ANSWERS FOR PRACTICE PAPER – 3

SECTION – A

1. What are the fundamental forces in nature ?

Ans. i) Gravitational force ii) Electromagnetic force iii) Strong nuclear force iv) weak nuclear force.

2. How can systematic errors be minimised (or) eliminated ?

Ans. Systematic errors can be minimised by improving experimental techniques, selecting better instruments and removing personal bias as far as possible. For a given set up, these errors may be estimated to a certain extent and the necessary corrections may be applied to the readings.

3. Define work, power and energy. State their S.I units ?

Ans. **Work :** The product of magnitude of displacement (S) and component of force (F cos θ) along the direction of force is called work. i.e., $W = \vec{F}.\vec{S} = F\,S\cos\theta$.

Unit $\rightarrow$ Joule;

Power : The rate of doing work by a force is called power.

$P = \frac{W}{t}$, Unit $\rightarrow$ watt (or) J/S

Energy : The capacity to do work is called energy.

Unit $\rightarrow$ Joule

4. By spinning eggs on a table top, how will you distinguish a hard boiled egg from a raw egg ?

Ans. A raw egg has some fluid in it and a hard boiled egg is solid form inside. Both eggs are spinning on a table top, the fluid is thrown outwards. Therefore ($I_r > I_b$) That means M. I of raw egg is greater than boiled egg. As $I\,\omega$ = constant;

$\omega_r < \omega_b$. That means Angular Velocity of raw egg is less than angular velocity of boiled egg.

5. What are polar satellites ?

Ans. Polar satellites are low altitude satellites (500 to 800 km), but they go around the poles of the earth in a north-south direction. Its time period is around 100 minutes.

6. State Hooke's law of elasticity.

Ans. With in the elastic limit stress directly proportional to the strain.

$$\text{Stress} \propto \text{strain}; \text{Stress} = k \times \text{strain}; k = \frac{\text{Stress}}{\text{Strain}}$$

Where k is modulus of elasticity.

7. What is magnus effect ?

Ans. The difference in the velocities of air results in the pressure difference between the lower and upper faces and there is a net upward force on the ball. This dynamic lift due to spinning is called magnus effect.

8. Can substance contract on heating ? Give an example.

Ans. Yes, Rubber, type metal, cast iron are contract on heating.

9. In summer, when the value of a bicycle tube is opened, the escaping air appears cold. Why ?

Ans. This happens due to adiabatic expansion of the air of the tube of the bicycle.

10. An electric heater supplies heat to a system at a rate of 100 W. If system performs work at a rate of 75 Joules per second. At what rate is the internal energy increasing ?

Ans. Given $\Delta Q = 100\text{ w} = 100\text{ J/s}$

$\Delta W = 75\text{ J/s}$

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

$\Delta U = \Delta Q - \Delta W = 100 - 75 = 25\text{ J/S}$

SECTION – B

11. Show that the maximum height reached by a projectile launched at an angle of 45° is one quarter of its range.

Ans. Range of the projectile, $R = \frac{u^2 \sin 2\theta}{g}$

When $\theta = 45^\circ \Rightarrow R = \frac{u^2 \sin 2 \times 45^\circ}{g} = \frac{u^2 \sin 90^\circ}{g} = \frac{u^2}{g}$

$\therefore R = \frac{u^2}{g}$

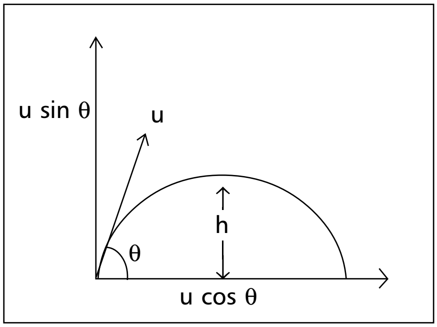
Maximum height $H = \frac{u^2 \sin^2 \theta}{2g}$

When $\theta = 45^o \Rightarrow H = \frac{u^2 (\sin 45^o)^2}{2g} = \frac{u^2\left(\frac{1}{2}\right)}{2g} = \frac{u^2}{4g}$

$$H = \frac{1}{4} \cdot \frac{u^2}{g} = \frac{R}{4} \quad \left[\because R = \frac{u^2}{g}\right] \quad \therefore H = \frac{R}{4}$$

12. Show that the Maximum height and range of projectile are $\frac{u^2 \sin^2 \theta}{2g}$ and $\frac{u^2 \sin 2\theta}{g}$ respectively where the terms have their regular meanings.

Ans. Maximum height : When the projectile is at the maximum height, its vertical component of velocity $v_y = 0$



Initial velocity = u sin θ

Final velocity = 0

distance = S

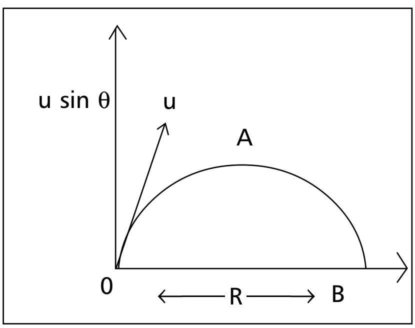
h = maximum height reached by the body

acceleration a = – g.

From the equation $v^2 - u^2 = 2as$; $0 - (u \sin \theta)^2 = -2gh$

Maximum height attained by the projectile $\boxed{h = \frac{u^2 \sin^2 \theta}{2g}}$ —— (1)

Horizontal range of projectile (R) : The horizontal distance travelled by the projectile from the point of projection during the time of flight is called its range.



Range (R) = Horizontal velocity × time of flight

$$R = u\cos\theta \times T = u\cos\theta \times \frac{2u\sin\theta}{g}$$

$$R = \frac{u^2 2\sin\theta\cos\theta}{g}; \quad \boxed{R = \frac{u^2\sin 2\theta}{g}} \qquad \text{—— (2)}$$

13. Mention the methods used to decrease friction.

Ans. 1) Polishing : By polishing the surfaces of contact, friction can be reduced.

2) Bearings : The rolling friction is less than the sliding friction hence free wheels of a cycle, motor car, dynamos etc., are provided with ball bearings to reduce friction. Bearings convert sliding motion into rolling motion.

3) Lubricants : The lubricant forms a thin layer between surfaces of contact. It reduces the friction. In light vehicles or machines, oils like "three in one" are used as lubricants. In heavy machines grease is used. In addition to this they guard the mechanical parts from over heating.

4) Streamlining : Automobiles and Aeroplanes are streamlined to reduce the friction due to air.

14. What is geostationary satellite ? State its uses.

Ans. Geo-stationary satellite : If the period of revolution of an artificial satellite is equal to the period of rotation of earth, then such a satellite is called geo-stationary satellite.

Time period of geo-sStationary satellite is 24 hours.

Uses :

1) Study the upper layers of atmosphere
2) Forecast the changes in atmosphere
3) Know the shape and size of the earth.
4) Identify the minerals and natural resources present inside and on the surface of the earth.
5) Transmit the T. V. programmes to distant objects
6) Under take space research i.e. to know obout the planets, satellites, comets etc.

15. Define Hooke's Law of elasticity, proportionality, permanent set and breaking stress.

Ans. Hooke's 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.

Proportionality limit : The maximum stress developed in a body till it obey's Hookes law is called proportionality limit.

Permanent Set : Permanent deformation produced when a body is stretched beyond its elastic limit.

Breaking stress : The maximum stress a body can bear before it breaks.

16. Compare isothermal and an adiabatic process.

Ans.

Isothermal change	Adiabatic change
1. Changes in volume and pressure of a gas taking place at constant temperature are called isothermal changes.	1. Changes in volume and pressure of a gas taking place in a thermally isolated system are called adiabatic changes.
2. Temperature of the gas remains constant.	2. Temperature of the gas changes.
3. The gas remains in good thermal contact with the surroundings and heat is exchanged.	3. The gas is isolated from the surroundings and heat is not exchanges $\Delta Q = O$.
4. Internal emergy remains constant. Change in internal energy $\Delta U = O$.	4. Internal energy changes.
5. This process takes place slow.	5. This process takes place quickly.
6. Boyle's law PV = Constant holds good	6. PV^r = Constant
7. Workdone $W = RT \log_e \frac{V_2}{V_1}$	7. Workdone $W = \frac{R}{(r - 1)}(T_1 - T_2)$

17. Define vector product. Explain the properties of a vector product with two examples.

Ans. The cross product of two vectors is given by $\vec{C} = \vec{A} \times \vec{B}$. The magnitude of the vector defined from cross product of two vectors is equal to product of magnitudes of the vectors and sine of angle between the vectors.

Direction of the vectors is given by right hand corkscrew rule and is perpendicular to the plane containing the vectors.

$\therefore |\vec{C}| = AB \sin\theta$. and $\vec{C} = AB \sin\theta\, \hat{n}$. Where, $\hat{n}$ is the unit vector perpendicular to the plane containing the vectors $\vec{A}$ and $\vec{B}$

Example : 1) Torque is cross product of position vector and Force. i.e., $\vec{T} = \vec{r} \times \vec{F}$. 2) Angular momentum is cross product of position vector and momentum i.e., $\vec{L} = \vec{r} \times \vec{p}$

Properties :

1) Cross product does not obey commutative law. But its magnitude obey's commutative low.
$\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A} \Rightarrow (\vec{A} \times \vec{B}) = -(\vec{B} \times \vec{A})$, $|\vec{A} \times \vec{B}| = |\vec{B} \times \vec{A}|$
2) It obeys distributive law $\vec{A} \times (\vec{B} \times \vec{C}) = \vec{A} \times \vec{B} + \vec{A} \times \vec{C}$
3) The magnitude cross product of two vectors which are parallel is zero. Since $\theta = 0$; $|\vec{A} \times \vec{B}| = AB \sin 0° = 0$
4) For perpendicular vectors, $\theta = 90°$, $|\vec{A} \times \vec{B}|$
$= AB \sin 90° \, |\hat{n}| = AB$

18. Explain conduction, convection and radiation with examples.

Ans. The heat is transmitted in three types. They are 1) Conduction 2) Convection 3) Radiation.

1) Conduction : The process of transmission of heat from one place to other without actual movement of the particles of the medium is called conduction.

Ex : When long iron rod is heated at one end, heat transmits to the other end.

2) Convection : The process of transmission of heat from one place to another by the actual movement of the particles is called convection. **Ex. :** If water in a beaker is heated, the particles of water at the bottom receive the heat first. These particles expand, become lighter and rise up. At the same time colder and denser particles reach the bottom. They get in their turn heated and move up. This process is known as convection.

3) Radiation : The process of transmission of heat from one place to another without any intervening medium is called radiation.

Ex. : Earth receives heat radiations from the sun.

SECTION – C

19. Develop the notions of work and kinetic energy and show that it leads to work energy theorem.

The bob of a pendulum is released from a horizontal position. If the length of the pendulum is 1.5m, what is the speed with which the bob arrives at the lowermost point, given that it dissipated 5% of its initial energy against air resistance ?

Ans. Statement : The change in kinetic energy of a particle is equal to the workdone on it by the net force. i.e., $k_f - k_i = W$

Proof : Consider a particle of mass 'm' is moving with initial speed 'u' to final speed 'v'. Let 'a' be its constant acceleration and S be its distance traversed. The kinematic relation is given by

$v^2 - u^2 = 2as$ —— (1)

Multiplying bothsides by $\frac{m}{2}$, we have

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mas = FS$ —— (2)

Where the last step follows from Newton's second law.

We can generalise Equation (1) to three dimensions by employing vectors $v^2 - u^2 = 2\,\vec{a}.\vec{d}$

Once again multiplying both sides by $\frac{m}{2}$, we obtain

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = m\,\vec{a}.\vec{d} = \vec{F}.\vec{d} \quad \text{—— (3)}$$

The above equation provides a motivation for the definitions of work and kinetec energy.

In equation (3) $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = k_f - k_i$,

Where k_i, k_f are initial and final kinetic energies and $\vec{F}.\vec{d} = W$, where W refers workdone by a force on the body over a certain displacement. $k_f - k_i = W$ —— (4)

Equation (4) is also a special case of the work–energy (WE) theorem.

Problem : Here, h = 1.5m, V = ?, Energy dissipated = 5%

Taking B as the lowest position of the bob, its potential energy at B is zero. At the horizontal position, A total potential energy of the bob is mgh.

In going from A to B, P.E of the bob is converted into K.E

Energy conserved = 95% (mgh)

If V is velocity acquired at B, then $K.E = \frac{1}{2}mv^2 = \frac{95}{100}mgh$

$$V = \sqrt{\frac{95}{100} \times 2gh} = \sqrt{\frac{19}{20} \times 2 \times 9.8 \times 1.5} = 5.285\,ms^{-1}.$$

20. Derive an expression for the variation of acceleration due to gravity (a) above and (b) below the surface of the Earth.

A satellite orbits the earth at a height equal to the radius of earth. Find it's (i) orbital speed and (ii) period of revolution.

Ans. i) Variation of g with height :

When an object is on the surface of the earth, it will be at a distance r = R radius of the earth, then we have $g = \frac{GM}{R^2} \longrightarrow (1)$

Where G = universal gravitational constant, M = Mass of the earth

When the object is at a height h above the surface of the earth, Then r = R + h

$$\therefore g_h = \frac{GM}{(R+h)^2} \longrightarrow (2) \qquad \frac{g_h}{g} = \frac{GM}{(R+h)^2} \times \frac{R^2}{GM}$$

$$g_h = \frac{R^2}{R^2\left(1+\frac{h}{R}\right)^2} \times g \qquad g_h = \left(1+\frac{h}{R}\right)^{-2} g \text{ for } h << R$$

$$g_h = g\left(1-\frac{2h}{R}\right) \longrightarrow (3) \text{ using Binomial expansion}$$

g value decreases with altitude.

ii) Variation of g with depth : Let us assume that the earth to be a homogeneous uniform sphere of radius R, mass M and of uniform density ρ

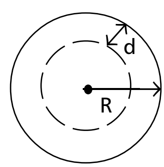
We know that $g = \frac{GM}{R^2} \quad \frac{4}{3}\pi \rho G R \longrightarrow (1)$

Consider a body of mass m be placed at a depth d.

$$g_d = \frac{4}{3}\pi \rho (R-d) G \longrightarrow (2) \qquad \left(\begin{array}{l} \because \text{Mass} = \text{volume} \times \text{density} \\ M = \frac{4}{3}\pi R^3 \times \rho \end{array}\right)$$

$$\frac{g_d}{g} = \frac{\frac{4}{3}\pi \rho (R-d) G}{\frac{4}{3}\pi \rho G R} \longrightarrow (3)$$

$$\frac{g_d}{g} = \frac{R-d}{R} \; ; \quad \boxed{g_d = g\left(1-\frac{d}{R}\right)} \longrightarrow (4)$$



The value of g decreases with depth.

Problem :

Sol. Height h = R

i) $v_o = \sqrt{\frac{GM}{R+h}} = \sqrt{\frac{GM}{(R+R)}} = \sqrt{\frac{GM}{2R}}$

$$= \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{2 \times 6400 \times 10^3}}$$

$$= \sqrt{0.3126 \times 10^8} = 0.5592 \times 10^4 = 5592 \text{ m/s};$$

$$v_o = 5.592 \text{ km/s}$$

ii) Time period (T) $= \dfrac{2\pi(R+h)}{v_o} = \dfrac{2\pi(2R)}{v_o}$

$$= \frac{4 \times 3.14 \times 2 \times 6400 \times 10^3}{5.592 \times 10^3} = 14374.8$$

$= 1.44 \times 10^4$ sec; T = 4 hours.

21. State Boyle's law and Charle's law. Hence, derive ideal gas equation. Which of the two laws is better for the purpose of thermometry and why ?

If the volume of nitrogen of mass 14 kg is 0.4 m^3 at 30ºC; calculate the pressure.

Ans. Boyle's Law : The volume of a given mass of gas is inversely proportional to its pressure at constant temperature.

$V \alpha \frac{1}{P}$ at constant temperature

Charle's Law : a) The volume of a given mass of gas is directly proportional to its absolute temperature, pressure remaining constant.

i.e., $V \alpha T$

b) The pressure of a given mass of gas is directly proportional to its absolute temperature, volume remaining constant. i.e., $P \alpha T$ at constant volume.

Ideal gas equation : Consider a given mass of gas having a volume V_1 at a pressure P_1 and absolute temperature T_1. When the temperature is changed to T_2. Let the gas occupy a volume V_2 at a pressure P_2.

Let this change take place in two steps.

i) Keeping the temperature constant at T_1K. Let the pressure of the gas be changed from P_1 to P_2. The volume of gas changes from V_1 to V(say).

From Boyle's law, $P_1V_1 = P_2V$; $V = \dfrac{P_1V_1}{P_2}$ —— (1)

ii) Now keeping the pressure of the gas constant at P_2. Let the temperature be changed from T_1 to T_2. Then the volume of the gas changes from V to V_2.

Applying Charles law, $\frac{V}{T_1} = \frac{V_2}{T_2}$; $V = \frac{V_2 T_1}{T_2}$ ——— (2)

From equations (1) and (2) $\frac{P_1 V_1}{P_2} = \frac{V_2 T_1}{T_2}$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$; $\frac{PV}{T} = r$

This constant depends on the mass and nature of the gas. This constant for one gram of gas at STP is called its gas constant and changes from gas to gas. But then 1 gram mole of the gas is considered this comes out to be a universal gas constant R. Then the gas equation can be written as PV = RT.

From Boyle's law and Charles law, Charles law is better for the purpose of thermometry with increasing temperature, pressure and volume of the gas also increases. At constant pressure, volume is proportional to absolute temperature. And at constant volume, pressure is proportional to absolute temperature.

Problem :

Sol. Given mass of the gas(m) = 14 kg = 14×10^3 gm

Molecular weight of N_2(M) = 28

$V = 0.4\ m^3$; $T = 30 + 273 = 303$ K

$PV = nRT = \frac{m}{M} RT$

$P = \frac{mRT}{MV} = \frac{14 \times 10^3 \times 8.317 \times 303}{28 \times 0.4}$

$\therefore P = 31.5 \times 10^5\ N/m^2$

❖ ❖ ❖ ❖ ❖