11th STD - PHYSICS SPECIAL GUIDE

KRISHNAGIRI DISTRICT 2024-2025

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UNIT-1 NATURE OF PHYSICAL WORLD AND MEASUREMENT.

2 MARK QUESTIONS

1. Briefly explain the types of physical quantities.

Fundamental quantity	Derived quantity
Quantities which cannot be expressed in terms of any other physical quantities are called fundamental quantities. Examples: Length, mass, time, electric current, temperature, luminous intensity and amount of substance.	Quantity that can be expressed in terms of fundamental quantities are called derived quantities. Examples: area, volume, velocity.

2. Define units.

An arbitrary chosen standard of measurement of a quantity, which is accepted internationally is called unit of the quantity.

3. Define one radian?

One radian is the plane angle subtended by an arc whose arc length is equal to its radius.

4. Define one Steradian.

One steradian is the solid angle subtended at the centre of a sphere, by that surface of the sphere, which is equal in area, to the square of radius of the sphere.

5.Define One light year.

It is the distance travelled by the light in vacuum in one year.1 Light year $= 9.467X10^{15}m$

6. Define one astronomical unit (AU).

It is the mean distance of the Earth from the sun. $\boxed{1\,AU = 1.496X10^{11}m}$

7. What is the difference between Accuracy and Precision?

Accuracy	Precision
Measurements close to true value	Measurements close to each other
All the accuracy values are precide	All the precide values are not accurate

8. What is meant by Absolute Error?

The magnitude of difference between the true value and the measured value of a quantity is called absolute error.

9. What is meant by Percentage error?

The relative error expressed as percentage is called percentage error.

percentage error= $\frac{\Delta a_m}{a_m} \times 100\%$

10. From a point on the ground, the top of a tree is seen to have an angle of elevation 60°. The distance between the tree and a point is 50 m. Calculate the height of the tree?

$$h = x \tan\theta$$

$$h = 50 \times \tan 60^0$$

The height of the tree $\boxed{h = 86.6\,m}$

3 MARK QUESTIONS

1.Explain The principle of homogeneity of dimensions. Give example?

The principle of homogeneity of dimensions states that the dimensions of all the terms in a physical expression should be the same.

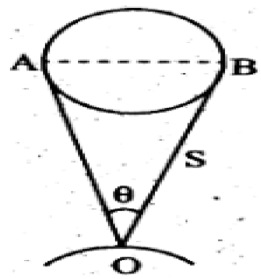
For example: $v^2 = u^2 + 2as$

The dimension of v^2, u^2 and 2as as are the same and equal to $[L^2T^{-2}]$.

2. What are the advantages of SI unit system?

- It is a rational system, in which only one unit is used for one physical quantity.
- It is a coherent system, which means all the derived units can be easily obtained from basic and supplementary units.
- It is a metric system, which means multiples and submultiples can be expressed as powers of 10.

3. How will you measure the diameter of the Moon using parallax method?



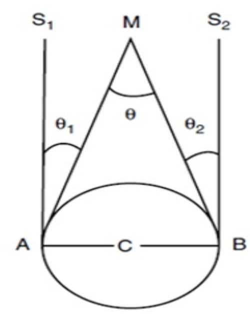
Diameter of the moon:

- Diameter of the moon $AB = d$
- Angle of parallax $\angle AOB = \theta$
- Distance of moon from Earth: $OA = OB = D$

$$\theta = \frac{AB}{OA} = \frac{d}{D}$$

$$\boxed{d = D\theta}$$

4.Determination of distance of Moon from Earth using parallax method?



- C is the centre of the Earth.
- A and B are two diametrically places on the surface of the Earth.
- θ_1 and θ_2 are the parallactic angles of the Moon with respect to some distance stars.

$\angle AMB = \theta_1 + \theta_2 = \theta$

$$\theta = \frac{AB}{AM} = \frac{AB}{MC} \qquad \because AM \approx MC$$

$$\boxed{MC = \frac{AB}{\theta}}$$

5. To check the dimensional correctness of a given physical equation.

(i) $v = u + at$ (ii) $\frac{1}{2}mv^2 = \text{mgh}$

$v = u + at$	$\frac{1}{2}mv^2 = \text{mgh}$
$[LT^{-1}] = [LT^{-1}] + [LT^{-2}][T]$ $[LT^{-1}] = [LT^{-1}] + [LT^{-1}]$	$[M]\,[LT^{-1}]^2 = [M]\,[LT^{-2}]\,[L]$ $[ML^2\ T^{-2}] = [ML^2\ T^{-2}]$

The dimension of both sides is same.

6. What are the applications of dimensional analysis method?

- Convert a physical quantity from one system of units to another.
- Check the dimensional correctness of a given physical equation.
- Establish relations among various physical quantities.

7. What are the limitations of dimensional analysis?

- It gives no information about the dimensionless constants like numbers, π, e, etc.
- It cannot decide whether the given quantity is a vector or a scalar.
- It is not suitable to derive relations involving trigonometric, exponential and logarithmic functions.
- It cannot be applied to an equation involving more than three physical quantities.
- It can only check on whether a physical relation is dimensionally correct but not the correctness of the relation. For example, using dimensional analysis, $s = ut + \frac{1}{3}at^2$ is dimensionally correct whereas the correct relation is $s = ut + \frac{1}{2}at^2$.

8. What is dimensional variables, dimensionless variables?

Dimensional variables	Dimensionless variables
Physical quantities, which possess dimensions and have variable values are called dimensional variables. Examples: length, velocity etc.	Physical quantities which have no dimensions, but have variable values are called dimensionless variables. Examples: strain, refractive index etc.

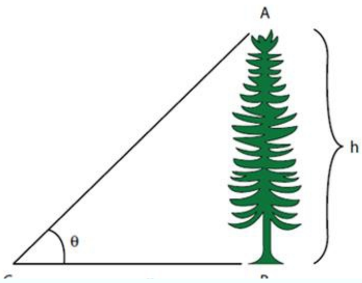
9. What is dimensional Constant dimensionless Constant?

Dimensional Constant	Dimensionless Constant
Physical quantities, which possess dimensions and have constant values are called dimensional constants. Examples: Gravitational constant, Planck's constant etc.	Physical quantities which have no dimensions, and have constant values are called dimensionless constants. Examples: π, e, numbers etc.

5 MARK QUESTIONS

1. Write a note on triangulation method and radar method to measure larger distances.

(i) Triangulation method:



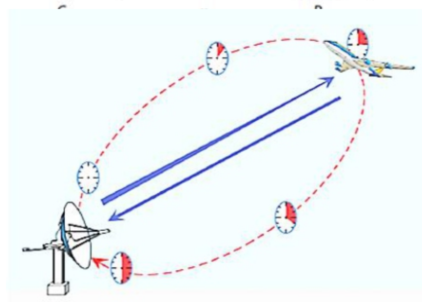
- Let $AB = h$ be the height of the tree.
- Let C be the point of observation at distance x from B.

$$\tan\theta = \frac{AB}{BC} = \frac{h}{x}$$

$$\boxed{\boldsymbol{h = x\tan\theta}}$$

(ii) RADAR method:

RADAR – *Radio Detection and Ranging*



- A radar can be used to measure accurately the distance of a nearby planet such as Mars.
- In this method, radio waves are sent from transmitters which, after reflection from the planet, are detected by the receiver.

Distance = Speed of radio waves × time taken.

$$\boxed{\boldsymbol{d = \frac{v \times t}{2}}}$$

2. Explain the rules framed to count significant figures with the examples.

Rule	Example
i) All non-zero digits are significant.	123 has three significant figures
ii) All zeros between two non-zero digits are significant.	102 has three significant figures
iii) For the number without a decimal point, the terminal zero(s) are not significant.	12300 has three significant figures
iv) All zeros to the right of a non-zero digit but to the left of a decimal point are significant.	12300**.** has five significant figures
v) All zeros are significant if they come from a measurement unit.	12300m has five significant figures
vi) The number of significant figures does not depend on the system of units used.	1.23 cm, 0.0123 m, has three significant figures

3.Explain Error Analysis.

(i) **Absolute Error:**

The magnitude of difference between the true value and the measured value of a quantity is called absolute error.

$$a_m = \frac{1}{n}\sum_{i=1}^{n} a_i$$

The absolute error in measured values is given by,

$$|\Delta a_1| = |a_m - a_1|$$
$$|\Delta a_2| = |a_m - a_2|$$
$$\dots\dots\dots\dots$$
$$|\Delta a_n| = |a_m - a_n|$$

(ii) **Mean Absolute error:**

The arithmetic mean of absolute errors in all the measurements is called the mean absolute error.

$$\Delta a_m = \frac{1}{n}\sum_{i=1}^{n} |\Delta a_i|$$

(iii) **Relative error (or) fractional error:**

The ratio of the mean absolute error to the mean value is called relative error.

$$\text{Relative error} = \frac{\text{Mean absolute error}}{\text{Mean value}}$$

(iv) **Percentage error:**

The relative error expressed as a percentage is called percentage error.

$$\text{percentage error} = \frac{\Delta a_m}{a_m} \times 100\%$$

4. Explain in detail the various types of errors.

The uncertainty in a measurement is called an error. Random error, systematic error and gross error are the three possible errors.

1. Systematic error:

Systematic errors are reproducible inaccuracies that are consistently in the same direction. Systematic errors can be classified as follows.

Systematic errors	Explanation
1. Instrumental errors	When an instrument is not calibrated properly at the time of manufacture, instrumental errors may arise. These errors can be corrected by choosing the instrument carefully.
2.Imperfections in experimental technique or procedure	These errors arise due to the limitations in the experimental arrangement.
3. Personal errors	These errors are due to individuals performing the experiment, may be due to incorrect initial setting up of the experiment or carelessness of the individual making the observation due to improper precautions.
4.Errors due to external causes	The change in the external conditions during an experiment can cause error in measurement. For example, changes in temperature, humidity etc.
5. Least count error	Least count is the smallest value that can be measured by the measuring instrument, and the error due to this measurement is least count error.

2. Random errors:

- Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc.
- Random errors are sometimes called "chance error".

3. Gross Error:

- The error caused due to the shear carelessness of an observer is called gross error.
- These errors can be minimized only when an observer is careful and mentally alert.

5. Obtain an expression for the time period T of a simple pendulum. The time period T depends on (i) mass 'm' of the bob (ii) length 'l' of the pendulum and (iii) acceleration due to gravity g at the place where the pendulum is suspended. (Constant $k = 2\pi$).

Solution:

$$T \,\alpha\, m^{a} l^{b} g^{c}$$

$$T = k\, m^{a} l^{b} g^{c} ----(1)$$

Rewriting the above equation with dimensions,

$$[T^1] = [M]^a \; [L]^b \; [LT^{-2}]^c$$

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

Comparing the powers we get , $a = 0, \quad b + c = 0, \quad -2c = 1$

$$a = 0,\ b = \frac{1}{2},\ c = -\frac{1}{2}$$

above values sub in eqn (1),

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

PHYSICS

UNIT-2 KINEMATICS

2 MARK QUESTIONS

1. Define frame of reference?

The co-ordinate system by which the position of an object is described relative to is called frame of reference.

2. Define Point mass?

The mass of any object be assumed to be concentrated at a point. Then this idealized mass is called "point mass".

3. Define acceleration.

Rate of change of velocity is called acceleration.

SI unit is ms^{-2}.

4. Differentiate scalar -vector quantities.

Scalar	vector
It is a property which have magnitude only.	It is a quantity which is described by both maginitude and direction.
Example: Distance, mass etc	Example: Force, Velocity

5. Define position vectors?

It is a vector which denotes the position of a particle at any instant of time, with respect to some reference frame or coordinate system.

6. What is uniform motion?

If an object is moving with constant velocity, then the motion is called uniform motion.

7. What is non-uniform or accelerated motion?

If an object is moving with various velocity with time, then the motion is called non-uniform or accelerated motion.

8.Define projectile.Give examples.

When an object is thrown in air with some initial velocity and then allowed to move under the action of gravity alone, the object is known as a projectile.

Examples: 1. A bullet fired from the gun.

2. A ball thrown in any direction.

9. Define Scalar or Dot product of two vectors.

The scalar of two vectors is defined as the product of the magnitudes of both the vectors and the cosine of the angle between them.

$$\vec{A} \cdot \vec{B} = AB\cos\theta$$

10. Define Vector or Cross product of two vectors.

The vector product of two vectors is defined as, the product of the magnitudes of two vectors and the sine of the angle between them.

$$\vec{A} \times \vec{B} = (AB\sin\theta)\hat{n}$$

3 MARK QUESTIONS

1. What are the difference between distance and displacement.

Distance	Displacement
It is total length of path travelled.	It is shortest distance between initial and final position of an object.
It is a Scalar quantity.	It is a Vector quantity.

2. Define Velocity and Speed.

Velocity	Speed
The rate of change of displacement of the particle.	The distance travelled in union time.
It is a Vector quantity.	It is a Scalar quantity.
Its unit is ms^{-1}	Its unit is ms^{-1}

3. What is the difference between velocity and average velocity?

Velocity	Average velocity
The rate of change of displacement of the particle.	Ratio of displacement vector to the corresponding time interval
It is a Vector quantity.	It is a Vector quantity.
Its unit is ms^{-1}	Its unit is ms^{-1}

4.What is the difference between Kinematic equations for linear motion and angular motion.

Linear motion	Angular motion
$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{(v+u)t}{2}$	$\omega = \omega_0 + \alpha t$ $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ $\omega^2 = \omega_0^2 + 2\alpha\theta$ $\theta = \frac{(\omega_0 + \omega)t}{2}$

5. What are the types of motion?Explain.

(i) Linear motion:

An object is said to be in linear motion if it moves in a straight line.

Example: An athlete running on a straight track.

(ii) Circular motion:

Circular motion is defined as a motion described by an object traversing a circular path.

Example: The motion of a satellite around the Earth.

(iii) Rotational motion:

If any object moves in a rotational motion about an axis, the motion is called 'rotation'.

Example: Spinning of the Earth about its own axis.

(iv) Vibratory motion:

If an object or particle executes a *to–and– fro* motion about a fixed point, it is said to be in vibratory motion.

Example: Movement of a swing.

6. Define angular displacement and angular velocity.

Angular displacement	Angular velocity
The angle described by the particle about the axis of rotation in a given time is called angular displacement. its unit is radian.	The rate of change of angular displacement is called angular velocity. its unit is radian per second.

7. What is one dimensional, Two dimensional and Three dimensional motion give the examples.

One dimensional motion:

The motion of a particle moving along a straight line. In this motion, only one of the three rectangular coordinates specifying the position of the object changes with time.

Example: An object falling freely under gravity close to Earth.

Two-dimensional motion:

If a particle is moving along a curved path in a plane, then it is said to be in two-dimensional motion. In this motion, two of the three rectangular coordinates specifying the position of object change with time.

Example: Motion of a coin on a carrom board.

Three-dimensional motion:

A particle moving in usual three-dimensional space has three-dimensional motion. In this motion, all the three coordinates specifying the position of an object change with respect to time.

Example: A bird flying in the sky

5 MARK QUESTIONS

1. Explain in detail the triangle law of addition.

Triangle Law: Represent the vectors $\vec{A}$ and $\vec{B}$ by the two adjacent sides of a triangle taken in the same order. Then the resultant is given by the third side of the triangle.

- The head of the first vector $\vec{A}$ is connected to the tail of the second vector $\vec{B}$.
- Let θ be the angle between $\vec{A}$ and $\vec{B}$.

Magnitude of resultant vector:

$$AN = B\cos\theta$$

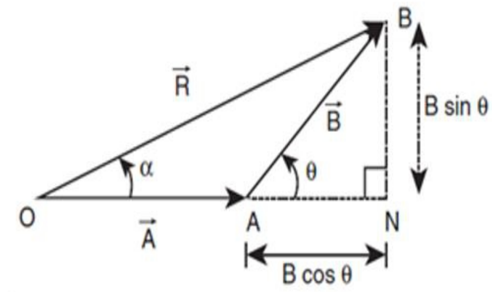
$$BN = B\sin\theta$$

$$\Delta OBN \text{ ல் } OB^2 = ON^2 + BN^2$$

$$R^2 = (A + B\cos\theta)^2 + (B\sin\theta)^2$$

$$R^2 = A^2 + B^2 + 2AB\cos\theta$$

$$\boldsymbol{R = \sqrt{A^2 + B^2 + 2AB\cos\theta}}$$



Direction of resultant vectors:

$$\boldsymbol{\alpha = \tan^{-1}\left(\frac{B\sin\theta}{A + B\cos\theta}\right)}$$

2. Derive the equation of motion, range and maximum height reached by the particle thrown at an oblique angle θ with respect to the horizontal direction.

Consider an object thrown with initial velocity $\vec{u}$ at an angle θ with the horizontal.

(i) Motion along x-direction:

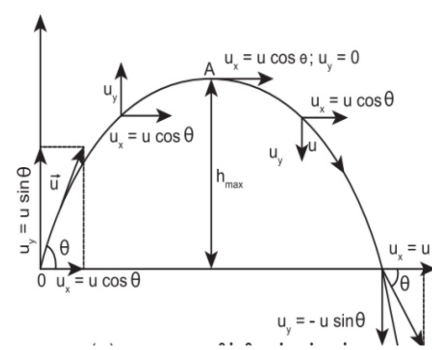
$$s_x = u_x t + \frac{1}{2} a_x t^2$$

$$t = \frac{x}{u\cos\theta}$$

(i) Motion along y-direction:

$$s_y = u_y t + \frac{1}{2} a_y t^2$$

$$y = x\tan\theta - \frac{g}{2}\frac{x^2}{u^2\cos^2\theta}$$



***M*aximum Height:**

The maximum vertical distance travelled by the projectile during its journey is called maximum height.

$$\text{maximum height} \quad \boldsymbol{h_{max} = \frac{u^2\sin^2\theta}{2g}}$$

Time of flight (T_f):

The total time taken by the projectile from the point of projection till it hits the horizontal plane is called time of flight.

$$\text{Time of flight} \quad \boldsymbol{T_f = \frac{2u\sin\theta}{g}}$$

Horizontal range (R):

The maximum horizontal distance between the point of projection and the point where the projectile hits the ground.

$$\text{Horizontal range} \quad \boldsymbol{R = \frac{u^2\sin 2\theta}{g}}$$

$$\boldsymbol{R_{max} = \frac{u^2}{g}}$$

3. Derive the expression for centripetal acceleration.

- The acceleration acting on an object towards the centre of the circle in a uniform circular motion is called centripetal acceleration.
- The directions of position and velocity vectors shift through the same angle θ in a small interval of time Δt, as shown in Figure.
- For uniformcircular motion, $r = |\vec{r}_1| = |\vec{r}_2|$ and $v = |\vec{v}_1| = |\vec{v}_2|$
  From figure,

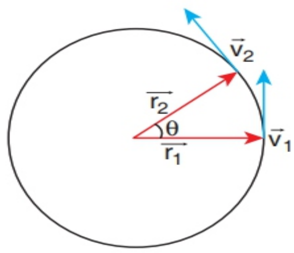
$$\frac{\Delta r}{r} = -\frac{\Delta v}{v} = \theta$$

$$\Delta v = -v\left(\frac{\Delta r}{r}\right)$$

$\div \Delta t$
$$\frac{\Delta v}{\Delta t} = -\frac{v}{r}\left(\frac{\Delta r}{\Delta t}\right)$$

$$\boxed{\boldsymbol{a = -\frac{v^2}{r}}} \qquad \because \boldsymbol{v = r\omega}$$

$$\boldsymbol{a = -\omega^2 r}$$



4. Discuss the properties of Scalar (or) Dot products.

- The product quantity $\vec{A}.\vec{B}$ is always a scalar.
- The scalar product is commutative. $\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$
- The vectors obey distributive law. $\vec{A} \cdot (\vec{B} + \vec{C}) = \vec{A} \cdot \vec{B} + \vec{A} \cdot \vec{C}$
- The angle between the vectors $\theta = \cos^{-1}\left[\frac{\vec{A}.\vec{B}}{AB}\right]$
- When $\vec{A}$ & $\vec{B}$ are parallel, $(\vec{A} \cdot \vec{B})_{max} = AB$
- When $\vec{A}$ & $\vec{B}$ are anti-parallel, $(\vec{A} \cdot \vec{B})_{mini} = -AB$
- When $\vec{A}$ & $\vec{B}$ are perpendicular, $\vec{A} \cdot \vec{B} = 0$
- Self-dot product of a unit vectors $\hat{\imath} \cdot \hat{\imath} = \hat{\jmath} \cdot \hat{\jmath} = \hat{k} \cdot \hat{k} = 1$

5. Discuss the properties of Vector (or) Cross products.

- The vector product of any two vectors is always another vector.
- The vector product of two vectors is not commutative. $\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$
- When $\vec{A}$ & $\vec{B}$ are parallel or anti-parallel, $(\vec{A} \times \vec{B})_{mini} = 0$
- When $\vec{A}$ & $\vec{B}$ are perpendicular, $(\vec{A} \times \vec{B})_{max} = AB\hat{n}$
- The self–cross product of a unit vectors $\hat{\imath} \times \hat{\imath} = \hat{\jmath} \times \hat{\jmath} = \hat{k} \times \hat{k} = 0$
- The self–cross product, i.e., product of a vector with itself is the null vector. $\vec{A} \times \vec{A} = \vec{0}$

6. Derive the kinematic equations of motion for constant acceleration.

Velocity-time relation	Displacement-time relation	Velocity-displacement relation
$dv = adt$ $\int_u^v dv = \int_0^t adt$ $v = u + at$	$ds = vdt = (u + at)dt$ $\int_0^s ds = \int_0^t udt + \int_0^t atdt$ $s = ut + \frac{1}{2}at^2$	$a = \frac{dv}{ds}v$ $\int_0^s ds = \int_u^v \frac{1}{2a}d(v^2)$ $v^2 = u^2 + 2as$ $s = \frac{(u+v)t}{2}$

UNIT-3 LAWS OF MOTION

2 MARK QUESTIONS

1. State Newton's First law.

Every object continues to be in the state of rest or of uniform motion unless there is an external force acting on it.

2. State Newton's second law.

The force acting on an object is equal to the rate of change of its momentum.

$$\vec{F} = \frac{d\vec{p}}{dt}$$

3. State Newton's third law.

Newton's third law states that for every action there is an equal and opposite reaction.

$$\vec{F}_{12} = -\vec{F}_{21}$$

4. What is inertia? What are its types?

The inability of objects to move on its own or change its state of motion is called inertia.

Types: 1. Inertia of rest
2.Inertia of motion
3.Inertia of direction

5. Define one newton.

One Newton is defined as the force which acts on 1 kg of mass to give an acceleration 1 $m\ s^{-2}$ in the direction of the force.

6.What are the steps followed in developing the free body diagram?

- Identify the forces acting on the object.
- Represent the object as a point.
- Draw the vectors representing the forces acting on the object.

7. What is the meaning by 'pseudo force'?

The pseudo force is a fictitious force. It is just an apparent but it makes real effect. It is represented only in non-inertial frames.

Example: centrifugal force.

8. Under what condition will a car skid on a leveled circular road?

If the static friction is not able to provide enough centripetal force to turn, the vehicle will start to skid.

$$\frac{mv^2}{r} > \mu_s mg$$

9 Define angle of Repose.

The angle of repose is the angle of inclined plane at which the object starts to slide.

10. What is Centripetal force?

If a particle is in uniform circular motion with respect to an inertial frame, there is a force acting towards the center of the circle is called centripetal force.

11.What is Centrifugal force?

If a particle is in circular motion with respect to a non-inertial frame, there is a pseudo force acting away from the centre of the circle is called centrifugal force.

3 MARK QUESTIONS

1. Explain the concept of inertia. Write two examples each for inertia of motion, inertia of rest and inertia of direction.

Inertia:

The inability of objects to move on its own or change its state of motion is called inertia.

(i) Inertia of rest:

The inability of an object to change its state of rest is called inertia of rest.

Example:

When a stationary bus starts to move, the passengers experience a sudden backward push. Due to inertia, the body will try to continue in the state of rest, while the bus moves forward.

(ii) Inertia of motion:

The inability of an object to change its state of uniform speed on its own is called inertia of motion.

Example:

When the bus is in motion, and if the brake is applied suddenly, passengers move forward and hit against the front seat.

(iii) Inertia of direction:

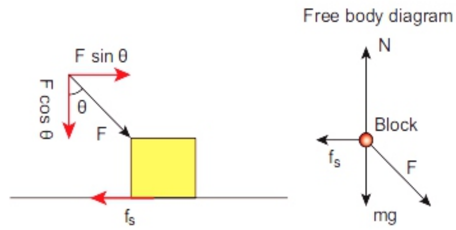
The inability of an object to change its direction of motion on its own is called inertia of direction.

Example:

When a stone attached to a string is in whirling motion, and if the string is cut suddenly, the stone will not continue to move in circular motion but moves tangential to the circle.

2. Using free body diagram, show that it is easy to pull an object than to push it.

push:



- The applied force F can be resolved into two components,

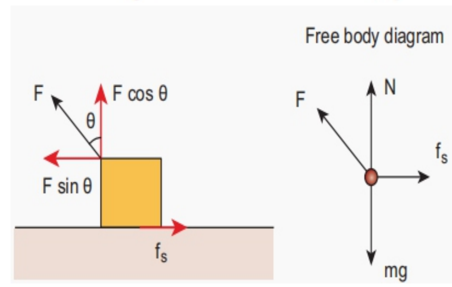
(1) $F\sin\theta$ −parallel to the surface

(2) $F\cos\theta$ − perpendicular to the surface

$$N_{push} = mg + F\cos\theta$$
$$f_s^{\max} = \mu_s(mg + F\cos\theta)$$

It implies that the normal force acting on the body increases.

pull:



- The applied force F can be resolved into two components,

(1) $F\sin\theta$ − parallel to the surface

(2) $F\cos\theta$ − perpendicular to the surface

$$f_s^{\max} = \mu_s N_{push} = \mu_s(mg + F\cos\theta)$$

It shows that the normal force is less than N_{push}.

- **It is Easier to pull** an object than to push**.**

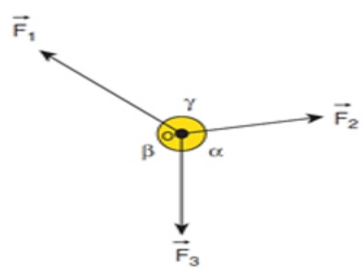
3.What are concurrent forces? State Lami's theorem.

Concurrent forces:

- A collection of forces is said to be concurrent, if the lines of forces act at a common point.

Lami's theorem:

- If a system of three concurrent and coplanar forces is in equilibrium, then Lami's theorem states that the magnitude of each force of the system is proportional to sine of the angle between the other two forces.
- Consider three coplanar and concurrent forces $\vec{F}_1, \vec{F}_2$ and $\vec{F}_3$ which act at a common point O.



$$|\vec{F}_1| \propto \sin\alpha$$
$$|\vec{F}_2| \propto \sin\beta$$
$$|\vec{F}_3| \propto \sin\gamma$$

$$\frac{|\vec{F}_1|}{\sin\alpha} = \frac{|\vec{F}_2|}{\sin\beta} = \frac{|\vec{F}_3|}{\sin\gamma}$$

Lami's theorem is useful to analyse the forces acting on objects which are in static equilibrium.

4. Compare the Static and Kinetic friction.

Static friction	Kinetic friction
1.It opposes the starting of motion.	It opposes the relative motion of the object with respect to the surface.
2.Independent of surface area of contact.	Independent of surface area of contact.
3.Depends on the magnitude of applied force.	Independent of magnitude of applied force.
4.It can take values from zero to μ_s N	It can never be zero and always equals to $\mu_k N$ whatever be the speed (true $v < 10\text{ms}^{-1}$)
5. $\mu_s > \mu_k$	Coefficient of kinetic friction is less than coefficient of static friction.

PHYSICS

5. Compare the centripetal and centrifugal forces.

Centripetal force	Centrifugal force
1.It is a real force which is exerted on the body by the external agencies like gravitational force, tension in the string, normal force etc.	It is a pseudo force or fictitious force which cannot arise from gravitational force, tension force, normal force etc.
2.It acts towards the axis of rotation or centre of the circle in circular motion.	It acts outwards from the axis of rotation or radially outwards from the centre of the circular motion.
3.Acts in both inertial and non-inertial frames.	Acts only in rotating frames (non-inertial frame)
4.Real force and has real effects.	Pseudo force but has real effects.
5.Origin of centripetal force is interaction between two objects.	Origin of centrifugal force is inertia. It does not arise from interaction.

6.When a cricket player catches the ball, he pulls his hands gradually in the direction of the ball's motion. Why?

- If he stops his hands soon after catching the ball, the ball comes to rest very quickly. It means that the momentum of the ball is brought to rest very quickly. So, the average force acting on the body will be very large. Due to this large average force, the hands will get hurt.
- To avoid getting hurt, the player brings the ball to rest slowly.

7. Compare the Inertial frames and non-Inertial frames.

Inertial frames	Non-Inertial frames
1. The frame of reference, which is not accelerated is known as inertial frame.	The frame of reference, which is accelerated is known as non-inertial frame.
2. Newton's laws are applicable in these frames.	Newton's laws are not applicable in these frames.

5 MARK QUESTIONS

1. Prove the law of conservation of linear momentum. Use it to find the recoil velocity of a gun when a bullet is fired from it.

Statement:

If there are no external forces acting on the system, then the total linear momentum of the system is always a constant vector.

Proof:

When two particles interact with each other, they exert equal and opposite forces on each other.

According Newton's second law $\vec{F}_{12} = \frac{d\vec{p}_1}{dt}$ *and* $\vec{F}_{21} = \frac{d\vec{p}_2}{dt}$.

According to Newton's third law $\vec{F}_{12} = -\vec{F}_{21}$

$$\frac{d\vec{p}_1}{dt} = -\frac{d\vec{p}_2}{dt}$$

$$\frac{d\vec{p}_1}{dt} + \frac{d\vec{p}_2}{dt} = 0$$

$$\frac{d}{dt}(\vec{p}_1 + \vec{p}_2) = 0$$

$$(\vec{p}_1 + \vec{p}_2) = \text{constant}$$

Recoil velocity of a gun:

Before firing:

- The momentum of the bullet $\vec{p}_1 = 0$
- The momentum of the gun $\vec{p}_2 = 0$
- Total momentum before firing the gun is zero $\vec{p}_1 + \vec{p}_2 = 0$

After firing:

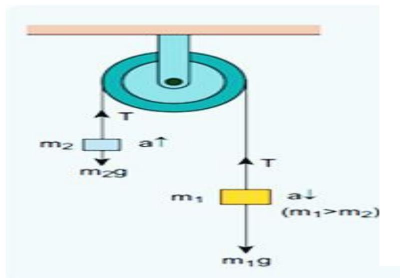
- The momentum of the gun $\vec{p}_1{}'$
- The momentum of the bullet $\vec{p}_2{}'$
- Total momentum After firing the gun is $\vec{p}_1{}' + \vec{p}_2{}' = 0$

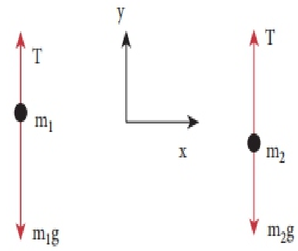
$$\boxed{\vec{p}_1{}' = -\vec{p}_2{}'}$$

The momentum of the gun is exactly equal, but in the opposite direction to the momentum of the bullet. This is the reason after firing, the gun suddenly moves backward with the momentum $(-\vec{p}_2)$. It is called 'recoil momemtum'.

2. Explain the motion of blocks connected by a string in Vertical motion.

- Consider two blocks of masses m_1 and m_2 $(m_1 > m_2)$ are connected by a light inextensible string that passes over a pulley.
- Let T be the tension in the string. When the system is released m_1 moves downward and m_2 moves upward with the same acceleration 'a'.





$$T\hat{j} - m_2 g\hat{j} = m_2 a\hat{j}$$

$$T - m_2 g = m_2 a --- (1)$$

$$T\hat{j} - m_1 g\hat{j} = -m_1 a\hat{j}$$

$$T - m_1 g = -m_1 a --- (2)$$

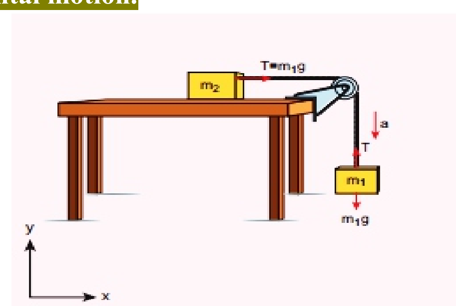
(1) + (2) $$\boxed{a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g}$$

If $m_1 = m_2$ then $a = 0$.Tension on the string can be obtained by substituting the acceleration into eqn (1) we get,

$$\boxed{T = \left(\frac{2m_1 m_2}{m_1 + m_2}\right) g}$$

3. Explain the motion of blocks connected by a string in Horizontal motion.

- In this case, mass m_2 is kept on a horizontal table and mass m_1 is hanging through a small pulley.
- The forces acting on a mass m_2 and m_1 are shown in free body diagram.



Applying Newton's second law for m_1

$$T\hat{j} - m_1 g\hat{j} = -m_1 a\hat{j} \quad \text{(along y direction)}$$

$$T - m_1 g = -m_1 a --- (1)$$

$$T\hat{i} = m_2 a\hat{i} \quad \text{(along x direction)}$$

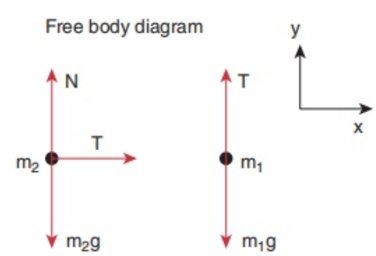
$$T = m_2 a --- (2)$$

There is no acceleration along y direction for m_2

$$N\hat{j} - m_2 g\hat{j} = 0$$

$$N = m_2 g$$

eqn (2) substituting in eqn (1) $$a = \left(\frac{m_1}{m_1 + m_2}\right) g$$

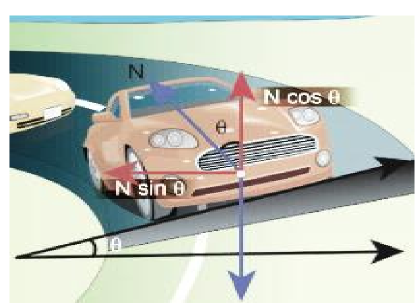


Tension on the string can be obtained by substituting the acceleration into eqn (2) we get,

$$\boxed{T = \left(\frac{m_1 m_2}{m_1 + m_2}\right) g}$$

4. Obtain the expression for safe speed of a car when it turns on a banking of tracks and discuss how it prevents from skidding.

- The banking angle θ and radius of curvature of the road or track determines the safe speed of the car at the turning.
- When the car just exceeds the safe speed, it will start to skid outward but the frictional force will provide additional centripetal force to prevent the outward skidding.
- When the car little slows the safe speed, it will start to skid inward but frictional force will reduce centripetal force to prevent the inward skidding.
- However, frictional force cannot prevent the car from skidding when the car speed is much greater than the safe speed.



- So that the normal force makes same angle θ with the vertical, can be resolved into $N\cos\theta$ and $N\sin\theta$

$$N\cos\theta = mg ----(1)$$

$$N\sin\theta = \frac{mv^2}{r} ----(2)$$

$$\frac{(2)}{(1)} \qquad \tan\theta = \frac{v^2}{rg}$$

$$\boxed{v = \sqrt{rg\tan\theta}}$$

5.Define-Angle of repose. Show that in an inclined plane, angle of friction is equal to angle of repose.

Define-Angle of repose:

The angle of repose is the angle of inclined plane with the horizontal such that an object placed on it begins to slide.

Explanation:

- Consider an inclined plane on which an object is placed.
- The gravitational force mg is resolved into components parallel $(mg\sin\theta)$ and perpendicular $(mg\cos\theta)$ to the inclined plane.
- The component of force perpendicular to the inclined plane $(mg\cos\theta)$ is balanced by the normal force (N)

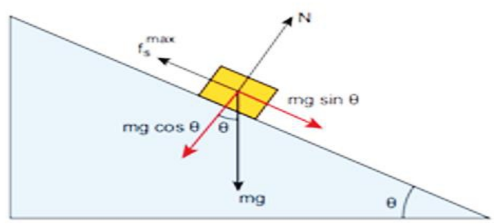
$$N = mg\cos\theta \text{-------(1)}$$

$$f_s^{max} = mg\sin\theta \text{ --------(2)}$$

$$\frac{(2)}{(1)} \qquad \frac{f_s^{max}}{N} = \tan\theta --- (3)$$

$$f_s^{max} = \mu_s N$$

$$\frac{f_s^{max}}{N} = \mu_s ----(4)$$



eqn (3) =(4) we get

$$\boxed{\mu_s = \tan\theta}$$

UNIT 4 WORK, ENERGY AND POWER

2 MARK QUESTIONS

1. what is work? Give its unit and dimension.

Work is said to be done by the force when the force applied on a body displaces it. Its SI unit is joule and dimension is ML^2T^{-2}.

2. Define Energy.Give its SI unit and dimension.

Energy is defined as the capacity to do work. Its SI unit is joule.its dimension ML^2T^{-2}.

3. Define power. Give its unit.

Power is defined as the rate of work done or energy delivered.its unit is Watt

$$power(P) = \frac{work\ done}{Time\ taken}$$

4. Define average power.

The average power is defined as the ratio of the total work done to the total time taken.

$$average\ power\ (P) = \frac{total\ work\ done}{total\ time\ taken}$$

5. Define instantaneous power.

Its defined as the power delivered at an instant. $\boxed{P_{avg} = \frac{dw}{dt}}$

6. Define one watt.

One watt is defined as the power when one joule of work is done in one second.

7. Write the various types of potential energy explain the formula.

1. Gravitational potential energy: $\boldsymbol{U = mgh}$
2. spring potential energy: $\boldsymbol{U = \frac{1}{2}Kx^2}$
3. electrostatic potential energy: $\boldsymbol{U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}}$

8. State law of conservation of energy.

The law of conservation of energy states that energy can neither be created nor be destroyed.one form of energy can be transformed to another form but total energy of an isolated system remains constant.

9.What is elastic collision?

The collision in which total kinetic energy before collision is equal to the total kinetic energy after collision is known as elastic collision.

10. What is inelastic or plastic collision?.

The collision in which total kinetic energy before collision is not equal to the total kinetic energy after collision is known as elastic collision.

11.Define COR or coefficient of restitution.

Its is defined as the ratio of velocity of separation after collision to the velocity of approach before collision

$$e = \frac{\text{velocity of separation (after collision)}}{\text{velocity of approach (before collision)}}$$

3 MARK QUESTIONS

1.Compare between elastic and inelastic collisions.

Elastic collision	Inelastic collision
1.Total momentum is conserved.	total momentum is conserved.
2.Total kinetic energy is conserved.	total kinetic energy is not conserved
3.Forces involved are conservative forces.	Forces involved are non-conservative forces.
4.Mechanical energy is not dissipated.	Mechanical energy is dissipated into heat, light, sound, etc.

2. Write difference between conservative and non-conservative forces.

Conservative force	Non-conservative force
1.It is independent of path.	it dependent of path.
2.Work done in a round trip is zero.	Work done in a round trip is not zero.
3.Work done is completely recoverable.	Work done is not completely recoverable.
4.Total energy remains constant.	Energy dissipated as heat energy.
5.Force is the negative gradiant of potential energy.	No such relation exists.

3.What is mean by conservative force and non-conservative force?

Conservative force:

It the work done by or against the force in moving body doesn't depend the nature of the path between initial and final position of the body, the force is called conservative force.

Non-conservative force:

If the work done by or against the force in moving body depends on the path between initial and final position of the body, the force is called non-conservative force.

4.Derive the relation between momentum and kinetic energy.

- Consider an object of mass m moving with a velocity $\vec{v}$.

The linear momentum is $\vec{P} = m\vec{v}$

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

$$KE = \frac{1}{2\text{m}}\ \text{m}\vec{v}.\text{m}\vec{v}$$

$$KE = \frac{1}{2\text{m}}\ \vec{P}.\vec{P} \qquad \because \vec{P} = m\vec{v}$$

PHYSICS

$$KE = \frac{P^2}{2m}$$

$$\boxed{\boldsymbol{P = \sqrt{2mKE}}}$$

5.Calculate the energy consumed in electrical units when a 75 W fan is used for 8 hours daily for one month.

solution:

Electrical energy = power x time of usage = $P \times t$

$= 75 \text{ watt} \times 240 \text{ hour}$

$= 18000 \text{ watt hour}$

$= 18\ kW\ h$

1 electrical unit $= 1\ kW\ h$

Electrical energy = 18 unit

5 MARK QUESTIONS

1.State and prove Work-energy theorem. mention any three examples for it.

Work-Energy theorem. The work done by the force on the body changes the kinetic energy of the body.

- Consider a body of mass m at rest on a frictionless horizontal surface.

$$W = Fs \text{--------(1)}$$

$$F = ma \text{ -------(2)}$$

The 3rd equation of motion can be written as

$$v^2 = u^2 + 2as$$

$$a = \frac{v^2 - u^2}{2s}$$

Substituting the value of a in equation 2 we get, $F = m\left(\frac{v^2-u^2}{2s}\right) - - - (3)$

Substituting equation 3 in 1 we have, $W = m\left(\frac{v^2-u^2}{2s}\right)s$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\boxed{\boldsymbol{W = \Delta KE}}$$

example:

1) work done is positive then its kinetic energy increases.

2) work done is negative then its kinetic energy decreases.

3) there is no work done then its kinetic energy constant.

2.Arrive at an expression for power and velocity.

The work done by a force $\vec{F}$ for a displacement $d\vec{r}$ is

$$W = \int \vec{F} \cdot d\vec{r} \text{ -----------(1)}$$

Multiplied and divided by dt

L.H.S $\quad W = \int dw = \int \frac{dW}{dt} dt$ ---------(2)

R.H.S $\quad \int \vec{F} \cdot d\vec{r} = \int \left(\vec{F} \cdot \frac{d\vec{r}}{dt}\right) dt$

$$\int \vec{F} \cdot d\vec{r} = \int (\vec{F} \cdot \vec{v}) dt - - - (3) \qquad \left[\because \vec{v} = \frac{d\vec{r}}{dt}\right]$$

substituting (2),(3) in (1) we get

$$\int \frac{dW}{dt} dt = \int (\vec{F} \cdot \vec{v}) dt$$

$$\int \left(\frac{dW}{dt} - \vec{F} \cdot \vec{v}\right) dt = 0$$

$$\boxed{\boldsymbol{\frac{dW}{dt} = \vec{F} \cdot \vec{v}}}$$

3.Find the loss of kinetic energy in one dimensional perfect inelastic collision of two bodies.

- Inelastic collision the Mechanical energy is dissipated into heat, light, sound. so

Total kinetic energy before collision

$$KE_i = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2$$

Total kinetic energy after collision

$$KE_f = \frac{1}{2}(m_1 + m_2)v^2$$

Then the loss of kinetic energy is

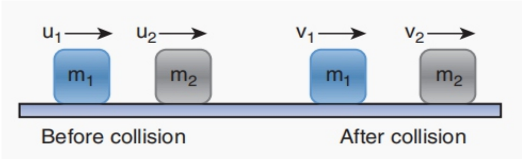
$$\Delta Q = KE_i - KE_f$$

$$\Delta Q = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 - \frac{1}{2}(m_1 + m_2)v^2$$

$$\boldsymbol{\Delta Q = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(u_1 - u_2)^2}$$

4.Arrive at an expression for elastic collision in one dimension and discuss various cases.

Consider two elastic bodies of masses m_1 and m_2 moving in a straight line along +ve x-direction on a frictionless horizontal surface as shown in figure.



Let $u_1 \& u_2$ and $v_1 \& v_2$ be the initial and final velocities of masses m_1 & m_2 respectively

According to law of conservation of linear momemtum,

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$m_1(u_1 - v_1) = m_2(v_2 - u_2)$$

	mass	velocity	momentum	Kinetic energy	Total linear momentum	Total kinetic energy
before collision	m_1	u_1	$m_1 u_1$	$\frac{1}{2} m_1 {u_1}^2$	$m_1 u_1 + m_2 u_2$	$\frac{1}{2} m_1 {u_1}^2 + \frac{1}{2} m_2 {u_2}^2$
	m_2	u_2	$m_2 u_2$	$\frac{1}{2} m_2 {u_2}^2$		
After collision	m_1	v_1	$m_1 v_1$	$\frac{1}{2} m_1 {v_1}^2$	$m_1 v_1 + m_2 v_2$	$\frac{1}{2} m_1 {v_1}^2 + \frac{1}{2} m_2 {v_2}^2$
	m_2	v_2	$m_2 v_2$	$\frac{1}{2} m_2 {v_2}^2$		

Elastic collision

$$\frac{1}{2} m_1 {u_1}^2 + \frac{1}{2} m_2 {u_2}^2 = \frac{1}{2} m_1 {v_1}^2 + \frac{1}{2} m_2 {v_2}^2$$

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

$$(2)/(1) \qquad u_1 - u_2 = -(v_1 - v_2)$$

$$v_1 = v_2 + u_2 - u_1 \text{--------}(3)$$

$$v_2 = v_1 + u_1 - u_2 \text{---------}(4)$$

substituting (3),(4) in (1) we get,

$$\mathbf{v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1 + \left(\frac{2\, m_2}{m_1 + m_2}\right) u_2}$$

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

PHYSICS

UNIT 5-MOTION OF SYSTEM OF PARTICLES AND RIGID BODIES

2 MARK QUESTIONS

1.Define centre of Mass.

A whole mass of the body supposed to be concentrated at a point called centre of mass of the body.

2.Define torque and mention its unit.

The moment of the external applied force about a point or axis of rotation. unit Nm.

$$\boxed{\vec{\tau} = \vec{r} \times \vec{F}}$$

3.Give any two examples of torque in day-to-day life.

- When you twist a bottle to open or close it.
- See-saws
- Wrenches
- Steering car.

4. What are the conditions in which force cannot produce torque?

- The torque is zero when $\vec{r}$ and $\vec{F}$ are parallel or antiparallel $\vec{\tau} = 0$
- If parallel then $\theta = 0^o$, $\sin\theta = 0$, If antiparallel $\theta = 0^o$, $\sin\theta = 0$
- Hence $\tau = 0$ the torque is zero if the force acts at the reference point $\vec{\tau} = 0$

5.Define couple.Give examples.

A pair of forces which are equal in magnitude but opposite in direction and separated by a perpendicular distance so that their lines of action do not coincide that causes a turning effect is called a couple.

Examples: (i) Steering wheel of a car

(ii) opening and closing of water tap.

6. What is radius of gyration.

The radius of gyration of on object is the perpendicular distance from the axis of rotation an equivalent point mass would have same mass and same moment of inertia.

7. Define centre of gravity

The centre of gravity of a body is the point at which the entire weight of the body acts irrespective of the position and orientation of the body.

8. State conservation of angular momentum.

When no external torque acts on the body the net angular momentum of a rotating rigid body remains constant.

$$\vec{\tau} = 0, \quad \frac{dL}{dt} = 0 \qquad \text{L – constant.}$$

9.Define moment of a couple.

The magnitude of moment of couple is defined as the product of either of the forces of a couple by the perpendicular distance between them. Its unit is Nm

10. Mention any two-physical significance of moment of inertia.

- Lesser the moment of inertia, greater the speed of rotation.
- Greater the mass concentrated away from the axis of rotation, greater the moment of inertia.

3 MARK QUESTIONS

1. Relation between torque and angular momentum

angular momentum $L = I\omega$

torque $\tau = I\alpha$.

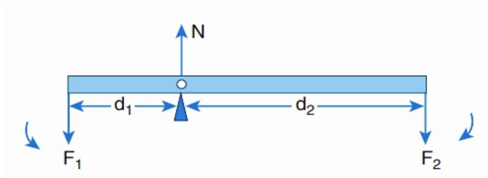
$$\tau = I\frac{d\omega}{dt} \quad \because \left(\alpha = \frac{d\omega}{dt}\right)$$

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

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

2. Explain principle of moments.

- principle: If the rod has to remain stationary in horizontal position. it should be in translational and rotational equilibrium.
- Then both the net force and net torque must be zero translational equilibrium.



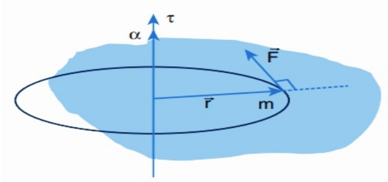
$$F_1 + N - F_2 = 0$$
$$N = F_1 + F_2$$
$$d_1F_1 - d_2F_2 = 0$$
$$\boxed{d_1F_1 = d_2F_2}$$

3. Give relation between angular momentum and angular velocity.

A point mass m in the body will execute a circular motion about the fixed axis.

angular momentum $L = rmv \; \sin 90^0 = rmv$

$$L = mr^2\omega \qquad \because v = r\omega$$



Angular momentum of the rigid body

$$L = \left(\sum m_i r_i^2\right)\vec{\omega} \quad \because \; I = \sum m_i r_i^2$$
$$\boxed{\vec{L} = I\,\vec{\omega}}$$

4. A force of $(4\hat{\imath} - 3\hat{\jmath} + 5\hat{k})N$ is applied at a point whose position vector is $(7\hat{\imath} + 4\hat{\jmath} - 2\hat{k})$m. Find the torque of force about the origin.

Torque $\vec{\tau} = \vec{r} \times \vec{F}$

$$\vec{\tau} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 7 & 4 & -2 \\ 4 & -3 & 5 \end{vmatrix}$$
$$\vec{\tau} = \hat{\imath}(20 - 6) - \hat{\jmath}(35 + 8) + \hat{k}(-21 - 16)$$
$$\vec{\tau} = (14\hat{\imath} - 43\hat{\jmath} - 37\hat{k})\text{ Nm}$$

5. What is the difference between sliding and slipping.

Sliding	Slipping
$V_{cm} > R\omega$	$V_{cm} < R\omega$
$V_{Trans} > V_{Rot}$	$V_{Trans} < V_{Rot}$
The Translation is more than the rotation.	The rotation is more than the translation.

5 MARK QUESTIONS

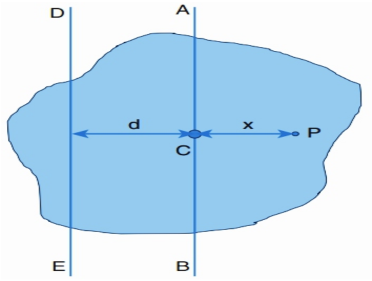
1. State and prove parallel axis theorem.

Theorem:

Parallel axis theorem states that the moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis through its centre of mass and the product of the mass of the body and the square of the perpendicular distance between the two axes.

.

$$I = \sum m(x + d)^2$$
$$I = \sum m(x^2 + d^2 + 2xd)$$
$$I = \sum mx^2 + \sum md^2 + 2d\sum mx$$
$$I = I_c + \sum md^2 \qquad \because \sum mx = 0$$
$$\boxed{\mathbf{I} = I_C + \mathbf{Md^2}} \qquad \because \sum mx^2 = I_c$$



2. State and prove perpendicular axis theorem.

Theorem:

The theorem states that the moment of inertia of a plane laminar body about an axis perpendicular to its plane is equal to the sum of moments of inertia about two perpendicular axes lying in the plane of the body such that all the three axes are mutually perpendicular and have a common point.

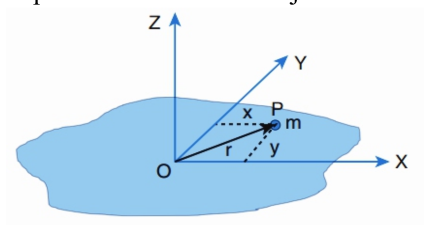
Let the X and Y-axes lie in the plane and Z-axis perpendicular to the plane of the laminar object.

$$I_Z = \sum mr^2$$

$$I_z = \sum m(x^2 + y^2) \qquad \because r^2 = x^2 + y^2$$

$$I_Z = \sum mx^2 + \sum my^2 \qquad \because I_X = \sum my^2$$

$$\boxed{I_Z = I_X + I_Y} \qquad \because I_Y = \sum mx^2$$



3. Explain the types of equilibrium with suitable examples.

1. Static equilibrium	Linear momentum and angular momentum are zero.	Net force and net torque are zero.
2. Dynamic equilibrium	Linear momentum and angular momentum are constant.	Net force and net torque are zero.
3. Stable equilibrium	Linear momentum and angular momentum are zero.	Potential energy of the body is minimum.
4. Unstable equilibrium	Linear momentum and angular momentum are zero.	Potential energy of the body is not minimum.
5. Neutral equilibrium	Linear momentum and angular momentum are zero.	Potential energy of the body remains same.

4. Derive the expression for moment of inertia of a rod about its centre and perpendicular to the rod.

Let us consider a uniform rod of mass m and length l. First an origin is to be fixed for the co-ordinate system. so that it coincides with the centre of mass.

$$dI = dm\, x^2 \;---\; (1)$$

$$dm = \lambda dx$$

$$\lambda = \frac{M}{l}$$

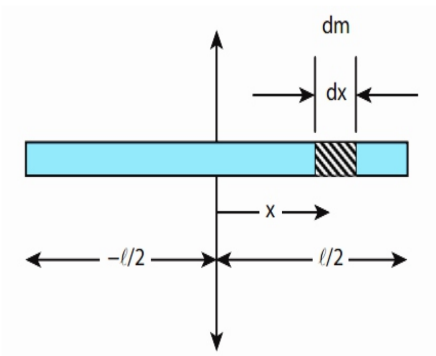
$$(1) \Rightarrow \quad dm = \frac{M}{l}dx$$

$$dI = \left(\frac{M}{l}dx\right) x^2$$

$$I = \frac{M}{\ell}\int x^2 dx$$

$$I = \frac{M}{\ell}\int_{-l/2}^{l/2} x^2 dx$$

$$\boxed{I = \frac{1}{12}M\ell^2}$$



5. Derive the expression for moment of inertia of a uniform ring about on Axis passing through the centre and perpendicular to the plane.

➢ Consider a uniform ring of mass M and radius R.

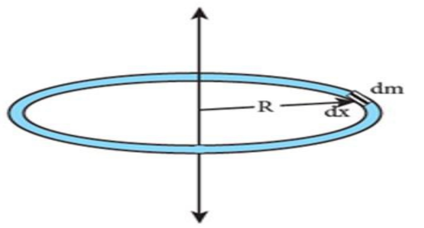
Let us take infinitesimally small mass dm of length dx of the ring

$$dI = (dm)R^2 \;---\; (1)$$

Linear density $\lambda = \frac{M}{2\pi R}$

$$dm = \lambda dx = \frac{M}{2\pi R}dx$$

$$(1) \Rightarrow \quad \int dI = \int \left(\frac{M}{2\pi R}dx\right) R^2$$



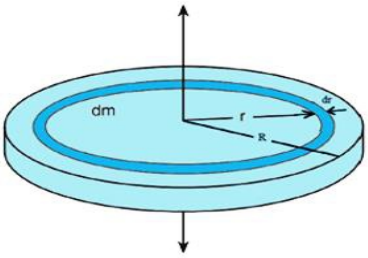
$$I = \frac{MR}{2\pi}\int_0^{2\pi R} dx$$

$$\boxed{I = MR^2}$$

6. The expression for moment of inertia of a uniform disc about an access passing through the centre and perpendicular to the plane.

- Consider a disc of mass M and radius R.
- Consider one such ring of mass dm and thickness dr and radius r.

$$dI = (dm)r^2$$
$$dm = \sigma 2\pi r dr$$
$$\sigma = \frac{M}{\pi R^2}$$
$$dm = \frac{2M}{R^2} r dr$$
$$dI = \frac{2M}{R^2} r^3 dr$$
$$\int dI = \frac{2M}{R^2}\int_0^R r^3 dr$$



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

UNIT 6-GRAVITATION

2 MARK QUESTIONS

1. State Newton's universal law of gravitation.

The force of attraction between any two bodies in the universe is directly proportional to the product of their Masses and is inversely proportional to the square of the distance between them.

$$\boxed{\vec{F} = \frac{GM_1M_2}{r^2}\hat{r}}$$

2. Define the gravitational field. Give its unit.

The gravitational field at a point is defined as the gravitational force experienced by unit mass placed at that point. Unist is ms^{-2}

3. What is meant by escape speed of the earth?

The minimum speed required by an object to escape from earth's gravitational field is called the escape speed.

4. Why is the energy of a satellite negative?

- The negative sign in the total energy of a satellite implies that the satellite is bound to the earth or the sun.
- it cannot escape from the Earth.

5. Define weight.

Weight is defined as the product of mass and acceleration due to gravity.

$$W = mg$$

6. Why there is no lunar and solar eclipse every month?

Since moon's orbit is tilted 5° with respect to Earth's orbit. Only during certain period of the year, the sun, earth and moon align in straight line leading to either lunar eclipse or solar eclipse depending on the alignment.

7. Why do we have seasons on earth?

The seasons in the earth arise due to the rotation of earth around the sun with 23.5° tilt. The part of the earth nearer to the sun become summer, and other becomes winter during this tilt rotation.

8. Water falls from the top of a hill to the ground. Why?

This is because the top of the hill is a point of higher gravitational potential than the surface of the Earth. $V_{hill} > V_{ground}$.

9. Define gravitational potential. Give its unit.

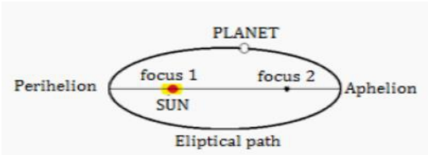
The gravitational potential at a distance r due to a mass is defined as the amount of work required to bring unit mass from infinity to the distance r. $J\ kg^{-1}$.

10. Define gravitational potential energy. Give its unit.

The gravitational potential energy is defined as the work done to bring the mass m_2 from infinity to a distance r in the gravitational field of mass m_1.Unit joule.

<u>3 MARK QUESTIONS</u>

1. State kepler's laws of planetary motion.

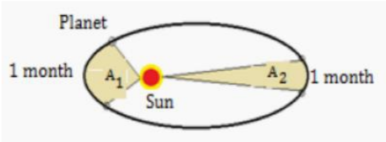


(i) <u>Law of orbits:</u>

Each planet moves around the sun in an elliptical orbit with the sun at one of the foci.

(ii) <u>Law area:</u>

The radial vector sweeps equal areas in equal intervals of time.



(iii) <u>Law of period:</u>

The square of the time period of revolution of a planet around the sun in its elliptical orbit is directly proportional to the cube of the semi-major axis of the eclipse.

$$\boxed{T^2\ \alpha\ a^3}$$

2. Explain in detail the geo stationary and polar satellites.

<u>Geo-stationary satellites:</u>

The satellites revolving the earth at the height of 36000 km above the equator,are appear to be stationary.When seen from earth is called geo-stationary satellites.

<u>Polar satellites:</u>

The satellites which revolve from north to south of the earth at the height of 500 to 800 km from the earth surface are called polar satellites.

3. Discuss the important features of the law of gravitation.

- F α $\frac{1}{r^2}$, distance increases the strength of the force decrease.
- The gravitational forces between two particles always constitute on action-reaction pair.
- The angular momentum of the earth about the sun is constant. $\vec{T} = \frac{d\vec{L}}{dt} = 0$
- A mass M placed in a hollow sphere, the force experienced by this mass will be zero.

4. Derive an expression for energy of satellite.

- The total energy of the satellite is the sum of its kinetic energy and the gravitational potential energy.

$$\text{potential energy} \quad U = -\frac{GM_sM_E}{(R_E+h)}$$

$$\text{kinetic energy } K.E = \frac{1}{2}M_sv^2$$

$$\text{orbital speed } \ v = \sqrt{\frac{GM_E}{(R_E+h)}}$$

$$Total\ \ \text{kinetic energy} \quad K.E = \frac{1}{2}\frac{GM_EM_s}{(R_E+h)}$$

$$\text{Total energy of the satellite} \quad E = \frac{1}{2}\frac{GM_EM_s}{(R_E+h)} - \frac{GM_sM_E}{(R_E+h)}$$

$$\boxed{\boldsymbol{E = -\frac{GM_sM_E}{2(R_E+h)}}}$$

5. Explain how Newton arrived at his law of gravitation from kepler's third law?

For circular orbit of radius r the centripetal acceleration towards the centre.

Centripetal acceleration $a = -\frac{v^2}{r}$ ------(1)

velocity $v = \frac{2\pi r}{T}$ --------(2)

$(2) in (1)$ $a = -\frac{4\pi^2 r}{T^2}$

Newton's second law, $F = ma$

$$F = m\left(-\frac{4\pi^2 r}{T^2}\right)$$

From kepler's third law, $\frac{r^3}{T^2} = k$

$$F = -\frac{4\pi^2 mk}{r^2}$$

$$\boxed{F = -\frac{GMm}{r^2}}$$

6. Explain in detail the idea of weight less using lift as an example.

Explanation:

(i) When the elevator is at rest

$$N = mg$$

(ii)When the elevator is moving uniformly upward or downward direction:

The net force acting on the man is still zero.

(iii)When the elevator is accelerating upwards:

$$N = m(g + a)$$

Weight of man is greater than this actual weight.

(iv) **Weightlessness:**

The down ward acceleration is equal to the acceleration due to the gravity of the earth.

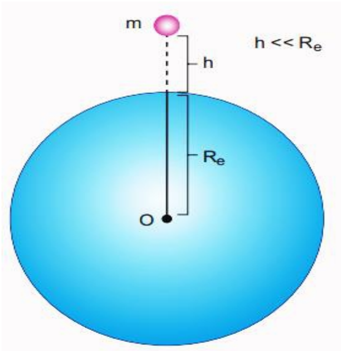
$a = g$ $N = m(g - g) = 0$

This is called state of weightlessness.

5 MARK QUESTIONS

1.Explain the variation of g with altitude?

Consider an object of mass m at a height h from the surface of the earth.



$$g' = \frac{GM}{(R_e + h)^2}$$

$$g' = \frac{GM}{R_e^2\left(1 + \frac{h}{R_e}\right)^2}$$

$$g' = \frac{GM}{R_e^2}\left(1 + \frac{h}{R_e}\right)^{-2}$$

h <<R_e using binomial expansion,

$$\boxed{g' = g\left(1 - \frac{2h}{R_e}\right)}$$

$$g' < g$$

This means that as **altitude h increases g decreases.**

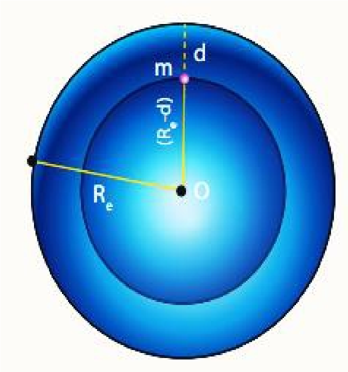
2. Explain the variation of g with depth from the Earth's surface?

Consider a particle of mass m which is in a deep mine on the earth.

To calculate g' at a depth.

$$g' = \frac{GM'}{(R_e - d)^2} --- (1)$$

Assuming the density of Earth ρ to be constant,



$$\rho = \frac{M}{V} \quad and \quad \rho = \frac{M'}{V'}$$

$$\frac{M'}{V'} = \frac{M}{V} \qquad \because V = \frac{4}{3}\pi {R_e}^3 \; and \; V' = \frac{4}{3}\pi (R_e - d)^3$$

$$M' = \frac{M}{R_e^3}(R_e - d)^3$$

Substituting M' in equation (1)

$$\boxed{g' = g\left(1 - \frac{d}{R_e}\right)} \qquad \because g = \frac{GM}{{R_e}^2}$$

$$g' < g$$

As depth increase g' decrease.

3. Derive an expression for escape speed.

Consider an object of mass m on the surface of the earth

When it is thrown up with an initial speed v_i.

The initial total energy $\quad E_i = \frac{1}{2}Mv_i^2 - \frac{GMM_E}{R_E}$

When the object reaches a height far away from Earth $\quad E_f = 0$

According to law of energy conservation $\quad E_i = E_f$

$$\frac{1}{2}Mv_i^2 - \frac{GMM_E}{R_E} = 0$$

$$\frac{1}{2}Mv_i^2 = \frac{GMM_E}{R_E}$$

$$v_e^2 = \frac{2GM_E}{R_E} \qquad \because g = \frac{GM_e}{{R_e}^2}$$

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

The escape speed of the Earth is $\boldsymbol{v_e = 11.2\ kms^{-1}}$

4. Derive the time period of satellite orbiting the earth.

The distance covered by the satellite during one rotation in its orbit is equal to $2\pi(R_E + h)$ and time taken for it is the time period, T.Then Speed equal to distance travelled time taken

$$\text{Speed } v = \frac{\text{Distance travelled}}{\text{Time taken}}$$

$$\sqrt{\frac{GM_E}{(R_E + h)}} = \frac{2\pi(R_E + h)}{T}$$

$$T = \frac{2\pi}{\sqrt{GM_E}}(R_E + h)^{3/2}$$

Squaring both sides $\qquad T^2 = \frac{4\pi^2}{GM_E}(R_E + h)^3$

If $h \ll R_E$ $\qquad T^2 = \frac{4\pi^2}{GM_E}{R_E}^3$

$$T^2 = \frac{4\pi^2}{\frac{GM_E}{{R_E}^2}}R_E \qquad \because g = \frac{GM_e}{{R_e}^2}$$

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

Time period $\quad T \cong 85 \quad$ minutes

5.Derive the expression for gravitational potential energy.

- Two masses m_1 and m_2 are initially seperated by a distance r'.
- m_1 to be fixed.
- Work must be done on m_2 to move the distance from r' to r

$$dW = \vec{F}_{ext}.\vec{dr}$$

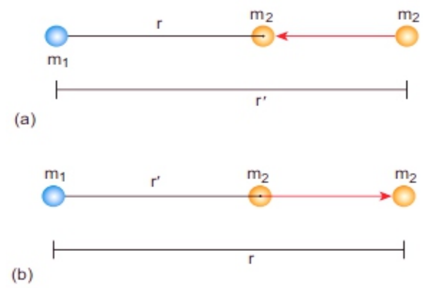
$$|\vec{F}_{ext}| = |\vec{F}_G| = \frac{Gm_1m_2}{r^2}$$

$$dW = \frac{Gm_1m_2}{r^2}\,dr$$

$$W = \int_{r'}^{r} dW = \int_{r'}^{r} \frac{Gm_1m_2}{r^2}\,dr$$

$$W = -\frac{Gm_1m_2}{r} + \frac{Gm_1m_2}{r'}$$

$$W = U(r) - U(r')$$



Let us choose $r' = \infty$

Gravitational potential energy $\boxed{U(r) = -\frac{Gm_1m_2}{r}}$

UNIT-7 PROPERTIES OF MATTER

2 MARK QUESTIONS

1. Define stress, write unit and dimension.

The force per unit area is called as stress. Stress = Force / area

Unit Nm^{-2} or pascal. dimension $ML^{-1}T^{2}$.

2. Define strain?

Strain deals with the fractional change in the size of the object.

$$\text{Strain} = \frac{\text{change in size}}{\text{original size}}$$

3. State Hooks law?

In elastic limit, when the stress and strain are proportional to each other.

$\boxed{\sigma\ \alpha\ \varepsilon}$

4. Define Poisson's ratio?

$$\text{Poisson's ratio } \mu = \frac{\text{lateral strain}}{\text{longitudinal strain}}$$

5. State Pascal's law.

If the pressure in a liquid is changed at a particular point, the change is transmitted to the entire liquid without being diminished in magnitude.

6. State Archimedes principle.

When a body is partially or wholly immersed in a fluid. It experiences an upward thrust equal to the weight of the fluid displaced by it and its upthrust acts through the centre of gravity of the liquid displaced.

7. Define terminal velocity.

The maximum constant velocity acquired by a body while falling freely through a viscous medium is called the terminal velocity.

8. What are the factors affecting the surface tension of a liquid?

- Impurities
- The presence of dissolved substances
- Electrification
- Temperature

9. Which one of these is more elastic, steel or rubber? Why?

Steel is more elastic than rubber. If an equal stress is applied to both steel and rubber, the steel produces less strain. Young's modulus is higher for steel than rubber.

10. A spring balance shows wrong readings after for a long time. Why?

The spring balance takes longer times it develops an elastic fatique.Hence spring balance shows wrong readings

11. What is meant by elastic limit?

The maximum stress within which the body regains its original size and shape after the removal of deforming force is called the elastic limit.

3 MARK QUESTIONS

1.Write the difference between streamlined flow and turbulent flow.

Streamlined flow	Turbulent flow
1.The particles are flowing in the same direction.	The particles are flowing randomly.
2.The flow is steady.	The flow is speedy.
3.The velocity of flow is less than the critical velocity.	The velocity of flow is greater than the critical velocity.
$R_c < 1000$	$R_c > 2000$

2. what are the practical applications of capillarity?

- Rising of oil in the cotton wick of earthen lamp.
- Absorption of ink by a blotting paper.
- Draining of tear fluid from the eye.
- Absorption of sweat by cotton dress.

3. Write stokes's law quation? and explain symbols.

$$F = 6\pi\eta rv$$

- Viscous force (F)
- Radius of the sphere (r)
- Velocity of the sphere (v)
- Coefficient of viscosity (η)

4.What is Reynold's number? Write its formula.

It is used to find out the nature of flow of the liquid.

$$R_c = \frac{\rho v D}{\eta}$$

where, ρ – density of the liquid
V – the velocity of flow of liquid
D – diameter of the pipe
η – the coefficient of viscosity of the fluid

5.What are the applications of viscosity?

- Viscosity of liquids helps in choosing the lubricants for various machinery parts.
- They are used in hydraulic brakes.
- Blood circulation through arteries and veins depends upon the viscosity of fluids.
- Viscosity is used in millikan's oil drop method to find the charge of an electron.

6. What are the applications of surface tension?

- Oil pouring on the water reduces surface tension so that the floating mosquitoe eggs drown and killed.
- Which helps in desktop printing, automobile painting and decorative items.
- Specks of dirt are removed from the cloth when it is washed in detergents added hot water, which has low surface tension.
- A fabric can be made waterproof by adding suitable waterproof materials to the fabric.

7. Define Surface tension. Give its unit and dimension.

The surface tension of a liquid is defined as the energy per unit area of the surface of a liquid.

$$T = \frac{F}{l}$$

Its unit is $N\,m^{-1}$. And dimension is $M\,T^{-2}$.

8. Derive an expression for the elastic energy stored per unit volume of a wire.

When a body is stretched, work is done against the restoring force. this work done is stored in the body in the form of elastic energy.

$$dw = Fdl$$

From young's modulus,

$$F = \frac{YAl}{L}$$

$$\int dw = \int_0^l \frac{YAl}{L} dl$$

$$\boxed{W = \frac{1}{2} Fl}$$

5 MARK QUESTIONS

1. Explain the different types of modulus of elasticity.

$$\text{Modulus of elasticity} = \frac{stress}{strain}$$

There are three types.

(i) young's modulus

(ii) bulk modulus

(iii) The rigidity modulus or shear modulus.

(i) young's modulus:

Its defined as the ratioof compressive stress to the compressive strain.

$$Y = \frac{\text{compressive stress}}{\text{compressive strain}}$$

$$\boxed{Y = \frac{\sigma_c}{\varepsilon_c}}$$

(ii) bulk modulus:

Its defined as the ratio of volume stress to the volume strain.

$$K = \frac{\text{volume stress}}{\text{volume strain}}$$

$$\boxed{K = \frac{\sigma_n}{\varepsilon_v}}$$

(iii) The rigidity modulus or shear modulus:

its is defined as the radio of the shearing stress to the shearing strain

$$\eta_R = \frac{\text{shearing stress}}{\text{shearing strain}}$$

$$\boxed{\eta_R = \frac{\sigma_s}{\varepsilon_s}}$$

2.State and prove Bernoulli's theorem for a flow of incompressible, non-viscous and streamlined flow of fluid .

Theroem:

Sum of pressure energy, kinetic energy, and potential energy per unit mass of an incompressible, non-viscous fluid in a streamlined flow remains a constant.

Proof:

Let us consider a flow of liquid through a pipe AB a_A, v_A, P_A be the area of cross section of the tube, velocity of the liquid and pressure exerted by the liquid at A respectively

At area A,

Force exerted by the liquid $F_A = P_A a_A$

distance $d = v_A t$

work done $W = P_A V$

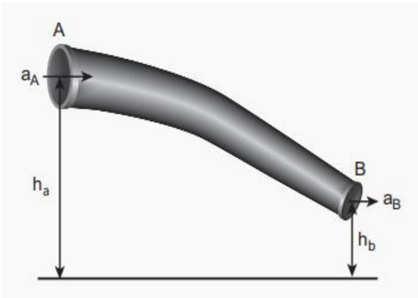
pressure energy $E_{PA} = \frac{mP_A}{\rho}$

kinetic energy $KE_A = \frac{1}{2} m v_A^2$

potential energy $PE_A = mgh_A$

Total energy at A $E_A = E_{PA} + KE_A + PE_A$

$$E_A = \frac{mP_A}{\rho} + \frac{1}{2} m v_A^2 + mgh_A$$



Total energy at B

$$E_B = \frac{mP_B}{\rho} + \frac{1}{2}mv_B^2 + mgh_B$$

$$E_A = E_B$$

$$\frac{mP_A}{\rho} + \frac{1}{2}mv_A^2 + mgh_A = \frac{mP_B}{\rho} + \frac{1}{2}mv_B^2 + mgh_B$$

$$\boxed{\frac{P}{\rho} + \frac{1}{2}v^2 + gh = CONSTANT}$$

3. Derive poiseuille's formula for the volume of a liquid flowing per second through a pipe under streamlined flow.

Conditions are:

- The flow of liquid through the tube is streamlined.
- The tube is horizontal so that gravity does not influence the flow.
- The layer in contact with the wall of the tube is at rest.
- Uniform pressure.

The volume of the liquid flowing out per second through a capillary tube

It depends on

(i) coefficient of viscosity (η)

(ii) radius of the tube (r)

(iii) the pressure gradient $(\frac{P}{l})$.

$$v = k\eta^a r^b \left(\frac{P}{l}\right)^c \text{ - - - - - (1)}$$

Apply dimension formula,

$$[L^3T^{-1}] = [ML^{-1}T^{-1}]^a \; [L]^b \; [ML^{-2}T^{-2}]^c$$

$$M^0L^3T^{-1} = M^{a+c} \; L^{-a+b-2c} \; T^{-a-2c}$$

Comparing the power,

$$a + c = 0,$$

$$-a + b - 2c = 3,$$

$$-a - 2c = -1$$

$$\boxed{a = -1, \quad b = 4, \quad c = 1} \quad and \;\; K = \frac{\pi}{8},$$

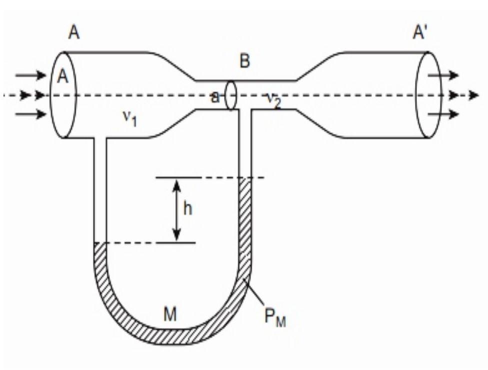
$$above\ value\ substitute\ in\ equ\ (1) \quad v = k\eta^{-1}r^4\left(\frac{P}{l}\right)^1$$

$$\boxed{v = \frac{\pi r^4 P}{8\eta l}}$$

4. Describe the construction and working of venturimeter and obtain an equation for the volume of liquid flowing per second through a wider entry of the tube.

Principle: Bernoulli theorem

- The device is used to measure the rate of flow of the incompressible fluid flowing through a pipe from the equation of continuity,



$$Av_1 = a\,v_2$$

$$v_2 = \frac{A}{a}v_1$$

Using bernoulli's equation,

$$P_1 + \rho\frac{v_1^2}{2} = P_2 + \rho\frac{v_2^2}{2} = P_2 + \rho\frac{1}{2}\left(\frac{A}{a}v_1\right)^2$$

$$\Delta P = P_1 - P_2 = \rho\frac{v_1^2}{2}\frac{(A^2 - a^2)}{a^2}$$

$$v_1 = \sqrt{\frac{2(\Delta P)a^2}{\rho(A^2 - a^2)}}$$

The volume of the liquid flowing out per second is

$$V = Av_1$$

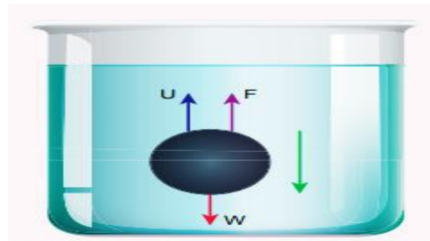
$$\boxed{\mathbf{V} = \mathbf{aA}\sqrt{\frac{\mathbf{2(\Delta P)}}{\boldsymbol{\rho}\mathbf{(A^2 - a^2)}}}}$$

5. derive the expression for the terminal velocity of a sphere moving in a high viscous fluid using stokes force.

The maximam constant velocity acquired by a body while falling freely though a viscous medium is called the terminal velocity.

- Consider a sphere of radius r which falls freely through a highly viscous liquid of coefficient of viscosity η
- Gravitational force acting on the sphere

$$F_G = mg = \frac{4}{3}\pi r^3 \rho g$$



Up thrust $U = \frac{4}{3}\pi r^3 \sigma g$

viscous force $F = 6\pi\eta r v_t$

The net downward force = upward force.

$$F_G = U + F$$

$$F_G - U = F$$

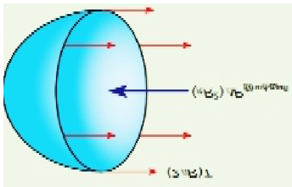
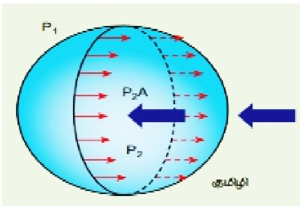
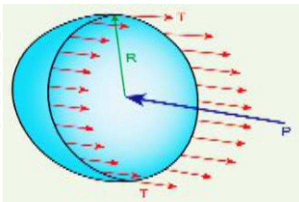
$$\frac{4}{3}\pi r^3 \rho g - \frac{4}{3}\pi r^3 \sigma g = 6\pi\eta r v_t$$

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

$$v_t \propto r^2$$

The terminal speed of the sphere is directly proportional to the square of its radius.

6. Obtain an expression for the excess of pressure inside 1) liquid drop 2) liquid bubble 3) Air bubble.

Force	Liquid Drop	Soap bubble	Air bubble
Force due to surface tension, towards right	$F_T = 2\pi RT$	$F_T = 4\pi RT$	$F_T = 2\pi RT$
Force due to outside pressure, towards right	$F_{p_1} = P_1\pi R^2$	$F_{p_1} = P_1\pi R^2$	$F_{p_1} = P_1\pi R^2$
Force due to inside pressure, towards left	$F_{p_2} = P_2\pi R^2$	$F_{p_2} = P_2\pi R^2$	$F_{p_2} = P_2\pi R^2$
$F_{p_2} = F_T + F_{p_1}$	$(P_2 - P_1)\pi R^2 = 2\pi RT$	$(P_2 - P_1)\pi R^2 = 4\pi RT$	$(P_2 - P_1)\pi R^2 = 2\pi RT$
Excess pressure	$\Delta P = \frac{2T}{R}$	$\Delta P = \frac{4T}{R}$	$\Delta P = \frac{2T}{R}$
Figure			

8.HEAT AND THERMODYNAMICS

2 MARK QUESTIONS

1.Define one mole.

One mole is the amount of the substance, which contains Avagadro number of particles.

2. Define latent heat capacity. Give its unit.

The amount of heat energy required to change the state of a unit mass of the material. Its Unit is $J\ kg^{-1}$ $\boldsymbol{L = \frac{Q}{m}}$

3. State Stefan Boltzmann law.

Stefan Boltzmann law states that, the total amount of heat radiated per second per unit area of a black body is directly proportional to the fourth power of its absolute temperature. $\boldsymbol{E = \sigma T^4}$

4. State Wein's displacement law.

The wavelength of maximum intensity of emission of a black body radiation is inversely proportional to the absolute temperature of the black body.

$$\boldsymbol{\lambda_m = \frac{b}{T}}$$

5. State zeroth law of thermodynamics.

If two systems A and B are in thermal equilibrium with a third system C then A and B are in thermal equilibrium with each other.

6. Define one calorie.

The amount of heat required at a pressure of standard atmosphere to rise the temperature of 1g of 1°C.

$$1cal = 4.186\ J$$

7. State the first law of thermodynamics.

Change the internal energy (ΔU) of the system is equal to heat supplied to the system (Q) minus the work done by the system(W) on the surroundings.

$$\boldsymbol{\Delta U} = Q - W$$

8. Define the coefficient of performance.

It is defined as the ratio of heat extracted from the cold body (sink) to the external work done by the compressor W.

$$\boldsymbol{COP = \frac{Q_L}{W}}$$

9. What is meant by 'thermal equilibrium'?

Two systems are said to be in thermal equilibrium with each other if they are at the same themperature, which will not change with time.

10. What is PV diagram?

- PV diagram is a graph between pressure P and volume V of the system.
- It is used to calculate the amount of work done by the gas during expansion or on the gas during compression.

11. What is a black body?

A black body is an idealized physical body which absorbs and radiates all kinds of electromagnetic wavelengths.

3 MARK QUESTIONS

1.Define heat capacity, specific heat capacity and molar specific heat capacity. Give its unit.

Heat Capacity:

The amount of heat energy required to raise the temperature of the given body from T to T + ΔT. Its unit $J\ K^{-1}$.

$$S = \frac{\Delta Q}{\Delta T}$$

Specific heat capacity:

The amount of heat energy required to raise the temperature of $1\ Kg$ of a substance by $1K$ or $1°C$. Its unit is $J\ kg^{-1}\ K^{-1}$

$$s = \frac{1}{m}\left(\frac{\Delta Q}{\Delta T}\right)$$

Molar specific heat capacity:

Molar specific capacity is defined as heat energy required to increase the temperature of one mole of substance by $1K$ or $1°C$.Its unit is $J\ mol^{-1}\ K^{-1}$

2. Specific heat capacity (i) Specific heat capacity at constant pressure (ii) Specific heat capacity at constant volume.

(i) Specific heat capacity at constant pressure:

The amount of heat energy required to rise the temperature of, 1 kg of a substance by $1K$ or $1°C$ by keeping the pressure constant is called specific heat capacity at constant pressure.

(ii) Specific heat capacity at constant volume:

The amount of heat energy required to raise the temperature of 1 kg of a substance by $1K$ or $1°C$ by keeping the volume constant is called specific heat capacity at constant volume.

3.Explain Quasi-Static process.

- It is an infinitely slow process (un defined process).
- This process in which the system is always equilibrium from surrounding enviroment.
- Using $PV = NKT$ we found pressure and temperature during the process.

4.What are the conditions for reversible process?

- The process should proceed at an extremely slow rate.
- The system should remain in mechanical, thermal and chemical equilibrium state at all the times with the surroundings, during the process.
- No dissipative forces such as friction, viscosity, electrical resistance should be present.

5.State (i) Clausius statement (ii) Kelvin-planck statement (iii) Entropy statement of second law of thermodynamics.

(i) Clausius statement:

"Heat always flows from hotter object to colder object spontaneously". This is known as the Clausius form of second law of thermodynamics.

(ii) Kelvin-planck statement:

It is impossible to construct a heat engine that operates in a cycle, whose sole effect is to convert the heat completely into work.

(iii) Entropy statement:

- "For all the processes that occur in nature (irreversible process), the entropy always increases.
- For reversible process entropy will not change".
- Entropy determines the direction in which natural process should occur.

6. Discuss various modes of heat transfer.

(i) Conduction:

Conduction is the process of direct transfer of heat through matter due to temperature difference. When two objects are in direct contact with one another, heat will be transferred from the hotter object to the colder one. Example: Iron is a good conductor of heat.

(ii) Convection:

Convection is the process in which heat transfer is by actual movement of molecules in fluids such as liquids and gases. Example: Boiling water in a cooking pot.

(iii) Radiation:

Radiation is a form of energy transfer from one body to another by electromagnetic waves.

Example: Solar energy from the Sun.

7. Discuss the ideal gas laws.

Boyle's law: When the gas is kept at constant temperature, the pressure of the gas is inversely proportional to the volume.

$$\boxed{P \propto \frac{1}{V}}$$

Charle's law: When the gas is kept at constant pressure, the volume of the gas is directly proportional to absolute temperature. $\boxed{V \propto T}$

8. Explain Wien's law and why our eyes are sensitive only to visible rays?

- Wien's law states that, the wavelength of maximum intensity of emission of a black body radiation is inversely proportional to the absolute temperature of the black body.

$$\lambda_m = \frac{b}{T} \qquad \because b = 2.898 \times 10^{-3} \text{mK}$$

$$\lambda_m = \frac{2.898 \times 10^{-3}}{5700} \approx 508\, nm$$

- The visible part of the spectrum lies between 400nm to 700nm.
- The human eye is sensitive only in the visible light.

9.What are reversible process, Irreversible process and cyclic process?

Reversible process: A thermodynamic process, which retrace the path in the opposite direction in such a way that the system and surroundings pass through the same states as in the initial direct process is called reversible process.

Example: The slow expansion-compression of a spring.

Irreversible process: A thermodynamic process, which does not retrace the path in the opposite direction as like direct process is called irreversible process.

Example: All-natural processes are irreversible.

Cyclic process: Cyclic process is a thermodynamic process in which the thermodynamic system returns to its initial state after undergoing a series of changes.

5 MARK QUESTIONS

1. Derive Mayer's relation for an ideal gas.

Consider μ mole of an ideal gas in a container with volume V, pressure P and temperature T.

Change in internal energy $dU = \mu C_V dT$

Heat supplied to system $Q = \mu C_P dT$

Workdone by the gas $W = PdV$

First law of thermodynamics $Q = dU + W$

$$\mu C_P dT = \mu C_V dT + PdV \text{---------(1)}$$

$$PV = \mu RT$$

$$PdV = \mu RdT \quad \because dP = 0$$

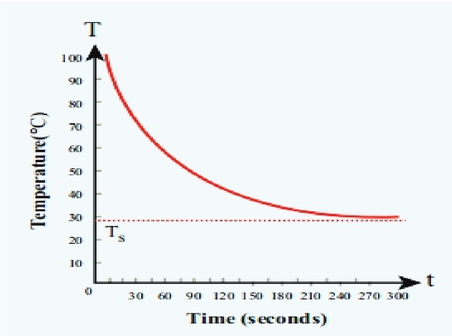
From eqn (1) $\mu C_P dT = \mu C_V dT + \mu RdT$

$$\boxed{C_P - C_V = R}$$

2. Explain in detail Newton's law of cooling.

Newton's law: It states that the rate of loss of heat of a object is directly proportional to the difference in the temperature between that object and its surroundings.

$$\frac{dQ}{dt} \propto -(T - T_s)$$



Let us consider an object of mass m and specific heat capacity s at temperature T.

$$dQ = msdT$$

Dividing both sides by dt

$$\frac{dQ}{dt} = \frac{msdT}{dt} ----(1)$$

From Newton's law of cooling

$$\frac{dQ}{dt} \propto -(T - T_s)$$

$$\frac{dQ}{dt} = -a(T - T_s) ----(2)$$

(1) = (2) $\quad -a(T - T_s) = ms\frac{dT}{dt}$

$$\frac{dT}{T - T_s} = -\frac{a}{ms}dt$$

$$\int \frac{dT}{T - T_s} = -\int \frac{a}{ms}dt$$

$$\ln(T - T_s) = -\frac{at}{ms} + b_1$$

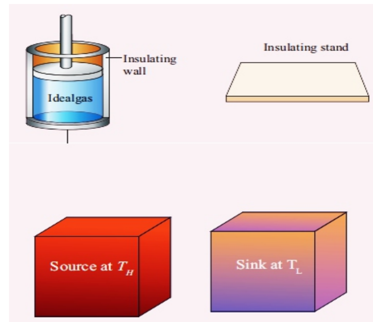
taking exponential both sides,

$$\boxed{T = T_s + b_2 e^{-\frac{at}{ms}}}$$

3. Explain in detail Carnot heat engine.

A reversible heat engine operating in a cycle between two temperatures in a particular way is called a Carnot Engine.

The carnot engine has four parts which are given below.

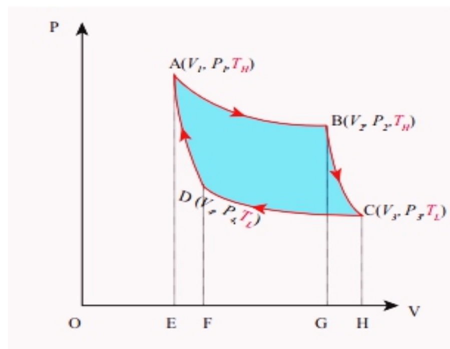


1. Source: It is the source of heat maintained at constant high temperature T_H. Any amount of heat can be extracted from it, without changing its temperature.

2.Sink: It is a cold body maintained at a constant low temperature T_L. It can absorb any amount of heat.

3.Insulating stand: It is made of perfectly non-conducting material. Heat is not conducted through this stand.

4. Working substance: It is an ideal gas enclosed in a cylinder with perfectly non-conducting walls and perfectly conducting bottom. A non-conducting and frictionless piston is fitted in it.



Step: A → B Quasi-static isothermal expansion:

$$Q_H = W_{A\to B} = \int_{V_1}^{V_2} PdV$$

$$W_{A\to B} = \mu RT_H \ln\left(\frac{V_2}{V_1}\right)$$

Step:B→C Quasi-static adiabatic expansion:

$$W_{B\to C} = \int_{V_2}^{V_3} PdV = \frac{\mu R}{\gamma - 1}[T_H - T_L]$$

Step:C → D Quasi-static isothermal compression:

$$W_{C\to D} = \int_{V_3}^{V_4} PdV = -\mu RT_L \ln\left(\frac{V_3}{V_4}\right)$$

Step:D→A: Quasi-static adiabatic compression:

$$W_{D\to A} = \int_{V_4}^{V_1} PdV = -\frac{\mu R}{\gamma - 1}[T_H - T_L]$$

The net work done by the carnot engine in one cycle,

$$\boxed{W = |W|_{A\to B} - |W|_{C\to D}}$$

4. Derive the expression for Carnot engine efficiency.

Efficiency is defined as the ratio of work done by the working substance in one cycle to the amount of heat extracted from the source.

$$\eta = \frac{\text{work done}}{\text{Heat extracted}} = \frac{W}{Q_H}$$

From the first law of thermodynamics,

$$W = Q_H - Q_L$$

$$\eta = \frac{Q_H - Q_L}{Q_H}$$

$$\eta = 1 - \frac{Q_L}{Q_H} --- (1)$$

Applying isothermal conditions,

$$Q_H = \mu RT_H \ln\left(\frac{V_2}{V_1}\right)$$

$$Q_L = \mu RT_L \ln\left(\frac{V_3}{V_4}\right)$$

$$\therefore \frac{Q_L}{Q_H} = \frac{T_L \ln\left(\frac{V_3}{V_4}\right)}{T_H \ln\left(\frac{V_2}{V_1}\right)} --- (2)$$

By applying adiabatic conditions,

$$T_H V_2^{\gamma-1} = T_L V_3^{\gamma-1}$$

$$T_H V_1^{\gamma-1} = T_L V_4^{\gamma-1}$$

By dividing the above two equations

$$\frac{V_2}{V_1} = \frac{V_3}{V_4}$$

From eqn (2)

$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$$

∴ From eqn (1) The efficiency,

$$\boxed{\eta = 1 - \frac{T_L}{T_H}}$$

5. Explain in detail the working of a refrigerator.

- A refrigerator is a Carnot's engine working in the reverse order.
- The working substance (gas) absorbs a quantity of heat Q_L from the cold body (sink) at a lower temperature T_L.
- A certain amount of work W is done on the working substance by the compressor and a quantity of heat Q_H is rejected to the hot body (source) ie, the atmosphere at T_H.

From the first law of thermodynamics,

$$Q_L + W = Q_H$$

Coefficient of performance (COP) (β):

COP is a measure of the efficiency of a refrigerator. It is defined as the ratio of heat extracted from the cold body (sink) to the external work done by the compressor W.

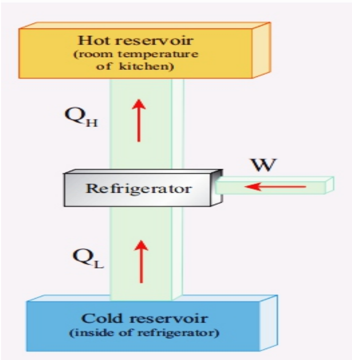
$$COP = \beta = \frac{Q_L}{W}$$

$$\beta = \frac{Q_L}{Q_H - Q_L}$$

$$\beta = \frac{1}{\frac{Q_H}{Q_L} - 1}$$

But we know that $\frac{Q_H}{Q_L} = \frac{T_H}{T_L}$

$$\boxed{\beta = \frac{T_L}{T_H - T_L}}$$



UNIT- 9 KINETIC THEORY OF GASES

2 MARK QUESTIONS

1.Why moon has no atmosphere?

- The escape speed of gases on the surface of moon is much less than the root means square speeds of gases due to low gravity.
- Due to this all gases escape from the surface of the moon.

2. Define the term degrees of freedom.

The minimum number of independent coordinates needed to specify the position and configuration of a thermos-dynamical system in space is called the degree of freedom of the system.

3. What is meant free path.

The average distance travelled by the molecule between collisions is called mean free path (**λ**).

$$\boxed{\lambda = \frac{KT}{\sqrt{2}\, n\pi d^2}}$$

4. List the factors affecting the mean free path?

- Mean free path increases with increasing temperature.
- Mean free path increases with decreasing pressure of the gas and diameter of the gas molecule.

5.What are the factors affecting Brownian motion?

- Brownian motion increases with increasing temperature.
- Brownian motion decreases with bigger particle size, high viscosity and density of the liquid or gas.

6.Why no hydrogen in Earth's atmosphere.

As the root mean square speed of hydrogen is much greater than that of nitrogen, it easily escapes from the earth's atmosphere.

7. Write the expression for rms speed, average speed and most probable speed of a gas molecule.

(i) Rms speed $v_{rms} = 1.73\sqrt{\frac{kT}{m}}$

(ii) Average speed $\bar{v} = 1.60\sqrt{\frac{kT}{m}}$

(iii) Probable speed $v_{mp} = 1.41\sqrt{\frac{kT}{m}}$

8.State Boyle's law.

Boyle's law states that pressure of a given gas is inversely proportional to its volume provided the temperature remains constant. $\boxed{P \,\alpha\, \frac{1}{V}}$

9. State Charles's law.

For a fixed pressure the volume of the gas is directly proportional to absolute temperature. $\boxed{V \,\alpha\, T}$

10. State Avagadro's law.

Avagadro's law states that at constant temperature and pressure, equal volumes of all gases contain the same number of molecules.

3 MARK QUESTIONS

1.State law of equlipartition of energy.

According to kinetic theory, the average kinetic energy of system of molecule in thermal equilibrium at temperature T is uniformly distributed by $\frac{1}{2}\ KT$ to all degrees of freedom. This is called law of equlipatition of energy.

2. What is the reason for Brownian motion?

According to kinetic energy, any particle suspended in a liquid or gas is continuously Bombarded from all the directions so that the mean free path is almost negligible. This leads to the Browian motion.

3. What is the relation between the average kinetic energy and pressure?

The internal energy of the gas, $U = \frac{3}{2}NkT = \frac{3}{2}\ PV \quad \because PV = Nk\ T$

$$P = \frac{1}{3}\ nm\overline{v^2} = \frac{1}{3}\rho\overline{v^2}$$

$$P = \frac{2}{3}\left(\frac{\rho}{2}\overline{v^2}\right)$$

$$\boxed{P = \frac{2}{3}\overline{KE}}$$

Pressure is equal to 2/3 of mean kinetic energy per unit volume.

4. Deduce Boyle's law based on kinetic theory.

$$PV = \frac{2}{3}U$$

$$PV = \frac{2}{3}N \in$$

$$P\ \alpha\ \frac{1}{V}$$

5. Deduce Charles's law based on kinetic theory.

$$PV = \frac{2}{3}U$$

$$V \propto T$$

$$\frac{V}{T} = constant$$

6. Deduce Avagadro's law based onkinetic theory.

For two different gases at the same temperature and pressure, the kinetic theory equation can be expressed as,

$$P = \frac{1}{3}\frac{N_2}{V} m_2 \overline{v_2}^2$$

At same temperature, average kinetic energy per molecule is same for two gases, so that

$$\frac{1}{2} m_1 \overline{V_1}^2 = \frac{1}{2} m_2 \overline{v_2}^2$$

$$N_1 = N_2$$

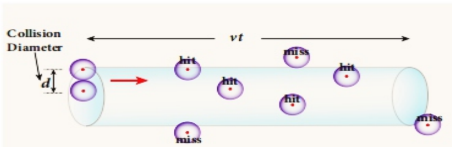
<u>5 MARK QUESTIONS</u>

1. Write down the postulates of kinetic theory of gases?

1. All the molecules of a gas are identical elastic spheres.
2. All molecules of different gases are different.
3. These molecules obey Newton's laws of motion.
4. The collisions are instantaneous.
5. The molecules of a gas are in a state of continuous random motion.
6. Between two successive collisions, a molecule moves with uniform velocity.
7. The molecules do not posses any potential energy and the energy is wholly kinetic.
8. The molecule collide with one another and also with the walls of the container
9. These collisions are perfectly elastic so that there is no loss of kinetic energy during collisions.

2. Derive the expression for mean free path of the gas.

- Between two successive collisions, a molecule moves along a straight path with uniform velocity. This path is called mean free path.
- Consider a system of molecules each with diameter d. Let n be the number of molecules per unit volume.
- If a molecule moves with average speed v in a time t, the distance travelled is vt. In this time t, consider the molecule to move in an imaginary cylinder of volume $= \pi d^2 vt$.



- It is equal to $\pi d^2 vtn$.The total path length divided by the number of collisions in time t is the mean free path.

$$\text{Mean free path } \lambda = \frac{\text{distance travelled}}{number\ of\ collisions}$$

$$\lambda = \frac{1}{\pi d^2 n\sqrt{2}}$$

$\lambda \propto \frac{1}{n}$, When the number density increases the molecular collisions increases.

$$\lambda = \frac{m}{\pi d^2 \rho\sqrt{2}}$$

$$\boxed{\lambda = \frac{kT}{\pi d^2 P\sqrt{2}}}$$

3.Derive the ratio of two specific heat capacities of monoatomic, diatomic and triatomic molecules.

<u>1.Monoatomic molecule:</u>

- Average kinetic energy of a molecule $= \frac{3}{2}\text{kT}$
- Total energy of one mole of gas $= \frac{3}{2}\text{RT}$
- For one mole the molar specific heat at constant volume $C_V = \left[\frac{3}{2}R\right]$

$$C_P = \frac{5}{2}R$$

The ratio of specific heats, $\boldsymbol{\gamma} = \frac{C_P}{C_V} = \mathbf{1.67}.$

2.Diatomic molecule:

- Average kinetic energy of a diatomic molecule = $\frac{5}{2}\ KT$
- Total energy of one mole of gas = $\frac{5}{2}$ RT
- For one mole, specific heat at constant volume $C_V = \frac{5}{2}R$

$$C_P = \frac{7}{2}R$$

The ratio of specific heats, $\boldsymbol{\gamma} = \frac{C_P}{C_V} = \mathbf{1.40}$.

At high Temperature,

$$C_V = \frac{7}{2}R$$

$$C_P = \frac{9}{2}R$$

$$\boldsymbol{\gamma} = \frac{C_P}{C_V} = \mathbf{1.28}.$$

3. Triatomic molecule:

(a) Linear molecule,

- Energy of one mole $= \frac{7}{2}RT$

$$C_V = \frac{7}{2}R$$

$$C_P = \frac{9}{2}R$$

- The ratio of specific heats, $\boldsymbol{\gamma} = \frac{C_P}{C_V} = \mathbf{1.28}$.

(b) Non-linear molecule,

- Energy of a mole $= 3RT$

$$C_V = 3R$$

$$C_P = 4R$$

- The ratio of specific heats, $\gamma = \frac{C_P}{C_V} = 1.33$

UNIT- 10 OSCILLATIONS

2 MARK QUESTIONS

1.What is meant by force constant of a spring?

Force per unit length of a spring is called force constant of a spring. Its unit is $N\ m^{-1}$. $\boxed{F_x = -Kx}$

2.Define time period of simple harmonic motion.

Time taken by a particle to complete one oscillation.SI unit is second.

$$\boxed{T = \frac{2\pi}{\omega}}$$

3. Define frequency of simple harmonic motion.

The number of oscillations produced by the particle per second is called frequency.SI unit is (HZ).

4. What is an epoch?

At time $t = 0$ s (initial time), the phase $(\emptyset = \emptyset_0)$is called epoch (initial phase) where $\emptyset_0$ is called the angle of epoch.

5.What is meant by free oscillations?

When the oscillator is allowed to oscillate by displacing its position from equilibrium position, it oscillates with a frequency which equal to the natural frequency of the oscillator.

(Examples): 1. Vibration of a tuning fork.
2. Vibration in a stretched string.

6. What is meant by maintained oscillations? Give an example.

By supplying energy from an external source, the amplitude of the oscillation can be made constant. such vibrations are known as maintained oscillations.

(Example): The vibration of a tuning fork getting energy from a battery.

7. Explain damped oscillation. Give an example.

If an oscillator moves in a resistive medium, its amplitude goes on decreasing and the energy of the oscillator is used to do work against the resistive medium. This type of oscillatory motion is known as damped oscillation.

(Example):1. The oscillations of a pendulum.

2. Oscillations in a dead beat and ballistic galvanometers.

8. Define forced oscillations. Give an example.

The body executing vibration initially vibrates with its natural frequency and due to the presence of external periodic force, the body later vibrates with the frequency of the applied force. Such vibrations are known as forced vibrations. Example: Sound board of a string instruments.

3 MARK QUESTIONS

1. What is meant by periodic and non-periodic motion? Give any two examples, for each motion.

Periodic motion	Non- Periodic motion
1. Any motion which repeats itself in a fixed time interval is known as periodic motion.	Any motion which does not repeat itself after a regular interval of time non-periodic motion.
Example: Hands in pendulam clock, the revolution of the Earth around the sun, etc.	Example: Occurrence of Earth quake, eruption of volcano, etc.

2. Soldiers are not allowed to march on a bridge. Why?

When soldiers march on the bridge, their stepping frequency may match on the natural frequency of the bridge. If it so, the bridge will vibrate with larger amplitude due to resonance. This may collapse the bridge.

3.Write down the difference between Simple Harmonic motion and Angular simple Harmonic motion.

Simple Harmonic motion	Angular Harmonic motion
1. The displacement of the particle is measured in terms of linear displacement $\vec{r}$.	The displacement of the particle is measured in terms of angular displacement $\vec{\theta}$.
2. Acceleration of the particle is $\vec{a} = -\omega^2\vec{r}$	Angular acceleration of the particle is $\vec{\alpha} = -\omega^2\vec{\theta}$
3. Force $\vec{F} = m\vec{a}$	Torque $\vec{\tau} = I\vec{\alpha}$
4. The restoring force $\vec{F} = -k\vec{r}$	The restoring torque $\vec{\tau} = -k\vec{\theta}$
5. Angular frequency, $\omega = \sqrt{\frac{k}{m}}$	Angular frequency, $\omega = \sqrt{\frac{k}{I}}$

4.State the laws of simple pendulum?

(i) Law of length:

The time period of a simple pendulum is directly proportional to the square root of length of the pendulum.

$$T \propto \sqrt{l}$$

(ii) Law of acceleration:

For a fixed length, the time period of a simple pendulum is inversely proportional to square root of acceleration due to gravity.

$$T \propto \frac{1}{\sqrt{g}}$$

(iii) Law of mass: Time period of oscillation is independent of mass of the simple pendulum.

(iv) Law of amplitude: The time period is independent of amplitude of the oscillation for small angled oscillation.

5. Explain resonance. Give an example.

- It is a special case of forced vibrations.
- When the frequency of external periodic force matches with the natural frequency of the vibrating body.
- As a result, the body starts to vibrate with maximum amplitude. This is known as Resonance.

Example: The breaking of glass due to sound.

6. Write short notes on two springs connected in series.

Let us consider only two springs whose spring constant are $K_1$and K_2 and which can be attached to a mass m in series.

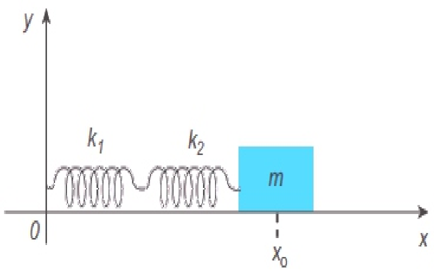
The net displacement of the mass $x = x_1 + x_2$

From Hookes's law,

$$x_1 + x_2 = -\frac{F}{K_s}$$

For springs in series connection,

$$x_1 = -\frac{F}{K_1} \quad , \quad x_2 = -\frac{F}{K_2}$$



The effective spring constant $-\frac{F}{K_1} + -\frac{F}{K_2} = -\frac{F}{K_s}$

$$\frac{1}{k_s} = \frac{1}{k_1} + \frac{1}{k_2}$$

$$\boxed{\mathbf{k_s = \frac{k_1 k_2}{k_1 + k_2}}}$$

7. Write short notes on two springs connected in parallel.

Let us consider only two springs whose spring constant are $K_1$and K_2 and which can be attached to a mass m in parallel.

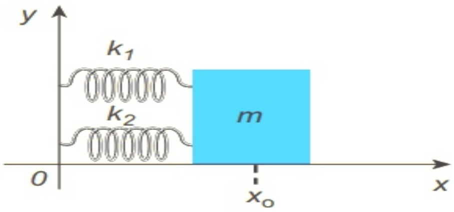
In this case,both the springs elongate or compress by the same amount of displacement.

$$F = -k_P x --- (1)$$

Then the net Force,

$$F = -k_1 x - k_2 x$$

$$F = -x(k_1 + k_2) --- (2)$$



Equating equations (1), (2) $\boxed{\boldsymbol{k_P = k_1 + k_2}}$

5 MARK QUESTIONS

1. What is meant by angular harmonic oscillation? Compute the time period of angular harmonic oscillation.

- When a body is allowed to rotate freely about a given axis then the oscillation is known as the angular oscillation.
- If the body is displaced from the mean position, then the resultant torque acts such that it is proportional to the angular displacement

$$\vec{\tau} \propto \vec{\theta}$$

$$\vec{\tau} = -\kappa\vec{\theta}$$

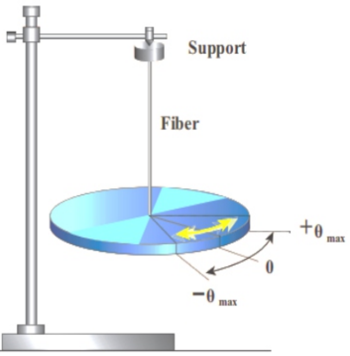
If I is the moment of inertia of the body and $\vec{\alpha}$ is the angular acceleration then,

$$\vec{\tau} = I\vec{\alpha} = -\kappa\vec{\theta} --- (1)$$

But $\vec{\alpha} = \frac{d^2\vec{\theta}}{dt^2}$

$$(1) \Rightarrow \quad \frac{d^2\vec{\theta}}{dt^2} = -\frac{\kappa\vec{\theta}}{I}$$

$$\omega = \sqrt{\frac{\kappa}{I}} \; rads^{-1}$$



The frequency of the angular harmonic motion

$$\boxed{\boldsymbol{f = \frac{1}{2\pi}\sqrt{\frac{\kappa}{I}} \, Hz}}$$

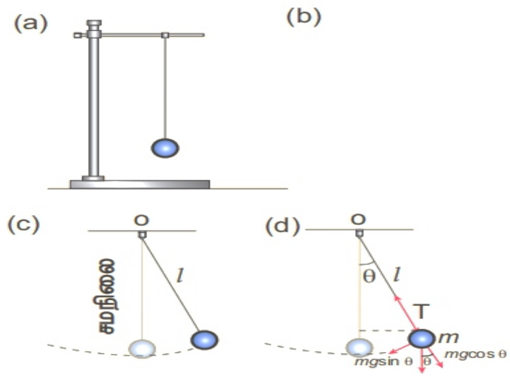
The time period $\boxed{\boldsymbol{T = 2\pi\sqrt{\frac{I}{\kappa}}}}$ second

2. Discuss the simple pendulum in detail.

- Let l be the length of the pendulum which is taken as the distance between the point of suspension and the centre of gravity of the bob.
- Two forces act on the bob of the pendulum at any displaced position,
  1. The gravitational force $\vec{F} = m\vec{g}$
  2. The tension in the string $\vec{T}$.

Resolving the gravitational force into its components:

1. Normal component: $F_{as} = mg\cos\theta$.
2. Tangential component: $F_{PS} = mg\sin\theta$.



$$T - \text{mg}\cos\theta = \frac{mv^2}{l}$$

$$\text{m}\frac{\text{d}^2\text{s}}{\text{dt}^2} = -\text{mg}\sin\theta$$

$$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$$

The angular frequency,

$$\omega^2 = \frac{g}{l}$$

$$\Rightarrow \omega = \sqrt{\frac{g}{l}}\, rads^{-1}$$

The frequency of oscillations is,

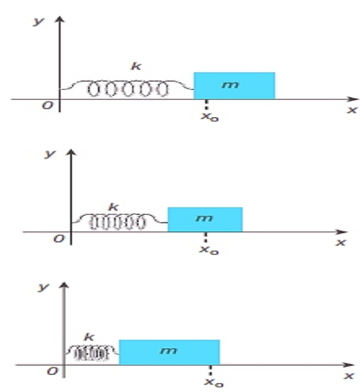
$$\boldsymbol{f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}\ Hz}$$

Time period of oscillations is $\boldsymbol{T = 2\pi\sqrt{\frac{l}{g}}}$ second

3. Explain the horizontal oscillations of a spring.

- Consider a system containing a block of mass m attached to a massless spring with spring constant k.
- It will oscillate back and forth about its mean position x_0.
- F be the restoring force which is proportional to the amount of displacement of block. $F \propto x$

$$F = -k\,x$$



From Newton's second law,

$$m\frac{d^2x}{dt^2} = -kx$$

$$\frac{d^2x}{dt^2} = -\frac{kx}{m}$$

Comparing the equation with simple harmonic motion equation, we get

$$\omega^2 = \frac{k}{m}$$

Angular frequency $\omega = \sqrt{\frac{k}{m}}\ rad\, s^{-1}$

The frequency of the oscillation is,

$$\boldsymbol{f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}\ HZ}$$

The Time period of the oscillation is,

$$\boldsymbol{T = 2\pi\sqrt{\frac{m}{k}}\ s}$$

4. Describe the vertical oscillations of a spring.

- Let us consider a massless spring with force constant k attached to a ceiling as shown in figure.
- If the block of mass m is attached to the other end of spring, then the spring elongates by a length l.

$$F_1 \propto l \Rightarrow F_1 = -kl --- (1)$$

When the system is under equilibrium, $F_1 + mg = 0$

$$(1) \Rightarrow \; -kl + mg = 0$$

$$\frac{m}{k} = \frac{l}{g} ---- (2)$$

But the spring elongates by small displacement l,

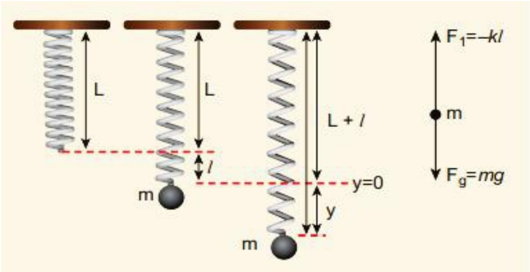
$$F_2 = -k(y + l)$$

$$F = F_2 + mg$$

$$F = -ky - kl + mg$$

$$(2) \Rightarrow \; F = -ky$$

$$\frac{d^2y}{dt^2} = -\frac{ky}{m}$$



The above equation is in the form of simple harmonic differential equation.

The time period $\boldsymbol{T = 2\pi\sqrt{\frac{m}{k}}\ second}$

UNIT- 11 WAVES

2 MARK QUESTIONS

1. What is meant by waves?

The disturbance, which carries energy and momentum from one point in space to another point in space without the transfer of the medium is known as wave.

2. Write down the types of wave.

(i) Mechanical wave – Waves which require a medium. Example: Sound waves.
(ii) Non – mechanical wave – Wave not require any medium. Example: Light wave.
(iii) Transverse waves and Longitudinal waves.

3. What are transverse waves? Give one example.

In transverse wave motion, the constituents of the medium oscillate or vibrate about their mean positions in a direction perpendicular to the direction of propagation of waves. Example: Light waves.

4.What are longitudinal waves. Give one example.

In longitudinal wave motion, the constituents of the medium oscillate or vibrete about their mean positions in a direction parallel to the direction of propagation. Example: Sound waves.

5. Define wavelength.

The distance between two neighbouring crests or troughs is known as the wavelength. The SI unit of wavelength is meter.

6. Explain the beat phenomenon.

When two or more waves superimpose each other with slightly different frequencies, then a sound of periodically varying amplitude at a point is observed. This phenomenon is known as beads.

7. What is meant by end correction in resonance air column apparatus?

In air column apparatus, the antinodes are not exactly formed at the open end, we have to include a correction, called end correction.

8.Explain Doppler Effect?

Whenever there is a relative motion between the source of sound and the listener, the frequency of the sound observed by the listener is different from the frequency produced by the source. This is known as Doppler effect.

9. Write down the factors affecting velocity of sound in gases.

- Pressure
- Temperature
- Density
- Moisture

10. What is meant by an echo. Explain.

An echo is a repetition of sound produced by the reflection of sound waves from a wall, mountain or other obstructing surfaces.

3 MARK QUESTIONS

1. Write the difference between transverse and longitudinal waves.

Transverse waves	Longitudinal waves
1.The direction of vibration of particles of the medium is perpendicular to the direction of propagation of waves.	The direction of vibration of particles of the medium is parallel to the direction of propagation of waves.
2.The disturbances are in the form of crests and troughs.	The disturbances are in the form of compressions and rarefactions.
3.Transverse waves are possible in elastic medium(solids).	Longitudinal waves are possible in all types of media (solid, liquid and gas).

2.Briefly explain the difference between travelling(progressive) waves and standing(stationary) waves.

Travelling waves	Standing waves
1.These wave carry energy while propagating.	These waves do not transport energy.
2.Crests and troughs are formed in transverse progressive waves, and compression and rarefaction are formed in longitudinal progressive waves.	Crests and troughs are formed in transverse stationary waves, and compression and rarefaction are formed in longitudinal stationary waves.
3.These waves move forward or backward in a medium.	These waves neither move forward nor backward in a medium.
4.All the particles in the medium vibrate such that the amplitude of the vibration for all particles is same.	Except at nodes, all other particles of the medium vibrate such that amplitude of vibration is different for different particles. The amplitude is minimum or zero at nodes and maximum at anti-nodes.

3. Write the Characteristics of progressive (travelling) waves.

- The phase of every particle ranges from 0 to 2π.
- Particles in the medium vibrate about their mean positions with the same amplitude.
- No particle remains at rest permanently. During wave propagation, particles come to the rest position only twice at the extreme points.
- Transverse progressive waves are characterized by crests and troughs whereas longitudinal progressive waves are characterized by compressions and rarefactions.
- When the particles pass through the mean position they always move with the same maximum velocity.
- The displacement, velocity and acceleration of particles separated from each other by nλ are the same, where n is an integer, and λ is the wavelength.

4. Discuss the law of transverse vibrations in stretched strings.

1. The law of length:

The frequency varies inversely with the vibrating length. $f = \frac{c}{l}$

2. The law of tension:

The frequency varies directly with the square root of the tension T. $f = A\sqrt{T}$

3. The law of mass:

The frequency varies inversely with the square root of the mass per unit length μ.

$$f = \frac{B}{\sqrt{\mu}}$$

5. Write the Characteristics of Stationary (Standing) waves

- The transfer of energy along the standing wave is zero.
- The distance between two consecutive nodes (or) anti-nodes is λ / 2
- The distance between a node and its neighbouring anti-node is λ / 4
- Certain points in the region in which the wave exists have maximum amplitude, called as anti-nodes and at certain points the amplitude is minimum or zero, called as nodes.
- Stationary waves are characterised by the confinement of a wave disturbance between two rigid boundaries.
- This means, the wave does not move forward or backward in a medium, it remains steady at its place. Therefore, they are called "stationary waves or standing waves".

5 MARK QUESTIONS

1. Describe Newton's formula for velocity of sound waves in air and also discuss the Laplace's correction.

Sir Isaac Newton assumed that when sound propagates in air, the formation of compression and rarefaction takes place in a very slow manner so that the process is isothermal in nature.

Boyle's law for an ideal gas,

$$PV = \text{Constant}$$

Differentiating above eqn, $PdV + VdP = 0$

$$P = -V\frac{dP}{dV} = K_I$$

The speed of sound in air, $v_T = \sqrt{\frac{K_I}{\rho}} = \sqrt{\frac{P}{\rho}}$

$$P = h\rho g$$

$$P = (0.76 \times 13.6 \times 10^3 \times 9.8) N\, m^{-2}$$

$$\rho = 1.293\ kg\, m^{-3}$$

The speed of sound in air at NTP is

$$v_T = \sqrt{\frac{(0.76 \times 13.6 \times 10^3 \times 9.8)}{1.293}}$$

$$\approx 280\ ms^{-1}$$

Laplace's correction:

"Laplace satisfactorily corrected this discrepancy by assuming that when the sound propagates through a medium, the particles oscillate very rapidly such that the compression and rarefaction occur very fast".

$$PV^{\gamma} = \text{Constant}$$

$$\text{Where } \gamma = \frac{C_P}{C_V}$$

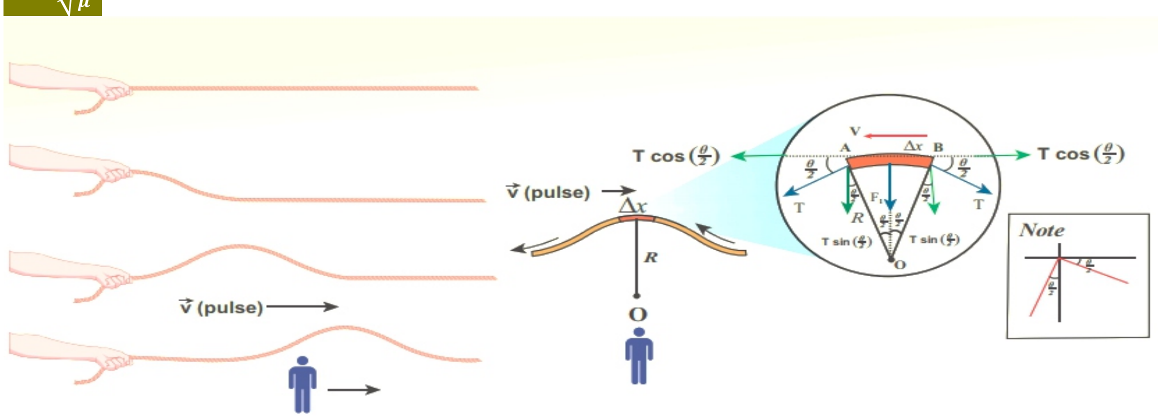
$$K_A = \gamma P$$

$$v_A = \sqrt{\frac{K_A}{\rho}}$$

$$\boxed{\boldsymbol{v_A = \sqrt{\gamma}\, v_t}}$$

Hence, speed of sound in air is $\boldsymbol{v_A} = 331.30 \text{ m s}^{-1}$

2. Show that the velocity of a travelling wave produced in a string is $v = \sqrt{\frac{T}{\mu}}$.



Let us compute the velocity of transverse travelling waves on a string. When a jerk is given at one end of the rope, the wave pulses move towards right end with a velocity v with respect to an observer who is at rest frame.

dm be the small mass of the string $\quad dm = \mu\, dl - - - (1)$

centripetal force is $\quad F_{cp} = \frac{(dm)v^2}{R} - - - (2)$

$(1)\ in\ (2) \quad F_{cp} = \frac{\mu v^2 dl}{R} - - - (3)$

The net radial force is $F_r = 2\,\text{T}\sin\left(\frac{\theta}{2}\right)$

$$F_r = T\theta \qquad \because \theta = \frac{dl}{R}$$

$$F_r = T\frac{dl}{R} \quad - - - (4)$$

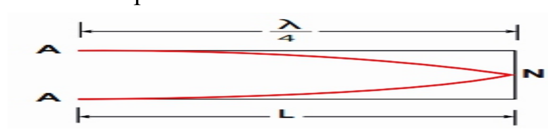
$$(3) = (4) \qquad \frac{\mu v^2 dl}{R} = T\frac{dl}{R}$$

$$\boxed{v = \sqrt{\frac{T}{\mu}}}$$

Explain how overtones are produced in a
3. Closed organ pipe:

- It is a pipe with one end closed and another end open.
  Example: Clarinet
- Nodes are formed at the closed end Anti-nodes are formed at open end.

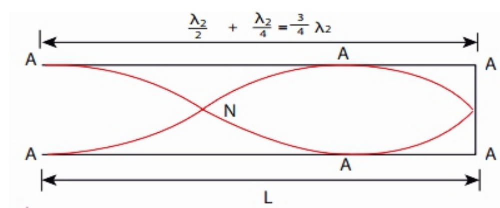
Fundamental mode of vibration:



Wave lenght $\lambda_1 = 4L$

Frequency $= \frac{v}{4L}$

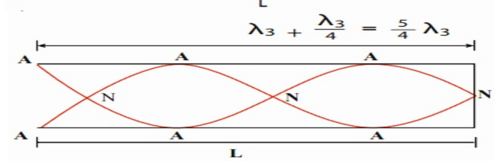
Second mode of vibration:



Wave lenght $\lambda_2 = \frac{4L}{3}$

Frequency $f_2 = \frac{3v}{4L} = 3f_1$

Third mode of vibration:



Wave lenght $\lambda_3 = \frac{4L}{5}$

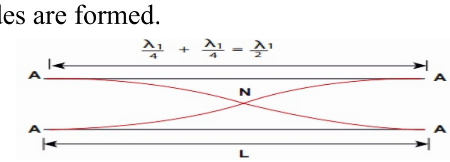
Frequency $f_2 = \frac{5v}{4L} = 5f_1$

Therefore, the frequency of harmonics are in the ratio $f_1 : f_2 : f_3 = 1:3:5:7:..$

4. Open organ pipe.

It is a pipe with both ends open. At both open ends, anti-nodes are formed.

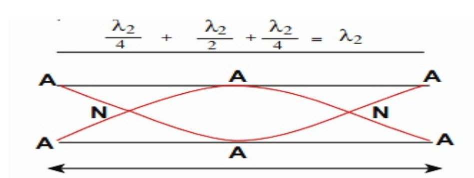
Fundamental mode of vibration:



Wave lenght $\lambda_1 = 2L$

Frequency $f_1 = \frac{v}{2L}$

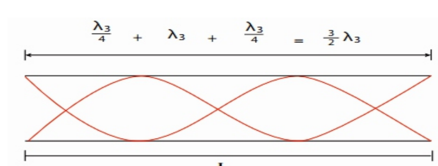
Second mode of vibration:



Wave lenght $\lambda_2 = \text{L}$

Frequency $f_2 = \frac{v}{L} = 2f_1$

Third mode of vibration:

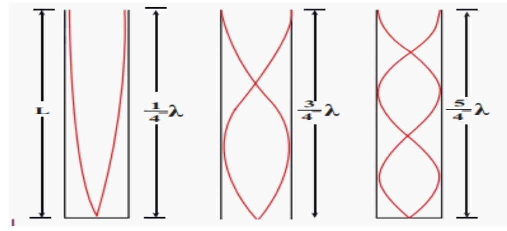


Wave lenght $\lambda_3 = \frac{2L}{3}$

Frequency $f_3 = \frac{3v}{2L} = 3f_1$

Therefore, the frequency of harmonics are in the ratio $f_1 : f_2 : f_3 : .. = 1:2:3:4\ ...$

5. How will you determine the velocity of sound using resonance air column apparatus?



- It consists of a cylindrical glass tube of one-meter length.
- whose one end A is open and another end B is connected to the water reservoir R through a rubber tube.
- When a vibrating tuning fork is brought near the open end of the tube, longitudinal waves are formed inside the air column.
- Let the first resonance occur at length $L_1 = \frac{\lambda}{4}$
- Including this end correction, the first resonance is $L_1 + e = \frac{\lambda}{4} - - - (1)$
- Including this end correction, the second resonance is $L_2 + e = \frac{3\lambda}{4} — (2)$

$$(2) - (1) \qquad L_2 - L_1 = \frac{\lambda}{2}$$

$$\lambda = 2\Delta L$$

The speed of the sound in air $\boldsymbol{v = 2f\,\Delta L}$

Further, to compute the end correction, we use eqn (1), (2) $\boxed{e = \frac{L_2 - 3L_1}{2}}$

ONE MARK QUESTIONS

UNIT 1-NATURE OF PHYSICAL WORLD AND MEASUREMENT

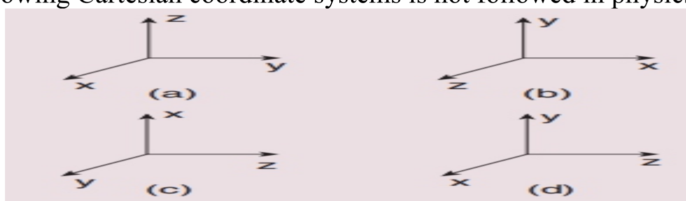
1. One of the combinations from the fundamental physical constants is hc/G. The unit of this expression is
   a) kg^2 b) m^3 c) s^{-1} d) m
2. If the error in the measurement of radius is 2%, then the error in the determination of volume of the sphere will be
   a) 8% b) 2% c) 4% d) 6%
3. If the length and time period of an oscillating pendulum have errors of 1% and 3% respectively then the error in measurement of acceleration due to gravity is
   a) 4% b) 5% c) 6% d) 7%
4. The length of a body is measured as 3.51m, if the accuracy is 0.01m, then the percentage error in the measurement is
   a) 351% b) 1% c) 0.28% d) 0.035%
5. Which of the following has the highest number of significant figures?
   a) 0.007 m^2 b) 2.64×10^{24} kg c) 0.0006032 m^2 d) 6.3200 J
6. If $\pi = 3.14$, then the value of π^2 is
   a) 9.8596 b) 9.860 c) 9.86 d) 9.9
7. Round of the following number 19.95 into three significant figures.
   a) 19.9 b) 20.0 c) 20.1 d) 19.5
8. Which of the following pairs of physical quantities have same dimension?
   a) force and power b) torque and energy c) torque and power d) force and torque
9. The dimensional formula of Planck's constant h is
   a) $[ML^2T^{-1}]$ b) $[ML^2T^{-3}]$ c) $[MLT^{-1}]$ d) $[ML^3T^{-3}]$
10. The velocity of a particle v at an instant t is given by $v = at+bt^2$. The dimensions of b is
   a) [L] b) $[LT^{-1}]$ c) $[LT^{-2}]$ d) $[LT^{-3}]$
11. The dimensional formula for gravitational constant G is
   a) $[ML^3T^{-2}]$ b) $[M^{-1}L^3T^{-2}]$ c) $[M^{-1}L^{-3}T^{-2}]$ d) $[ML^{-3}T^2]$
12. The density of a material in CGS system of units is 4 g cm^{-3} . In a system of units in which unit of length is 10 cm and unit of mass is 100 g, then the value of density of material will be
   a) 0.04 b) 0.4 c) 40 d) 400
13. If the force is proportional to square of velocity, then the dimension of proportionality constant is
   a) $[MLT^0]$ b) $[MLT^{-1}]$ c) $[ML^{-2}T]$ d) $[ML^{-1}T^0]$
14. The dimension of $(\mu_0\varepsilon_0)^{-\frac{1}{2}}$ is
   (a) length (b) time (c) velocity (d) force

15. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are taken as three fundamental constants. Which of the following combinations of these has the dimension of length?

$(a)\ \frac{\sqrt{hG}}{c^{\frac{3}{2}}}\quad (b)\ \frac{\sqrt{hG}}{c^{\frac{5}{2}}}\quad (c)\ \sqrt{\frac{hc}{G}}\quad (d)\ \sqrt{\frac{Gc}{h^{\frac{3}{2}}}}$

UNIT 2-KINEMATICS

1. Which one of the following Cartesian coordinate systems is not followed in physics?



2. Identify the unit vector in the following.

$(a)\hat{\imath}+\hat{\jmath}\quad (b)\frac{\hat{\imath}}{\sqrt{2}}\quad (c)\hat{k}-\frac{\hat{\jmath}}{\sqrt{2}}\quad (d)\frac{\hat{\imath}+\hat{\jmath}}{\sqrt{2}}$

3. Which one of the following physical quantities cannot be represented by a scalar?
(a) Mass (b) length (c) momentum (d) magnitude of acceleration

4. Two objects of masses m_1 and m_2 fall from the heights h_1 and h_2 respectively. The ratio of the magnitude of their momenta when they hit the ground is

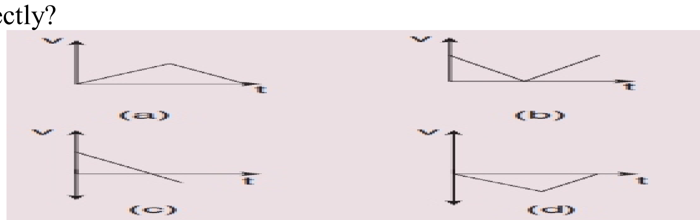
$(a)\sqrt{\frac{h_1}{h_2}}\quad (b)\sqrt{\frac{m_1h_1}{m_2h_2}}\quad (c)\frac{m_1}{m_2}\sqrt{\frac{h_1}{h_2}}\quad (d)\frac{m_1}{m_2}$

5. If a particle has negative velocity and negative acceleration, its speed
(a) increases (b) decreases (c) remains same (d) zero

6. If the velocity is $\bar{v} = 2\vec{\imath} + t^2\vec{\jmath} - 9\vec{k}$, then the magnitude of acceleration at t = 0.5 s is
(a) 1 ms^{-2} (b) 2 ms^{-2} (c) zero (d) $-1ms^{-2}$

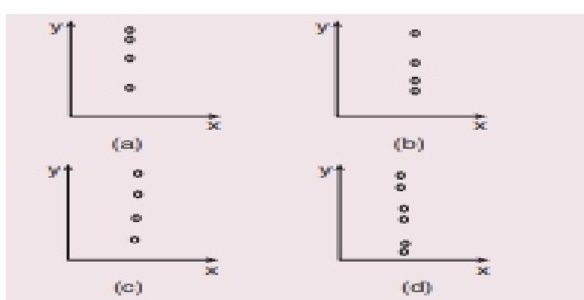
7. If an object is dropped from the top of a building and it reaches the ground at t = 4 s, then the height of the building is (ignoring air resistance) (g = 9.8 ms^{-2})
$(a) 77.3\ m\quad (b) 78.4\ m\quad (c) 80.5\ m\quad (d) 79.2\ m$

8. A ball is projected vertically upwards with a velocity v. It comes back to ground in time t. Which v-t graph shows the motion correctly?



9. If one object is dropped vertically downward and another object is thrown horizontally from the same height, then the ratio of vertical distance covered by both objects at any instant t is
(a) 1 (b) 2 (c) 4) (d) 0.5

10. A ball is dropped from some height towards the ground. Which one of the following represents the correct motion of the ball?



11. If a particle executes uniform circular motion in the xy plane in clock wise direction, then the angular velocity is in
(a) +y direction (b) +z direction (c) -z direction (d) -x direction

12. If a particle executes uniform circular motion, choose the correct statement.
(a) The velocity and speed are constant. (b) The acceleration and speed are constant.
(c) The velocity and acceleration are constant. (d) The speed and magnitude of acceleration are constant.

13. If an object is thrown vertically up with the initial speed u from the ground, then the time taken by the object to return back to ground is
$(a)\ \frac{u^2}{2g}$ $(b)\frac{u^2}{g}$ $(c)\frac{u}{2g}$ $(d)\ \frac{2u}{g}$

14. Two objects are projected at angles 30° and 60° respectively with respect to the horizontal direction. The range of two objects are denoted as $R_{30°}$ and $R_{60°}$. Choose the correct relation from the following
$(a)R_{30^0} = R_{60^0}$ $(b)\ R_{30^0} = 4R_{60^0}$ $(c)R_{30^0} = \frac{R_{60^0}}{2}$ $(d)\ R_{30^0} = 2R_{60^0}$

15. An object is dropped in an unknown planet from height 50 m, it reaches the ground in 2 s. The acceleration due to gravity in this unknown planet is
$(a)g = 20\ ms^{-2}$ $(b)g = 25\ ms^{-2}$ $(c)g = 15\ ms^{-2}$ $(d)g = 30\ ms^{-2}$

UNIT-3 LAWS OF MOTION

1. When a car takes a sudden left turn in the curved road, passengers are pushed towards the right due to
(a) inertia of direction (b) inertia of motion (c) inertia of rest (d) absence of inertia

2. An object of mass m held against a vertical wall by applying horizontal force F as shown in the figure. The minimum value of the force F is

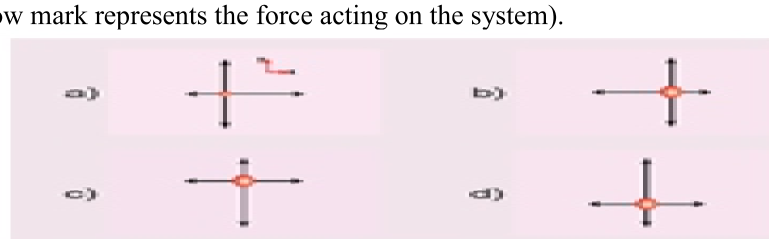
(a) Less than mg (b) Equal to mg (c) Greater than mg (d) Cannot determine

3. A vehicle is moving along the positive x direction, if sudden brake is applied, then
(a) frictional force acting on the vehicle is along negative x direction
(b) frictional force acting on the vehicle is along positive x direction
(c) no frictional force acts on the vehicle
(d) frictional force acts in downward direction

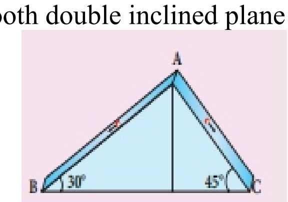
4. A book is at rest on the table which exerts a normal force on the book. If this force is considered as reaction force, what is the action force according to Newton's third law?
(a) Gravitational force exerted by Earth on the book (b) Gravitational force exerted by the book on Earth
(c) Normal force exerted by the book on the table (d) None of the above

5. Two masses m_1 and m_2 are experiencing the same force where $m_1 < m_2$. The ratio of their acceleration $\frac{a_1}{a_2}$ is
(a) 1 (b) less than 1 (c) greater than 1 (d) all the three cases

6. Choose appropriate free body diagram for the particle experiencing net acceleration along negative y direction. (Each arrow mark represents the force acting on the system).

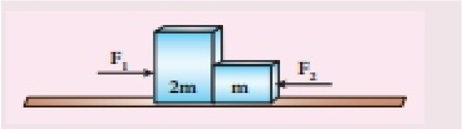


7.A particle of mass m sliding on the smooth double inclined plane (shown in figure) will experience



(a) greater acceleration along the path AB (b) greater acceleration along the path AC
(c) same acceleration in both the paths (d) no acceleration in both the paths.

8. Two blocks of masses m and 2m are placed on a smooth horizontal surface as shown. In the first case only a force F_1 is applied from the left. Later only a force F_2 is applied from the right. If the force acting at the interface of the two blocks in the two cases is same, then $F_1 : F_2$ is
(Physics Olympiad 2016)



a) 1:1 b) 1:2 c) 2:1 d) 1:3

9. Force acting on the particle moving with constant speed is
(a) always zero (b) need not be zero
(c) always non zero (d) cannot be concluded

10. An object of mass m begins to move on the plane inclined at an angle θ . The coefficient of static friction of inclined surface is μ_s . The maximum static friction experienced by the mass is

a) mg b) $\mu_s mg$ c) $\mu_s mg \sin\theta$ d) $\mu_s mg \cos\theta$

11. When the object is moving at constant velocity on the rough surface,
(a) net force on the object is zero (b) no force acts on the object
(c) only external force acts on the object (d) only kinetic friction acts on the object

12. When an object is at rest on the inclined rough surface,
(a) static and kinetic frictions acting on the object is zero
(b) static friction is zero but kinetic friction is not zero
(c) static friction is not zero and kinetic friction is zero
(d) static and kinetic frictions are not zero

13. The centrifugal force appears to exist
(a) only in inertial frames (b) only in rotating frames
(c) in any accelerated frame (d) both in inertial and non-inertial frames

14. Choose the correct statement from the following
(a) Centrifugal and centripetal forces are action reaction pairs
(b) Centripetal forces is a natural force
(c) Centrifugal force arises from gravitational force
(d) Centripetal force acts towards the centre and centrifugal force appears to act away from the centre in a circular motion

15. If a person moving from pole to equator, the centrifugal force acting on him
(a) increases (b) decreases (c) remains the same (d) increases and then decreases

UNIT 4-WORK, ENERGY AND POWER

1.A uniform force of $(2\hat{\imath} + \hat{\jmath})$N acts on a particle of mass 1 kg. The particle displaces from position $(3\hat{\jmath} + \hat{k})$m to $(5\hat{\imath} + 3\hat{\jmath})$m. The work done by the force on the particle is

$(a) 9J$ $(b) 6J$ $(c) 10J$ $(d) 12J$

2. A ball of mass 1 kg and another of mass 2 kg are dropped from a tall building whose height is 80 m. After, a fall of 40 m each towards Earth, their respective kinetic energies will be in the ratio of

(a) √2:1 (b) 1: √2 (c) 2:1 (d) 1:2

3. A body of mass 1 kg is thrown upwards with a velocity 20 ms^{-1}. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction?. (Take $g = 10ms^{-2}$)

(a) 20J (b) 30J (c) 40J (d) 10J

4. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water of the jet. What is the rate at which kinetic energy is imparted to water?.

$(a)\frac{1}{2}mv^3$ $(b)\ mv^3$ $(c)\frac{3}{2}mv^2$ $(d)\frac{5}{2}mv^2$

5. A body of mass 4 m is lying in xy-plane at rest. It suddenly explodes into three pieces. Two pieces each of mass m move perpendicular to each other with equal speed v. The total kinetic energy generated due to explosion is

$(a)\ mv^2$ $(b)\frac{3}{2}mv^2$ $(c)\ 2mv^2$ $(d)\ 4mv^2$

6. The potential energy of a system increases, if work is done
(a) by the system against a conservative force (b) by the system against a non-conservative force
(c) upon the system by a conservative force (d) upon the system by a non-conservative force

7. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?.
$(a)\sqrt{2gR}$ $(b)\sqrt{3gR}$ $(c)\sqrt{5gR}$ $(d)\sqrt{gR}$

8. The work done by the conservative force for a closed path is
(a) always negative (b) zero (c) always positive (d) not defined

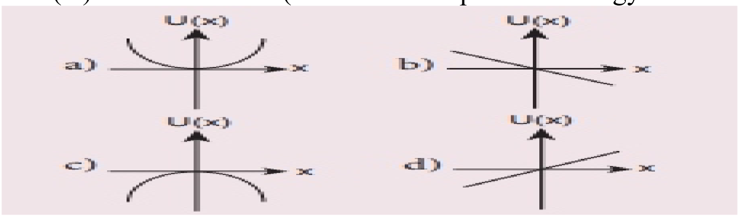
9. If the linear momentum of the object is increased by 0.1%, then the kinetic energy is increased by
(a) 0.1% (b) 0.2% (c) 0.4% (d) 0.01%

10. If the potential energy of the particle $\alpha - \frac{\beta}{2}x^2$ then force experienced by the particle is
(a) $F = \frac{\beta}{2}x^2$ (b) $F = \beta x$ (c) $F = -\beta x$ (d) $F = -\frac{\beta}{2}x^2$

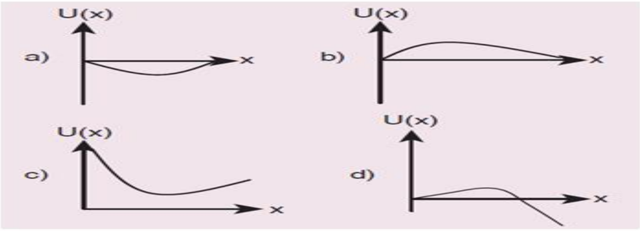
11. A wind-powered generator converts wind energy into electric energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to
(a) v (b) v^2 (c) v^3 (d) v^4

12. Two equal masses m_1 and m_2 are moving along the same straight line with velocities 5ms $^{-1}$ and -9ms^{-1} respectively. If the collision is elastic, then calculate the velocities after the collision of m_1 and m_2, respectively
(a) $-4\ \text{ms}^{-1}$and $10\ \text{ms}^{-1}$ (b) $10\ \text{ms}^{-1}$and $0\ \text{ms}^{-1}$ (c) $-9\ \text{ms}^{-1}$and $5\ \text{ms}^{-1}$ (d) $5\ \text{ms}^{-1}$and $1\ \text{ms}^{-1}$

13. A particle is placed at the origin and a force F=kx is acting on it (where k is a positive constant). If $U(0) = 0$, the graph of U (x) versus x will be (where U is the potential energy function)



14. A particle which is constrained to move along x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here, k and a are positive constants. For x ≥ 0, the functional form of the potential energy U(x) of the particle is



15. A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then, the long piece will have a force constant of
$(a)\ \frac{2}{3}k$ $(b)\frac{3}{2}k$ $(c)3k$ $(d)6k$

UNIT 5-MOTION OF SYSTEM OF PARTICLES AND RIGID BODIES

1. The centre of mass of a system of particles does not depend upon,
(a) position of particles (b) relative distance between particles
(c) masses of particles (d) force acting on particle

2. A couple produces,
(a) pure rotation (b) pure translation (c) rotation and translation (d) no motion

3. A particle is moving with a constant velocity along a line parallel to positive X-axis. The magnitude of its angular momentum with respect to the origin is,
(a) zero (b) increasing with x (c) decreasing with x (d) remaining constant

4. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force 30 N?

(a) 0.25 rad s^{-2} (b) 25 rad s^{-2} (c) 5 ms^{-2} (d) 25 ms^{-2}

5. A closed cylindrical container is partially filled with water. As the container rotates in a horizontal plane about a perpendicular bisector, its moment of inertia,

(a) increases (b) decreases (c) remains constant (d) depends on direction of rotation.

6. A rigid body rotates with an angular momentum L. If its kinetic energy is halved, the angular momentum becomes,

(a) L (b) $\frac{L}{2}$ (c) $2L$ (d) $\frac{L}{\sqrt{2}}$

7. A particle undergoes uniform circular motion. The angular momentum of the particle remain conserved about,

(a) the centre point of the circle. (b) the point on the circumference of the circle.
(c) any point inside the circle. (d) any point outside the circle.

8. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along,

(a) a line perpendicular to the plane of rotation (b) the line making an angle of 45° to the plane of rotation
(c) the radius (d) tangent to the path

9. Two discs of same moment of inertia rotating about their regular axis passing through centre and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought in to contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is,

(a) $\frac{1}{4}I(\omega_1-\omega_2)^2$ (b) $I(\omega_1-\omega_2)^2$ (c) $\frac{1}{8}I(\omega_1-\omega_2)^2$ (d) $\frac{1}{2}I(\omega_1-\omega_2)^2$

10. A disc of moment of inertia I_a is rotating in a horizontal plane about its symmetry axis with a constant angular speed ω. Another discinitially at rest of moment of inertia I_b is dropped coaxially on to the rotating disc. Then, both the discs rotate with same constant angular speed. The loss of kinetic energy due to friction in this process is,

(a) $\frac{1}{2}\frac{I_b^2}{(I_a+I_b)}\omega^2$ (b) $\frac{I_b^2}{(I_a+I_b)}\omega^2$ (c) $\frac{(I_b-I_a)^2}{(I_a+I_b)}\omega^2$ (d) $\frac{1}{2}\frac{I_bI_b}{(I_a+I_b)}\omega^2$

11. The ratio of the acceleration for a solid sphere (mass m and radius R) rolling down an incline of angle θ without slipping and slipping down the incline without rolling is,

(a) 5:7 (b) 2:3 (c) 2:5 (d) 7:5

12. From a disc of radius R a mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis passing through it

(a) $\frac{15MR^2}{32}$ (b) $\frac{13MR^2}{32}$ (c) $\frac{11MR^2}{32}$ (d) $\frac{9MR^2}{32}$

13. The speed of a solid sphere after rolling down from rest without sliding on an inclined plane of vertical height h is,

(a) $\sqrt{\frac{4}{3}gh}$ (b) $\sqrt{\frac{10}{7}gh}$ (c) $\sqrt{2gh}$ (d) $\sqrt{\frac{1}{2}gh}$

14. The speed of the centre of a wheel rolling on a horizontal surface is v_o . A point on the rim in level with the centre will be moving at a speed of speed of,

(a) zero (b) v_o (c) $\sqrt{2}v_0$ (d) $2v_o$

15. A round object of mass M and radius R rolls down without slipping along an inclined plane. The frictional force,

(a) dissipates kinetic energy as heat. (b) decreases the rotational motion.
(c) decreases the rotational and transnational motion (d) converts transnational energy into rotational energy

UNIT 6-GRAVITATION

1. The linear momentum and position vector of the planet is perpendicular to each other at

(a) perihelion and aphelion (b) at all points (c) only at perihelion (d) no point

2. If the masses of the Earth and Sun suddenly double, the gravitational force between them will

(a) remain the same (b) increase 2 times (c) increase 4 times (d) decrease 2 times

3. A planet moving along an elliptical orbit is closest to the Sun at distance r_1 and farthest away at a distance of r_2. If v_1 and v_2 are linear speeds at these points respectively. Then the ratio $\frac{V_1}{V_2} =$ is

(a) $\frac{r_2}{r_1}$ (b) $\left(\frac{r_2}{r_1}\right)^2$ (c) $\frac{r_1}{r_2}$ (d) $\left(\frac{r_1}{r_2}\right)^2$

4. The time period of a satellite orbiting Earth in a cirular orbit is independent of .

(a) Radius of the orbit (b) The mass of the satellite
(c) Both the mass and radius of the orbit (d) Neither the mass nor the radius of its orbit

5. If the distance between the Earth and Sun were to be doubled from its present value, the number of days in a year would be

(a) 64.5 (b) 1032 (C) 182.5 (C) 730

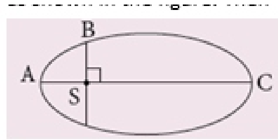
6. According to Kepler's second law, the radial vector to a planet from the Sun sweeps out equal areas in equal intervals of time. This law is a consequence of

(a) conservation of linear momentum (b) conservation of angular momentum
(c) conservation of energy (d) conservation of kinetic energy

7. The gravitational potential energy of the Moon with respect to Earth is

(a) always positive (b) always negative (c) can be positive or negative (d) always zero

8. The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A, K_B and K_C respectively. AC is the major axis and SB is perpendicular to AC at the position of the Sun S as shown in the figure. Then



(a) $K_A > K_B > K_C$ (b) $K_B < K_A < K_C$ (c) $K_A < K_B < K_C$ (d) $K_B > K_A > K_C$

9. The work done by the Sun's gravitational force on the Earth is

(a) always zero (b) always positive (c) can be positive or negative (d) always negative

10. If the mass and radius of the Earth are both doubled, then the acceleration due to gravity g'

(a) remains same (b) $g/2$ (c) $2g$ (d) $4g$

11. The magnitude of the Sun's gravitational field as experienced by Earth is

(a) same over the year
(b) decreases in the month of January and increases in the month of July
(c) decreases in the month of July and increases in the month of January
(d) increases during day time and decreases during night time.

12. If a person moves from Chennai to Trichy, his weight

(a) increases (b) decreases (c) remains same (d) increases and then decreases

13. An object of mass 10 kg is hanging on a spring scale which is attached to the roof of a lift. If the lift is in free fall, the reading in the spring scale is

(a) 98N (b) zero (c) 49N (d) 9.8N

14. If the acceleration due to gravity becomes 4 times its original value, then escape speed

(a) remains same (b) 2 times of original value (c) becomes halved (d) 4 times of original value

15. The kinetic energy of the satellite orbiting around the Earth is

(a) equal to potential energy (b) less than potential energy (c) greater than kinetic energy (d) zero

UNIT 7-PROPERTIES OF MATTER

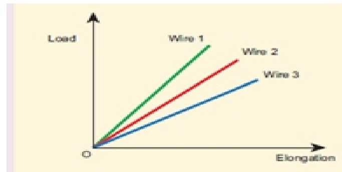
1. Consider two wires X and Y. The radius of wire X is 3 times the radius of Y. If they are stretched by the same load then the stress on Y is

(a) equal to that on X (b) thrice that on X (c) nine times that on X (d) Half that on X

2. If a wire is stretched to double of its original length, then the strain in the wire is

(a) 1 (b) 2 (c) 3 (d) 4

3. The load – elongation graph of three wires of the same material are shown in figure. Which of the following wire is the thickest?



(a) wire 1 (b) wire 2 (c) wire 3 (d) all of them have same thickness

4. For a given material, the rigidity modulus is (1/3)rd of Young's modulus. Its Poisson's ratio is

(a) 0 (b) 0.25 (C) 0.3 (d) 0.5

5. A small sphere of radius 2cm falls from rest in a viscous liquid. Heat is produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity is proportional to

(a) 2^2 (b) 2^3 (c) 2^4 (d) 2^5

6. Two wires are made of the same material and have the same volume. The area of cross sections of the first and the second wires are A and 2A respectively. If the length of the first wire is increased by Δl on applying a force F, how much force is needed to stretch the second wire by the same amount?

(a) 2F (b) 4F (c) 8F (d) 16F

7. With an increase in temperature, the viscosity of liquid and gas, respectively will

(a) increase and increase (b) increase and decrease (c) decrease and increase (d) decrease and decrease

8. The Young's modulus for a perfect rigid body is

(a) 0 (b) 1 (c) 0.5 (d) infinity

9. Which of the following is not a scalar?

(a) viscosity (b) surface tension (c) pressure (d) stress

10. If the temperature of the wire is increased, then the Young's modulus will

(a) remain the same (b) decrease (c) increase rapidly (d) increase by very a small amount

11. Copper of fixed volume V is drawn into a wire of length l. When this wire is subjected to a constant force F, the extension produced in the wire is Δl. If Y represents the Young's modulus, then which of the following graphs is a straight line?

(a) Δl versus V (b) Δl versus Y (c) Δl versus F (d) Δl versus $1/l$

12. A certain number of spherical drops of a liquid of radius R coalesce to form a single drop of radius R and volume V. If T is the surface tension of the liquid, then

(a) energy = $4VT\left(\frac{1}{r}-\frac{1}{R}\right)$is released (b) energy = $3VT\left(\frac{1}{r}+\frac{1}{R}\right)$is absorbed

(c) energy = $3VT\,(\frac{1}{r}-\frac{1}{R})$) is released (d) energy is neither released nor absorbed

13. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied?

(a) length = 200 cm, diameter = 0.5 mm (b) length= 200 cm, diameter = 1 mm

(c) length = 200 cm, diameter = 2 mm (d) length= 200 cm, diameter = 3 m

14. The wettability of a surface by a liquid depends primarily on

(a) viscosity (b) surface tension (c) density (d) angle of contact between the surface and the liquid

15. In a horizontal pipe of non-uniform cross section, water flows with a velocity of 1 ms^{-1} at a point where the diameter of the pipe is 20 cm. The velocity of water (1.5 ms^{-1}) at a point where the diameter of the pipe is (in cm)

(a) 8 (b) 16 (c) 24 (d) 32

UNIT 8-HEAT AND THERMODYNAMICS

1. In hot summer after a bath, the body's

a) internal energy decreases b) internal energy increases

c) heat decreases d) no change in internal energy and heat

2. The graph between volume and temperature in Charles' law is

a) an ellipse b) a circle c) a straight line d) a parabola

3. When a cycle tyre suddenly bursts, the air inside the tyre expands. This process is

a) isothermal b) adiabatic c) isobaric d) isochoric

4. An ideal gas passes from one equilibrium state (P_1, V_1, T_1, N) to another equilibrium state $(2P_1, 3V_1, T_2, N)$.Then

a) $T_1 = T_2$ b) $T_1 = T_2/6$ c) $T_1 = 6T_2$ d) $T_1 = 3T_2$

5. When a uniform rod is heated, which of the following quantity of the rod will increase

a) mass b) weight c) center of mass d) moment of inertia

6. When food is cooked in a vessel by keeping the lid closed, after some time the steam pushes the lid outward. By considering the steam as a thermodynamic system, then in the cooking process

a) $Q > 0, W > 0,$ b) $Q < 0, W > 0,$ c) $Q > 0, W < 0,$ d) $Q < 0, W < 0$

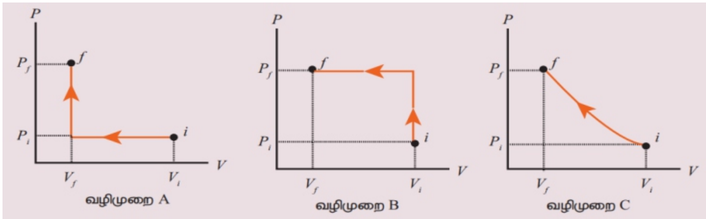
7. When you exercise in the morning, by considering your body as thermodynamic system, which of the following is true?

a) $\Delta U > 0, W > 0,$ b) $\Delta U < 0, W > 0,$ c) $\Delta U < 0, W < 0,$ d) $\Delta U = 0, W > 0,$

8. A hot cup of coffee is kept on the table. After some time it attains a thermal equilibrium with the surroundings. By considering the air molecules in the room as a thermodynamic system, which of the following is true

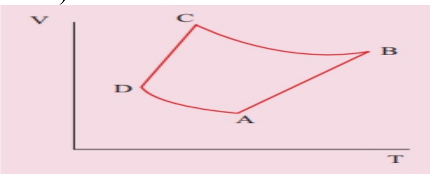
a) $\Delta U > 0, Q = 0$ b) $\Delta U > 0, W < 0$ c) $\Delta U > 0, Q > 0$ d) $\Delta U = 0, Q > 0$

9. An ideal gas is taken from (P_i,V_i) to (P_f,V_f) in three different ways. Identify the process in which the work done on the gas the most.

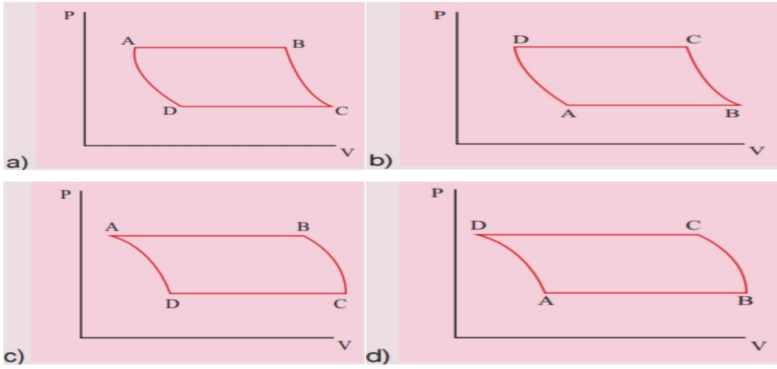


a) Process A b) Process B c) Process C d) Equal work is done in Process A,B &C

10. The V-T diagram of an ideal gas which goes through a reversible cycle A→B→C→D is shown below. (Processes D→A and B→C are adiabatic)



The corresponding PV diagram for the process is (all figures are schematic)



11. A distant star emits radiation with maximum intensity at 350 nm. The temperature of the star is

(a) 8280 K (b) 5000 K (c) 7260 K (d) 9044 K

12. Identify the state variables given here?

a) Q, T, W b) P, T, U c) Q, W d) P, T, Q

13. In an isochoric process, we have

a) $W = 0$ b) $Q = 0$ c) $\Delta U = 0$ d) $\Delta T = 0$

14. The efficiency of a heat engine working between the freezing point and boiling point of water is

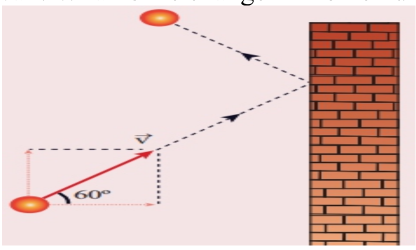
a) 6.25% b) 20% c) 26.8% d) 12.5%

15. An ideal refrigerator has a freezer at temperature −12°C. The coefficient of performance of the engine is 5. The temperature of the air (to which the heat ejected) is

a) 50°C b) 45.2°C c) 40.2°C d) 37.5°C

UNIT 9-KINETIC THEORY OF GASES

1. A particle of mass m is moving with speed u in a direction which makes 60° with respect to x axis. It undergoes elastic collision with the wall. What is the change in momentum in x and y direction?



(a) $\Delta p_x = -mu$, $\Delta p_y = 0$ (b) $\Delta p_x = -2mu$, $\Delta p_y = 0$ (c) $\Delta p_x = 0$, $\Delta p_y = mu$ (d) $\Delta p_x = mu$, $\Delta p_y = 0$

2. A sample of ideal gas is at equilibrium. Which of the following quantity is zero?
(a) rms speed (b) average speed (c) average velocity (d) most probable speed

3. An ideal gas is maintained at constant pressure. If the temperature of an ideal gas increases from 100K to 10000K then the rms speed of the gas molecules
(a) increases by 5 times (b) increases by 10 times (c) remains same (d) increases by 7 times

4. Two identically sized rooms A and B are connected by an open door. If the room A is air conditioned such that its temperature is 4°C lesser than room B, which room has more air in it?
(a) Room A (b) Room B (c) Both room has same air (d) Cannot be determined

5. The average translational kinetic energy of gas molecules depends on
(a) number of moles and T (b) only on T (c) P and T (d) P only

6. If the internal energy of an ideal gas U and volume V are doubled then the pressure
(a) doubles (b) remains same (c) halves (d) quadruples

7. The ratio $\gamma = \frac{C_p}{C_v}$ for a gas mixture consisting of 8 g of helium and 16 g of oxygen is

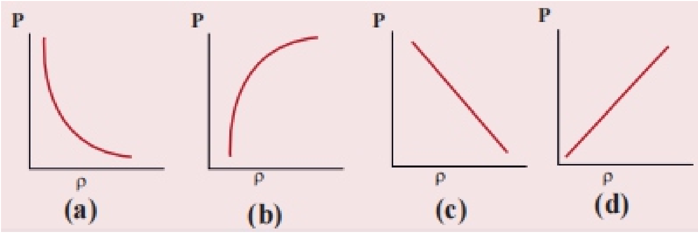
$(a)\ 23/15$ $(b)\ 15/23$ $(c)\ 27/17$ $(d)\ 17/27$

8. A container has one mole of monoatomic ideal gas. Each molecule has f degrees of freedom. What is the ratio of $\boldsymbol{\gamma = \frac{C_p}{C_v}}$

$(a)\ f$ $(b)\ \frac{f}{2}$ $(c)\ \frac{f}{f+2}$ $(d)\ \frac{f+2}{f}$

9. If the temperature and pressure of a gas is doubled the mean free path of the gas molecules
(a) remains same (b) doubled (c) tripled (d) quadrapoled

10. Which of the following shows the correct relationship between the pressure and density of an ideal gas at constant temperature?



11. A sample of gas consists of μ_1 moles of monoatomic molecules, μ_2 moles of diatomic molecules and μ_3 moles of linear triatomic molecules. The gas is kept at high temperature. What is the total number of degrees of freedom?

(a) $[3\mu_1 + 7(\mu_2 + \mu_3)]\ N_A$ (b) $[3\mu_1 + 7\mu_2 + 6\mu_3]\ N_A$

(c) $[7\mu_1 + 3(\mu_2 + \mu_3)]\ N_A$ (d) $[3\mu_1 + 6(\mu_2 + \mu_3)]\ N_A$

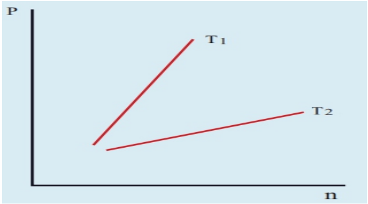
12. If S_P and S_V denote the specific heats of nitrogen gas per unit mass at constant pressure and constant volume respectively, then
$(a)\ S_P - S_V = 28R$ $(b)\ S_P - S_V = R/28$ $(c)\ S_P - S_V = R/14$ $(d)\ S_P - S_V = R$

13. Which of the following gases will have least rms speed at a given temperature?
(a) Hydrogen (b) Nitrogen (c) Oxygen (d) Carbon dioxide

14. For a given gas molecule at a fixed temperature, the area under the Maxwell-Boltzmann distribution curve is equal to

$(a)\ \frac{PV}{kT}$ $(b)\ \frac{kT}{PV}$ $(c)\ \frac{P}{NkT}$ $(d)\ PV$

15. The following graph represents the pressure versus number density for ideal gas at two different temperatures T_1 and T_2. The graph implies



$(a)\ T1 = T2$ $(b)\ T1 > T2$ $(c)\ T1 < T2$ d) Cannot be determined

UNIT 10-OSCILLATIONS

1. In a simple harmonic oscillation, the acceleration against displacement for one complete oscillation will be
a) an ellipse b) a circle c) a parabola d) a straight line

2. A particle executing SHM crosses points A and B with the same velocity. Having taken 3 s in passing from A to B, it returns to B after another 3 s. The time period is
$(a) 15s$ $(b) 6s$ $(c) 12s$ $(d)\ 9s$

3. The length of a second's pendulum on the surface of the Earth is 0.9 m. The length of the same pendulum on surface of planet X such that the acceleration of the planet X is n times greater than the Earth is
$a)\ 0.9\,n$ $b)\ \frac{0.9}{n}\,m$ $c)\ 0.9n^2m$ $d)\ \frac{0.9}{n^2}$

4. A simple pendulum is suspended from the roof of a school bus which moves in a horizontal direction with an acceleration a, then the time period is
$a)\ T \propto \frac{1}{g^2+a^2}$ $b)\ T \propto \sqrt{\frac{1}{\sqrt{g^2+a^2}}}$ $c)\ T \propto \sqrt{g^2+a^2}$ $d)\ T \propto (g^2+a^2)$

5. Two bodies A and B whose masses are in the ratio 1:2 are suspended from two separate massless springs of force constants k_A and k_B respectively. If the two bodies oscillate vertically such that their maximum velocities are in the ratio 1:2, the ratio of the amplitude A to that of B is
$(a)\ \sqrt{\frac{k_B}{2k_A}}$ $(b)\ \sqrt{\frac{k_B}{8k_A}}$ $(c)\ \sqrt{\frac{2k_B}{k_A}}$ $(d)\ \sqrt{\frac{8k_B}{k_A}}$

6. A spring is connected to a mass m suspended from it and its time period for vertical oscillation is T. The spring is now cut into two equal halves and the same mass is suspended from one of the halves. The period of vertical oscillation is
$(a) T' = \sqrt{2}\ T$ $(b)\ T' = \frac{T}{\sqrt{2}}$ $(c)\ T' = \sqrt{2T}$ $(d)\ T' = \sqrt{\frac{T}{2}}$

7. The displacement of a simple harmonic motion is given by $y(t) = A\sin(\omega t + \varphi)$ where A is amplitude of the oscillation,ω is the angular frequency and φ is the phase.Let the amplitude of the oscillation be 8 cm and the time period of the oscillation is 24s.If the diaplacement at initial time $(t = 0)$is 4 cm, then the displacement at $t = 6s$ is
a) 8 cm b) 4 cm c) $4\sqrt{3}$ cm d) $8\sqrt{3}$ cm

8. A simple pendulum has a time period T_1. When its point of suspension is moved vertically upwards according as y = k t^2, where y is vertical distance covered and k = 1ms^{-2},its time period becomes T_2. Then, $\frac{T_1^2}{T_2^2}$ is (g = 10 m s^{-2})
a) 5/6 b) 11/10 c) 6/5 d) 5/4

9. An ideal spring of spring constant k, is suspended from the ceiling of a room and a block of mass M is fastened to its lower end. If the block is released when the spring is un-stretched, then the maximum extension in the spring is
a) 4 Mg/k b) Mg/k c) 2 Mg/k d) Mg/2k

10. A pendulum is hung in a very high building oscillates to and fro motion freely like a simple harmonic oscillator. If the acceleration of the bob is $16\ ms^{-2}$ at a distance of 4 m from the mean position, then the time period is

a) 2s b) 1s c) 2πs (d) πs

11. A hollow sphere is filled with water. It is hung by a long thread. As the water flows out of a hole at the bottom, the period of oscillation will

a) first increase and then decrease b) first decrease and then increase
c) increase continuously d) decrease continuously

12. The damping force on an oscillator is directly proportional to the velocity. The units of the constant of proportionality are

a) $kg\ m\ s^{-1}$ b) $kg\ m\ s^{-2}$ c) $kg\ s^{-1}$ (d) kg s

13. Let the total energy of a particle executing simple harmonic motion with angular frequency is 1 rad s^{-1} is 0.256 J.If the displacement of the particle at time $t = \frac{\pi}{2}$ s is $8\sqrt{2}$ cm then the amplitude of motion is

a) 8 cm b) 16 cm c) 32 cm d) 64 cm

14. A particle executes simple harmonic motion and displacement y at time t_o, $2t_o$ and $3t_o$ are A, B and C, respectively. Then the value of $\frac{A+C}{2B}$ is

a) $\cos \omega t_o$ b) $\cos 2\omega t_o$ c) $\cos 3\omega t_o$ d) 1

15. A mass of 3 kg is attached at the end of a spring moves with simple harmonic motion on a horizontal frictionless table with time period 2π and with amplitude of 2m,then the maximum fore exerted on the spring is

a) 1.5 N b) 3 N c) 6 N d) 12 N

UNIT 11-WAVES

1. A student tunes his guitar by striking a 120 Hertz with a tuning fork, and simultaneously plays the 4th string on his guitar. By keen observation, he hears the amplitude of the combined sound oscillating thrice per second. Which of the following frequencies is the most likely the frequency of the 4th string on his guitar?.

a) 130 b) 117 c) 110 d) 120

2. A transverse wave moves from a medium A to a medium B. In medium A, the velocity of the transverse wave is $500\ ms^{-1}$ and the wavelength is 5 m. Th e frequency and the wavelength of the wave in medium B when its velocity is $600\ ms^{-1}$, respectively are

a) 120 Hz and 5 m b) 100 Hz and 5 m c) 120 Hz and 6 m d) 100 Hz and 6 m

3. For a particular tube, among six harmonic frequencies below 1000 Hz, only four harmonic frequencies are given : 300 Hz, 600 Hz, 750 Hz and 900 Hz. What are the two other frequencies missing from this list?.

a) 100 Hz, 150 Hz b) 150 Hz, 450 Hz c) 450 Hz, 700 Hz d) 700 Hz, 800 Hz

4. Which of the following options is correct?.

A	B
(1) Quality	(A) Intensity
(2) Pitch	(B) Waveform
(3)Loudness	(C) Frequency

Options for(1)(2)and(3)respectively are

a) (B),(C) and (A) b) (C), (A) and (B) c) (A), (B) and (C) d) (B), (A) and (C)

5.Equation of travelling wave on a stretched string of linear density 5 g/m is y=0.03sin(450t-9x), where distance and time are measured in SI units. The tension in the string is

a) 5N b) 12.5N c)7.5N d)10N

6. A sound wave whose frequency is 5000 Hz travels in air and then hits the water surface. The ratio of its wavelengths in water and air is

a) 4.30 b) 0.23 c) 5.30 d) 1.23

7. A person standing between two parallel hills fires a gun and hears the first echo after t_1 sec and the second echo after t_2 sec. The distance between the two hills is

a) $\frac{v(t_1 - t_2)}{2}$ b) $\frac{v(t_1 t_2)}{2(t_1 + t_2)}$ c) $v(t_1 + t_2)$ d) $\frac{v(t_1 + t_2)}{2}$

8. An air column in a pipe which is closed at one end, will be in resonance with the vibrating body of frequency 83Hz. Then the length of the air column is

(a) 1.5 m (b) 0.5 m (c) 1.0 m (d) 2.0 m

9. The displacement y of a wave travelling in the x direction is given by $y = (2 \times 10^{-3}) \sin\left(300t - 2x + \frac{\pi}{4}\right)$, where x and y are measured in metres and t in second. The speed of the wave is

(a) 150 ms^{-1} (b) 300 ms^{-1} (c) 450 ms^{-1} (d) 600 ms^{-1}

10. Consider two uniform wires vibrating simultaneously in their fundamental notes. The tensions, densities, lengths and diameter of the two wires are in the ratio 8 : 1, 1 : 2, x : y and 4 : 1 respectively. If the note of the higher pitch has a frequency of 360 Hz and the number of beats produced per second is 10, then the value of x : y is

(a) 36 : 35 (b) 35 : 36 (c) 1 : 1 (d) 1 : 2

11. Which of the following represents a wave

(a) $(x - vt)^3$ (b) x(x+vt) (c) 1 /(x+vt) (d) sin(x+vt)

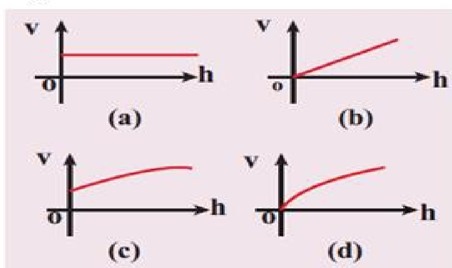
12. A man sitting on a swing which is moving to an angle of 60° from the vertical is blowing a whistle which has a frequency of 2.0 k Hz. The whistle is 2.0 m from the fixed support point of the swing. A sound detector which detects the whistle sound is kept in front of the swing. The maximum frequency the sound detector detected is

(a) 2.027 kHz (b) 1.974 kHz (c) 9.74 kHz (d) 1.011 kHz

13. Let $y = \frac{1}{1+x^2}$ at t = 0 s be the amplitude of the wave propagating in the positive x-direction. At t = 2 s, the amplitude of the wave propagating becomes $y = \frac{1}{1+(x-2)^2}$.Assume that the shape of the wave does not change during propagation. The velocity of the wave is

(a) 0.5 ms^{-1} (b) 1.0 ms^{-1} (c) 1.5 ms^{-1} (d) 2.0 ms^{-1}

14. A uniform rope having mass m hangs vertically from a rigid support. A transverse wave pulse is produced at the lower end. Which of the following plots shows the correct variation of speed v with height h from the lower end?



15. An organ pipe A closed at one end is allowed to vibrate in its first harmonic and another pipe B open at both ends is allowed to vibrate in its third harmonic. Both A and B are in resonance with a given tuning fork. The ratio of the length of A and B is

(a) 8/3 (b) 3/8 (c) 1/6 (d) 1/3