second law for the blocks:

$$F - T = M_1 a \quad \text{..... (i)}$$

$$M_1 g - N_1 = 0 \quad \text{..... (ii)}$$

$$T = M_2 a \quad \text{..... (iii)}$$

$$M_2 g - N_2 = 0 \quad \text{..... (iv)}$$

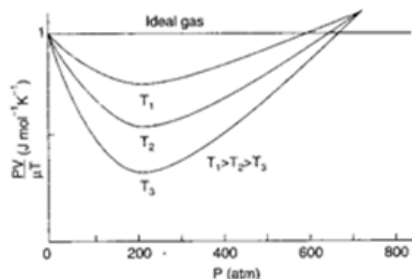
Solving equation (i) and (iii)

$$a = \frac{F}{M_1 + M_2}$$

$$T = \frac{M_2 F}{M_1 + M_2}$$

19. According to the ideal gas equation $PV = \mu RT$

According to this equation $\frac{PV}{\mu T} = R$

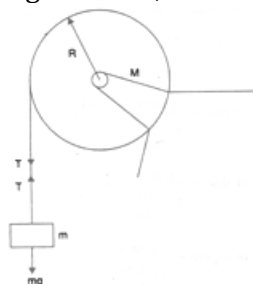


Experimentally value of $\frac{PV}{\mu T}$ for real gas was calculated by altering the pressure of gas at different temperatures. The graphs obtained have been shown in the diagram. Here for the purpose of comparison, graph for an ideal gas has also been drawn, which is a straight line parallel to pressure axis.

From the graph it is clear that behaviour of real gases is differ from an ideal gas. However at high temperatures and low pressures behaviours is nearly same as that of an ideal gas.

20. Let T be the tension in the chord

$$mg - T = ma, \dots\dots\dots (i)$$



Where a is the tangential acceleration of apoint on the rim of the disc.

$$\tau = I\alpha$$

But the resultant torque on the disc = TR and the rotational inertia

$$I = \frac{1}{2} MR^2$$

$$TR = \frac{1}{2} MR^2 \left(\frac{a}{R} \right)$$

$$2TR = Ma$$

$$a = \frac{2T}{M} \dots\dots\dots (ii)$$

From the equation (i) and (ii)

$$mg - \left(\frac{Ma}{2} \right) = ma$$

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

$$mg - T = m \times \left(\frac{2T}{M} \right)$$

$$T = \left(\frac{mM}{M+2m} \right) g$$

21. The equation of stationary wave is $y = 4 \cos \frac{\pi x}{3} \sin 40 \pi t$

$$y = 2 \times 2 \cos \frac{2\pi x}{6} \sin \frac{2 \times (120)t}{6}$$

$$\text{We know that } y = 2a \cos \frac{2\pi x}{\lambda} \sin \frac{2\pi vt}{\lambda}$$

By comparing tow equations we get,

a= 2cm, $\lambda=6\text{cm}$ and $v=220 \text{ cm/sec}$.

The component waves are

$$y_1 = a \sin \frac{2\pi}{\lambda} (vt-x)$$

$$y_2 = a \sin \frac{2\pi}{\lambda} (vt+x)$$

Distance between two adjacent nodes

$$= \frac{\lambda}{2} = \frac{6}{2} = 3\text{cm}$$

$$\text{Particle velocity } \frac{dy}{dt} = 4 \cos \frac{\pi x}{3} \cos (40\pi t) \cdot 40\pi$$

$$= 160 \cos \frac{\pi x}{3} \cos 40 \pi t$$

$$= 160 \pi \cos \frac{\pi x}{3} \cos \left(40\pi \times \frac{1}{8} \right)$$

$$= 160\pi$$

$$\text{Particle velocity} = 160 \text{ cm/sec.}$$

$$22. l = l_1 + l_2 \dots\dots\dots (i)$$

$$l_1 = n l_2 \dots\dots\dots (ii)$$

$$k = \frac{Mg}{l} \dots\dots\dots (iii)$$

$$k_1 = \frac{Mg}{l_1} \dots\dots\dots (iv)$$

$$k_2 = \frac{Mg}{l_2} \dots\dots\dots (v)$$

Dividing the equation (iv) by (iii),

$$\frac{k_1}{k} = \frac{l}{l_2} = 2 \frac{l_1 + l_2}{l_1} = 1 + \frac{l_2}{l_1}$$

From the equation (ii) we find $\frac{l_1}{l_2} = n$

$$\frac{k_1}{k} = 1 + \frac{1}{n}$$

From equation (v) and (iii)

$$\frac{k_2}{k} = \frac{l}{l_2} = \frac{l_1 + l_2}{l_2} = \frac{l_1}{l_2} + 1$$

From equation (ii) we have $\frac{l_1}{l_2} = n$

$$\frac{k_2}{k} = (n+1)$$

$$k_2 = k(n+1)$$

Or

$$(a) \text{ Stress} = \frac{F}{A} = \frac{F}{\pi r^2} = 3.18 \times 10^8 \text{ N/m}^2$$

$$(b) \text{ Elongation } \Delta L = \frac{\left(\frac{F}{A} \right) L}{Y} = 1.59 \text{ mm}$$

$$(c) \text{ Strain} = \frac{\Delta L}{L} = 0.16\%$$

23. (a) Crash diet should not be taken as it makes body weak and less immune to diseases. It makes the body deficient in certain nutrients which is harmful for body.
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(b) The SI unit of heat = Joule and the CGS unit of heat = Calorie

$$1 \text{ calorie} = 4.18 \text{ J}$$

(c) Substituting the values for $\Delta Q = cm\Delta T$, we get

$$\Delta T = 40.16^\circ\text{C}$$

24. The tunnel is dug along the diameter of the earth. Consider the case of a particle of mass m at a distance y from the Centre of the earth. There will be a gravitational attraction of the earth on this particle due to the portion of matter contained in a sphere of radius y . the mass of the sphere of radius y is given by

$$M = \text{volume} \times \text{density}$$

$$M = \frac{4}{3} \pi y^3 \times d$$

This mass can be regarded as concentrated at the centre of the earth. The force F between this mass and the particle of mass m is given by

$$F = -\frac{GMm}{y^2}$$

Negative sign shows that the force is of attraction

$$F = -G \left(\frac{4}{3} \pi y^3 d \right) \frac{m}{y^2} = -G \left(\frac{4}{3} \pi y d \right) m$$

$$F \propto y$$

The force is directly proportional to the displacement hence the motion is simple harmonic motion.

$$\text{The constant } k = \frac{4}{3} \pi m d G$$

$$\text{The time period } T = 2\pi \sqrt{m/k}$$

$$T = 2\pi \sqrt{\left(\frac{3m}{4\pi m d G} \right)} = 2\pi \sqrt{\left(\frac{3}{4\pi d G} \right)}$$

$$T = \sqrt{\left(\frac{3\pi}{dG} \right)} = \sqrt{\left(\frac{3 \times 3.14}{5.51 \times 10^5 \times 6.67 \times 10^{-11}} \right)}$$

$$T = 42.2 \text{ minutes}$$

Or

- (a) A sound wave decrease in displacement node cause an increase in the pressure there. Also an increase in displacement is due to the increase in pressure.
- (b) Bats emit ultrasonic waves of high frequency from their mouths. These waves after being reflected back from the obstacles on their path are observed by the bats. Using these waves' bats can find the direction, distance, nature and size of the object.
- (c) This is due to the fact that gases have only the bulk modulus of elasticity whereas solids have both the shear modulus as well as the bulk modulus of elasticity.
- (d) A pulse of sound consists of a combination of waves of different wavelength. In a dispersive medium these waves travel with different velocities giving rise to the distortion in the wave.
25. Mass of the diamond = 175 g

$$\text{Density} = 3.5 \text{ gcm}^{-3}$$

$$\text{Volume} = \frac{175}{3.5} = 50 \text{ cm}^3$$

If the original volume of the diamond were V , then

$$V = 50 + \Delta V$$

Where ΔV is the increase in volume under the pressure during its formation,

$$\text{Bulk modulus} = B = \frac{PV}{\Delta V}$$

Substituting $(V - 50)$ for ΔV and the values of P and B , we have

$$\frac{B}{P} = \frac{62 \times 10^{10}}{1.55 \times 10^{10}} = \frac{40V}{V - 50}$$

$$V = 40V - 2000$$

$$39V = 2000$$

$$V = 51.28 \text{ cm}^3$$

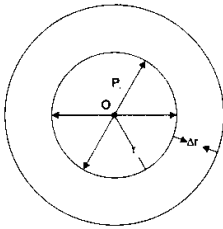
$-\Delta V$ can be calculated as,

$$(-\Delta V) = \frac{PV}{B} = \frac{1.55 \times 10^{10} \times 50}{62 \times 10^{10}} = 1.25 \text{ cm}^3$$

Now adding this value to the present value giving $V = 51.25 \text{ cm}^3$. The difference is only in the second decimal place, less than 0.06%. Hence the original volume of the diamond must have been equal to 51.3 cm^3 .

Or

(a)



Let r = radius of a spherical liquid drop of Centre O , T = surface tension of the liquid.

Let P_i and P_o be the value of pressure inside and outside the drop.

$$\text{Excess pressure inside the liquid drop} = P_i - P_o$$

Let Δr be the increase in its radius due to excess pressure. It has one free surface outside.

$$\text{Increase in surface area of the liquid drop} = 4\pi(r + \Delta r)^2 - 4\pi r^2$$

$$= 4\pi[r^2 + (\Delta r)^2 + 2r\Delta r - r^2]$$

$$= 8\pi r\Delta r$$

$$\text{Increase in surface energy of the drop is } W = \text{surface tension} \times \text{increase in area} = T \times 8\pi r\Delta r$$

$$W = \text{force due to excess of pressure} \times \text{displacement} \dots\dots\dots (i)$$

$$= \text{Excess pressure} \times \text{area of drop} \times \text{increase in radius}$$

$$= (P_i - P_o) 4\pi r^2 \Delta r \dots\dots\dots (ii)$$

From equation (i) and (ii) we get,

$$(P_i - P_o) \times 4\pi r^2 \Delta r = T \times 8\pi r\Delta r$$

$$P_i - P_o = \frac{2T}{r}$$

(a) Inside the liquid Bubble: A liquid bubble has air both inside and outside it therefore it has two free surfaces.

$$\text{Increase in surface area} = 2[4\pi(r + \Delta r)^2 - 4\pi r^2]$$

$$= 2 \times 8\pi r \Delta r$$

$$= 16\pi r \Delta r$$

$$W = T \times 16\pi r \Delta r \dots\dots\dots (1)$$

$$W = (P_i - P_0) 4\pi r^2 \times \Delta r \dots\dots\dots (2)$$

From equation (1) and (2)

$$(P_i - P_0) \times 4\pi r^2 \times \Delta r$$

$$= T \times 16\pi r \Delta r$$

$$P_i - P_0 = \frac{4T}{r}$$

(b) Inside an air bubble: Air bubble is formed inside the liquid, thus air bubble has one free surface inside it and liquid is outside.

r = radius of the air bubble, Δr = increase in its radius due to excess of pressure $(P_i - P_0)$

inside it, T = surface tension of the liquid in which bubble is formed

Increase in surface area = $8\pi r \Delta r$

$$W = T \times 8\pi r \Delta r$$

$$W = (P_i - P_0) \times 4\pi r^2 \Delta r$$

$$(P_i - P_0) \times 4\pi r^2 \Delta r$$

$$= T \times 8\pi r \Delta r$$

$$P_i - P_0 = \frac{2T}{r}.$$

26. Let $x = A \cos(\omega t + \phi)$ and if phase angle ϕ is zero

$$x = A \cos \omega t,$$

$$v = \frac{dx}{dt} = -A\omega \sin \omega t$$

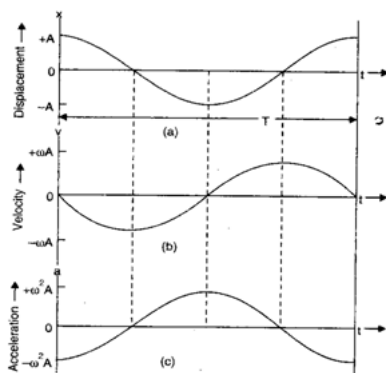
$$a = \frac{dv}{dt} = -A\omega^2 \cos \omega t$$

$$= -\omega^2 x$$

The values of 'x', 'v' and 'a' at different times over one complete cycle as follow:

Time t	0	T/4	T/2	3T/4	T
ωt	0	$\frac{\pi}{2}$	π	$\frac{3\pi}{2}$	2π
x	A	0	-A	0	A
v	0	$-A\omega$	0	$A\omega$	0
a	$-A\omega^2$	0	$A\omega^2$	0	$-A\omega^2$

Using the given data, $x - t$, $v - t$ and $a - t$ graphs are plotted as shown below:



Or

For closed column $l = 15 \text{ cm}$ or 0.15 m

For open column $l = 30.5 \text{ cm}$ or 0.305 m

Let v_1 and v_2 be the frequencies of the tuning fork A and B.

As tuning fork A resounds with a closed column

$$v_1 = \frac{v}{4l} = \frac{v}{4 \times 0.15} = \frac{v}{0.60} \dots\dots\dots (i)$$

The fork B resounds with an open air column

$$v_2 = \frac{v}{2l} = \frac{v}{2 \times 0.305} = \frac{v}{0.61} \dots\dots\dots (ii)$$

Fork A and B produces $\frac{9}{3} = 3$ beats per second.

$$v_1 - v_2 = 3$$

$$\frac{v}{0.60} - \frac{v}{0.61} = 3$$

$$v(0.61 - 0.60) = 3 \times 0.60 \times 0.61$$

$$v = \frac{3 \times 0.60 \times 0.61}{0.01} = 109.8 \text{ ms}^{-1}$$