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T N-(XI-PHYSICS)

IMPORTANT STUDY MATERIAL

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I. NATURE OF PHYSICAL WORLD AND MEASUREMENT

Short Answer:-

1. Scientific Method:-

- * Systematic observation
- * Controlled experimentation
- * Qualitative and quantitative reasoning
- * Mathematical modeling
- * Prediction and Verification

2. Science :-

The word 'Science' has its root in the Latin verb *Scientia*, meaning "to know". In Tamil language, it is 'அறிவு' (Arivu) meaning 'knowing the truth'.

3. Physics:-

The word 'physics' is derived from the Greek word "Φυσις" meaning nature.

4. Physical Quantities:-

Quantities that can be measured and in terms of which law of physics are described are called Physical quantities. Eg: mass, length, force etc.

5. Measurement :-

The comparison of any physical quantity with its standard unit is known as Measurement.

6. Types of Physical Quantities:-

- * Fundamental or base quantities are quantities which cannot be expressed in terms of any other physical quantities Eg: length, mass etc.
- * Derived Quantities that can be expressed in terms of fundamental quantities are called derived quantities. Eg: area, volume etc.

7. Advantage of SI unit:-

- * This system makes use of only one unit for one physical quantity, which means a rational system of units.
- * In this system, all the derived units can be easily obtained from base and supplementary units, which means it is a coherent system of units.

8. Radian (rad):

The radian is the angle subtended at the centre of a circle, by an arc equal in length to the radius of the circle.

Steradian (sr):

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 radii of the sphere.

9. Theory of error:

The result obtained from any measurement will contain some uncertainty. Such an uncertainty is termed error.

10. Significant digits :-

It is defined as the number of meaningful digits which contain numbers that are known reliably and first uncertain number.

11. Significant figures :-

The digits that are known which tell as the number of units we are responsible for of having counted in making a measurement called significant figures.

12. Accuracy and precise :-

If a measurement is precise, that does not necessarily mean that it is accurate. However, if the measurement is consistently accurate, it is also precise.

13. Unit :-

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

14. Length: unit - metre Symbol: m
One metre is the length of the path travelled by light in Vacuum in $1/299,792,458$ of a second (1983).

Mass: Mass of a body is defined as the quantity of matter contained in a body. The SI unit of mass is Kilogram (kg)

15. Measurement of Time intervals

A clock is used to measure the time interval. An atomic standard of time, is based on the periodic vibration produced in a caesium atom.

16. Parallax method (moon):-

$\theta = \frac{AB}{MC}$ or $MC = \frac{AB}{\theta}$; Knowing the values of AB and θ , we can calculate the distance MC of Moon from the Earth.

17. Limitation of the dimensional analysis:-

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

Extra
18.

Principle of homogeneity of dimensions:

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

2. KINEMATICS

Short Answer:-

1. Kinematics:-

Kinematics is the branch of mechanics which deals with the motion of objects without taking force into account. The Greek word "kinema" means "motion".

2. Frame of Reference:

If we imagine a coordinate system is called Frame. Position of an object is described relative to it, then such a coordinate system is called Frame of Reference.

3. Scalar:-

It is a property which can be described only by magnitude. In physics a number of quantities can be described by scalars.

Eg: Distance, mass, speed etc.

4. Vector:-

It is a quantity which is described by both magnitude and direction. Geometrically a vector is a directed line segment which in physics certain quantities can be described only by vectors.

5. Magnitude of a vector.

The length of a vector is called magnitude of a vector.

6. Scalar Product of two Vectors.

The Scalar product (or dot product) of two vectors is defined as the product of the magnitudes of the both vectors and the cosine of the angle between them.

7. Vector Product of two vectors.

The vector product or Cross product of two vectors is defined as another vector having a magnitude equal to the product of the magnitudes of two vectors and the sine of the angle between them.

8. Distance:

It is the actual path length travelled by an object in the given interval of time during the motion. It is a positive scalar.

Displacement:

It is the difference between the final and initial position of the object in a given interval of time.

9. Acceleration:

The rate of change of velocity : $a = \frac{dv}{dt}$.

10. Relative Velocity in One and two dimensional :

When two object A and B are moving with different velocities, then the velocity of one object A with respect to another object B is called relative velocity of object with respect to B.

11. Projectile motion.

When an object is thrown in the air with some initial velocity (NOT just upwards) and then allowed to move under the action of gravity alone, the object is known as a projectile.

12. Time of Flight :

The time taken for the projectile to complete its trajectory or time taken by the projectile to hit the ground called time of flight.

13. Horizontal range:

The horizontal distance covered by the projectile from the foot of the tower to the point where the projectile hits the ground is called horizontal range.

14. Angular displacement :

The angle described by the particle about axis of rotation (or centre O) in a given time is called angular displacement.

15. Velocity:

The rate of change of velocity = $\frac{dp}{dt}$
displacement

16. Momentum

It is defined as $\vec{p} = m\vec{v}$.

17. Angular Velocity ($\vec{\omega}$)

The rate of change of angular displacement is called angular velocity.

Angular acceleration

The rate of angular velocity is called angular acceleration

18. Maximum height (h_{max})

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

19. Average Speed.

The average speed is defined as the ratio of total path length travelled by the particle in a time interval

20. Cartesian Coordinate System:

At any given instant of time, the frame of reference with respect to which the position of the object is described in terms of position coordinates (x, y, z) is called "Cartesian Coordinate System".

21. Two vectors are perpendicular

If the scalar product of two vectors $\vec{A}$ & $\vec{B}$ is zero i.e. $\vec{A} \cdot \vec{B} = AB \cos \theta = 0$, then the given vectors are perpendicular. Because $\cos 90^\circ = 0$.

22. non-uniform Circular motion:-

* When an object is moving on a circular path with change in speed and direction, it is called non-uniform Circular motion.

* When the bob attached to a string moves in vertical circle, the speed of the bob is not the same at all time.

23. Kinetic equation for angular motion:-

$$\omega = \omega_0 + \alpha t$$

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$\theta = \frac{(\omega_0 + \omega)t}{2}$$

24. Expression for angle made by resultant acceleration and radius vector in the non-uniform circular motion

* As the speed of the particle changes, acceleration has a tangential component,

$$a_t = \frac{dv}{dt} = r\alpha$$

* As the direction of motion changes continuously, the acceleration has a radial component (ie). Centripetal acceleration.

$$\therefore a_c = \frac{v^2}{r}$$

* The Magnitude of this resultant acceleration is given by $a_R = \sqrt{a_i^2 + \left(\frac{v^2}{r}\right)^2}$

* This angle is given by $\tan \theta = \frac{a_i}{\left(\frac{v^2}{r}\right)}$

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3. LAW OF MOTION

1. Newton's First law

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

2. Newton's Second law.

The Force acting on an object is equal to the rate of change of its momentum $\vec{F} = m\vec{a}$.

3. Newton's Third law.

For every action there is an equal and opposite reaction $\vec{F}_{12} = -\vec{F}_{21}$

4. Inertia :

The inability of object to move on its own or change its state of motion is called inertia. Inertia means inability to change its state or uniform motion.

- * Inertia of rest
- * Inertia of Direction.
- * Inertia of motion

5. Free body diagram :

Free body diagram is a simple tool to analyse the motion of the object using Newton's laws.

Developing the free body diagram

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

8. Concurrent forces:

A number of forces, acting at the same point are called concurrent forces.

9. Lami's Theorem:

The magnitude of each force of the system is proportional to sine of the angle between the other two forces. The constant of proportionality is same for all three forces.

10. Law of Conservation of linear momentum.

If there are no external forces acting on the system, then the total linear momentum of the system ($\vec{P}_{tot}$) is always a constant vector. In other words, the total linear momentum of the system is conserved in time.

11. Impulse.

If a very large force acts on an object for a very short duration, then the force is called impulse.

$$J = \frac{1}{T}$$

12. Frictional Force

The Force which opposes the relative motion between an object and the surface where it is placed.

13. Kinetic friction :-

If the external force acting on the object is greater than maximum static friction, the object begins to slide. When an object slides, the surface exerts a frictional force called kinetic friction $\vec{f}_k$ also called sliding friction or dynamic friction.

Static friction :-

Static friction is the force which opposes the initiation of motion of an object on the surface.

14. Centripetal

If a particle is in uniform circular motion, there must be centripetal acceleration towards the centre of the circle. If there is acceleration, then there must be some force acting on it with respect to an inertial frame. This force is called centripetal force.

Centrifugal

To use Newton's first and second laws in the rotational frame of reference, we need to include a pseudo force called centrifugal force.

15. Inertia of a body:

Inertia is the property of the body by virtue of which a body cannot change on its own state of rest or uniform motion in a straight line.

16. One Newton:

It 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.

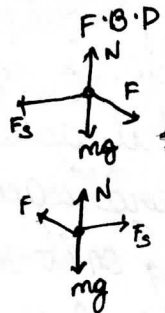
17. Impulse is the change of momentum:

The integral $\int_{t_i}^{t_f} F dt = J$ is called the impulse and it is equal to change in momentum of the object.

18. Easier to pull an object than to push it.

$$N_{\text{push}} = mg + F \cos \theta$$

$$N_{\text{pull}} = mg - F \cos \theta$$



19. Pseudo force:

A pseudo force is an apparent force that acts on all masses whose motion is described using a non-inertial frame of reference such as a rotating reference.

20. Empirical law of static and kinetic friction.

* The Magnitude of static frictional force satisfies the following empirical relation.

$$0 \leq f_s \leq \mu_s N,$$

where μ_s is the coefficient of static friction.

* The force of static friction can take any value from zero to $\mu_s N$.

21. Car Skid on a levelled circular road:-

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

$$\mu_s < \frac{v^2}{rg} \text{ (skid)}$$

4. WORK, ENERGY AND POWER.

1.

Energy :

Energy of a body is the capacity of doing work. In SI unit is joule.

2.

Work done is Scalar product :-

Because, It has only magnitude and no direction.

3.

Work done is zero in the following cases.

- * when the force is zero ($F = 0$).
- * when the displacement is zero ($dr = 0$).
- * when the force and displacement are perpendicular ($\theta = 90^\circ$) to each other.

4.

Energy is defined as the ability to do work.

5.

Law of Conservation of Energy.

This means that the energy disappearing in one form reappears in another form. This is known as the law of Conservation of Energy.

6.

Types of mechanical energy:

- * Kinetic energy
- * Potential energy.

7. Kinetic Energy:

The energy possessed by a body due to its motion is called Kinetic Energy.

8. Potential Energy:

The Energy possessed by the body by virtue of its position is called potential energy.

9. Work Kinetic Energy theorem.

This implies that the work done by the force on the body changes the kinetic energy of the body. This is called work. Kinetic energy theorem.

10. Types of potential Energy.

- * Gravitational potential Energy $U = mgh$
- * Elastic potential Energy $U = \frac{1}{2}kx^2$
- * Electrostatic potential Energy $U = -E \cdot dr$

11. Elastic potential Energy.

The potential Energy possessed by a spring due to a deforming force which stretches or compresses the spring is termed as elastic potential Energy.

12. Conservative force:

If the work done by or against the force in moving the body depends only on the initial and final positions of the body and not on the nature of the path followed between the initial and final positions.

Non-Conservative force.

A force is said to be non-conservative if the work done by or against the force in moving a body depends upon the path between the initial and final position.

13. Power:

It is defined as the rate of work done or energy delivered:

$$P = \frac{W}{t}$$

Average power:

The average power (P_{av}) is defined as the ratio of the total work done to the total time taken.

14. Instantaneous Power

The instantaneous power (P_{inst}) is defined as the power delivered at an instantaneous time interval approach zero.

$$P_{inst} = \frac{dW}{dt}$$

15. Watt

One watt is defined as the power when one joule of work is done in one second ($1W = 1Js^{-1}$).

16. Electricity:

Electricity bills are generated in unit of kWh. for Electrical Energy Consumption unit of electrical energy is kWh.

17. Collisions

Collision is a common phenomenon that happens around us every now and then. For example carom, billiards, marbles etc...

18. Types of Collisions

- * Elastic Collision
- * Inelastic Collision

19. Elastic Collision:

In a collision, the total initial kinetic energy of the bodies (before collision) is equal to the total final kinetic energy of the bodies (after collision) then, it is called as elastic collision.

20. COR:

The amount of kinetic energy after the collision of two bodies, in general can be measured through a dimensionless number called the coefficient of restitution.

21. Ratio of velocity:

It is defined as the ratio of velocity of separation (relative velocity) after collision to the velocity of approach (relative velocity) before collision.

22. Work in Physics:

- * Any activity can generally be called as work.
- * But in physics, work is said to be called done by the force when the force applied on a body displaces it.

23. Types of Potential Energy:

- * Gravitational potential energy $U = mgh$.
- * Elastic potential energy $U = \frac{1}{2} kx^2$
- * Electrostatic potential energy $U = -E \cdot dr$.

24. Coefficient of restitution.

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

25. Loss of Kinetic energy in inelastic collision.

Total Kinetic energy
before collision,

$$KE_i = \frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 \dots \rightarrow (1)$$

Total Kinetic energy
after collision

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

Loss of KE, $\Delta Q = KE_i - KE_f$

$$= \frac{1}{2} (m_1 + m_2) v^2 - \left(\frac{1}{2} m_1 u_1^2 + \frac{1}{2} m_2 u_2^2 \right) \dots \rightarrow (3)$$

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

5. Motion of System of Particles and Particles of Rigid Bodies.

Short Answer:-

1. Internal forces:

The forces acting among the particles within a system that constitute the body.

External forces:

The forces acting on the particles of a system from outside.

2. Rigid body:

It is the one which maintains its definite and fixed shape even when an external force acts on it.

3. Center of mass:

A point where the entire mass of the body appears to be concentrated.

4. Point mass:

It is a hypothetical point particle which has non zero mass and no size or shape.

5. Torque:

Torque is defined as the moment of the external applied force about a point or axis of rotation.

$$\vec{\tau} = \vec{r} \times \vec{F} = (rF \sin \theta) \hat{n}; \text{ Unit is Nm.}$$

6. Angular Momentum :

The angular momentum of a point mass is defined as the moment of its linear momentum. In words, the angular momentum L of a point mass having a linear momentum p at a position r with respect to a point or axis mathematically written as $\vec{L} = \vec{r} \times \vec{p}$ or $L = rp \sin \theta$.

7. Law of Conservation of angular momentum :

When no external torque acts on the body, the net angular momentum of a rotating rigid body remains constant. This is known as Law of conservation of angular momentum.

8. Equilibrium of rigid bodies Condition:

* When all the forces act upon the object are balanced, then the object said to be in equilibrium.

* A rigid body is said to be in Mechanical equilibrium when both its linear momentum and angular momentum remain constant.

9. Center 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.

10. Couple :

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

11. Moment of Inertia :

In rotational motion, Moment of inertia is a measure of rotational inertia. It is given by $I = \sum m_i r_i^2$

Its unit is kg m^2 and its dimension is ML^2 .

12. Radius of gyration :

The radius of gyration is of an object is the perpendicular distance from the axis of rotation is equivalent point mass, which would have the same mass as well as the same moment of inertia of the body.

13. Parallel axis theorem :

It 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 center of mass and the product of the mass of the body and the square of the perpendicular distance between the two axes

$$I = I_c + Md^2$$

14. Perpendicular axis theorem:

It states that the moment of inertia of a plane lamina or 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.

$$\text{i.e. } I_z = I_x + I_y,$$

15. Conservation of angular Momentum:

When no external torque acts on the body, the net angular momentum of a rotating rigid body remains constant. This is known as law of conservation of angular momentum.

16. Principle of moments:

Sum of the clockwise moments is equal to sum of the anticlockwise moments when a body is in rotational equilibrium or algebraic sum of moment at any point is zero.

17. Conditions in which force can not produce torque?

- * The torque is zero when $\vec{r}$ and $\vec{F}$ are parallel or anti-parallel.
- * If parallel, then $\theta = 0$ and $\sin \theta = 0$.
- * If anti-parallel then $\theta = 180$ and $\sin 180 = 0$.
- * Hence, $\tau = 0$. The torque is zero if the force acts at the reference.

Point .ie as $r=0$, $z=0$.

18. Torque in day to day life.

- * opening and closing of a door about the hinges
- * Turning of a nut using a wrench
- * Opening a bottle (cap) or Water top.

19. Stable Equilibrium

- * Linear momentum and angular momentum are zero.
- * The body tries to come back to equilibrium if slightly disturbed and released.
- * The center of mass of the body shifts slightly higher if disturbed from equilibrium.
- * Potential energy of the body is minimum and it increases if disturbed..

Unstable Equilibrium

- * Linear momentum and angular momentum are zero
- * The body cannot come back to equilibrium if slightly disturbed and released.
- * The center of mass of the body shifts slightly lower if disturbed from equilibrium
- * Potential energy of the body is not minimum and it decreases if disturbed.

20. Two physical significance of Moment of inertia.

- * For rotational motion, moment of inertia is a measure of rotational inertia.
- * The moment of inertia of a body is not an invariable quantity. It depends not only on the mass of the body, but also on the way the mass is distributed around the axis of rotation.

21. Condition for pure rolling:

Rolling is the combination of rotational and translational motions.

$$v_{\text{roll}} = 0 = \text{translational velocity} + \text{tangential velocity due to rotation i.e. } v - r\omega = 0.$$

22. Sliding

- * Sliding is the case when $v_{\text{cm}} > R\omega$ or $v_{\text{TRANS}} > v_{\text{ROT}}$
- * The translation is more than the rotation.

Slipping

- * Slipping is the case when $v_{\text{cm}} < R\omega$ or $v_{\text{TRANS}} < v_{\text{ROT}}$
- * The rotation is more than the translation.

23. Rotational equivalents

- For Mass: Moment of inertia, $I = mr^2$
- For Force: Torque $\tau = I\alpha$.

6. GRAVITATION

1. Kepler's Three laws.

1. Law of Orbits:

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

2. Law of area:

The radial vector (line joining the Sun to a planet) around the Sun sweeps equal areas in equal interval of time

3. Law of period:

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 ellipse.

2. Newton's Universal Law of gravitation:

It states that a particle of mass M_1 attracts any other particle of mass M_2 in the universe with an attractive force. The strength of this force of attraction was found to be directly proportional to the product of their masses and is inversely proportional to the square of the distance between them.

3. Gravitational field:

The space surrounding material body within which its gravitational force of attraction can be experienced is called its gravitational field.

$$\vec{E} = -\frac{Gm_1}{r^2} \hat{r}$$

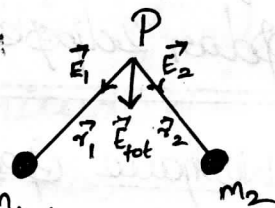
4. Super position of gravitational field:

Consider 'n' particle of masses $m_1, m_2, \dots, m_n$, distributed in space at positions $\vec{r}_1, \vec{r}_2, \vec{r}_3, \dots$ etc, with respect to point P. The total gravitational field at a point P due to all the masses is given by the vector sum of the gravitational field due to the individual masses. This principle is known as super position of gravitational fields.

$$\begin{aligned} \vec{E}_{\text{total}} &= \vec{E}_1 + \vec{E}_2 + \dots + \vec{E}_n \\ &= -\frac{Gm_1}{r_1^2} \hat{r}_1 - \frac{Gm_2}{r_2^2} \hat{r}_2 - \dots - \frac{Gm_n}{r_n^2} \hat{r}_n \\ &= -\sum_{i=1}^n \frac{Gm_i}{r_i^2} \hat{r}_i \end{aligned}$$

Figure (a)

Superposition of two gravitational field intensities giving resultant field.



5. Gravitational potential:

The gravitational potential at a distance r due to its physical mass is defined as the amount of work required to bring unit mass from infinity to the distance r .

Gravitational Potential energy:-

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 . Its unit is joule.

6. Weightlessness:

The gravitational force acting on an object of mass m is mg . This force always acts downward towards the center of the Earth.

7. No lunar eclipse and solar eclipse every month:

If the objects orbits of the Moon and Earth lie on the same plane, during full Moon of every month, we can observe lunar eclipse. If this is so during New Moon we can observe solar eclipse.

8. We have seasons on Earth?

The common misconception is that Earth revolves around the Sun so when the Earth is very far away, it is winter and when the Earth is nearer, it is summer. Actually, the seasons in the Earth arise due to the rotation of Earth around the Sun with 23.5° tilt.

9. Angular momentum of a planet be conserved:

$$\vec{L} = \vec{r} \times \vec{F} = \vec{r} \times \left(-\frac{GM_s M_E}{r^2} \hat{r} \right) = 0$$

$$\text{Since } \vec{r} = r\hat{r}, (\vec{r} \times \hat{r}) = 0.$$

$$\text{So, } \vec{L} = \frac{d\vec{L}}{dt} = 0$$

That is Yes.

10. Potential Energy the property of a single object:

Potential energy is a property of a system rather than of a single object due to its physical position. Because gravitation potential energy depends on relative position. So, a reference level at which to set the potential energy equal to zero.

11. Weight:

The weight of an object, W is defined as the downward force whose magnitude W is equal to that of upward force that must be applied to the object to hold it at rest or at constant velocity relative to the earth.

12. Geostationary Satellites:

Geostationary Satellites appear to be stationary, when seen from earth.

Polar Satellites:

Satellite that orbits earth from North pole to South pole is called a polar satellite.

18. Earth itself is spinning:

The Earth's spinning motion can be proved by observing star's position over a night. Due to Earth's spinning motion, the stars in sky appear to move in circular motion about the pole star.

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7. PROPERTIES OF MATTER

Short Answer's

1. Equilibrium position:

When a deforming force is applied on a body, its atoms are pulled apart or pushed closer. When the deforming force is removed, interatomic forces of attraction or repulsion restore the atoms to their equilibrium position.

2. Elasticity:-

If a body regains its original shape and size after the removal of deforming force, it is said to be elastic and the property is called elasticity.

3. Deforming force:

The force which changes the size or shape of a body is called a deforming force.

4. Plasticity :

If a body does not regain its original shape and size after removal of the deforming force, it is said to be plastic body and the property is called plasticity.

5. Stress:

It is defined as the internal restoring force acting per unit area of a deformed body.

$$\text{Stress} = \frac{\text{Restoring Force}}{\text{Area}} = \frac{F}{A} \quad \text{Its unit is } \text{Nm}^{-2}$$

Strain:

It is defined as the ratio of change in Dimension of a deformed body because of a deforming force on it, to the original Dimension of the body.

$$\text{Strain} = \frac{\text{Change in Dimension}}{\text{Original Dimension}}$$

It has no unit.

6. Hooke's law

Hooke's law is for a small deformation, when the stress and strain are proportional to each other.

7. Three types of elastic modulus.

- * Young's modulus.
- * Rigidity modulus (or shear modulus).
- * Bulk modulus.

8. Compressibility

The reciprocal of the bulk modulus is called Compressibility. It is defined as the fractional change in volume per unit increase in pressure.

It is defined as the ratio of relative contraction (lateral strain) to relative expansion (longitudinal strain). It is denoted by the symbol μ .

$$\mu = \frac{\text{lateral strain}}{\text{longitudinal strain}}.$$

10. More elastic (rubber or steel).

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

11. Pascal's law:

It is 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.

12. upthrust:

The upward force exerted by a fluid that opposes the weight of an immersed object in a fluid is called upthrust or buoyant force and the phenomenon is called buoyancy.

13. Archimedes principle:

It states that 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

Center of gravity of the liquid displaced.

14. Law of floatation:

It states that a body will float in a liquid if the weight of the liquid displaced by the immersed part of the body equals the weight of the body.

eg: Ice floats on water.

15. Viscosity:

It is defined as the property of a fluid to oppose the relative motion between its layers.

16. Tube of flow:

If we imagine a bundle of streamlines having the same velocity over any cross section perpendicular to the direction of flow then such bundle is called a 'tube of flow'.

17. Streamlined flow:

When a liquid flows such that each particle of the liquid passing through a point travels along the same path with the same velocity as its predecessor then the same velocity as its predecessor - for then the flow of liquid is said to be a streamlined flow.

18. Terminal velocity:-

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

19. Stoke's law:-

The viscous force acting on a spherical body of radius r depends directly on.

- (i) radius (r) of the sphere
- (ii) velocity (v) of the sphere and
- (iii) coefficient of viscosity η of the liquid.

Therefore $F \propto \eta r v$

20. Practical applications of Stoke's law:-

- * Flootation of clouds.
- * Larger raindrops hurt us more than the smaller ones.
- * A man coming down with the help of a parachute acquires constant terminal velocity.

21. Poiseuille's Equation (conditions):-

- * The flow of liquid through the tube of stream-lined.
- * 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.

22

Cohesive force:

The force between the like molecules which holds the liquid together is called 'Cohesive force'.

Adhesive force:

When the liquid is in contact with a solid the molecules of the solid and liquid will experience an attractive force which is called 'adhesive force'.

23

Sphere of influence

The distance through which the influence of these molecular forces can be felt in all directions constitute a range and is called Sphere of influence.

24

Surface Energy:

The amount of work done is stored as potential energy. Thus, the molecules lying on the surface possess greater potential energy than other molecules. This excess energy per unit area of the free surface of the liquid is called Surface Energy.

$$\text{Surface Energy} = \frac{W}{\Delta A} \quad \text{It is expressed } \text{Jm}^{-2} \text{ or } \text{Nm}^{-1}$$

Surface tension:

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

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

The SI unit Nm^{-1}

25. Capillarity :

It means that the tube having a very small diameter is called a 'capillary tube'.

26. Practical applications of Capillarity :

- * Absorption of ink by a blotting paper
- * Capillary action is also essential for the tear fluid from the eye to drain constantly.
- * Cotton dresses are preferred in summer because cotton dresses have fine pores which acts as capillaries for sweat.

27. Bernoulli's theorem:

According to Bernoulli's theorem, the sum of pressure energy, kinetic energy and potential energy per unit mass of a incompressible, non-viscous fluid in a streamlined flow remains a constant.

$$\frac{P}{\rho} + \frac{1}{2} v^2 + gh = \text{Constant}.$$

8. HEAT AND THERMODYNAMICS

Short Answer:-

1. Temperature :

Temperature is the degree of hotness or coldness of a body. Hotter the body higher is its temperature.

The SI unit of temperature is Kelvin (K).

2. Ideal gas law from Boyle's and Charles's law:

* Acceleration to Boyle's law $p \propto \frac{1}{V}$

* Acceleration to Charles's law $V \propto T$. By combining these two equations we have

$PV = CT$. Here C is a positive constant.

* So we can write the constant as k times the number of particles N .

Here k is the Boltzmann Constant. ($1.381 \times 10^{-23} \text{ K}^{-1}$) and it is found to be a universal constant.

So the ideal gas law can be stated as follows $PV = NKT$.

3. Heat :

The process of energy transfer from higher temperature object to lower temperature object is called heating.

4. Boltzman Constant:

Here k is the Boltzman Constant ($1.381 \times 10^{-23} \text{ JK}^{-1}$)

5. One mole:

One mole of any substance is the amount of that substance which contains Avogadro number (N_A) of particles (such as atoms or molecules).

6. Heat Capacity : $S = \frac{\Delta Q}{\Delta T}$

Heat Capacity is the amount of heat energy required to raise the temperature of the given body from T to $T + \Delta T$.

Specific heat Capacity :

Specific heat capacity of a substance is defined as the amount of heat energy required to raise the temperature of 1 kg of a substance by 1 K or 1°C .

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

7. Molar specific heat Capacity :

Molar specific heat capacity is defined as heat energy required to increase the temperature of one mole of substance by 1K or 1°C . It can be written as follows.

$$C = \frac{1}{\mu} \left(\frac{\Delta Q}{\Delta T} \right)$$

8. Thermal Expansion :

Thermal Expansion is the tendency of matter to change in shape, area and volume due to a change in temperature.

9. Linear Expansion

In solids, for a small change in temperature ΔT , the fractional change in length $\left(\frac{\Delta L}{L_0} \right)$ is directly proportional to ΔT .

$$\frac{\Delta L}{L_0} = \alpha \Delta T \quad \therefore \alpha_L = \frac{\Delta L}{L_0 \Delta T}$$

1. Area Expansion:

For a small change in temperature ΔT the fractional change in area $\left(\frac{\Delta A}{A_0} \right)$ of a substance is directly proportional to ΔT and it can be written as

$$\frac{\Delta A}{A_0} = \alpha_A \Delta T \quad \therefore \alpha_A = \frac{\Delta A}{A_0 \Delta T}$$

Volume Expansion :

For a small change in temperature ΔT the fractional change in volume $(\frac{\Delta V}{V_0})$ of a substance is directly proportional to ΔT .

$$\frac{\Delta V}{V_0} = \alpha_v \Delta T.$$

$$\alpha_v = \frac{\Delta V}{V_0 \Delta T}.$$

10. Latent heat Capacity :

Latent heat capacity of a substance is defined as the amount of heat energy required to change the state of a unit mass of the material.

$$Q = m \times L$$

$$L = \frac{Q}{m}.$$

11. Tripole point

The tripole point of a substance is the temperature and pressure at which the three phases (gas, liquid and solid) of that substance coexist in thermodynamic equilibrium.

12. Calorimetry:

Calorimetry means the measurement of the amount of heat released or absorbed by thermodynamic system during the heating process.

13. Thermal Conductivity:

The quantity of heat transferred through a unit length of a material in a direction normal to unit surface area due to a unit temperature difference under steady state conditions is known as thermal conductivity of a material.

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

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

15. 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.

$$E \propto T^4 \text{ or } E = \sigma T^4.$$

16. Chemical Equilibrium:

If there is not a chemical reaction between two thermodynamic system in contact with each other then it is said to be in chemical equilibrium.

17. Zeroth law of thermodynamic:

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.

18. First law of thermodynamics

This law states that 'change in internal energy (S.U.) of the system is equal to heat supplied to the system (Q) minus the work done by the system (W) on the surroundings'.

19. Second law of thermodynamics

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

20. All types of process

* Isothermal	$PV = \text{constant}$
* Isobaric	$\frac{V}{T} = \text{constant}$
* Isochoric	$\frac{P}{T} = \text{constant}$
* Adiabatic	$PV^\gamma = \text{constant}$

21. Reservoir:

It is defined as a thermodynamic system which has very large heat capacity. By taking in heat from reservoir or giving heat to reservoir, the reservoir's temperature does not change.

Eg: pouring a tumble of hot water into lake will not increase the temperature of the lake.

22. 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.

23.

Extra

You try it

Padasalai

9. KINETIC THEORY OF GASES.

1. Root mean square. (V_{rms}):

It is defined as the square root of the mean of the square of speeds of all molecules.

It's denoted by $V_{rms} = \sqrt{V^2}$

2. Degree of freedom :

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

3. Monoatomic molecule:

A monoatomic molecule by virtue of its nature has only three translational degrees of freedom.

$$\therefore f = 3.$$

Eg: Helium, Neon, Argon.

4. Mean free path:

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

5. Brownian Motion:

Grains of pollen suspended in a liquid move randomly from one place to other. The random (zig-zag path) motion of pollen suspended in a liquid is called Brownian Motion.

6. Factor's 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.

7. Avogadro's law:

From the equation,
$$p = \frac{1}{3} \frac{N_1}{V} m_1 \overline{v_1^2} = \frac{1}{3} \frac{N_2}{V} m_2 \overline{v_2^2}$$

where $\overline{v_1^2}$ and $\overline{v_2^2}$

$$\frac{1}{2} m_1 \overline{v_1^2} = \frac{1}{2} m_1 \overline{v_2^2}$$

Dividing equ (1) by (2) $N_1 = N_2$

This is Avogadro's law.

Charles's law:

From the equation

$$p = \frac{2}{3} \frac{U}{V} = \frac{2}{3} U, \text{ we get}$$

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

It implies that

$$V \propto T \text{ or } = \frac{V}{T} \text{ Constant}$$

Boyle's law:

From equation $p = \frac{2}{3} \frac{U}{V} = \frac{2}{3} U$, we know that

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

But the internal energy of an ideal gas is equal to N times the average kinetic energy (E) of each molecule.

$$U = Ne.$$

10. OSCILLATIONS

1. Short Answer:-

1. periodic motion:

* Any motion which repeats itself in a fixed time interval is known as periodic motion. Eg: Hands in pendulum clock.

Non-periodic motion

* Any motion which does not repeat itself after a regular interval of time is known as non-periodic motion.

Eg: Occurrence of Earth quake.

2. Vibratory:

When an object or a particle moves back and forth repeatedly for some duration of time its motion is said to be oscillatory (or vibratory). Eg: Our heart beat.

3. Simple harmonic:

The time period is defined as the time taken by a particle to complete one oscillation. It is usually denoted by T . For one complete revolution, the time taken is $t = T$, therefore.

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

4. Displacement:

The distance travelled by the vibrating particle at any instant of time t from its mean position is known as displacement.

5. Dummy Variable:

6. Types of Oscillation :

- * Free Oscillations
- * Damped Oscillations
- * Forced Oscillations
- * Resonance.

7. Resonance:

- * The frequency of external periodic force (or driving force) matches with the natural frequency of the vibrating body (driver).
 - * As a result the oscillating body begins to vibrate such that its amplitude increases at each step and ultimately it has a large amplitude.
 - * Such a phenomenon is known as resonance.
- Eg: The breaking of glass due to sound.

8. Two springs connected in series:

Consider only two springs whose spring constant's are k_1 and k_2 and which can be attached to a mass. The result can be generalized to any number of springs in parallel.

$$k_p = \sum_{i=1}^n k_i$$

11. WAVES

1. Mechanical wave motion and its types:

waves which require a medium for propagation are known as mechanical waves.

eg: sound waves, ripples formed on the surface of the water etc.

Non-mechanical wave - Waves which do not require any medium for propagation are known as non-mechanical waves.

2. Characteristics of wave motion:

- * For the propagation of the waves, the medium must possess both inertia and elasticity, which decide the velocity of the wave in that medium.
- * Waves undergo reflection, refraction, interference, diffraction and polarization.

3. Transverse Waves.

- * The direction of vibration of particles of the medium is perpendicular to the direction of propagation of waves.
- * The disturbances are in the form of crests and troughs.
- * Transverse waves are possible in elastic medium.

Longitudinal waves

- * The direction of vibration of particles of the medium is parallel to the direction of propagation of waves.
- * The disturbances are in the form of compressions and rarefactions.
- * Longitudinal waves are possible in all type of medium (solid, liquid and gas).

Trough:

4. The highest point in the shaded portion is called crest. with respect to the reference level. the lowest point of the un-shaded portion is called trough.

5. Time period:

- It is defined as the time taken by one wave to cross a point.

6. Propagation of Sound Waves are longitudinal waves:

In the following section, we compute the speed of sound in air by Newton's method and also discuss the Laplace correction and the factors affecting sound in air.

7. Reflection of sound:

If the medium is highly dense (highly rigid), the sound can be reflected completely (bounced back) to the original medium.

Refraction of sound:

When the sound waves propagate from one medium to another medium such that there can be some energy loss due to absorption by the second medium.

8. Law of reflection :

Similar to light, sound can also obey the laws of reflection, which states that

- * The angle of incidence of sound is equal to the angle of reflection.
- * When the sound wave is reflected by a surface then the incident wave.

9. Specular reflection :

Similar to reflection of light from a mirror sound also reflects from a harder that surface flat. This is called as specular reflection.

10. Super position waves :

Only waves can possess each such a peculiar property and it is called superposition of waves. This means that the principle of superposition explains the net behaviour of the waves overlap.

11. Principle of superposition can explain :

- * Space (or spatial) Interference also known as Interference).
- * Time (or Temporal) Interference also known as beats.
- * Concept of stationary waves.

12. Interference :

It is a phenomenon in which two waves superimpose to form a resultant wave of greater

beats are the same amplitude.

13. Formation of beat:

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 beats. The number of amplitude maxima per second is called beat frequency.

Number of beats per second $n = |f_1 - f_2|$ per second.

14. Nodes:

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.

15. Sonometer:

Sono means sound related and sonometer implies sound-related measurements. It is a device for demonstrating the relationship between the frequency of the sound produced in the transverse standing wave in a string, and the tension, length and mass per unit length of the string.

16. Harmonics:

If natural frequencies are written as integral multiple of fundamental frequencies, then the frequencies are called harmonics.

17. The law of length:

The Frequency varies inversely with the vibrating length.

$$\therefore f \propto \frac{1}{l}$$

$\Rightarrow l \times f = c$, where c is a constant.

The law of tension:

The frequency varies directly with the square root of the tension T .

$$f \propto \sqrt{T} \Rightarrow f = A\sqrt{T}, \text{ where } A \text{ is constant.}$$

The law of mass: $\Rightarrow f = \frac{B}{\sqrt{\mu}}$, where B is a constant.

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

18. Loudness of sound:

To quantify such thing, we define two different quantities known as intensity and loudness of sound.

(or)
The loudness of sound is defined as "the degree of penetration of sound produced in the ear or the perception of sound by the listener".

19. Overtone:

The frequencies higher than fundamental frequency can be produced by blowing air strongly at open end. Such frequencies are called overtones.

20. Doppler effect:

The frequency of the sound wave observed at different from the frequency of the source. This phenomenon is called Doppler Effect. The frequency

Perceived by the observer is known as apparent frequency. We can consider the following situations for the study of Doppler effect in sound waves.

21. Doppler effect three cases:

- * Source in motion and observer is at rest
 - (a) source moves towards observer
 - (b) source moves away from the observer.
- * Observer in motion and source is at rest.
 - (a) observer moves towards source.
 - (b) observer receding away from the source.
- * Both are in motion:
 - (a) source and observer approach each other.
 - (b) source and observer recede from each other.
 - (c) source chases observer
 - (d) observer chases source.

22. Application of Doppler effect:

- * Doppler effect has many application specific. Doppler effect in light has many applications in astronomy.
- * As an example while observing the spectra from distant objects like stars or galaxies
- * It is possible to determine the velocities at which distant objects like stars or galaxies move towards or away from Earth.

TN-(XI-PHYSICS)

IMPORTANT PROBLEMS MATERIAL

PREPARED BY: Thevaran.K - BAS

1. A radar signal beamed from radar is towards a planet is received 7 minutes later. find the distance of the planet and the earth.

Sol:

Given, 7 minutes.

Let take

$$7 \times 60, c = 3 \times 10^8 \text{ m/s.}$$

$$D = \frac{v \times t}{2} = \frac{3 \times 10^8 \text{ m/s} \times 7 \times 60}{2}$$

$$= 3 \times 10^8 \text{ m/s} \times 210$$

$$D = 6.30 \times 10^{10} \text{ m/s.}$$

2. A displacement of a particle in x-direction vary with time given by $x = 5t^2 + 6t - 2$ find the initial velocity of the particle.

Sol:

Given,

$$x = 5t^2 + 6t - 2$$

$$v = \frac{dx}{dt}$$

$$v = \frac{d}{dt} x \Rightarrow \frac{d}{dt} (5t^2 + 6t - 2)$$

$$\Rightarrow 10t + 6 \dots \dots \rightarrow (1)$$

$t = 0$ is substituting on (1)

$$v = 10(0) + 6$$

$$v = 6 \text{ m.s}^{-1}$$

3. A physical quantity is expressed as $x = \frac{a^3 b^4}{c^2}$ if the error in a, b and c are 1%, 2%, 3% respectively find the error in the measurement of x .

Sol:

Given,

$$x = \frac{a^3 b^4}{c^2}$$

$$\begin{aligned} \frac{\Delta x}{x} \times 100 &= \left(3 \frac{\Delta a}{a} \times 100 \right) + \left(4 \frac{\Delta b}{b} \times 100 \right) + \left(2 \frac{\Delta c}{c} \times 100 \right) \\ &= (3 \times 1\%) + (4 \times 2\%) + (2 \times 3\%) \\ &= 3\% + 8\% + 6\% \end{aligned}$$

$$x = 17\%$$

4. A projectile is thrown with initial speed 10 m/s at an angle of projection 30° find the height reached and range of projectile

Sol:

Given,

$$u = 10 \quad h = ?$$

$$\theta = 30^\circ \quad R = ?$$

$$g = 9.8$$

$$h = \frac{u^2 \sin^2 \theta}{2g}$$

$$h = \frac{10^2 \sin^2 30^\circ}{2 \times 9.8} = \frac{100 \times \frac{1}{2} \times \frac{1}{2}}{2 \times 9.8} = \frac{100 \times \frac{1}{4}}{19.6} = \frac{25}{19.6}$$

$$h = 1.28$$

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$R = \frac{u^2 \sin \theta \cos \theta}{g} = \frac{100 \times \sqrt{3} \times 1}{2 \times 9.8} = \frac{100 \times \sqrt{3}}{19.6}$$

$$R = 8.84$$

5. Using Method of dimensional analysis, obtain an expression for the time period of Simple pendulum the time period of T depends upon (i) mass ' m ' of the bob (ii) length ' l ' of the pendulum (iii) acceleration due to gravity ' g ' at the place, where the pendulum is suspended.

Sol:

Given,

$$T \propto m^a l^b g^c$$

$$T = k \cdot m^a l^b g^c$$

Here k is the dimension constant.

Replacing the above equation with dimensions

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

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

Comparing the powers of M , L and T on the both sides

$$a=0, \quad b+c=0, \quad -2=c=1; \quad c=-1/2.$$

Solving for a , b and c [$a=0$, $b=1/2$ and $c=-1/2$]

From the above equation $T = k \cdot m^0 l^{1/2} g^{-1/2}$

$$T = k \left(\frac{l}{g} \right)^{1/2} = k \sqrt{\frac{l}{g}}$$

Experimentally $k=2\pi$ hence

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

6. The radius of the circle is 3.12 cm. Calculate the area of the circle with respect to significant figures.

Sol: Given,

$$r = 3.12 \text{ cm}$$

$$A = \pi r^2$$

$$A = 3.14 \times 3.12 \times 3.12 = 30.6 \text{ m}^2$$

According to the rule of significant figures

$$\boxed{A = 30.6 \text{ m}^2}$$

7. A car takes a turn with velocity 50 ms⁻¹ on the circular road of radius of curvature 10 m. Calculate the centrifugal force experienced by a person of mass 60 kg inside the car.

Sol:

Given,

$$V = 50 \text{ ms}^{-1} \quad m = 60 \text{ kg}$$

$$r = 10 \text{ m}$$

$$F = \frac{mv^2}{r}$$

$$F = \frac{60 \times 50 \times 50}{10}$$

$$\boxed{F = 15,000 \text{ N}}$$

8. Water is a bucket tied with rope whirled around in vertical line circle of radius 0.5 m . Calculate the minimum velocity at the lowest point so that the water does not spill it in the course of motion ($g = 10\text{ ms}^{-2}$).

Sol:

Given, $r = 0.5\text{ m}$.

The required at the highest point

$$v = \sqrt{gr}$$

$$v = \sqrt{10 \times 0.5}$$

$$v = \sqrt{5}\text{ ms}^{-1}$$

The speed at lowest point $v_1 = \sqrt{5gr} = \sqrt{5 \times 10gr}$

$$\boxed{2\sqrt{5} = 5\text{ ms}^{-1}}$$

9. Suppose an object is thrown with initial speed of 10 m/s at the angle $\frac{\pi}{4}$ with the horizontal. What is the range covered? Suppose the same object is thrown similarly in the moon will there be any change in the range? If yes what is the change? (The acceleration due to gravity in the moon $= \frac{1}{6}g$)

Sol:

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$\theta = \frac{\pi}{4} \quad u = v_0 = 10\text{ ms}^{-1}$$

$$\therefore R_{\text{earth}} = \frac{(10)^2 \sin \frac{\pi}{2}}{9.8} = \frac{100}{9.8}$$

$$R_{\text{earth}} = 10.20\text{ m (approximately 10 m)}.$$

19. Continue,

$$g_{\text{moon}} = \frac{g}{6}$$

$$R_{\text{moon}} = \frac{u^2 \sin 2\theta}{g_{\text{moon}}} = \frac{v_0^2 \sin 2\theta}{g/6}$$

$$\therefore R_{\text{moon}} = 6 R_{\text{earth}}$$

$$R_{\text{moon}} = 6 \times 10.20 = 61.20 \text{ m (Approximately)}$$

10. A vehicle of mass 1250 kg is driven with an acceleration 0.25 ms^{-1} along a straight line level road against an external resistive force 500 N. Calculate the power delivered by the vehicle's engine if the velocity of the vehicle is 30 ms^{-1}

Sol: Given, $m = 1250 \text{ kg}$ $F = 500 \text{ N}$ $a = 0.25 \text{ ms}^{-1}$

$$P = (\text{resistive force} + \text{mass} \times \text{acceleration}) \times \text{velocity}$$

$$P = \vec{F}_{\text{tot}} \cdot \vec{v} = (F_{\text{resistive}} + F) \cdot \vec{v}$$

$$P = \vec{F}_{\text{tot}} \cdot \vec{v} = (F_{\text{resistive}} + ma) \cdot \vec{v}$$

$$P = [500 + 1250 \times 0.25] \times 30$$

$$P = 24.375 \text{ kW}$$

11. The position vectors of two point masses 10 kg and 5 kg are $(-3\hat{i} + 2\hat{j} + 4\hat{k})\text{ m}$ and $(3\hat{i} + 6\hat{j} + 5\hat{k})\text{ m}$ respectively locate the position of Center Mass.

Sol:

$$M_1 = 10\text{ kg}$$

$$\vec{r}_1 = (-3\hat{i} + 2\hat{j} + 4\hat{k})\text{ m.}$$

$$M_2 = 5\text{ kg}$$

$$\vec{r}_2 = (3\hat{i} + 6\hat{j} + 5\hat{k})\text{ m}$$

$$\vec{r} = \frac{M_1 \vec{r}_1 + M_2 \vec{r}_2}{M_1 + M_2}$$

$$\therefore \vec{r} = \frac{(10(-3\hat{i} + 2\hat{j} + 4\hat{k}) + (5(3\hat{i} + 6\hat{j} + 5\hat{k})))}{15}$$

$$\vec{r} = \frac{-30\hat{i} + 20\hat{j} + 40\hat{k} + 15\hat{i} + 30\hat{j} + 25\hat{k}}{15}$$

$$\vec{r} = \frac{-15\hat{i} + 50\hat{j} + 65\hat{k}}{15}$$

$$\boxed{\vec{r} = (-\hat{i} + \frac{10}{3}\hat{j} + \frac{13}{3}\hat{k})}$$

12. A particle moving along the x-axis in such a way that its coordinates x varies with time 't' according to the equation $x = 2 - 5t + 6t^2$ what is the initial velocity of the part

Sol:

$$\text{velocity } v = \frac{dx}{dt} = \frac{d}{dt} (2 - 5t + 6t^2)$$

$$v = -5 + 12t$$

For initial velocity $t = 0$

$$\therefore \text{Initial velocity } \boxed{u = -5\text{ m s}^{-1}}$$

13. If the length of the simple pendulum is increased by 44% from its original length. Calculate the percentage increase in time period of the pendulum.

Sol:

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

$$\therefore T = \text{Constant} \sqrt{l}$$

$$\frac{T_f}{T_i} = \sqrt{\frac{l + \frac{44}{100}l}{l}} = \sqrt{1.44} = 1.2.$$

$$\therefore T_f = 1.2 T_i = T_i + 20\% T_i$$

14. An Oxygen Molecule is travelling in air at 3 and 1 atm and the diameter of oxygen molecule is $1.2 \times 10^{-10} \text{ m}$. Calculate the mean free path of oxygen molecule.

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

$$n = \frac{N}{V} = \frac{P}{KT} = \frac{101.3 \times 10^3}{1.381 \times 10^{-23} \times 300}$$

$$n = 2.449 \times 10^{25} \text{ molecules/m}^3.$$

$$\lambda = \frac{1}{\sqrt{2} \times \pi \times 2.449 \times 10^{25} \times (1.2 \times 10^{-10})^2}$$

$\therefore \pi = 3.14$

$$\lambda = \frac{1}{15.65 \times 10^5}$$

$$\lambda = 0.63 \times 10^{-6} \text{ m}$$

15. Two Pistons of a hydraulic lift have diameter of 60 cm and 5 cm what is the force exerted by the larger piston when 50 N is placed on the smaller piston.

sol:

$$\therefore r = \frac{D}{2}$$

Area of smaller piston $A_1 = \pi \left(\frac{5}{2}\right)^2 = \pi (2.5)^2$

Area of larger piston $A_2 = \pi \left(\frac{60}{2}\right)^2 = \pi (30)^2$

$$F_2 = \frac{A_2}{A_1} \times F_1 = (50 \text{ N}) \times \left(\frac{30}{2.5}\right)^2 = 7200 \text{ N}$$

This means, with the force of 50 N, the force of 7200 N can be lifted.

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