Telangana State Board of
INTERMEDIATE Education
FIRST YEAR

BASIC LEARNING MATERIAL

PHYSICS

For The Academic Year : 2021-2022

TELANGANA STATE BOARD OF INTERMEDIATE EDUCATION

PHYSICS

FIRST YEAR

(English Medium)

BASIC LEARNING MATERIAL

ACADEMIC YEAR 2021-2022

Coordinating Committee

Sri Syed Omer Jaleel, IAS
Commissioner, Intermediate Education &
Secretary, Telangana State Board of Intermediate Education
Hyderabad

Dr. Md. Abdul Khaliq
Controller of Examinations
Telangana State Board of Intermediate Education

Educational Research and Training Wing

Ramana Rao Vudithyala
Reader

Mahendar Kumar Taduri
Assistant Professor

Vasundhara Devi Kanjarla
Assistant Professor

Learning Material Contributors

G.Venugopal
JL in Physics, GJC Ramannapeta
Yadadri District

S. Swarnalatha
Principal, GJC Kachiguda
Hyderabad Dist.

B. Vishnuvardhan
JL in Physics, GJC Ibrahimpatnam

Naaz Sultana
JL in Physics, GJC Jinnaram
Sangareddy Dist

Ch. Shashidhar Sharma
JL in Physics
GJC A&C Karimnagar

PREFACE

The ongoing Global Pandemic Covid-19 that has engulfed the entire world has changed every sphere of our life. Education, of course is not an exception. In the absence of Physical Classroom Teaching, Department of Intermediate Education Telangana has successfully engaged the students and imparted education through TV lessons. In the back drop of the unprecedented situation due to the pandemic TSBIE has reduced the burden of curriculum load by considering only 70% syllabus for class room instruction as well as for the forthcoming Intermediate Examinations. It has also increased the choice of questions in the examination pattern for the convenience of the students.

To cope up with exam fear and stress and to prepare the students for annual exams in such a short span of time , TSBIE has prepared "Basic Learning Material" that serves as a primer for the students to face the examinations confidently. It must be noted here that, the Learning Material is not comprehensive and can never substitute the Textbook. At most it gives guidance as to how the students should include the essential steps in their answers and build upon them. I wish you to utilize the Basic Learning Material after you have thoroughly gone through the Text Book so that it may enable you to reinforce the concepts that you have learnt from the Textbook and Teachers. I appreciate ERTW Team, Subject Experts, who have involved day in and out to come out with the, Basic Learning Material in such a short span of time.

I would appreciate the feedback from all the stake holders for enriching the learning material and making it cent percent error free in all aspects.

The material can also be accessed through our website**www.tsbie.cgg.gov.in.**

Commissioner & Secretary
Intermediate Education, Telangana.

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Unit **1**

Physical World

Very Short Answer Questions (2 Marks)

1. What is Physics?

A. Physics is a branch of science which deals with the study of nature and natural phenomena.

3. What are the fundamental forces in nature?

A. Fundamental forces in nature are

1) Gravitational force, 2) Electromagnetic force,
3) Strong nuclear force and 4) Weak nuclear force

Unit **2**

Units and Measurements

Very Short Answer Questions (2 Marks)

1. Distinguish between accuracy and precision.

A.

	Accuracy		Precision
i)	It is defined as the closeness of the measured value to the true value	i)	It is defined as to what resolution the quantity is measured
ii)	It depends on the minimization of errors	ii)	It depends on the least count of the measuring instrument

2. What are the different types of errors that can occur in a measurement?

A. The errors in measurement can be broadly classified as " Systematic errors and Random errors.

3. How systematic errors be minimised or eliminated?

A. Systematic errors can be minimised by improving experimental techniques, selecting better instruments and removing personal bias as far as possible.

5. **What are significant figures and what do they represent when reporting the result of a measurement?**

A. The digits of a number that are definitely known plus one more digit that is estimated are called significant digits (or) significant figures.

Example : If a given value is .002308 in that significant figures are four.

6. **Distinguish between fundamental units and derived units.**

A. The units of fundamental quantities are called as fundamental units, they are independent (Ex: Meter, kg)

The units of derived quantities are called as derived units.

They are derived from fundamental units.

(Ex: Newton, Joule)

7. **Why do we have different units for the same physical quantity?**

A. A physical quantity possesses a wide range of magnitudes. Hence, we need different units for different ranges. **Ex:** mg, gm, kg etc., for mass: mm, cm, m, km for length.

8. **What is dimensional analysis?**

A. Dimensional analysis is a method in which fundamental quantities are raised to suitable powers to express a physical quantity. **Ex:** Force = MLT^{-2}

9. **Express unified atomic mass unit in kg.**

A. Unified atomic unit is defined as 1/12 of the mass of an atom of carbon-12 isotope $\left({}_{6}^{12}C\right)$ 1 amu = $1.66\times10^{-27}kg$.

Unit **3**

Motion in Straight Line

Short Answer Questions (4 Marks)

1. How is average velocity different from instantaneous velocity?

A. Average velocity is the ratio of the total displacement to the total time interval in which the displacement occurs. $v = \frac{\Delta x}{\Delta t}$

The velocity of the particle at any instant of time or at any one point is called instantaneous velocity. Instantaneous velocity $v = \frac{\Delta x}{\Delta t}$ as $\Delta t \to 0$

2. A particle moves in a straight line with uniform acceleration. Its velocity at time t = 0 is v_1 and at time t = t is v_2. The average velocity of the particle in this time interval is $(v_1 + v_2)/2$. Is this correct? Substantiate your answer.

A. Consider a particle moving with uniform acceleration a

At t = 0, the (initial) velocity = v1

At t = t, the final) velocity = v2

time = t

Acceleration, $a = \frac{v_2 - v_1}{t - 0} \left[\because a = \frac{v_2 - v_1}{t_2 - t_1} \right]$

Displacement $S = v_1 t + \frac{1}{2} a t^2 \qquad \left(\because S = ut + \frac{1}{2} a t^2 \right)$

$$S = v_1 t + \frac{1}{2} \left[\frac{v_2 - v_1}{t} \right] t^2$$

$$S = t \left[v_1 + \frac{v_2}{2} - \frac{v_1}{2} \right] = t \left[\frac{v_1 + v_2}{2} \right]$$

$$\Rightarrow \frac{S}{t} = \left[\frac{v_1 + v_2}{2} \right]$$

Average velocity $= \frac{S}{t} = \frac{v_1 + v_2}{2}$

Hence value $= \frac{v_1 + v_2}{2}$ $\therefore$ The given statement is true.

3. A ball is dropped from the roof of a tall building and simultaneously another ball is thrown horizontally with some velocity from the same roof. Which ball lands first? Explain your answer.

A. Let height of the building = Displacement of ball = h

For first ball $u = 0;\ S = h,\ a = g;\ t = t_1$

Substituting these values in $S = ut + \frac{1}{2}at^2$

$$\Rightarrow h = 0 + \frac{1}{2}gt_1^2$$

$$\therefore t_1 = \sqrt{\frac{2h}{g}}$$

For second ball, $u_x = u$ (say) $u_y = 0, a_y = g, S_y = h; t = t_2$

Substituting these values in

$$S_y = u_y t + \frac{1}{2}a_y t^2,\ h = 0 + \frac{1}{2}gt_2^2 \qquad \therefore t_2 = \sqrt{\frac{2h}{g}}$$

From equation (1) and equation (2), $t_1 = t_2$

$\therefore$ Two balls will reach the ground in same time.

4. A parachutist flying in an aeroplane jumps when it is at a height of 3 km above ground. He opens his parachute when he is about 1 km above ground. Describe his motion.

A. Consider that the aeroplane is flying horizontally. The person jumping from the aeroplane is treated as a freely falling body, because his initial velocity in the vertically downward direction is zero. Some time after opening the parachute the person get a uniform velocity called terminal velocity due to air friction. Hence the acceleration becomes zero. Hence the person falls with a constant velocity.

5. A man runs across the roof of a tall building and jumps horizontally on to the (lower) roof of an adjacent building. If his speed is $9\,\text{m s}^{-1}$ and the horizontal distance between the buildings is 10 m and the height difference between the roofs is 9m, will he be able to land on the next building? (take $g = 10\,\text{m s}^{-2}$)

A. Horizontal range of the person $H = u\sqrt{\frac{2h}{g}}$

$u = 9m/s; h = 9m; g = 10m/s^2$

the distance between buildings $x = 10m$

$$\therefore H = 9\sqrt{\frac{2 \times 9}{10}} = 9 \times \sqrt{1.8}$$

$$= 9 \times 1.34$$

$$= 12.06m > x(= 10m)$$

$\therefore$ he will land on the 2nd building.

Unit **4**

Motion in a Plane

Very Short Answer Questions (2 Marks)

1. The vertical component of a vector is equal to its horizontal component. What is the angle made by the vector with X-axis?

A. Let $\vec{A} = A_x\hat{i} + A_y\hat{j}$

Horizontal component of a vector = Vertical component of a vector

Let θ be the angle made by $\vec{A}$ with X-axis

$A\cos\theta = A\sin\theta$

$\tan\theta = 1 \Rightarrow \theta = 45^\circ$

2. Two forces of magnitudes 3 units and 5 units act at 60^0 with each other. What is the magnitude of their resultant?

A. $\therefore R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$|\vec{R}| = \sqrt{(3)^2 + (5)^2 + 2\times3\times5\cos 60}$

$= \sqrt{9 + 25 + 2\times3\times5\times\frac{1}{2}} = \sqrt{49} = 7$ units

3. $\vec{A} = \vec{i} + \vec{j}$. What is the angle between the vector and x-axis?

A. Comparing the vector $\vec{i} + \vec{j}$ with $x\vec{i} + y\vec{j}$, we get x =1 and y=1

If $\overline{A} = x\overline{i} + y\overline{j}$ makes an angle θ with the X-axis then $\tan\theta = \frac{y}{x} = \frac{1}{1} = 1$ $\therefore \theta = 45^\circ$

4. When two right angled vectors of magnitude 7 units and 24 units combine, what is the magnitude of their resultant?

A. $\therefore R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$|\vec{R}| = \sqrt{(7)^2 + (24)^2 + 2\times7\times24\cos 90} = \sqrt{49 + 576} = \sqrt{625} = 25$ units

5. If $\vec{P} = 2\hat{i}+4\hat{j}+14\hat{k}$ and $\vec{Q} = 4\hat{i}+4\hat{j}+10\hat{k}$ find the magnitude of $\vec{P}+\vec{Q}$.

A. $\vec{P}+\vec{Q} = (2\hat{i}+4\hat{j}+14\hat{k})+(4\hat{i}+4\hat{j}+10\hat{k}) = 6\hat{i}+8\hat{j}+24\hat{k}$

$|\vec{P}+\vec{Q}| = \sqrt{36+64+576} = \sqrt{676} = 26\,\text{Units}$

6. What is the acceleration of projectile at the top if its trajectory?

A. a = g (Acceleration due to gravity), and is directed vertically downwards.

Short Answer Questions (4 Marks)

1. Define unit vector,null vector and position vector.

A. **Unit Vector** : A vector whose magnitude equals one and used to specify a convenient direction is called a unit vector.

Null Vector or Zero Vector: A vector whose magnitude is equals to zero is called a null vector. Its direction is indeterminate.

Position Vector : The position of a particle is described by a position vector which is drawn from the origin of a reference frame. The position vector helps to locate the particle in space.

2. If $|\vec{a}+\vec{b}| = |\vec{a}-\vec{b}|$ prove that the angle between $\vec{a}$ and $\vec{b}$ is 90^0.

A. Let 'θ' be the angle between $\vec{a}$ and $\vec{b}$

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

given that $|\vec{a}+\vec{b}| = |\vec{a}-\vec{b}|$

$\Rightarrow \sqrt{a^2+b^2+2ab\cos\theta}$

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

squaring on both sides $\Rightarrow a^2+b^2+2ab\cos\theta = a^2+b^2-2ab\cos\theta$

$\Rightarrow 4ab\cos\theta = 0$

$\Rightarrow \cos\theta = 0$

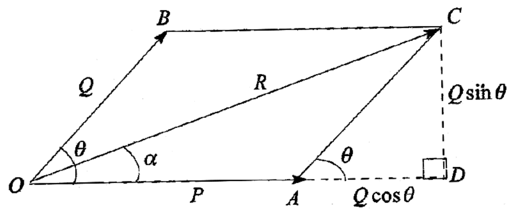
Angle between the two vectors $\theta = 90^0$.

3. State parallelogram law of vectors. Derive an expression for the magnitude and direction of the resultant vector.

A. **Statement :** If two vectors are represented both in magnitude and direction by the two adjacent sides of a parallelogram drawn from a point, then their resultant is represented both in magnitude and direction by the diagonal passing through the same point.

Expression : Consider two Vectors $\vec{P}$ and $\vec{Q}$ are drawn from 'O' as a common initial point. Let 'θ' be the angle between the two vectors $\vec{P}$ and $\vec{Q}$. The horizontal component of $\vec{Q}$ is $AD = Q\cos\theta$

The vertical compontnt of $\vec{Q}$ is $CD = Q\sin\theta$



From the right angle triangle

ODC, $OC^2 = OD^2 + CD^2$

$$R^2 = (OA + AD)^2 + CD^2$$

$$R^2 = (P + Q\cos\theta)^2 + (Q\sin\theta)^2$$

$$R^2 = P^2 + Q^2\cos^2\theta + Q^2\sin^2\theta + 2PQ\cos\theta$$

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

Direction of the resultant : If the resultant $\vec{R}$ makes an angle α with the vector $\vec{P}$

$$Tan\ \alpha = \frac{CD}{OD} = \frac{CD}{OA + AD}$$

$$Tan\ \alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$$

$$\alpha = Tan^{-1}\left(\frac{Q\sin\theta}{P + Q\cos\theta}\right).$$

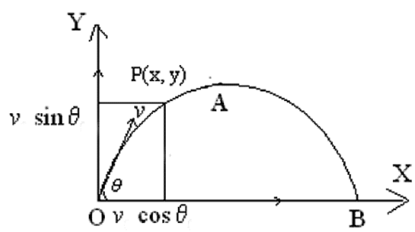
4. **Show that the trajectory of an object thrown at certain angle with the horizontal is a parabola.**

A. Suppose an object is projected from the origin with initial velocity v at an angle θ with the horizontal. Let $v_x = v\cos\theta$, $v_y = v\sin\theta$ are the horizontal, vertical component of v

Along X-direction

Using $s = ut + \frac{1}{2}at^2 \Rightarrow s = v_x t + \frac{1}{2}at^2$

here $v_x = v\cos\theta$, a = 0 and s = X



so X = $(v\cos\theta)$ t, $t = \frac{x}{v\cos\theta}$ -------(1)

Along Y- direction: S = Y, $u_y = v\sin\theta$

and a_Y = -g substituting in $s = u_y t + \frac{1}{2}at^2$

$$Y = (v\sin\theta)t - \frac{1}{2}gt^2 \text{--------------(2)}$$

Using equation (1) in equation (2) we get,

$$Y = (v\sin\theta)\frac{X}{v\cos\theta} - \frac{1}{2}g\left(\frac{X}{v\cos\theta}\right)^2$$

$$Y = (\tan\theta)X - \left(\frac{g}{2v^2\cos^2\theta}\right)X^2$$

Let $\tan\theta = A$ and $\frac{g}{2v^2\cos^2\theta}$ =B ; Where A and B are constants for a given angle of projection.

$$\boxed{\therefore Y = AX - BX^2}$$

The above equation represents a parabola and hence the trajectory or the path of a projectile is a parabola.

Unit **5**

Laws of Motion

Very Short Answer Questions (2 Marks)

1. When a bullet is fired from a gun. The gun gives a kick in the backward direction. Explain

A. According to law of conservation of linear momentum, when a bullet is fired from a gun, the bullet gets forward momentum and the gun will get equal and backward momentum. So, the gun gives a backward kick and bullet moves in forward.

2. If a bomb at rest explodes into two pieces, the pieces must travel in opposite directions. explain.

A. According to law of conservation of momentum, $0 = m_1v_1 + m_2v_2$.
$\Rightarrow m_1v_1 =- m_2v_2$
(or) $m_1v_1= m_2(-v_2)$
i.e.,it is clear that, v_1 and v_2 are in opposite direction.
i.e., the two pieces m_1 and m_2 must travel in opposite directions.

3. Can the coefficient of friction be greater than one ?

A. Yes, In general coefficient of friction is less than one. In some cases if the surfaces are heavily polished the adhesive force between the molecules increases then the coefficient of friction will be greater than one.

4. Why does the car with a flattened tyre stop sooner than the one with inflated tyres ?

A. Flattened deforms more and area of contact is more than the inflated tyre. Due to greater deformation of the tyre rolling friction is large hence it stops soon.

5. A horse has to pull harder during the start of the motion than latter. Explain.

A. We know the limiting frictional force is greater than kinetic frictional force. For starting motion of the cart, the limiting friction is to be overcome. Once motion is set, frictional force reduces. Therefore, the horse has to pull harder during starting of the cart.

6. What happens to the coefficient of friction if the weight of the body is doubled ?

A. If weight of the body is doubled, normal reaction also doubled and corresponding frictional force doubles, so coefficient of friction does not change.

7. Why does a heavy rifle not recoil as strongly as a light rifle using the same cartridges?

A. According to law of conservation of linear momentum. The recoil velocity of rifle is inversely proporotional to mass of the rifle. So, a heavy rifle not recoil as much as a light rifle using the same catridge.

Short Answer Questions (4 Marks)

1. Explain advantages and disadvantages of friction.

A. Advantages of friction :

1) Safe walking on the floor is possible because of friction between the floor and the feet.
2) Nails and Screws are held in the walls or wooden surfaces due to friction.
3) Friction helps the fingers to hold a drinking water tumbler .
4) Vehicles move on the road without slipping due to friction and they can be stopped due to friction.

Disadvantages of friction :

1) Due to friction wear and tear of Machines increases.
2) Heat generated due to friction, decreases the efficiency of engine.

2. Mention the methods used to decrease friction

A. Methods used to decrease friction :

1) Polishing : Friction between two surfaces of contact can be reduced by polishing the surface to some extent.

2) Ball - bearings : Another way is to use ball bearings between the moving parts of a machine, since the rolling friction b/w ball-bearings and the surfaces in cotact is very small, power dissipation is reduced.

3) Lubricants : A thin layer of an oil or fluid is used between the surfaces in contact to reduce friction.

4) Streamlining : Automobiles and aeroplanes are specially designed with curved surfaces, so that the air layers may get streamlined during the motion and hence reduce the friction due to air.

3. State the laws of rolling friction.

A. When a body is rolling over the other, then the friction between the bodies is known as rolling friction.

Laws of rolling friction :

1) The smaller the area of contact the lesser will be the rolling friction.
2) The larger the radius of the rolling body, the lesser will be rolling friction.
3) The rolling friction is directly proportional to normal reaction.

If "F_R" is the rolling friction and 'N' is the normal reaction at the contact, then

$$F_R \propto N$$

$$\text{(or) } F_R = \mu_R N$$

Where 'μ_R' is the coefficient of rolling friction.

Unit **6**

Work Energy and Power

Long Answer Questions (8 Marks)

1. State and prove law of conservation of energy in case of a freely falling body.

A. Statement : "Energy can neither be created nor destroyed. But it can be converted from one form to another form. The total energy of a closed system always remains constant". This law is called law of conservation of energy.

Proof : In case of freely falling body : A body of mass 'm' is freely falling at a height 'H' from the ground. The total mechanical energy of the body E = K.E + P.E

where K.E = kinetic energy ; P.E = potential energy.

Suppose A, B and C are the points at heights H, h and ground respectively.

At 'A' : At the highest point, velocity u = 0

$K.E = \frac{1}{2}mu^2 = 0$

P.E. = mgH

Total mechanical energy of the body $= E_A = P.E + K.E = mgH + 0$

$\boxed{\therefore E_A = mgH}$ ....(1)

At 'B' : When the body falls from A to B, which is at a height 'h' from the ground. The velocity of the body at 'B' is V_B.

At 'B' the body possesses both P.E and K.E

$S = H - h$

$u = 0$

$a = g$

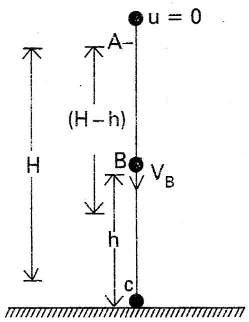
$v = v_B = ?$

$v_B^2 - u^2 = 2as$

$a = g \qquad v_B^2 - 0 = 2g(H - h)$

$v = v_B = ? \qquad v_B^2 = 2g(H - h)$

K.E of the body



$$K.E = \frac{1}{2}mv_B^2 = \frac{1}{2}m2g(H-h)$$

$K.E = mg(H-h)$

$P.E = mgh$

$\therefore$ Total mechanical energy at $B = KE + PE$

$E_B = mg(H-h) + mgh$

$\boxed{E_B = mgH}$ ....(2)

At 'C' : When the body reaches the point 'c' on the ground. The velocity of the body at 'c' is 'v_c' can be found by using $v^2 - u^2 = 2as$ equation.

$S = H \qquad v_c^2 - 0 = 2gH$

$u = 0 \qquad v_c^2 = 2gH$

$a = g \qquad v_c = \sqrt{2gH}$

$v = v_c = ?$

$$K.E = \frac{1}{2}mv_c^2 = \frac{1}{2}m\ 2gH = mgH$$

P.E = 0

Total energy at C = $K.E + P.E$

$\boxed{\therefore E_C = mgH}$ .... (3)

From the above three equations (1), (2) and (3), the mechanical energy of the body remains constant under the action of gravitational force. Hence, law of conservation of energy is proved incase of freely falling body.

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

A. **Work :** Work done by the force is the product of component of force in the direction of the displacement and the magnitude of the displacement.

Suppose a constant force $\vec{F}$ acting on a body produces a displacment $\vec{S}$ in the body along the positive x - direction as show in fig.

W = (F Cosθ) S $\qquad$ W = $\vec{F}.\vec{S}$

Thus, work done is the dot product of force and displacement. Work is scalar quantity.

Conditions : Work done is zero if displacement is zero (or) forces is zero (or) force and displacement are mutually perpendicular.

Kinetic energy : The energy possessed by a body by virtue of its motion is called kinetic energy.

Work energy theorem : The work done by the resultant force acting on a body is equal to the change in kinetic energy.

Proof : In rectilinear motion under constant acceleration 'a', we have the equation

$V^2 - u^2 = 2as$........................(1)

Where, u and V are the initial and final speeds and S is the distance traversed.

multiplying equation (1) both sides by $\left(\frac{m}{2}\right)$, we have

$$\frac{1}{2}mV^2 - \frac{1}{2}mu^2 = mas$$

From newton's second law F = ma

$$\boxed{\frac{1}{2}mV^2 - \frac{1}{2}mu^2 = FS}\text{......................(2)}$$

$$K_f - K_i = W$$

(Where K_f - final K.E of the object
K_i - initial K.E of the object)

This is Work - Energy theorm.

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

A. Collision : A strong interaction between two bodies which involves exchange of momenta is called collision.

Collision are of two types. They are (i) Elastic collision and (ii) Inelastic collision.

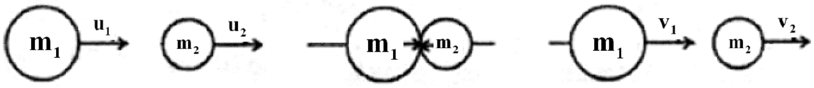
Elastic Collision : The collision in which both the momentum and kinetic energy of the system remain conserved is called elastic collision.

Ex : The collisions between atomic and subatomic particles (atomic nuclei, fundamental particles. etc)

Inelastic collision : The collision in which only momentum of the system is conserved but kinetic energy is not conserved is called inelastic collision.

Ex : Collision between cricket bat and ball.

Elastic collision in one dimension : Consider two bodies of masses m_1 and m_2 moving along the same direction with initial velocities u_1 and u_2 respectively. Let $u_1 > u_2$. Let v_1 and v_2 be their final velocities respectively after the collision along their initial direction of motion. Let us assume that it is perfectly elastic collision. So, both momentum and kinetic energy of the system are conserved.



Before Collision **After Collision**

According to the law of conservation of linear momentum

$$\Rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_1v_2$$

$$\text{i.e., } m_1(u_1 - v_1) = m_2(v_2 - u_2)\text{............................(1)}$$

According to the law of conservation of kinetic energy

$$\Rightarrow \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$\text{i.e., } m_1\left(u_1^2 - v_1^2\right) = m_2\left(v_2^2 - u_2^2\right) \text{ ....(2)}$$

Dividing (2) by (1) we get

$$\frac{\left(u_1^2 - v_1^2\right)}{\left(u_1 - v_1\right)} = \frac{\left(v_2^2 - u_2^2\right)}{\left(v_2 - u_2\right)}$$

i.e., $u_1 + v_1 = v_2 + u_2$

(or) $\boxed{\left(u_1 - u_2\right) = \left(v_2 - v_1\right)}$ ....(3)

i.e., relative velocity of approach before collision = relative velocity of separation after collision

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

Sub. this value in equ. (1) we get

$$m_1(u_1 - v_1) = m_2\left[(u_1 - u_2 + v_1) - u_2\right]$$

(or) $\quad m_1u_1 - m_1v_1 = m_2u_1 - 2m_2u_2 + m_2v_1$

$$\left(m_1 + m_2\right)v_1 = 2m_2u_2 + \left(m_1 - m_2\right)u_1$$

$$\boxed{\therefore v_1 = \left[\frac{2m_2}{m_1 + m_2}\right]u_2 + \left[\frac{m_1 - m_2}{m_1 + m_2}\right]u_1} \text{ ....(A)}$$

From equation (3)

$$v_1 = v_2 + u_2 - u_1$$

Substituting this value in equation (1) we get

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

(or) $\quad 2m_1u_1 - m_1v_2 - m_1u_2 = m_2v_2 - m_2u_2$

$$\left(m_1 + m_2\right)v_2 = 2m_1u_1 + \left(m_2 - m_1\right)u_2$$

$$\boxed{\therefore v_2 = \left[\frac{2m_1}{m_1 + m_2}\right]u_1 + \left[\frac{m_2 - m_1}{m_1 + m_2}\right]u_2} \text{ ....(B)}$$

From equations (A) and (B) we can find the final velocities of the two bodies after collision.

Attached Problems

1. **A machine gun fires 360 bullets per minute and each bullet travels with a velocity of 600 ms^{-1}.If the mass of each bullet is 5gm, find the power of the machine gun ?**

Sol: $\frac{N}{t} = 360$ bullets / min $= \frac{360}{60} = 6$ bullets / s ec

$v = 600$ m/s, $m = 5gm = 5 \times 10^{-3}$ kg

$P = \frac{w}{t} = \frac{N \times 1/2mv^2}{t}$ $\quad P = \frac{6x5 \times 10^{-3} x600x600}{2}$

P = 5400 W = 5.4 KW.

2. **A pump is required to lift 600 kg of water per minute from a well 25m deep and to eject it with a speed of 50ms^{-1}. Calculate the power required to perform the above task ?**

Sol: $\frac{m}{t} = \frac{600}{60} = 10kg/s, h = 25m, v = 50m/s$

$$P = \frac{mgh + \frac{1}{2}mv^2}{t}$$

$$= \frac{600x10x25 + \frac{1}{2} \times 600 \times (50)^2}{60}$$

$$= \frac{1,50,000 + 7,50,000}{60} = 15kW.$$

Unit 7

System of Particles and Rotational Motion

Very Short Answer Questions (2 Marks)

1. **Is it necessary that a mass should be present at the centre of mass of any system ?**

A. No, **Ex:** In the case of uniform ring, no mass particle present at its centre of mass.

2. **Why should a helicopter necessarily have two propellers ?**

A. If there were one propeller, then according to law of conservation of angular momentum, the helicopter would rotate itself in the opposite direction.

$\therefore$ Helicopter are provided with two propellers.

3. **We can not open or close the door by applying force at the hinges why ?**

A. Torque (τ) = force (F) x perpendicular distance (r)

If you are applying force at the hinges means r =0.

Then Torque τ =0. i.e., There is no turning effect.

$\therefore$ We cannot open or close the door by applying force at the hinges.

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

A. The hard boiled egg has less moment of inertia (I) than raw egg. As $I_1\omega_1 = I_2\omega_2$ boiled egg rotate faster than raw egg.

5. **Why are spokes provided in a bicycle wheel ?**

A. Spokes are provided in a bicycle wheel to increase its moment of inertia, and then cycle runs smoother and steadier.

If spokes are not provided then cycle would be driven in jerks and hence unsafe.

6. **Why is it easier to balance a bicycle in motion ?**

A. The rotating wheels of a bicycle posses angular momentum. In the absence of an external torque, neither the magnitude nor the direction of angular momentum can change. The direction of angular momentum is along the axis of the wheel. So, the bicycle does not get tilted. (or) Due to law of conservation of angular momentum, bicycle is balanced in motion.

7. **What is the difference in the positions of a girl carrying a bag in one of her hands and another girl carrying a bag in each of her two hands.**

A. (i) In the case of first girl who is carrying a bag in one hand, centre of mass (CM), shift towards the hand in which there is bag.

(ii) In the case of second girl, the position of the centre of mass does not change.

8. Two rigid bodies have same moment of interia about their axes of symmetry of the two, which body will have greater kinetic energy ?

A. $K.E = L^2/2I$. The body with greater angular momentum will have greater kinetic energy.
($\because K.E \propto L^2$ and 'I' is constant)

9. Why do we prefer a spanner of longer arm as campared to the spanner of shorter arm.

A. Torque (τ) = force (F) x perpendicular distance (r).
In the case of a spanner of longer arm, i.e. 'r' is more, so Torque (τ) is more. Hence turning effect is more.
$\therefore$ Spanner of longer arm is preffered.

10. If the polar ice caps of the earth were to melt what would the effect of the length of the day be ?

A. (i) If the polar ice caps melt, the water formed will spread over the surface of the earth. So the moment of inertia (I) will increase.
According to law of conservation of angular momentum, (Iω =constant) angular velocity (ω) of the earth will decrease. Hence the length of the day will increase $\left(\because T = \frac{2\pi}{\omega}\right)$.

Short Answer Questions (4 Marks)

1. Distinguish between centre of mass and centre of gravity ?

A.

Centre of mass	Centre of gravity
1 Centre of mass is a point at which whole mass of the body is concentrated.	1 Centre of a gravity is a point at which total weight of the body is concentrated.
2 It does not depend on accelaration due to gravity (g).	2 It depends on acceleration due to gravity (g).
3 It explains the total motion of the body.	3 It explains the stability of the body.
4 It may or may not lie inside the body.	4 It always lies inside the body.

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

A. Vector product : The product of magnitudes of the two vectors and sine of angle between them is called magnitude of vector product of two vectors.

$\boxed{\bar{a}\times\bar{b} = |\bar{a}|\,|\bar{b}|\,\sin\theta.\hat{n}}$ **or** $|\bar{a}\times\bar{b}| = a\,b\sin\theta$, $\quad \hat{n} \rightarrow$ Unit vector along $\bar{a}\times\bar{b}$

Properties of vector product :-

(i) Vector product of vectors does not obey commutative property.

$$\therefore\ \bar{a}\times\bar{b} \neq \bar{b}\times\bar{a}$$

(ii) Vector product of two vectors obeys the distributive law.

$i.e.\ \bar{a}\times(\bar{b}+\bar{c})=(\bar{a}\times\bar{b})+(\bar{a}\times\bar{c})$

(iii) If two vectors are parallel to each other (θ=0°), their vector product will be zero

$|\bar{a}\times\bar{b}|=ab\sin\theta=ab\sin 0°$

$|\bar{a}\times\bar{b}|=0$

(iv) If two vectors are perpendicular to each other $(\theta=90°)$, their vector product will be equal to the product of the magnitude of the vectors (i.e. maximum).

$|\bar{a}\times\bar{b}|=ab\sin\theta=ab\sin 90°$

$|\bar{a}\times\bar{b}|=$ ab ($\because$ sin 90°=1)

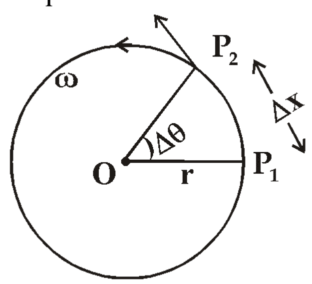
Examples: (i) Torque $\bar{\tau}=\bar{r}\times\bar{F}$

(ii) Angular momentum $\bar{L}=\bar{r}\times\bar{p}$ ($\bar{p}$ - Linear momentum)

3. Define angular velocity. Derive v = rω

A. Angular velocity (ω): - The rate of change of angular displacement is called angular velocity (ω).

Angular velocity $\omega=\dfrac{d\theta}{dt}$ rad/s



Derivation of v = rω

(i) Let us consider a particle 'p' is moving in a circular path of radius 'r' with uniform angular velocity 'ω'.

(ii) In Δt time interval, angular displacement of the particle is $\Delta\theta$

$\therefore$ angular velocity of the particle $\omega=\dfrac{\Delta\theta}{\Delta t}$

$$\boxed{\omega=\frac{d\theta}{dt}}\quad\left(\because \underset{\Delta t\to 0}{Lt}\frac{\Delta\theta}{\Delta t}=\frac{d\theta}{dt}\right)$$

From the figure $\Delta x=r.\Delta\theta$

$$\frac{\Delta x}{\Delta t}=r.\frac{\Delta\theta}{\Delta t}$$

$$\underset{\Delta t\to 0}{Lt}\frac{\Delta x}{\Delta t}=r\ \underset{\Delta t\to 0}{Lt}\frac{\Delta\theta}{\Delta t}$$

$\Delta x\rightarrow$ linear displacement

$$\frac{dx}{dt}=r\frac{d\theta}{dt}$$

$$\boxed{v=r\omega}\qquad(\because \frac{dx}{dt}=v\ \text{linear velocity})$$

4. State and prove the principle of conservation of angular momentum. Explain the principle of conservation of angular momentum with examples.

A. Conservation of angular momentum:

If there is no external torque acting on a system, then its angular momentum will remain consant.

Proof : According to definition of torque.

$$\tau = \frac{dL}{dt}$$

If $\tau = 0$

$$\frac{dL}{dt} = 0$$

dL=0

$\therefore$ angular momentum L = constant

Example:

A ballet-dancer can increase her angular velocity by folding her arms and bringing the stretched leg close to the other leg. Due to this moment of inertia decreases and as a result the angular speed increases.

5. Define angular acceleration and torque. Establish the relation between angular acceleration and torque.

A. Angular accleration (α): The rate of change of angular velocity (ω) is known as angular acceleration (α).

$$\boxed{\alpha = \frac{d\omega}{dt}}$$

Torque (τ) :- The rate of change of angular momentum (L) is called Torque.

$$\tau = \frac{dL}{dt}$$

Relation between 'α' and 'τ' :-

From definition of torque $\tau = \frac{dL}{dt}$ $\quad L \rightarrow$ Angular moment

but $L = I\omega$ $\quad$ I $\rightarrow$ moment of inertia

$\omega \rightarrow$ angular velocity

$$\therefore \tau = \frac{dL}{dt} = \frac{d}{dt}(I\omega)$$

$$= I\frac{d\omega}{dt}$$

$$\boxed{\therefore \tau = I\alpha}$$

Unit **8**

Oscillations

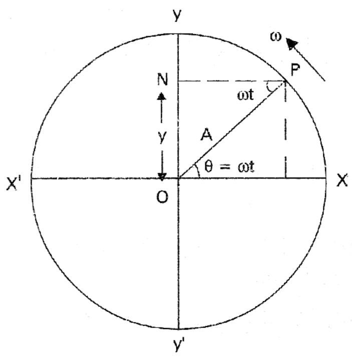
Long Answer Questions (8 Marks)

1. Define simple harmonic motion. Show that the motion of (point) projection of a particle performing uniform circular motion, on any diameter, is simplpe harmonic

A. Simple harmonic motion : "A body is said to be in simple harmonic motion, if it moves to and for along a straight line, about its mean position such that, at any point its acceleration is proportional to its displacement but opposite in direction and is directed always towards the mean position". $\boxed{a \propto -y}$

Projection of a particle in uniform circular motion on any diameter is performing S.H.M:

Show that the projection of uniform circular motion on any diameter is simple harmonic: Consider a particle P moving on the circumference of a circle of radius A with uniform angular velocity ω . Let O be the centre of the circle. XX' and YY' are two mutually perpendicular diameters of the circle as shown in the figure. let PN be drawn perpendicular to the diameter YY' from P. As P moves on the circumference of the circle, N moves on the diameter YY' to and fro about the centre O. let us consider the position of N at any time t, after leaving the point 'O', during its motion. The corresponding angular displacement of the particle P is $\underline{|XOP} = \theta = \omega t$.



From $\Delta^{le} ONP, \sin \omega t = \frac{ON}{OP}$

$ON = OP \sin \omega t \quad (\because ON = y, OP = A)$

$y = A \sin \omega t$ ----(1)

Differentiating eq (1) w.r.t 't', we get velocity

$$v = \frac{dy}{dt} = \frac{d}{dt}(A \sin \omega t)$$

$v = A\omega \cos \omega t$ --- (2)

Again differentiating equation (2) w.r.t 't', we get acceleration

$$a = \frac{dv}{dt} = \frac{d(A\omega \cos \omega t)}{dt}$$

$a = -A\omega^2 \sin \omega t \qquad (\because y = A \sin \omega t)$

$a = -\omega^2 y -----(3)$

From eq (4) $\boxed{a \propto -y} -----(4)$

Hence acceleration is directly proportional to the displacement and opposite direction. Hence motion of N is simple harmonic.

2. Show that the motion of a simple pendulum is simple harmonic and hence derive an equation for its time period. What is seconds pendulum ?

A. Simple Pendulum : A heavy metal point mass suspended by a light inextensible string is called an ideal simple pendulum.

Let us suppose that m is mass of the bob and L is length of the simple pendulum. At an instant, its angular displacement is θ. The weight of the bob mg acts vertically downwards. Its two perpendicular components are mg cos θ and mg sin θ. The component mg cos θ is balanced by tension T in the string.

The component mg sin θ forms restoring torque τ on the bob.

$\tau = -mg \sin \theta L$

But $\tau = I\alpha$

where I is moment of inertia and α is angular acceleration. (or) $I\alpha = -mg \sin\theta L$

But moment of inertia $I = mL^2$

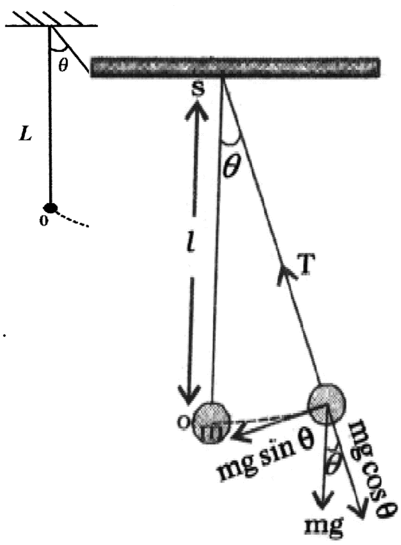
$\therefore mL^2\alpha = -mg\sin\theta L$

or $L\alpha = -g\sin\theta$

or $\alpha = -\frac{g}{L}\sin\theta$

But here θ is very small and $\sin\theta \equiv \theta$

$\therefore \alpha = -\frac{g}{L}\theta \quad .....(1)$



where $\left(\frac{g}{L}\right)$ is constant

$\therefore \alpha \propto -\theta$

$\therefore$ The motion of simple pendulum is simple harmonic.

In general in S.H.M

$\alpha = \omega^2\theta \rightarrow (2)$

From (1) and (2)

$$\omega = \sqrt{\frac{mgL}{I}}$$

$\therefore$ Time period is $T = \frac{2\pi}{\omega}$

$$\Rightarrow T = 2\pi\sqrt{\frac{I}{mgL}}$$

for simple pendulum $I = mL^2$

$$\boxed{\therefore T = 2\pi\sqrt{\frac{L}{g}}}$$

Seconds Pendulum : The simple pendulum whose time period is 2s is called seconds pendulum.

3. **Derive the equation for the kinetic energy and potential energy of a simple harmonic oscillator and show that the total energy of a particle in simple harmonic motion is constant at any point on its path.**

A. **i) Expression of K.E (K) :** A particle having mass 'm' is under simple harmonic motion

Its displacement y = A sinωt

velocity $v = \omega\sqrt{A^2 - y^2}$

kinetic energy $KE = \frac{1}{2}mv^2$

$$= \frac{1}{2}m\left(\omega\sqrt{A^2 - y^2}\right)^2$$

$$\therefore KE = \frac{1}{2}m\omega^2\left(A^2 - y^2\right)$$

ii) Expression of P.E (U) : Potential energy of a simple harmonic oscillator is equal to restoring force on a displaced particle

work done in small displacement 'dy'

$d\omega = -F\,dy$

$d\omega = -(-m\omega^2 y)\,dy$ [Œ $F = -m\omega^2 y$]

work done in total displacement 'y'

$$\omega\int d\omega = \int (n\omega^2 y)\,dy$$

$$\therefore \omega = \frac{1}{2}m\,\omega^2 y^2$$

Here, work done = P.E. (Potential Energy)

$\therefore U = \frac{1}{2} m\omega^2 y^2$

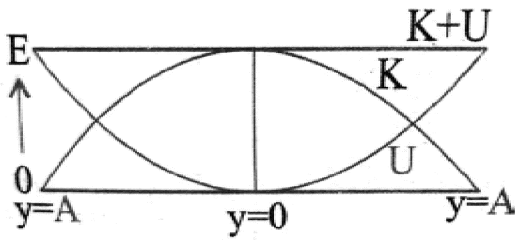
In simple harmonic oscillation total energy is constant :

Total energy

E = K + U

$$E = \frac{1}{2} m\omega^2 (A^2 - 0) + \frac{1}{2} m\omega^2 (0)$$

$$\therefore E = \frac{1}{2} m\omega^2 A^2 \qquad ......(1)$$



at any point, displacement = y

$$\therefore E = \frac{1}{2} m\omega^2 (A^2 - y^2) + \frac{1}{2} m\omega^2 y^2$$

$$\therefore E = \frac{1}{2} m\omega^2 A^2 \qquad ......(2)$$

At any, end point, displacement = A

$$\therefore E = \frac{1}{2} m\omega^2 (A^2 - A^2) + \frac{1}{2} m\omega^2 A^2$$

$$\therefore E = \frac{1}{2} m\omega^2 A^2 \qquad ......(3)$$

According to equation (1) and (2) and (3) total energy at any point is constant.

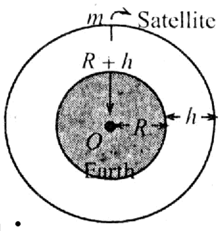
Unit **9**

Gravitation

Short Answer Questions (4 Marks)

1. What is orbital velocity ? Obtain an expression for it.

A. Orbital Velocity : The horizontal velocity required by a body to move around a planet in a circular orbit is called orbital velocity.



Expression :

Let M = mass of the earth, R = radius of the earth

m = mass of the satellite, V_0 = orbital velocity of satellite,

h = height of the satellite above earth's surface.

R+h = orbital radius of the satellite.

According to the law of gravitation, the force of gravity on the satellite is $F = \frac{GMm}{(R+h)^2}$

The centripetal force required by the satellite to keep it in its orbit is $F = \frac{mv_0^2}{(R+h)}$

At equilibrium, the centripetal force is balanced by the gravitational pull of the earth,

So $\frac{mv_0^2}{(R+h)} = \frac{GMm}{(R+h)^2}$ or $v_0^2 = \frac{GM}{(R+h)}$

$\therefore$ orbital velocity , $v_0 = \sqrt{\frac{GM}{(R+h)}} = \sqrt{\frac{gR^2}{R+h}} \left[\because GM = gR^2\right]$

When the satellite revolves close to the surface of the earth (h = 0) then $v_0 = \sqrt{gR}$

2. What is escape velocity? Obtain an expression for it.

A. Escape velocity : It is the minimum velocity with which a body should be projected, so that it moves into the space by overcoming the earth's gravitational field.

Expression for escape velocity :

Consider a body of mass m thrown with a velocity v_e,

Then $K.E = \frac{1}{2}mv_e^2 \quad \rightarrow (1)$

The gravitational force of attraction of the earth of mass M and Radius R on a body of mass m at its surface is $F = \frac{GMm}{R^2} \quad \rightarrow (2)$

Gravitational P.E = work done on the body

$\therefore P.E. = F \times R = \frac{GMm}{R^2} \times R$

$P.E. = \frac{GMm}{R} \quad \rightarrow (3)$

A body just escapes when its K.E. = P.E

$\frac{1}{2} m v_e^2 = \frac{GMm}{R}$

$v_e^2 = \frac{2GM}{R} \quad \left(\because g = \frac{GM}{R^2} \right)$

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

$\boxed{v_e = \sqrt{2gR}} \quad \left(gR = \frac{GM}{R} \right)$

$v_e = \sqrt{2} \times \sqrt{gR} \quad \left(\because v_0 = \sqrt{gR} \right)$

$\boxed{v_e = \sqrt{2} \times v_0}$

$\therefore$ Escape velocity is $\sqrt{2}$ times the orbital velocity.

3. What is a geostationary satellite ? State its uses.

A. If the period of revolution of an artificial satellite is equal to the period of rotation of earth, then such a satellite is called geostationary satelliet.

The time period of geostationary satellite is 24 hours. Its relative velocity with respect to earth is zero. Such a satellite is palced at a hight of 35, 800 km and orbital radius of 42, 250km.

Uses :

1) To study upper layers of atmosphere
2) To forecast the changes in atmosphere
3) To know the shape and size of the earth
4) To identify the minerals and natural resources present inside and on the surface of the earth.

4. An object projected with a velocity greater than or equal to 11.2 km.s^{-1} will not return to earth. Explain the reason.

A. The escape velocity on the surface of the earth is 11.2km/s. Hence an object is projected with a velocity greater than or equal to 11.2km/s, the object will not come back to the earth.

$$\boxed{v_e = \sqrt{2gR}}$$

Escape velocity is the minimum velocity with which a body should be projected, so that it moves into the space by overcoming the earth's gravitational field.

Unit **10**

Mechanical Properties of Solids

Short Answer Questions (4 Marks)

1. Define Hooke's law of elasticity, proportionality, permanent set and breaking stress.

A. **Hooke's law of elasticity :** "With in elastic limit, the stress is directly proportional to strain".

i.e., Stress $\propto$ Strain $\Rightarrow$ stress = E (strain)

Here E is called modulus of elasticity.

Proportionality limit : The maximum stress on the wire upto which stress is proportional to strain and Hooke's law is obeyed, is called proportionality limit.

Permanent set : Permanent deformation produced in the wire when it is stretched beyond elastic limit is called Permanent set.

Breaking stress : The stress for which the wire breaks is called breaking stress.

2. Define Stress and explain the types of stress.

A. **Stress :** The restoring force per unit area is known as stress.

Different types of Stress :

1) Longitudinal (or) Linear Stress :

When a deformation force is applied along the length of the body to cause a change in its length, the restoring force per unit area is called longitudinal stress.

2) Bulk stress (or) Volume stress (or) Normal stress :

When the deforming force is applied to cause a change in the volume of a body, the restoring force per unit area is called bulk stress.

3) Shearing stress (or) tangential stresss :

When deformation force is applied along the tangential plane of a body to cause change in the shape of the body at constant volume, the restoring force per unit area of cross section is called tangential stress.

3. Define Strain and explain the types of strain.

A. **Strain :** The change in dimension per unit original dimension of a body is called strain. It has no units and no dimensional formula.

Different types of Strain :

Longitudinal strain : The ratio between the change in length to original length is called longitudinal strain

$$longitudinal\, strain = \frac{\Delta L}{L}$$

Bulk Strain :

When the deforming force is applied on a body to cause change in its volume, the ratio of change in volume to original volume is called bulk strain.

$$\therefore \text{Bulk strain} = \frac{\Delta V}{V}$$

Shearing strain : The ratio of the relative displacement between two layers of the body to the normal distance between those two layers is called shear strain.

$$\therefore \text{Shearing strain} = \frac{\Delta x}{L} = \tan\theta \simeq \theta$$

Where θ is the angular displacement of layers.

4. Explain why steel is preferred to copper, brass, aluminium in heavy duty machines and in structural designs.

A. Steel is more elastic than copper, brass and aluminium. So,steel is preferred in heavy duty machines and in structural designs.

5. Describe the behaviour of a wire under gradually increasing load.

A. **Behaviour of a metal wire under increasing load :** Let us consider a wire suspended from a rigid support and a load is applied at the other end of the wire. The load is gradually increased. A graph is drawn between strain along X-axis and stress along Y-axis the graph is shown below

A - Proportional limit

B- Elastic limit

E - Breaking point (or) Fracture point

OP - Permanent set

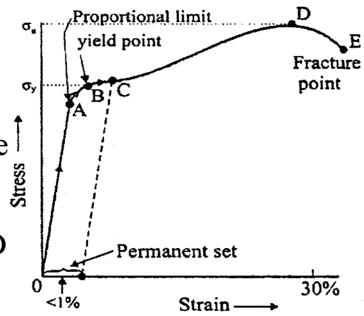
OB - Elastic range

BD - Plastic range

Proportional Limit (A) : Upto 'A' the stress is directly proportional to the strain and the wire obeys Hook's law. The shape of graph OA is straight line. The point A is called proportionality limit.

Elastic Limit (B) : If the stress is further increased from A,

the wire does not obey's Hook's law up to the point B. But elastic nature exist, if the wire is unloaded it follows the path BAO. Hence 'B' is called elastic limit and also called as Yielding Point. The corresponding strength is known as Yielding strength (σ_y)



If the load is increased further stress developed exceeds the yield strength and strain increases rapidly even for a small change in stress. The portion of the curve between B and D showsthis.

Permanent Set (OP) : When load is removed at any point between B and D for example at C the wire does not regain its original dimension. In this case wire is said to have a permanent set. The deformation is said to be plastic deformation. The point 'D' on the graph is Ultimate tensil strength (σ_u) of the material.

Braking (or) Fracture point (E) : Beyond the point 'D' strain is produces even when the load is reduced and fracture occur at point (E). If the ultimate strength and Fracture point D and E are close, the material is said to be "BRITTLE". If they are far a part the material is said to be "DUCTILE".

6. Two identical solid balls. One of ivory and the other of wet- clay are dropped from the same height onto the floor. Which one will rise to a greater height after striking the floor and why ?

A. Consider two identical solid balls , one of Ivory and the other of wet clay are dropped from the same height on the floor.

The ball which is more elastic rises to a greater height after striking the floor.

Ivory is more elastic than wet - clay.

Unit **11**

Mechanical Properties of Fluids

Very Short Answer Questions (2 Marks)

1. Define average pressure, mention its units and dimensional formula?

A. The normal force acting per unit surface area is called average pressure.

Average Pressure $P_{av} = \frac{F}{A}$ It is a scalar quantity.

SI unit : Nm^{-2}

Dimensional formula : $ML^{-1}T^{-2}$

2. Define viscosity. What are its units and dimension formula?

A. The property of the fluids which oppses the relative motion between two fluid layers in contact is called viscosity.

Units : $Nm^{-2}s$ or $Pa - s$

Dimensional formula : $ML^{-1}T^{-1}$

3. What is the working principle of carburetor?

A. Carburetor works on the principle of Bernoulli's theorem.

4. Why are water frops and Bubbles in spherical shape?

A. Due to surface tension. The surface tension fo liquid tends to have minimum surface area. Hence water drops and Bubbles are in spherical shape.

5. What is angle of contact?

A. The angle between tangent to the liquid surface at the point of contact of liquid with solid and solid surface inside the liquid is called angle of contact.

6. What is Magnus effect?

A. The dynamic lift experienced by a spinning ball is called Magnus effect.

7. Give the expression for excess pressure in a liquid drop?

A. Excess pressure inside a Liquid Drop.

$P = \frac{2S}{r}$ where S is surface tension and r is radius of the drop.

8. Give the expression for the excess pressure in an air bubble inside the liquid?

A. Excess pressure of air bubble inside a liquid.

$P = \frac{2S}{r}$ where S is surface tension and r is radius of the drop.

9. Give the expression for excess pressure of soap bubble in air?

A. Excess pressure of soap bubble in air

$P = \frac{4S}{r}$ where S is surface tension and r is radius of the drop.

10. What are water proofing agents and water wetting agents? What do they do?

A. The substances which are used to increase the angle of contact are called waterproofing agents. ExG Soaps and detergents.

11. Mention any two examples or applications that obey Bernoulli's theorem and justify them?

A. Applications of Bernoulli's theorem

1) Dynamic lift on the wings of an aeroplane

2) During cyclones the roof of thatched houses will fly away.

12. When water flows through a pipe, which of the layers move faster and slower?

A. When water is flowing through a pipe the layers in contact with the walls of the pipe move slower and the layers at the centre move faster.

13. "Terminal velocity is more if surface area of the body is more". Give reasons in the support of your answer?

A. According to Stoke, the expression for Terminal Velocity is

$$V = \frac{2}{9} r^2 \frac{(\rho - \sigma)g}{\eta}$$

The surface area of the body is $A = 4\pi r^2$, and terminal velocity $v \propto r^2$.

Hence when surface area increases, r^2 increases and hence Terminal Velocity increases.

Unit **12**

Thermal Properties of Matter

Short Answer Questions (4 Marks)

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

A. Celsius scale of temperature : In this scale of temperature the freezing point of water is taken as lower fixed point (0°C) and boiling point of water is taken as upper fixed point (100°C) at atmospheric pressure. The interval between these two fixed points is divided into 100 equal parts and each part is called 1°C.

Fahrenheit scale of temperature : In this scale of temperature the freezing point of water is taken as lower fixed point (32°F) and boiling point of water is taken as upper fixed point (212°F) at atmospheric pressure. The interval between these two fixed points is divided into 180 equal parts and each part is called 1°F.

Relation between Celsius and Fahrenheit Scales

$$\frac{C-0}{100-0} = \frac{F-32}{212-32} \rightarrow \frac{C}{100} = \frac{F-32}{180}$$

$$\frac{9}{5}C = F-32 \text{ or } 1.8C = F-32$$

2. Pendulum clocks generally go fast in winter and slow in summer why?

A. In general pendulum clock are designed to make required oscillations per day.

Length of the pendulum is $l_1 = l(1+\alpha\Delta t)$

Time period of pendulum clock is

$$T = 2\pi\sqrt{\frac{t}{g}} \text{ or } T \propto \sqrt{l}$$

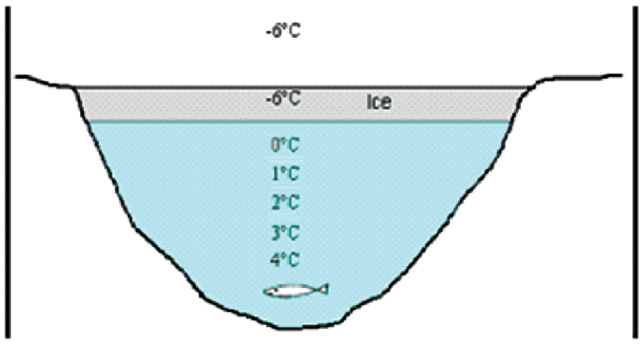
In summer the length of the pendulum increases and hence it takes more time to make required oscillations, so it goes slow in summer.

In winter the length of the pendulum decreases and hence it takes less time to make required oscillations, so it goes fast in winter.

3. In what way is the anomalous behaviour of water advantageous to aquatic animals?

A. In cold countries and at polar regions the temperature falls below 0°C in winter, so the surface of rivers, lakes and seas are frozen. But ice is a bad conductor of heat hence temperature will be $1°C, 2°C, 3°C$ as we go deep into the water. The bottom layer of will be at 4°C as water has maximum density at 4°C.

Significance : The surfaces of seas are frozen but even then aquatic animals are survived due to anomalous behaviour of water



Long Answer Questions (8 Marks)

1. 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?

A. Newton's law of cooling : The rate of cooling of a body is directly proportional to mean excess temperature of body over the surroundings.

The rate of heat loss $-\frac{dQ}{dt} \propto \left(\frac{\theta 1+\theta 2}{2} - \theta_0\right)$

Where θ_1 Initial temperature of the body

θ_2 Final temperature of the body.

θ_0 Temperature of the surroundings

$$-\frac{dQ}{dt} = K\left(\frac{\theta 1+\theta 2}{2} - \theta_0\right) ....(1)$$

where k is a constant

but $Q = ms\theta$

$$\frac{dQ}{dt} = ms\frac{d\theta}{dt} ....(2)$$

From equations (1), (2)

$$-ms\frac{d\theta}{dt} = k\left(\frac{\theta 1+\theta 2}{2} - \theta_0\right)$$

$$-\frac{d\theta}{dt} = \frac{k}{ms}\left(\frac{\theta 1+\theta 2}{2} - \theta_0\right)$$

Let $\frac{k}{ms} = k$

$$\boxed{-\frac{d\theta}{dt}K\left(\frac{\theta 1+\theta 2}{2} - \theta_0\right)}$$

Condition under which Newton's law of cooling is applicable : newton's laws of cooling is applicable if

1) Loss of heat by conduction and radiation is neglected and due to convection only is considered.
2) The temperature difference between body and the surrounding must not be more than 30K

Problem :

Initial temperature $\theta_1 = 60°C$

Final temperature $\theta_2 = 50°C$

Temperature of surroundings $= \theta_0$

Time = 5 min|| = 300s

According to Newton's law of cooling

$$\frac{d\theta}{dt} = K\left(\frac{\theta 1+\theta 2}{2} - \theta_0\right) \qquad \rightarrow \frac{60-50}{300} = K\left(\frac{60+50}{2} - \theta_0\right)$$

$$\rightarrow \frac{10}{300} = K(55-\theta_0 \qquad \rightarrow \frac{1}{30} = K(55-\theta_0)...........(1)$$

In second case it takes 8 min(480s0 to fall to 40°C,

Again using Newton's law

$$\rightarrow \frac{50-40}{8\times 60} = K\left(\frac{50+40}{2} - \theta_0\right) \qquad \rightarrow \frac{10}{480} = K(45-\theta_0)$$

$$\frac{1}{48} = K(45-\theta_0)........... (2)$$

From equations (1), (2) $30K(55-\theta_0) = 48K(45-\theta_0)$

$$275K - 5\theta_0 = 360 - 8\theta_0 \rightarrow 3\theta_0 = 360 - 275$$

$$\theta_0 = \frac{85}{3} = 28.33°C$$

Unit 13

Thermodynamics

Very Short Answer Questions (2 Marks)

1. State and explain first law of thermodynamics?

A. **First law of thermodynamics :** The heat energy (dQ) supplied to a system is equal to sum of increase in its internal energy (dU) and external work done (dW) by it.

i.e., $dQ = dU + dW$ but $dW = PdV$ hence $dQ = dU + PdV$

If the system does some work without supplying heat energy, then

$dQ = 0 \Rightarrow 0 = dU + PdV \Rightarrow PdV = -dU$

i.e., decrease in internal energy equal to external work done by the system.

Limitations of first law of thermodynamics :

1) It does not tell about direction of heat flow i.e., it does not specify provide the work.

2) It does not give any information about the efficiency with which heat can be converted into work.

2. Define two principle specific heats of gas? Which is greater and why?

A. **Specific heat of gas at constant vloume (C_v):** It is defined as the amount of heat energy required to raise the temperature of 1 mole of gas by 1 Degree Celsius at constant volume.

$C_v = \frac{1}{n}\frac{dQ}{dT}$ n = number of moles of gas.

Specific heat of gas at constant Pressure (C_p): It is defined as the amount of heat energy required to raise the temperature of 1 mole of gas by 1 Degree Celsius at constant pressure.

$C_p = \frac{1dQ}{ndT}$ n= number of moles of gas

Out of the two specific heats of gas, $C_p > C_v$

$C_p > C_v$ **Explanation :** For same raise of temperature the heat energy required in the case of constant pressure is more than that of in constant volume case. Because at constant volume the heat energy supplied is totally utilized to increase the temperature or internal energy only. But at constant pressure the heat energy is used to increase the internal energy as well as to do some external work.

3. Obtain an expression for the work done by an ideal gas during isothermal change?

A. When a system undergoes changes in pressure and volume such that temperature of the system remains constant then it is called isothermal process. This process obeys PV=nRT law.

If the Volume of system changes from V_1 and V_2 at pressure P at constant temperature, then work done.

$dW = PdV$ but $P = \frac{nRT}{V}$ here n = number of moles of gas

Total work done by the gas $W = \int dW = \int PdV$

$$= \int_{V_2}^{V_1} \frac{nRT}{V} dV = nRT \int_{V2}^{V1} \frac{dV}{V} = nRT\left[\log_e V\right]_{V1}^{V2}$$

$$= nRT\left[\log_e V_2 - \log_e V_1\right]$$

Work done in Isothermal process $W = nRT \log_e \frac{V2}{V1}$

4. Obtain an expression for the work done by an ideal gas during adiabatic Change?

A. When a system undergoes change in pressure, volume and temperature such that total heat content of system remains constant then it is called adiabatic process.

This process obeys $PV^{\gamma} = K(\text{Constant})$

In an adiabatic process let a gas expands such that pressure increases from P_1 to P_2 and Volume increases from V_1 to V_2 and temperature from T_1 to T_2.

Total work done in this process $W = \int dW = \int PdV$

But in adiabatic process $PV^{\gamma} = K$ or $P = K/V^{v}$

Total work $W = \int_{V2}^{V1} \frac{K}{V^{\gamma}}$

Integrating this $W = \frac{K}{1-y}[V^{1-\gamma}]_{V1}^{V2} = \frac{K}{1-\gamma}[V_2^{1-\gamma}] = \frac{1}{\gamma-1}[KV_1^{1-\gamma} - KV_2^{1-\gamma}]$

but $PV^{\gamma} = K - K = P_1V_1^{\gamma} - P_2V_2^{\gamma}$ substituting this value in above equation.

$$W = \frac{1}{\gamma-1}[P_1V_1^{\gamma} - P_2V_2^{\gamma}V_2^{1-\gamma}] = \frac{1}{\gamma-1}[P_1V_1 - P_2V_2] = \frac{1}{\gamma-1}[nRT_2]$$

$$\Rightarrow W = \frac{nR}{\gamma-1}[T_1 - T_2]$$

5. Explain the following processes?

(i) cyclic process with example

(ii) non cyclic process with example.

A. A process in which the system after passing through various stages wuch as change in pressure, volume and temperature etc., returns to its initial state is defined as "cyclic process".

Ex : All heat engines and refrigerators.

A on cyclic process consists of series of changes involved and do not return the system back to its initial state.

Ex: Work done by a gas enclosed in a cylinder fitted with movable piston.

Unit **14**

Kinetic Theory

Very Short Answer Questions (2 Marks)

1. Define mean free path?

A. The average distance travelled by a gas molecule between two successive collision is called mean free path.

2. When does a real gas behave like an ideal gas?

A. At low pressure and high temperature a real gas behaves like an ideal gas.

3. State Dalton's law of partial pressures?

A. For a mixture of non interacting ideal gases at same temperature and volume, total pressure in the vessel is the sum of partial pressure due to individual gases.

$$P = P_1 + P_2 + P_3 ....$$

4. Explain the concept of degrees of freedom for molecules of a gas?

A. The total number of coordinates are independent quantities required to describe the position and configuration of gas molecule is called degrees of freedom.

5. What is the expression between pressure and kinetic energy of a gas molecule?

A. The pressure exerted by a gas is numerically equal to $\frac{2}{3}$ of kinetic energy of the system.

$$P = \frac{2}{3}E$$

6. The absolute temperature of a gas is increased 3 times. What will be the increase in RMS velocity of the gas molecule?

A. The relation between RMS velocity and Absolute Temperature of gas is $c \propto \sqrt{T}$

If the temperature is increased by 3 times, then rms velocity increases by $\sqrt{3}$ times.

Increase in rms velocity $= \sqrt{3}C - C = 0.732C = 73.2\%$