ANSWERS FOR PRACTICE PAPER – 4

SECTION – A

1. What is the contribution of S.Chandra Sekhar to physics ?

Ans. While studying the constitution of the stars, he has proved that the maximum mass that a white dwarf can have is 1.4 times the solar mass. This mass is known as chandrasekhar limit. If a star crosses this limit, it has to face a catostropic collapse.

2. The percentage error in the mass and speed are 2% and 3% respectively. What is the maximum error in kinetic energy calculated using these quantities ?

Ans. $\frac{\Delta M}{M} \times 100 = 2\%$; $\frac{\Delta V}{V} \times 100 = 3\%$; Kinetic energy $= \frac{1}{2} mV^2$

$$\frac{\Delta K}{K} \times 100 = \frac{\Delta M}{M} \times 100 + 2\frac{\Delta V}{V} \times 100 = 2 + 2(3) = 2 + 6 = 8\%$$

3. The states of motion and rest are relative. Explain.

Ans. Rest and motion are relative. They are not absolute. A body can be in the rest or in motion w.r.t. reference frame. A man in a moving train is a rest w.r. to a co–passenger, but he is in motion w.r.t a man on the ground.

4. Which physical quantity remains constant ? i) In an elastic collision, ii) In an inelastic collision.

Ans. i) **In an elastic collision :** Both momentum and kinetic energy is constant.

ii) **In an inelastic collision :** Momentum remains constant.

5. Why are spokes provided in a bicycle wheel ?

Ans. By connecting to the rim of wheel to the axle through the spokes the mass of the wheel gets concentrated at its rim. this increases its moment of inertia. This ensures its uniform speed.

6. A girl is swinging seated in a swing. What is the effect on the frequency of oscillation if she stands ?

Ans. Frequency (n) $= \frac{1}{2\pi}\sqrt{\frac{g}{l}}$, $n \propto \frac{1}{\sqrt{l}}$

A girl swinging in standing position location of centre of mass shifts upwards l decreases, frequency of oscillation increases.

7. What is the principle behind the carburetor of an automobile ?

Ans. The carburetor of automobile has a venturi channel (nozzle) through which air flows with a large speed. The pressure is then lowered at the narrow neck and the petrol is sucked up in the chamber to provide the correct mixture of air to fuel necessary for combustion.

8. Why gaps are left between rails on a railway track ?

Ans. The length of the rails increases in summer due to high temperature. Therefore a gap is left to allow this expansion

9. A refrigerator is to maintain estables kept inside at 9°C. If room temperature is 36°C. Calculate the coefficient of performance.

Ans. Here $T_1 = 36^oC = 36 + 273 = 309$ K; $T_2 = 10^oC = 10 + 273 = 283$ K

$$COP = \frac{T_2}{T_1 - T_2} = \frac{283}{309 - 283} = \frac{283}{26} = 10.9$$

10. Four molecules of a gas have speeds 1, 2, 3 and 4 km/s. Find the rms speed of the gas molecule.

Ans. Given $V_1 = 1$ km/s; $V_2 = 2$ km/s; $V_3 = 3$ km/s; $V_4 = 4$ km/s;

$V_{rms} = ?$;

$$V_{rms} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + V_4^2}{n}}$$

$$= \sqrt{\frac{1^2 + 2^2 + 3^2 + 4^2}{4}} = \sqrt{\frac{1 + 4 + 9 + 16}{4}}$$

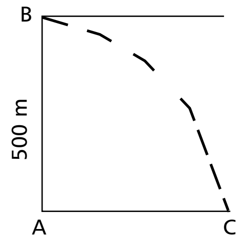
$$= \sqrt{\frac{30}{4}} = \sqrt{7.5} = 2.735 \text{ kms}^{-1}$$

SECTION – B

11. A food packet is dropped from an aeroplane, moving with a speed of 360 kmph in a horizontal direction, from a height of 500 m. Find (i) its time of descent (ii) the horizontal distance between the point at which the food packet reaches the ground and the point above which it was dropped.

Ans. Velocity of aeroplane v = 360 kmph

$$v = 360 \times \frac{5}{18} = 100 \text{ m/s}; \quad h = 500 \text{ m}$$



i) Time of descent = $t = \sqrt{\frac{2h}{g}}$

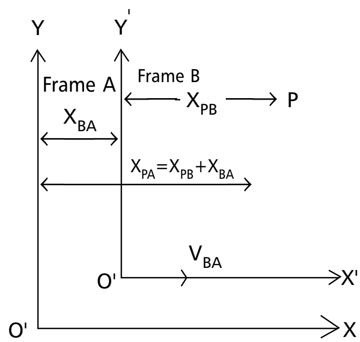
$= \sqrt{\frac{2 \times 500}{10}} = 10$ sec

ii) Horizontal range $R = u \times \sqrt{\frac{2h}{g}}$

$= 100 \times 10$ sec $= 1000$ sec

12. What is relative motion ? Explain it.

Ans. Relative velocity is defined as the velocity of one body with respect to another body.



Let us consider two observers A and B are making measurements of an event P in space from two frames of reference as shown in figure. At the beginning let the two origins of the two reference frames coincide and are on the same line.

Let the observer B is moving with a constant velocity V_{BA} with respect to A. Now we can connect the positions of the event P as measured by A with the position of P as measured by B.

As B is moving with constant velocity at the time of observation of event P, the frame B has moved a distance X_{BA} with respect to A.

$X_{PA} = X_{PB} + X_{BA}$ ⟶ (1)

"The position of P as measured by observer A is equal to the position of P as measured by B plus the position of B as measured by A".

eq (1) can also be written as $V_{PA} = V_{PB} + V_{BA}$ ⟶ (2)

13. Explain advantages and disadvantages of friction.

Ans. Advantages of friction :

1) Safe walking on the floor, motion of vehicles etc., are possible only due to friction.

2) Nails, screws are driven into walls (or) wooden surfaces due to friction.

3) Friction helps the fingures hold the things (or) objects like pen, pencil and water tumbler etc.
4) Speed running vehicles etc. can be stopped suddenly when friction is present, otherwise accidents become large. Due to friction vehicles move on the roads without slipping and they can be stopped.
5) The mechanical power transmission of belt drive is possible due to friction.

Disadvantages of friction :

1) Due to friction there is large amount of power loss in machines and engines.
2) Due to friction wear and tear of the machines increases and reducing their life.
3) Due to friction some energy gets converted into heat which goes as waste.

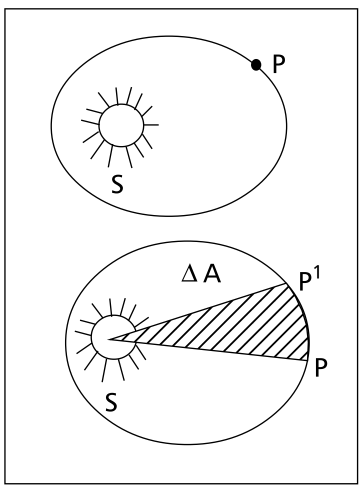
14. State Kepler's laws of planetary motion.

Ans. The three laws of Kepler can be stated as follows.

1) Law of orbits : All planets move in elliptical orbits with the sun situated at one of the foci.

2) Law of areas : The line that joins any planet to the sun sweeps equal areas in equal areas in equal intervals of time.

3) Law of periods : The square of the time period of revolution of a planet is proportional to the cube of the semi-major axis of the ellipse traced out by the planet. $T^2 \alpha R^3$



15. Define modulus of elasticity, stress, strain and Poisson's ratio.

Ans. Modulus of elasticity : It is the ratio stress applied on a body to the strain produced in the body.

$$k = \frac{\text{Stress}}{\text{Strain}}; \text{ S.I unit} \longrightarrow N/m^2 \text{ (or) Pascal}$$

Stress : When a body is subjected to an external force, the force per unit area is called stress.

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{F}{A}\text{; S.I unit} \longrightarrow N/m^2 \text{ (or) Pascal}$$

Strain : When deforming forces act on a body, the fractional deformation produced in the body.

It has no units

Poisson's ratio (σ) : The ratio between lateral strain to longitudinal strain of a body is called poisson's ratio.

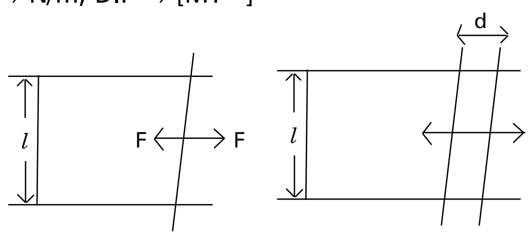
$$\sigma = \frac{\text{Lateral Strain}}{\text{Longitudinal Strain}} = \frac{\frac{-\Delta r}{r}}{\frac{\Delta L}{L}}$$

16. Explain Surface Tension and Surface energy.

Ans. Surface tension (S) : The force acting per unit length of an imaginary line drawn on the surface of a liquid, normal to it and parallel to the surface is called surface tension.

$$T = \frac{F}{l}\text{; S.I unit} \rightarrow N/m\text{; D.F} \rightarrow [MT^{-2}]$$

Surface energy (E) : The additional potential energy due to molecular forces per unit surface area is called surface tension.



$$\text{Surface energy} = \frac{\text{Workdone}}{\text{Area}}\text{; S.I Unit} \rightarrow J/m^{2;}\ \text{D.F} \rightarrow (MT^{-2})$$

Consider a horizontal liquid film ending in bar free to slide over parallel guides. We move the bar by a small distance d. The area of the surface increases, the system now has more energy, this means that some work has to be done against an internal force F.

Work done (W) = F.d

If the surface energy of the film is S per unit area, the extra area is 2dl. A film has two sides and the liquid in between them.

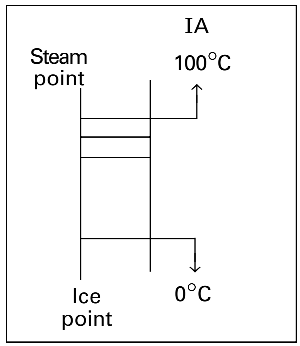
So there are two surfaces and the extra energy is

$$S\,(2dl) = Fd; \;\; S = \frac{F}{2l}$$

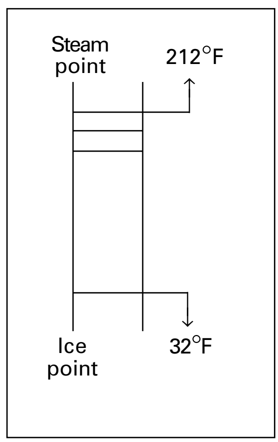
Surface tension is equal to the surface energy and is also equal to the force per unit length exerted by the fluid on the movable bar.

17. Explain Celsius and Fahrenheit scales of temperature. Obtain the relation between Celsius and Fahrenheit scales of temperature.

Ans. Centigrade (Celsius) scale of temperature : In the Celsius scale of temperature, the lower fixed point is called the ice point and is assigned the value 0°C. The upper fixed point is called the steam point and is assigned the value 100°C. The interval between these two points (i.e., 100°C – 0 = 100°C) is subdivided into 100 equal parts each one corresponding to 1°C.



Fahrenheit scale of temperature : In the Fahrenheit scale of temperature, the lower fixed point is the ice point and is assigned a value 32°F and the upper fixed point is the staempoint and is assigned a value 212°F. The interval between these two points (i.e., 212°F – 32°F = 180°F) is subdivided into 180 equal parts, each one corresponding to 1°F.



Relation between Celsius and Fahrenheit scales of temperature :

Difference of 100 Celsius degrees = Difference of 180 Fahrenheit degress

When the temperature of a body is measured on both the Celsius and Fahrenheit scales, let the readings be t_C and t_F respectively. Then

$$\frac{t_C - 0}{t^{100}} = \frac{t_F - 32}{180} \Rightarrow \frac{t_C}{5} = \frac{t_F - 32}{9}\,; \; C = \frac{5}{9}(F - 32)$$

18. Define two principal specific heats of a gas. Which is greater and why ?

Ans. Two principal specific heats of a gas are (1) Molar specific heat capacity at constant pressure (2) molar specific heat capacity at constant volume.

1) Molar Specific heat capacity at constant pressure (C_p) : The amount of heat required to raise the temperature of 1gm – mole of a gas through 1°C at constant pressure is called molar specific heat at constant pressure. i.e., $C_p = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$ where μ is no of moles

2) Molar Specific heat capacity at constant volume (Cv) : The amount of heat required to raise the temperature of 1gm - mole of a gas through 1°C at constant valume is called molar specific heat at constant volume i.e., $Cv = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$

Explanation of C_p is greater that C_v : When a gas is heated at a constant pressure, it expands. The heat supplied to it is used partly in raising its temperature and partly in doing work against the external pressure. If, on the other hand, the gas is heated at constant volume, no work is done. Therefore, the heat supplied is to be used only in raising the temperature. Hence the amount of heat required to be supplied to a gas to raise its temperature by 1°C (say) at constant pressure will be greater than the amount required at constant volume.

SECTION – C

19. What are collisions ? Explain the possible types of collisions ? Develop the theory of one dimensional elastic collision.

Ans. Collisions : A strong interactions between bodies that occurs for a very short interval during which redistribution of momenta occur ignoring the effect of other forces are called collisions.

Collisions are of two types :

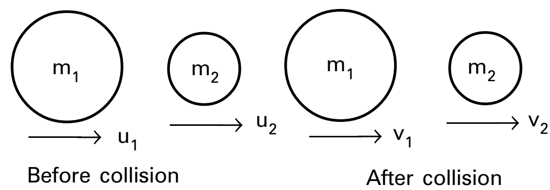
i) Elastic collision : The collision in which both momentum and kinetic energy is constant is called elastic collision.

ii) Inelastic collision: The collision in which momentum remains constant but not kinetic energy is called Inelastic collision.

Elastic collision in one dimension : Consider two smooth, non-rotating spheres of masses m_1 and m_2 moving along a straight line which coincides with the line joining their centres of mass. They are moving in the same direction with initial velocities u_1 and u_2 and after collision the two bodies move with final velocities v_1 and v_2 respectively in the same direction.

Let the colli sion be elastic in nature.

Hence both momentum and kinetic energy are conserved. According to law of conservation of linear momentum.



Elastic collision between two bodies

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2, m_1(u_1 - v_1) = m_2(v_2 + u_2)$ —— (1)

According to law of conservation of kinetic energy

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m\,u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2,\ m_1(u_1^2 - v_1^2)$

$= m_2(v_2^2 - u_2^2)$ —— (2)

$\frac{\text{equ. (2)}}{\text{equ. (1)}} = \frac{m_1(u_1 - v_1)(u_1 + v_1)}{m_1(u_1 - v_1)} = \frac{m_2(v_2 - u_2)(v_2 + u_2)}{m_2(v_2 - u_2)}$

$u_1 + v_1 = v_2 + u_2,\ \boxed{u_1 - u_2 = v_2 - v_1}$ —— (3)

In one dimensional elastic collision, the relative velocity before collision is equal to the relative velocity of separation after collision.

From equation (3) $u_1 - u_2 = -v_1 + v_2, v_2 = u_1 - u_2 + v_1$ —— (4)

Sub equation (4) in equation (1) we get

$m_1(u_1 - v_1) = m_2(u_1 - u_2 + v_1 - u_2), m_1u_1 - m_1v_1$

$= m_2u_1 - 2m_2u_2 + m_2v_1$

$m_1u_1 - m_2u_1 + 2m_2u_2 = m_1v_1 + m_2v_1, (m_1 - m_2)u_1 + 2m_2u_2$

$= (m_1 + m_2)v_1$

$$\boxed{v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2}$$ —— (5)

From the equation (4), $v_1 = v_2 - u_1 + u_2$

Sub. this value in equation (1) we get

$m_1 (u_1 - v_2 + u_1 - u_2) = m_2 (v_2 - u_2), - 2m_1u_1 - m_1v_2 - m_1u_2$
$= m_2 v_2 - m_2 u_2$

$2m_1 u_1 + (m_2 - m_1) = (m_2 + m_2)v_2$

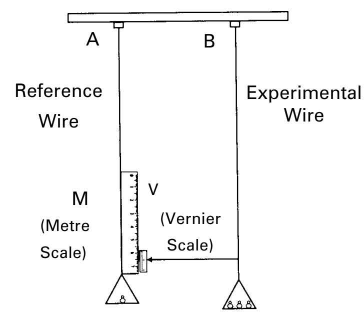
$$\therefore v_2 = \left(\frac{2m_1}{(m_1 + m_2)}\right)u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2$$

20. Define Hooke's law of elasticity and describe an experiment to determine the Young's modulus of the material of a wire. Determine the pressure required to reduce the given volume of water by 2%. Bulk modulus of water is 2.2×10^9 Nm^{-2}.

Ans. Hookes law : With in the elastic limit, stress is directly proportional to the strain.

Stress $\propto$ strain; Stress = k $\times$ strain. Where k is modulus of elasticity.

Determination of young's modulus of the material of a wire :



Young's Modulus of the Material of a wire

1. It consists of two long straight wires of same length and same area of cross-section suspended side by side from a rigid support.
2. The wire A (reference wire) carries a metre scale M and a pan to place a weight.
3. The wire B (experimental wire) carries a pan in which known weights can be placed.
4. A vernier scale v is attached to a pointer at the bottom of the experimental wire B and the main scale M is fixed to the wire A.
5. The weights placed in the pan, the elongation of the wire is measured by the vernier arrangement.
6. The reference wire is used to compensate for any change in length that may occur due to change in room temperature.

7. Both the reference and experimental wires are given an initial small load to keep the wires straight and the vernier reading is noted.
8. Now the experimental wire is gradually loaded with more weights, the vernier reading is noted again.
9. The difference between two vernier readings gives the elongation produced in the wire.
10. Let r and L be the radius and initial length of the experimental wire. Let M be the mass that produced an elongation ΔL in the wire.

Young's modulus of the material of the experimental wire is given by

$$y = \frac{\text{Longitudinal Stress}}{\text{Longitudinal Strain}} = \frac{\frac{F}{A}}{\frac{\Delta L}{L}}; \; y = \frac{FL}{A\Delta L}; \; y = \frac{MgL}{\pi r^2 \times \Delta L}$$

From above equation young's modulus of the material of the wire is determined.

Problem :

Sol. $\frac{-\Delta V}{V} = 2\% = \frac{2}{100}$; $B = 2.2 \times 10^9$ N/m^2; $B = \frac{-PV}{\Delta V}$

$$P = -B \times \frac{\Delta V}{V} = 2.2 \times 10^9 \times \frac{2}{100}; \; P = 4.4 \times 10^7 \text{ N/m}^2.$$

21. State and explain Newton's law of cooling. State the conditions under which Newton's law of cooling is applicable. A body cools down from 60°C to 50°C in 5 minutes and to 40°C in another 8 minutes. Find the temperature of the surroundings.

Ans. Statement : The rate of cooling of a body is directly proportional to the difference in the temperature of the body and its surrounding.

Explanation : If T_B and T_S are the temperatures of the body and the surroundings and let dQ be the quantity of heat lost by the body during the time dt.

Rate of cooling $\frac{dQ}{dt} \alpha (T_B - T_S)$

According to Stefan's law, The rate of cooling due to radiation is directly proportional to $(T_B^4 - T_S^4)$

If the difference between T_B and T_S is small leading to

$$T_B + T_S = 2T_S, \text{ then } \frac{dQ}{dt} = (T_B^2 + T_S^2)(T_B + T_S)(T_B - T_S)$$

$$= 4T_S^3(T_B - T_S); \ \frac{dQ}{dt} \alpha (T_B - T_S)$$

When the object is placed in the surroundings of low temperatures, the rate of cooling due to convection is known as "Newton's law of cooling".

Newton's law of cooling is applicable :

1) Loss of heat is negligible by conduction and only when it is due to convection.
2) Loss of heat occurs in a stream lined flow of air i.e., forced convection.
3) Temperature of the body is uniformly distributed over it.
4) Temperature differences are moderate i.e., upto 30 K, however if heat body is due to forced convection the law is valid for large differences of temperature also.

Problem : $\frac{d\theta}{dt} = K(\theta_{av} - \theta_o)$

Case (i) : $\theta_1 = 60°C$, $\theta_2 = 50°C$, $t = 5$ min

$$\Rightarrow \frac{(60°C - 50°C)}{5} = K\left[\frac{(60°C + 50°C)}{2} - \theta_o\right]$$

$$\frac{10°C}{5} = K[55°C - \theta_0] \qquad \text{—— (1)}$$

Case (ii) : $\theta_1 = 50°C$, $\theta_2 = 40°C$, $t = 8$ min

$$\frac{50 - 40}{8} = K\left[\left(\frac{50 + 40}{2}\right) - \theta_0\right] \ \frac{10}{8} = K[45 - \theta_0] \qquad \text{—— (2)}$$

$$\frac{(1)}{(2)}, \ \frac{10/5}{10/8} = \frac{K(55 - \theta_0)}{K(45 - \theta_0)}; \ \frac{8}{5} = \frac{55 - \theta_0}{45 - \theta_0} = 8(45 - \theta_0) = 5(55 - \theta_0)$$

$$= 360 - 8\theta_0 = 275 - 5\theta_0 = 3\theta_0 = 85 \ \theta_0 = \frac{85}{3} = 28.33°C$$

❖ ❖ ❖ ❖ ❖