PM SHRI SCHOOLS

LEARNING ENHANCEMENT PROGRAM

CLASS: 11th

Subject: Physics (LEP)

STUDY MATERIAL (Session 2025-26)

LEARNING OUTCOMES

- ☑ Critical Thinking
- ☑ Problem Solving
- ☑ Application of Concepts
- ☑ Analytical Skills
- ☑ Scientific Literacy

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CONTENTS

Key Points Physics 11

Ch 1 Units and Measurement

1. A unitless quantity will always be dimensionless. But reciprocal may not be true. A dimensionless quantity may possess units. For example angle is dimensionless but has units as radian.
2. Physics is a quantitative science, based on measurement of physical quantities. Certain physical quantifies have been chosen as fundamental or base quantities (such as length. mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity).
3. Each base quantity is defined in terms of a certain basic unit (such as metre, kilogram, second, ampere, kelvin, mole and candela). The units for the fundamental or base quantities are called fundamental or base units.
4. Other physical quantities, derived from the base quantities, can be expressed as a combination of the base units and are called derived units. A complete set of units both fundamental and derived, is called a system of units.
5. The International System of Units (SI) based on seven base units is at present internationally accepted unit system and is widely used throughout the world.
6. The SI units have well defined and internationally accepted unit symbols (such as m for metre. kg for kilogram, s for second, A for ampere, N for newton etc.).
7. In measured and computed quantities proper significant figures only should be retained. Rules for determining the number of significant figures, carrying out arithmetic operations with them and rounding off the uncertain digits must be followed.
8. A dimensionally consistent equation need not be actually an exact (correct) equation but a dimensionally wrong or inconsistent equation must be wrong.

Ch 2 Motion in a straight line

1. The path length traversed by an object between two points is, in general, not the same as the magnitude of displacement. The displacement depends only on the end points: the path length (as the name implies) depends on the actual path. In one dimension, the two quantities are equal only if the object does not change its direction during the course of motion. In all other cases, the path length is greater than the magnitude of displacement.
2. In view of point 1 above, the average speed of an object is greater than or equal to the magnitude of the average velocity over a given time interval. The two are equal only if the path length is equal to the magnitude of displacement.
3. The origin and the positive direction of an axis are a matter of choice. You should first specify this choice before you assign signs to quantities like displacement, velocity and acceleration.
4. If a particle is speeding up, acceleration is in the direction of velocity, if its speed is decreasing, acceleration is in the direction opposite to that of the velocity. This statement is independent of the choice of the origin and the axis.
5. The sign of acceleration does not tell us whether the particle's speed is increasing or decreasing. The sign of acceleration (as mentioned in point 3) depends on the choice of the positive direction of the axis. For example, if the vertically upward direction is chosen to be the positive direction of the axis, the acceleration due to gravity is negative. If a particle is falling under gravity, this acceleration, though negative, results in increase in speed. For a particle thrown upward, the same negative acceleration (of gravity) results in decrease in speed.

6. The zero velocity of a particle at any instant does not necessarily imply zero acceleration at that instant. A particle may be momentarily at rest and yet have non-zero acceleration. For example, a particle thrown up has zero velocity at its uppermost point but the acceleration at that instant continues to be the acceleration due to gravity.

Ch 3 Motion in a Plane

1. It is not necessary that all the quantities having magnitude and direction should be called vectors. For example current has both magnitude and direction yet it is a scalar quantity because current obeys the scalar laws not vector laws.
2. The kinematic equations for uniform acceleration do not apply to the case of uniform circular motion, since in this case the magnitude of acceleration is constant but its direction is changing.
3. The resultant acceleration of an object in circular motion is towards the centre only if the speed is constant.
4. The shape of the trajectory of the motion of an object is not determined by the acceleration alone but also depends on the initial conditions of motion (initial position and initial velocity). For example, the trajectory of an object moving under the same acceleration due to gravity can be a straight line or a parabola depending on the initial conditions.
5. The path of a parabola never becomes a straight line. It always remains inclined somewhat to the horizontal. Therefore, more is the height of projection point, more will be the range of projectile.

Ch 4 Laws of Motion

1. Force is not always in the direction of motion. Depending on the situation, F may be along v, opposite to v, normal to v or may make some other angle with v. In every case, it is parallel to acceleration.
2. If v = 0 at an instant i.e. If a body is momentarily at rest, it does not mean that force or acceleration are necessarily zero at that instant. For example, when a ball thrown upward reaches its maximum height, v = 0 but the force continues to be its weight mg and the acceleration is not zero but g.
3. Force on a body at a given time is determined by the situation at the location of the body at that time. Force is not 'carried' by the body from its earlier history of motion. The moment after a stone is released out of an accelerated train, there is no horizontal force (or acceleration) on the stone, if the effects of the surrounding air are neglected. The stone then has only the vertical force of gravity.
4. In the second law of motion F = ma, F stands for the net force due to all material agencies external to the body. a is the effect of the force. ma should not be regarded as yet another force, besides F.
5. The centripetal force should not be regarded as yet another kind of force. It is simply a name given to the force that provides inward radial acceleration to a body in circular motion. We should always look for some material force like tension, gravitational force, electrical force, friction, etc as the centripetal force in any circular motion.
6. Static friction is a self-adjusting force up to its limit $\mu_S N$ ($F_S \leq \mu_S N$). Do not put $F_S = \mu_S N$ without being sure that the maximum value of static friction is coming into play.
7. The familiar equation mg = R for a body on a table is true only if the body is in equilibrium. The two forces mg and R can be different (e.g. a body in an accelerated lift). The equality of mg and R has no connection with the third law.
8. The terms 'action' and 'reaction' in the third law of motion simply stand for simultaneous mutual forces between a pair of bodies. Unlike their meaning in ordinary language, action does not precede or cause reaction. Action and reaction act on different bodies.

9. The different terms like 'friction', 'normal reaction' 'tension', 'air resistance', 'viscous drag', ''thrust', 'buoyancy', 'weight', 'centripetal force' all stand for 'force' in different contexts. For clarity, every force, and its equivalent terms encountered in mechanics should be reduced to the phrase force on A by B
10. For applying the second law of motion, there is no conceptual distinction between inanimate and animate objects. An animate object such as a human also requires an external force to accelerate. For example, without the external force, of friction, we cannot walk on the ground.
11. The objective concept of force in physics should not be confused with the subjective concept of the 'feeling of force. On a merry-go-around, all parts of our body are subject to an inward force, but we have a feeling of being pushed outward the direction of impending motion.

Ch 5 Work, Energy and Power

1. The phrase 'calculate the work done' is incomplete. We should refer to the work done by a specific force or a group of forces on a given body over a certain displacement.
2. Work done is a scalar quantity. It can be positive or negative unlike mass and kinetic energy which are positive scalar quantities. The work done by the friction or viscous force on a moving body is negative.
3. For two bodies, the sum of the mutual forces exerted between them is zero from Newton's Third Law, $F_{12} + F_{21} = 0$, But the sum of the work done by the two forces need not always cancel, i.e. $W_{12} + W_{21} \neq 0$ However, it may sometimes be true.
4. The WE theorem is not independent of Newton's second law. The WE theorem may be viewed as a scalar form of the second law. The principle of conservation of mechanical energy may be viewed as a consequence of the WE theorem for conservative forces.
5. The WE theorem holds in all inertial frames. It can also be extended to non-inertial frames provided we include the pseudo forces in the calculation of the net force acting on the body under consideration.
6. Every force encountered in mechanics does not have an associated potential energy. For example, work done by friction over a closed path is not zero and no potential energy can be associated with friction.
7. During a collision: (a) the total linear momentum is conserved at each instant of the collision (b) the kinetic energy conservation (even if the collision is elastic) applies after the collision is over and does not hold at every instant of the collision. In fact the two colliding objects are deformed and may be momentarily at rest with respect to each other.

Ch 6 Systems of Particles and Rotational Motion

1. To determine the motion of the centre of mass of a system no knowledge of internal forces of the system is required. For this purpose we need to know only the external forces on the body.
2. Separating the motion of a system of particles as the motion of the centre of mass, (i.e. the translational motion of the system) and motion about the centre of mass of the system is a useful technique in dynamics of a system of particles. One example of this technique is separaṭing the kinetic energy of a system of particles K' as the kinetic energy of the system about its centre of mass K and the kinetic energy of the centre of mass $MV^2/2$.
$K' = K + MV^2/2$
3. Newton's second law for finite sized bodies (or systems of particles) is based in Newton's second law and also Newton's third law for particles.
4. To establish that the time rate of change of the total angular momentum of a system of particles is the total external torque in the system, we need not only Newton's second law for particles, but also Newton's third law with the provision that the forces between any two particles act along the line joining the particles.
5. The vanishing of the total external force and the vanishing of the total external torque are independent

conditions. We can have one without the other. In a couple, total external force is zero, but total torque is non-zero.
6. The total torque on a system is independent of the origin if the total external force is zero.
7. The centre of gravity of a body coincides with its centre of mass only if the gravitational field does not vary from one part of the body to the other.
8. The angular momentum L and the angular velocity are not necessarily parallel vectors. However, for the simpler situations discussed in this chapter when rotation is about a fixed axis which is an axis of symmetry of the rigid body, the relation L = lω holds good. where I is the moment of the inertia of the body about the rotation axis.

Ch 7 Gravitation

1. In considering motion of an object under the gravitational influence of another object the following quantities are conserved: (a) Angular momentum (b) Total mechanical energy
Linear momentum is not conserved
2. Angular momentum conservation leads to Kepler's second law. However, it is not special to the inverse square law of gravitation. It holds for any central force.
3. In Kepler's third law $T^2 = KR^3$, the constant K is the same for all planets in circular orbits. This applies to satellites orbiting the earth.
4. An astronaut experiences weightlessness in a space satellite. This is not because the gravitational force is small at that location in space. It is because both the astronaut and the satellite are in "free fall" towards the earth.
5. The gravitational potential energy associated with two particles separated by a distance r is given by
$V = -\frac{Gm_1m_2}{r} + \text{constant}$
The constant can be given any value. The simplest choice is to take it to be zero.
With this choice $V = -\frac{Gm_1m_2}{r}$ This choice implies that $V \rightarrow 0$ as $r \rightarrow \infty$. Choosing location of zero of the gravitational energy is the same as choosing the arbitrary constant in the potential energy. Note that the gravitational force is not altered by the choice of this constant.
6. The total mechanical energy of an object is the sum of its kinetic energy (which is always positive) and the potential energy. Relative to infinity (i.e. if we presume that the potential energy of the object at infinity is zero), the gravitational potential energy of an object is negative. The total energy of a satellite is negative.
7. The commonly encountered expression mgh for the potential energy is actually an approximation to the difference in the gravitational potential energy discussed in the point 6, above.
8. Although the gravitational force between two particles is central, the force between two finite rigid bodies is not necessarily along the line joining their centre of mass. For a spherically symmetric body however the force on a particle external to the body is as if the mass is concentrated at the centre and this force is therefore central.
9. The gravitational force on a particle inside a spherical shell is zero. However, (unlike a metallic shell which shields electrical forces) the shell does not shield other bodies outside it from exerting gravitational forces on a particle inside. Gravitational shielding is not possible.

Ch 8 Solids

1. In the case of a wire, suspended from ceiling and stretched under the action of a weight (F) suspended from its other end, the force exerted by the ceiling on it is equal and opposite to the weight. However, the

tension at any cross-section A of the wire is just F and not 2F. Hence, tensile stress which is equal to the tension per unit area is equal to F/A.
2. Hooke's law is valid only in the linear part of stress-strain curve.
3. The Young's modulus and shear modulus are relevant only for solids since only solids have lengths and shapes.
4. Bulk modulus is relevant for solids, liquid and gases. It refers to the change in volume when every part of the body is under the uniform stress so that the shape of the body remains unchanged.
5. Metals have larger values of Young's modulus than alloys and elastomers. A material with large value of Young's modulus requires a large force to produce small changes in its length.
6. In daily life, we feel that a material which stretches more is more elastic, but it is a misnomer. In fact material which stretches to a lesser extent for a given load is considered to be more elastic.
7. In general, a deforming force in one direction can produce strains in other directions also. The proportionality between stress and strain in such situations cannot be described by just one elastic constant. For example, for a wire under longitudinal strain, the lateral dimensions (radius of cross section) will undergo a small change, which is described by another elastic constant of the material (called Poisson ratio).
8. Stress is not a vector quantity since, unlike a force, the stress cannot be assigned a specific direction. Force acting on the portion of a body on a specified side of a section has a definite direction.

Ch 9 Mechanical Properties of Fluids

1. Pressure is a scalar quantity. The definition of the pressure as "force per unit area" may give one false impression that pressure is a vector. The "force" in the numerator of the definition is the component of the force normal to the area upon which it is impressed. While describing fluids as a concept, shift from particle and rigid body mechanics is required. We are concerned with properties that vary from point to point in the fluid.
2. One should not think of pressure of a fluid as being exerted only on a solid like the walls of a container or a piece of solid matter immersed in the fluid. Pressure exists at all points in a fluid. An element of a fluid is in equilibrium because the pressures exerted on the various faces are equal.
3. The expression for pressure $P = P_a + \rho gh$ holds true if fluid is incompressible. Practically speaking it holds for liquids, which are largely incompressible and hence is a constant with height.
4. The gauge pressure is the difference of the actual pressure and the atmospheric pressure. $P - Pa = Pg$ Many pressure-measuring devices measure the gauge pressure. These include the tyre pressure gauge and the blood pressure gauge (sphygmomanometer).
5. A streamline is a map of fluid flow. In a steady flow two streamlines do not intersect as it means that the fluid particle will not have two possible velocities at the point.
6. Bernoulli's principle does not hold in presence of viscous drag on the fluid. The work done by this dissipative viscous force must be taken into account in this case.
7. As the temperature rises, the atoms of the liquid become more mobile and the coefficient of viscosity, η falls. In a gas the temperature rise increases the random motion of atoms and η increases.
8. Surface tension arises due to excess potential energy of the molecules on the surface in comparison to their potential energy in the interior. Such a surface energy is present at the interface separating two substances at least one of which is a fluid. It is not the property of a single fluid alone.

Ch 10 Thermal Properties of Matter

1. The relation connecting Kelvin temperature (T_K) and the Celsius temperature T_C, $T_K = T_C + 273.15$ and the assignment T = 273.16 K for the triple point of water are exact relations (by choice). With this choice, the Celsius temperature of the melting point of water and boiling point of water (both at 1 atm pressure) are very close to, but not exactly equal to 0 °C and 100 °C respectively. In the original Celsius scale, these latter fixed points were exactly at 0 °C and 100 °C (by choice), but now the triple point of water is the preferred choice for the fixed point, because it has a unique temperature.
2. A liquid in equilibrium with vapour has the same pressure and temperature throughout the system; the two phases in equilibrium differ in their molar volume (i.e. density). This is true for a system with any number of phases in equilibrium.
3. Heat transfer always involves temperature difference between two systems or two parts of the same system. Any energy transfer that does not involve temperature difference in some way is not heat.
4. Convection involves flow of matter within a fluid due to unequal temperatures of its parts. A hot bar placed under a running tap loses heat by conduction between the surface of the bar and water and not by convection within water.

Ch 11 Thermodynamics

1. Temperature of a body is related to its average internal energy, not to the kinetic energy of motion of its centre of mass. A bullet fired from a gun is not at a higher temperature because of its high speed.
2. Equilibrium in thermodynamics refers to the situation when macroscopic variables describing the thermodynamic state of a system do not depend on time. Equilibrium of a system in mechanics means the net external force and torque on the system are zero.
3. In a state of thermodynamic equilibrium, the microscopic constituents of a system are not in equilibrium (in the sense of mechanics).
4. Heat capacity, in general, depends on the process the system goes through when heat is supplied.
5. In isothermal quasi-static processes, heat is absorbed or given out by the system even though at every stage the gas has the same temperature as that of the surrounding reservoir. This is possible because of the infinitesimal difference in temperature between the system and the reservoir.

Ch 12 Kinetic Theory

1. Pressure of a fluid is not only exerted on the wall. Pressure exists everywhere in a fluid. Any layer of gas inside the volume of a container is in equilibrium because the pressure is the same on both sides of the layer.
2. We should not have an exaggerated idea of the intermolecular distance in a gas. At ordinary pressures and temperatures, this is only 10 times or so the interatomic distance in solids and liquids. What is different is the mean free path which in a gas is 100 times the interatomic distance and 1000 times the size of the molecule.
3. The law of equipartition of energy is stated thus: the energy for each degree of freedom in thermal equilibrium is $\frac{1}{2} k_BT$. Each quadratic term in the total energy expression of a molecule is to be counted as a degree of freedom. Thus, each vibrational mode gives 2 (not 1) degrees of freedom (kinetic and potential energy modes), corresponding to the energy $2 \times \frac{1}{2} k_BT = k_BT$.
4. Molecules of air in a room do not all fall and settle on the ground (due to gravity) because of their high speeds and incessant collisions. In equilibrium, there is a very slight increase in density at lower heights (like in the atmosphere). The effect is small since the potential energy (mgh) for ordinary heights is much less than the average kinetic energy $\frac{1}{2} mv^2$ of the molecules.

5. $< v^2 >$ is not always equal to $(< v >)^2$. The average of a squared quantity is not necessarily the square of the average.

Ch 13 Oscillations

1. The period T is the least time after which motion repeats itself. Thus, motion repeats itself after nT where n is an integer.
2. Every periodic motion is not simple harmonic motion. Only that periodic motion governed by the force law $F = -k\,x$ is simple harmonic.
3. For linear simple harmonic motion with a given ω, two initial conditions are necessary and sufficient to determine the motion completely. The initial conditions may be (i) initial position and initial velocity or (ii) amplitude and phase or (iii) energy and phase.
4. From point 3 above, given amplitude or energy, phase of motion is determined by the initial position or initial velocity.
5. A combination of two simple harmonic motions with arbitrary amplitudes and phases is not necessarily periodic. It is periodic only if frequency of one motion is an integral multiple of the other's frequency. However, a periodic motion can always be expressed as a sum of infinite number of harmonic motions with appropriate amplitudes.
6. The period of SHM does not depend on amplitude or energy or the phase constant. Contrast this with the periods of planetary orbits under gravitation (Kepler's third law).
7. The motion of a simple pendulum is simple harmonic for small angular displacement.
8. For motion of a particle to be simple harmonic, its displacement x must be expressible in either of the following forms : $x = A\cos\omega t + B\sin\omega t$, $x = A\cos(\omega t + \alpha)$, $x = B\sin(\omega t + \beta)$ The three forms are completely equivalent (any one can be expressed in terms of any other two forms).

Ch 14 Waves

1. A wave is not motion of matter as a whole in a medium. A wind is different from the sound wave in air. The former involves motion of air from one place to the other. The latter involves compressions and rarefactions of layers of air.
2. In a wave, energy and not the matter is transferred from one point to the other.
3. In a mechanical wave, energy transfer takes place because of the coupling through elastic forces between neighbouring oscillating parts of the medium.
4. Transverse waves can propagate only in medium with shear modulus of elasticity, Longitudinal waves need bulk modulus of elasticity and are therefore, possible in all media, solids, liquids and gases.
5. In a harmonic progressive wave of a given frequency, all particles have the same amplitude but different phases at a given instant of time. In a stationary wave, all particles between two nodes have the same phase at a given instant but have different amplitudes.
6. Relative to an observer at rest in a medium the speed of a mechanical wave in that medium (v) depends only on elastic and other properties (such as mass density) of the medium. It does not depend on the velocity of the source.

1. UNITS AND MEASUREMENT

MULTIPLE CHOICE QUESTIONS:

1. **The units that are used for fundamental physical quantities are called**
(A) System of units (B) fundamental units
(C) Derived units (D) All of these
2. **Which of the following physical quantity has same unit in CGS, FPS, MKS and SI systems of unit?**
(A) Mass (B) Length (C) Time (D) Energy
3. **Which of the following physical quantity is not a fundamental quantity?**
(A) Length (B) temperature (C) electric current (D) energy
4. **The SI unit of electric current is**
(A) watt (B) joule (C) volt (D) ampere
5. **The SI unit of solid angle is**
(A) Radian (B) degree (C) steradian (D) radian/metre
6. **pascal is the unit of**
(A) force (B) pressure (C) force (D) energy
7. **The SI unit of frequency is**
(A) metre/second (B) radian/second (C) newton-metre (D) hertz
8. **Which of the following statement is incorrect regarding significant figures?**
(A) All non-zero digits are significant.
(B) All the zeros between two non-zero digits are significant.
(C) The trailing zero(s) in a number with a decimal point are significant.
(D) The power of 10 is counted while counting the number of significant figures.
9. **The number of significant figures in 30600**
(A) 3 (B) 2 (C) 5 (D) 4
10. **The number of significant figures in 0.03400**
(A) 2 (B) 3 (C) 4 (D) 5
11. **Which of the following pairs of physical quantities have same dimensions?**
(A) Force and power (B) force and torque
(C) Torque and work (D) torque and power
12. **The dimensional formula of frequency**
(A) $[M^0L^0T^{-1}]$ (B) $[M^0L^1T^{-2}]$ (C) $[M^1L^1T^{-2}]$ (D) $[M^0L^1T^0]$
13. **The dimensional formula of gravitational constant**
(A) $[M^{-1}L^3T^{-2}]$ (B) $[M^1L^3T^{-2}]$ (C) $[M^2L^3T^{-1}]$ (D) $[M^2L^{-2}T^0]$
14. **Which of the following physical quantity has a unit but no dimensions?**
(A) Strain (B) relative density (C) plane angle (D) stress
15. **Which of the following constant is a dimensionless constant?**
(A) G (B) π (C) c (D) h
16. **The physical quantity having the dimensions $[M^1L^{-1}T^{-2}]$ is**
(A) Angular momentum(B) energy (C) pressure (D) force
17. **Statement i: When we change the unit of measurement of a quantity, its numerical value changes.**
Statement ii: Smaller the unit of measurement smaller is its numerical value.
(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.
18. **Statement i: The units of a derives are expressed as combination of the basic units**
Statement ii: There are only seven basic quantities
(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement i is true but statement ii is false. (D) Both the statements are false.

19. Statement i: The number of significant figures in 3050 is three and the number 0.02300 has four significant figures.

Statement ii: All non-zero digits are significant.

(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement I is true but statement ii is false.
(D) Both the statements are false.

20. If force F, acceleration A and time T are basic physical quantities, the dimensions of energy are

(A) $[F^2A^{-1}T^1]$ (B) $[F^1A^1T^2]$ (C) $[F^1A^1T^{-2}]$ (D) $[F^1A^{-1}T^1]$

FILL IN THE BLANKS

(***strain, plane angle, temperature, frequency, significant***)

1. ________ is a basic physical quantity.
2. In a number, the zeros between two non-zero digits are _________
3. ___________ is a supplementary quantity.
4. The physical quantity that has neither a unit nor a dimesion is ___________
5. The physical quantity having the dimension $[M^0L^0T^{-1}]$ is ___________

TWO MARK QUESTIONS

1. What are basic units? Give one example.
2. Write the SI unit and dimensional formula for moment of inertia.
3. State the principle of homogeneity of dimensions.
4. Give any two limitations of dimensional method.

THREE MARK QUESTIONS

1. Check the dimensional correctness of the equation $x = v_0t + ½\ at^2$ where the symbols having their usual meaning.
2. Check the dimensional correctness of the equation $T = 2\pi\sqrt{\frac{L}{g}}$ where L is the length of a simple pendulum, T is its time period and g is the acceleration due to gravity.
3. Derive the expression for period of a simple pendulum which depends on its length (l) and acceleration due to gravity (g) using dimensional analysis.

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	**C**	**D**	**D**	**C**	**B**	**D**	**D**	**A**	**C**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	**A**	**A**	**C**	**B**	**C**	**C**	**A**	**B**	**B**

ANSWERS TO FIBS:

1. temperatutre; 2. singnificant 3. plane angle 4. strain 5. frequency

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2. MOTION IN A STRAIGHT LINE

MULTIPLE CHOICE QUESTIONS:

1. If the distance covered by a particle is zero, then it's displacement

(A) may or may not be zero (B) cannot be zero
(C) must be zero (D) negative

2. The numerical ratio of distance travelled to displacement is

(A) always equal to one (B) always less than one
(C) always more than one (D) greater than equal to one

3. The area under velocity-time graph represents

(A) displacement (B) uniform acceleration
(C) average speed (D) average velocity

4. The slope of the tangent drawn to position-time graph at any instant gives

(A) Instantaneous velocity (B) instantaneous acceleration
(C) Average velocity (D) average speed

5. Stopping distance of a vehicle moving with uniform acceleration is directly proportional to

(A) Acceleration (B) square of the acceleration
(C) initial velocity (D) square of initial velocity

6. The slope of velocity time graph gives

(A) average velocity (B) acceleration
(C) average speed (D) distance travelled

7. When a body thrown vertically upward, it will take t time to reach its highest point. Then the time taken to return to ground is

(A) 2t (B) t^2 (C) t (D) $\sqrt{t}$

8. A body thrown from the top of a tower in horizontal direction and at the same time another body dropped from the same point. The two bodies will reach the earth

(A) Simultaneously (B) dropped body reached first
(C) depending on their masses (D) horizontally thrown body reach first

9. A body cannot have

(A) A constant speed and varying velocity (B) an acceleration and a constant speed
(C) A uniform velocity and varying speed (D) non zero speed and zero acceleration.

10. A body is released from the certain height. After falling for some time, suppose the acceleration due to gravity vanishes. Then

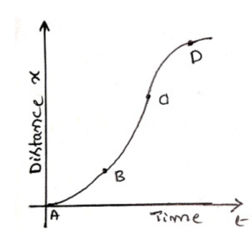
(A) Body continues to move with uniform acceleration.
(B) Body continues to move with uniform retardation.
(C) Body continues to move with uniform variable velocity
(D) Body continues to move with uniform/constant velocity.

11. A vehicle travels half the distance L with speed v_1 and the other half with speed v_2, then its average speed is

(A) $\frac{v_1 + v_2}{2}$ (B) $\frac{2v_1 + v_2}{v_1 + v_2}$ (C) $\frac{2v_1\, v_2}{v_1 + v_2}$ (D) $\frac{L(v_1 + v_2)}{v_1\, v_2}$

12. The distance-time graph for a particle in motion as shown in figure. The maximum instantaneous velocity of the particle is around the point.

(A) A (B) C (C) B (D) D



13. Statement i: The displacement of a body may be zero, when distance travelled by it is not zero.
Statement ii: The displacement is the longer distance between initial and final position

(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

14. Statement i: The average speed of an object is greater than or equal to the average velocity over a given time interval.
Statement ii: The two are equal only if the path length is equal to the magnitude of displacement.

(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

15. Statement i: A particle may be momentarily at rest and yet have non-zero acceleration.
Statement ii: The zero velocity of a particle at any instant does not necessarily imply zero acceleration at that instant.

(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

16. Statement i: An object may fall with a constant velocity.
Statement ii: This happens when acceleration of the object is equal to acceleration due to gravity.

(A) Both the statements are true and statement ii is the correct explanation of statement i.
(B) Both the statements are true but statement ii is not correct explanation of statement i
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

FILL IN THE BLANKS:

(velocity, uniform acceleration, displacement, scalar, downwards)

1. The shortest distance between initial and final position of a body in motion is called ___________
2. Speed is a __________ quantity.
3. If body has equal changes in velocity in equal intervals of time, the body is said to be in ________
4. The slope of position-time graph of a body in uniform motion gives ______________
5. A body moving under earth's gravitational field, the direction of acceleration is always ____________

TWO MARK QUESTIONS:

1. Write any two differences between instantaneous speed and instantaneous velocity.
2. Draw a position-time graph for a body moving with constant speed.
3. Draw a position-time graph for a body moving in positive direction with negative acceleration.
4. Define average velocity and uniform velocity.
5. A body moving with an initial velocity 5m/s and uniform acceleration 1 m/s^2. Determine its velocity after 20 s. **[25 m/s]**

THREE MARK QUESTIONS:

1. Derive the expression $v = v_0 + at$ using velocity-time graph.
2. Derive the expression $v^2 = v_0^2 + 2ax$ using $v - t$ graph.
3. Mention three applications of velocity-time graph.
4. A car moving along a straight road with a speed of 126 km/h is brought to a stop within a distance of 200 m. What is the retardation of the car? **($3.06\ ms^{-2}$)**

5. A stone thrown vertically upward with velocity of 20 m/s. Calculate the maximum height reached by it. ($g = 10\ ms^{-2}$). **(20 m)**

FIVE MARK QUESTIONS:

1. Derive the expression $x = v_0t + \frac{1}{2}at^2$ using velocity-time graph.

2. A body covers the first one-third distance at a constant speed of $20ms^{-1}$, next one-third distance with a speed of $40\ ms^{-1}$ and last one-third distance at $60\ ms^{-1}$. Calculate the average velocity of the body over the complete journey. **($32.72\ ms^{-1}$)**

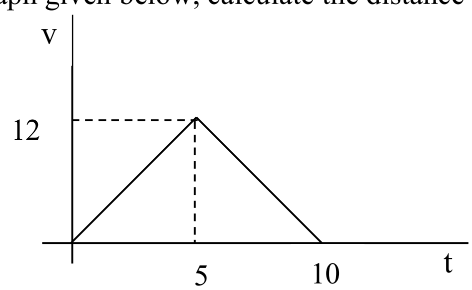
3. A player throws a ball vertically upwards with a speed of $29.4\ ms^{-1}$. Calculate
(i) maximum height attained by the ball (ii) time taken by the ball to reach the highest point.
(h = 44.1m, t = 3s)

4. A body let fall from the top of a tower covers 45 m in the last second of its fall. Find the height of the tower. ($g = 10\ ms^{-2}$). **(125 m)**

5. A body projected vertically upwards with a velocity of $15\ ms^{-1}$ from the top of a tower reaches ground in 5s. Find the height of the tower. ($g = 9.8\ ms^{-2}$). **(47.52m)**

6. A ball A thrown vertically upwards reaches the balcony of a house 100m high. At the same time another ball B is dropped from rest from the balcony of the house. When and where will the two balls pass each other. ($g = 10\ ms^{-2}$). **($t = \sqrt{5}$ s, at a height x = 75m above the ground)**

7. From the velocity time graph given below, calculate the distance travelled during the time interval 2s to 6 s.



(36m)

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
C	**D**	**A**	**A**	**D**	**B**	**C**	**A**
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
C	**D**	**C**	**B**	**C**	**A**	**A**	**C**

ANSWERS TO FIBS:

1. displacement; 2. scalar; 3. uniform acceleration; 4. velocity; 5. downwards

****

3. MOTION IN A PLANE

MULTIPLE CHOICE QUESTIONS:

1. **The physical quantity that has both magnitude and direction is called**
   (A) Scalar (B) vector (C) dimensional (D) phasor
2. **Which of the following is not a vector quantity?**
   (A) work (B) impulse (C) displacement (D) momentum
3. **Two vectors are said to be equal if they have**
   (A) Only same magnitude (B) same magnitude and perpendicular
   (C) Only in same direction (D) same magnitude and same direction
4. **If a vector is multiplied by a positive scalar, the resulting quantity is**
   (A) A scalar having same magnitude as initial vector.
   (B) A vector having same direction as initial vector.
   (C) A vector having different direction of initial vector.
   (D) A scalar having magnitude different from that of initial vector.
5. **Which of the following statement is incorrect?**
   (A) In one dimensional motion, the velocity and acceleration of an object are always along the same line
   (B) In two or three dimensional motion the angle between velocity and acceleration vectors may have any value between 0^o and 180^o.
   (C) The maximum height attained by a projectile is always equal to its horizontal rage.
   (D) The resultant acceleration of an object in circular motion is towards the centre only if the speed is constant.
6. **It is found that $\vec{A} + \vec{B} = \vec{A}$. This necessarily implies**
   (A) $\vec{B} = 0$ (B) $\vec{A}$ *and* $\vec{B}$ are opposite to each other
   (C) $\vec{A}$ *and* $\vec{B}$ are perpendicular to each other (D) $\vec{A}.\vec{B} \leq 0$
7. **The motion in a plane can be treated as superposition of two separate simultaneous one dimensional motion along two ________ directions.**
   (A) Same (B) perpendicular (C) opposite (D) any
8. **The resultant of two vectors acting at a point is minimum if they are**
   (A) in same direction (B) perpendicular to each other
   (C) making an angle 120^o with each other (D) opposite to each other
9. **In a projectile motion, the maximum range is always equal to**
   (A) maximum height (B) twice of the maximum height
   (C) thrice of the maximum height (D) four times the maximum height.
10. **At maximum height, the velocity and accelerations of the projectile are**
    (A) In same direction (B) perpendicular to each other
    (C) Opposite to each other (D) both are zero
11. **For maximum range for a projectile, the angle of projection should be**
    (A) 45^o (B) 30^o (C) 60^o (D) 90^o
12. **For maximum height of a projectile, the angle of projection should be**
    (A) 45^o (B) 30^o (C) 60^o (D) 90^o
13. **The trajectory of a projectile motion is a**
    (A) parabola (B) straight line (C) circle (D) hyperbola
14. **If a body is projected with an angle θ to the horizontal, then**
    (A) Its velocity is always perpendicular to its acceleration.
    (B) Its velocity becomes zero at its maximum height.
    (C) Its velocity is in horizontal direction at maximum height
    (D) When the just hitting the ground, its velocity and acceleration are in same direction.
15. **The centripetal acceleration is**
    (A) Directly proportional to its velocity and radius of the circular path.
    (B) Directly proportional to its velocity and inversely radius of the circular path.

(C) Directly proportional to its square of its velocity and inversely proportional to square of the radius of the circle.
(D) Directly proportional to its square of its velocity and inversely proportional to the radius of the circular path.

16. **Statement i: Vectors addition is commutative.**
Statement ii: Two vectors may be added graphically using triangle law of vector addition.
(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement two is not correct explanation for statement i.
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

17. **Statement i: The difference of two vectors can be treated as sum of two vectors.**
Statement ii: Subtraction of vectors can be defined in terms of addition of vectors.
(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement two is not correct explanation for statement i.
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

18. **Statement i: For the motion in two or three dimensions, velocity and acceleration vectors must have any angle from 0^0 to 90^0 between them.**
Statement ii: For such motion velocity and acceleration of an object is always in the opposite direction.
(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement two is not correct explanation for statement i.
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

19. **Statement i: The trajectory of a projectile motion under the acceleration due to gravity can be a straight line.**
Statement ii: The shape of the trajectory of the motion of an objects determined by the Acceleration alone.
(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement two is not correct explanation for statement i.
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

20. **Statement i: Centripetal acceleration is always directed towards the centre of the circular path.**
Statement ii: Centripetal acceleration is a constant vector.
(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement two is not correct explanation for statement i.
(C) Statement i is true but statement ii is false.
(D) Both the statements are false.

21. **Statement i: In projectile motion, the angle between the instantaneous velocity and acceleration at the highest point is 180°.**
Statement ii: At the highest point, velocity of projectile will be in horizontal direction only.
(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement two is not correct explanation for statement i.
(C) Statement i is true but statement ii is false.
(D) Statement i is false and statement ii is correct.

FILL IN THE BLANKS:

(resolution, unit, speed, null, horizontal, same direction)

1. A vector with zero magnitude is called________ vector.
2. The splitting up of a vector into two or more components are called _______ of vector.
3. The resultant of two vectors is maximum if they are acting in __________
4. _________ velocity remains constant throughout the motion of a projectile.
5. In uniform circular motion, the body moves in a circle with constant ___________

TWO MARK QUESTIONS:

1. Define scalar product of two vectors. Give an example for scalar product of vector.
2. Write the expression for resultant of two concurrent vectors ***A*** and ***B*** and explain the terms.
3. Write the expression for time of flight of a projectile motion and explain the terms.
4. Write the expression for range of a projectile and explain the terms.
5. Write the expression for centripetal acceleration and explain the terms.

THREE MARK QUESTIONS:

1. Explain the triangle method of vector addition.
2. If $\vec{A} = 3\hat{\imath} + 2\hat{\jmath}$ and $\vec{B} = \hat{\imath} - 2\hat{\jmath} + 3\hat{k}$, find the magnitude of $\vec{A} + \vec{B}$.
3. Two forces of 4 N and 3 N act at a point making an angle of 60º with one another. Find the magnitude of resultant of the two forces.
4. Obtain the expression for time of flight of a projectile motion.
5. Obtain the expression for maximum height of a projectile motion.
6. A projectile is projected at an angle of 30º to the horizontal with an initial speed of 20 ms^{-1}. Calculate its time of flight.
7. Obtain the expression for horizontal range of a projectile motion.
8. A stone of mass 2 kg is tied with a string of length 1.5 m is rotating in a circle with a constant speed of 10 ms^{-1}. Calculate its centripetal acceleration.

FIVE MARK QUESTIONS:

1. Derive the expression for magnitude and direction of resultant of two concurrent vectors.
2. Obtain the equation of path of a projectile. OR
   Show that the trajectory of a projectile is a parabola.
3. What is centripetal acceleration? Derive the expression for centripetal acceleration.
4. The resultant of two forces acting at an angle of 120º is at right angle to the smaller force. If the greater force is 8 N, find the smaller force and the resultant. **(F = 4 N, R = 6.93 N)**
5. A football player kicks a ball at an angle of 30º to the horizontal with an initial speed of 20 ms^{-1}. Calculate (A) maximum height and (B) horizontal range reached by the ball. **(H = 5 m, R = 34.64 m).**
6. The ceiling of a long hall is 25m high. What is the maximum horizontal distance that a ball thrown with a speed of 40ms^{-1} can go without hitting the ceiling of the hall? **(150.5m)**
7. A foot ball player kicks a ball so that it just clears a 4 m high wall at a distance of 5 m. It falls at a distance of 11 m from the wall. Determine the initial speed and the angle of projection of the ball. **(v_0 = 12.59 ms^{-1}, θ = 49.3º)**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11
B	A	D	C	C	A	B	B	D	B	A
12	13	14	15	16	17	18	19	20	21	
D	A	C	D	B	A	D	C	B	D	

ANSWERS TO FIBS:

1. null; 2. resolution; 3. same direction; 4. horizontal 5. speed

****

4. LAWS OF MOTION

MULTIPLE CHOICE QUESTIONS:

1. **No force is required to keep**
(A) an object moving in circular motion
(B) an object moving in straight line with constant velocity
(C) an object moving with constant acceleration
(D) an object moving in elliptical path.

2. **What is the term for an object's tendency to resist changes in the state of motion?**
(A) Friction (B) Force (C) Momentum (D) Inertia

3. **The ratio of force on an object to its acceleration is:**
(A) mass (B) velocity (C) momentum (D) mass density

4. **What happens to the acceleration of an object when the force applied to it increases?**
(A) Decreases (B) Remains constant (C) Increases (D) Become zero

5. **When object A exerts a force on object B, what force does object B exert on object A?**
(A) Equal force in same direction (B) Equal force in opposite direction
(C) Lesser force in same direction (D) Greater force in opposite direction

6. **Forces always occurs in**
(A) Triplets (B) Quarters (C) Pairs (D) None

7. **Rocket works on the principle of conservation of:**
(A) Energy (B) Momentum (C) Mass (D) All of these

8. **A force F is applied to object for time Δt. What is the impulse?**
(A) I = F/**Δ**t (B) I = F**Δ**t **(C) I = ΔpΔt** **(D)** I = Δp/Δt

9. **The component of contact force that is perpendicular to the surface in contact is referred to as:**
(A) Frictional force (B) Normal reaction force
(C) Both (A) and (B) (D) None of the mentioned

10. **The spring force is given by**
(A) F = kx (B) F = k/x (C) F = -k/x (D) F = – kx

11. **A block of wood is placed on a surface. A force is applied parallel to the surface to move the block. The frictional force developed acts**
(A) along the direction of the applied force (B) opposite to the direction of applied force
(C) normal to the surface upward (D) normal to the surface downward

12. **Which of the following is a self-adjusting force?**
(A) Limiting friction (B) Dynamic friction (C) Sliding friction (D) Static friction.

13. **Which of the following statement is correct?**
(A) Friction does not depend on the area of contact
(B) Friction is always less than the applied force
(C) Friction depends on the size of the body
(D) Friction depends on the area of contact

14. **On a banked road, which force is essential to provide the necessary centripetal force to a car to take a turn while driving at the optimum speed?**
(A) Component of frictional force
(B) Component of normal reaction
(C) Both (A) and (B)
(D) None of these

15. **A cyclist bends while taking a turn in order to**
(A) reduce apparent speed
(B) reduce friction
(C) reduce speed
(D) provide necessary centripetal force

16. Match the physical quantities of Column I with their dimensions in Column II.

Column I	Column II
(i) Weight	(a) $[M^1L^1T^{-1}]$
(ii) Acceleration	(b) $[M^1L^1T^{-2}]$
(iii) Impulse	(c) $[M^0L^1T^{-2}]$

(A) (i)-(a), (ii)-(c), (iii)-(b) (B) (i)-(a), (ii)-(b), (iii)-(c)
(C) (i)-(b), (ii)-(c), (iii)-(a) (D) (i)-(b), (ii)-(a), (iii)-(c)

17. Statement I: There is a stage when frictional force is not needed at all to provide the necessary centripetal force on a banked road.

Statement II: On a banked road, due to its inclination the vehicle tends to remain inwards without any chances of skidding.

(A) Both Statements I and Statement II are true and the Statement II is a correct explanation of the Statement I.
(B) Both Statements I and Statement II are true but Statement II is not a correct explanation of the Statement I.
(C) Statement I is true but the Statement II is false.
(D) Statement I and Statement II both are false.

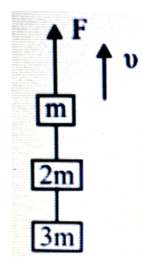
18. Which one of the following statements is incorrect?

(A) Frictional force opposes the relative motion.
(B) Limiting value of static friction is directly proportional to normal reaction.
(C) Rolling friction is smaller than sliding friction
(D) Coefficient of sliding friction has dimensions of length.

19. A mass M kg is suspended from a spring balance, which in turn is hanging from the hook of another spring balance. What will be the readings on both of these balances? (Neglect the mass of the spring balances)

(A) Both will read M kg.
(B) Both will read M/2 kg.
(C) The lower one will read M kg, and the upper one zero.
(D) The sum of both their readings will be M kg.

20. Three blocks with masses m, 2m and 3m are connected by strings, as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass 2m? (g is the acceleration due to gravity)



(A) 6 mg (B) Zero (C) 2 mg (D) 3 mg

21. A block slides down an inclined plane with angle θ. What is the force of kinetic friction?

(A) $f_k = \mu_k N \cos\theta$ (B) $f_k = \mu_k N \sin\theta$ (C) $f_k = \mu_k mg$ (D) $f_k = \mu_k mg \cos\theta$

FILL IN THE BLANKS:

(impulse, Nm^{-1}, Nm, constant, zero, mass)

1. _________ is a measure of the inertia of a body.
2. When no external force is applied on a system, its total momentum is _____________
3. A force acting for a short duration is called _____________.
4. At equilibrium net force on a body is _________.
5. The SI unit of spring constant is __________.

TWO MARK QUESTIONS:

1. Name the two physical quantities which are defined on the basis of Newton's first law.
2. Write the expression for momentum in vector form and explain the terms.
3. Mention the SI unit and dimensional formula of momentum.

4. Distinguish between mass and weight of a body.
5. Write Newton's second law in component form.
6. State and explain Newton’s I law of motion.
7. Mention the significance of component form of Newton's second law.
8. What is an impulsive force? Give example.
9. Define impulse of a force with an example.
10. State and explain Newton's third law of motion.
11. Give an example which illustrates the law of conservation of linear momentum.
12. State the principle of rocket propulsion.
13. Mention the common forces in mechanics.
14. What are normal reaction and friction?
15. What are contact forces? Give examples for contact forces in mechanics.
16. Mention the types of friction.
17. Mention the advantages of friction.
18. Name the types of kinetic friction.
19. What is sliding friction? Give example.
20. What is rolling friction? Give example.
21. What is banking of roads? Why banking is necessary for a curved road?
22. A constant force of 8 N is applied to a body of mass 3 kg. Find the acceleration of the body. **[2.66 ms^{-2}]**
23. A 10 kg object accelerates at 2 m/s^2. What is the magnitude of the force? **[20 N]**
24. A body of mass 1.5 kg has linear moment of 6 $kgms^{-1}$. Find its linear velocity. **[4 ms^{-1}]**

THREE MARK QUESTIONS:

1. Write Galileo's experimental observations of motion of objects on a single inclined plane.
2. Explain (i) inertia of rest, (ii) inertia of motion and (iii) inertia of direction, with example for each.
3. Show that the impulse of a force is equal to the change in momentum produced in the body.
4. Write the important points to be noted about the Newton's third law of motion with regard to the usage of the terms "action and reaction".
5. What are concurrent forces? Obtain the condition for the equilibrium of the concurrent forces.
6. State the laws of limiting friction.
7. State the laws of kinetic friction.
8. Mention any three disadvantages of friction. OR Friction is an evil. Explain.
9. Mention any three methods of reducing friction.
10. Derive an expression for maximum speed of circular motion of a car on a level road.
11. A body of mass 25 kg moving initially with a speed of 15 ms^{-1} brought to stop with an average retardation of 2.5 ms^{-2}. How long does the body take to stop? **[6 s]**
12. Constant force acting on a body of mass 5 kg changes its speed from 4 ms^{-1} to 7 ms^{-1} in two seconds, the direction of the body remains unchanged. What is the magnitude of force? **[7.5 N]**
13. Two billiard balls each of mass 0.05 kg moving in opposite directions with speed 6 ms^{-1} collide and rebound with the same speed. What is the impulse imparted to each ball due to the other? **[– 0.6 Ns]**
14. A bullet of mass 0.04 kg moving with a speed of 90 ms^{-1} enters a heavy wooden and is stopped after a distance of 0.6 m. What is the average resistive force exerted by the block on the bullet? **[– 270 N]**

FIVE MARK QUESTIONS:

1. State Newton's second law of motion. Hence, derive the relation $\vec{F} = m\vec{a}$, where symbols have their usual meaning. **OR**
   State Newton's second law motion. Arrive at an expression for force acting on a particle of mass m producing in it an acceleration a.

2. State and prove the law of conservation of linear momentum in the case of two colliding bodies. **OR** Arrive at the principle of conservation of linear momentum for two bodies colliding while moving along same straight line.
3. Derive an expression for maximum speed of a car on a banked road in circular motion. **OR** Obtain the expression for the maximum speed with which a vehicle can safely negotiate a curved road banked at an angle θ.
4. A driver of a car moving at 25 ms^{-1} sees a child on the road 70 m ahead and stops the car 20 m earlier to the child. If the mass of the car with the driver is 1000 kg, calculate the force exerted by the brakes on the car and the time taken to stop the car. **[6250 N, 4 s]**
5. A body of mass 2 kg is acted upon by two perpendicular forces 4 N and 3 N. Calculate the magnitude and direction of the acceleration of the body. **[5 N, 53° 8′ with 4 N force]**
6. A machine gun of 15 kg fires 0.02 kg bullets at the rate of 10 per second with a speed of 300 ms^{-1}. Calculate the force required to hold the gun in position. **[60 N]**
7. A body of mass 2 kg is placed on a horizontal surface having kinetic friction 0.4 and static friction 0.5. If the force applied on the body is 18 N, calculate the acceleration of the body. Take g = 10 ms^{-2}. **[5 ms^{-2}]**
8. Two masses 8 kg and 12 kg are connected at the two ends of a light inextensible string that goes over a frictionless pulley. Calculate the acceleration of the masses and the tension in the string when the masses are released. **[1.96 ms^{-2}, 94.08 N]**
9. A 70 kg man stands in contact against the inner wall of a hollow cylindrical drum of radius 3 m rotating about its vertical axis with 200 rev/min. The coefficient of friction between the wall and his clothing is 0.15. What is the minimum rotational speed of the cylinder to enable the man to remain stuck to the wall (without falling) when the floor is suddenly removed? **[4.7 rad s^{-1}]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
B	**D**	**A**	**C**	**B**	**C**	**B**	**B**	**B**	**D**	**B**
12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**2**
D	**A**	**C**	**D**	**C**	**C**	**D**	**A**	**B**	**D**	

ANSWERS TO FIBS:

1. mass 2. constant 3. impulse 4. zero 5. Nm^{-1}

****

5. WORK, ENERGY AND POWER

MULTIPLE CHOICE QUESTIONS:

1. **The scalar product is given by**

(A) $\vec{A} \times \vec{B} = AB\cos\theta$ (B) $\vec{A} \bullet \vec{B} = AB\cos\theta$

(C) $\vec{A} \bullet \vec{B} = AB\sin\theta$ (D) $\vec{A} \times \vec{B} = AB\sin\theta$

2. **Scalar product obeys**

(A) Distributive law over addition (B) Commutative law

(C) Both (A) and (B) (D) None

3. **For unit vectors $\hat{\imath}, \hat{\jmath}, \hat{k}$**

(A) $\hat{\imath} \bullet \hat{\imath} = \hat{\jmath} \bullet \hat{\jmath} = \hat{k} \bullet \hat{k} = 1$ (B) $\hat{\imath} \bullet \hat{\imath} = \hat{\jmath} \bullet \hat{\jmath} = \hat{k} \bullet \hat{k} = 0$

(C) Both (A) and (B) (D) None

4. **The work performed on an object does not depend upon**

(A) the displacement.
(B) the force applied.
(C) the angle at which the force is applied to the displacement
(D) initial velocity of the object.

5. **Which of the following is an example of positive work?**

(A) Force applied in the opposite direction of displacement
(B) Force applied perpendicular to displacement
(C) Force applied in the same direction of displacement
(D) No force applied

6. **A particle made to go around a circle with a constant speed with the help of a rope. The work done by the rope is**

(A) positive non–zero (B) negative non–zero

(C) Zero (D) None of the these

7. **A ball slips down on a frictionless inclined table. The work done by the table surface on the ball is**

(A) Negative (B) Zero (C) Positive (D) Unity

8. **If a light body and heavy body have same kinetic energy, then which one has greater linear momentum?**

(A) Lighter body (B) Heavier body

(C) Both have same momentum (D) can’t be predicted

9. **The potential energy of a system increases if work is done**

(A) upon the system by a non conservative force
(B) by the system against a non conservative force
(C) by the system against a conservative force
(D) upon the system by a conservative force

10. **What is the primary difference between kinetic and potential energy?**

(A) Kinetic energy is stored, while potential energy is dynamic
(B) Kinetic energy is dynamic, while potential energy is stored
(C) Kinetic energy is mechanical, while potential energy is thermal
(D) Kinetic energy is electrical, while potential energy is gravitational

11. **A spring is compressed by 2 cm. What type of energy is stored in the spring?**

(A) Kinetic energy (B) Thermal energy (C) Potential energy (D) Electrical energy

12. **Which of the following statements is true?**

(A) Power is the rate of doing work
(B) Energy is the rate of change of power
(C) Work is the rate of change of force
(D) Force is the rate of change of work

13. **Which is the type of collision in which both the linear momentum and the kinetic energy of the system remain constant before and after the collision?**

(A) Inelastic Collision (B) Elastic Collision

(C) Destructive collision (D) None

14. In a perfectly inelastic collision, the two bodies ___________ after collision.

(A) move in opposite direction (B) move with different velocities

(C) moves in perpendicular direction (D) stick together

15. If a body of mass m collides head on, elastically with velocity u with another identical body at rest. After collision velocity of the second body will be

(A) 2u (B) u (C) zero (D) can't decide

16. Match the CGS units of physical quantities of Column I with their SI unit conversion factors in Column II.

Column I	Column II
(i) 1 dyne	(a) **10^{-7} J**
(ii) 1 erg	(b) **746 W**
(iii) 1 hp	(c) **10^{-5} N**

(A) (i)-(b), (ii)-(c), (iii)-(a) (B) (i)-(a), (ii)-(b), (iii)-(c)

(C) (i)-(c), (ii)-(a), (iii)-(b) (D) (i)-(b), (ii)-(a), (iii)-(c)

17. Statement I: Kinetic energy of a body is quadrupled, when its velocity is doubled. Statement II: Kinetic energy is proportional to square of velocity.

(A) Both Statements I and Statement II are true and the Statement II is a correct explanation of the Statement I.

(B) Both Statements I and Statement II are true but Statement II is not a correct explanation of the Statement I.

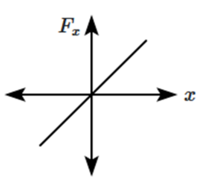
(C) Statement I is true but the Statement II is false.

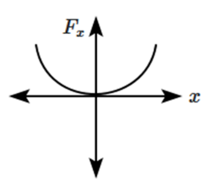
(D) Statement I and Statement II both are false.

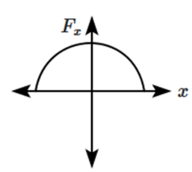
18. A bullet of mass m and velocity v is fired into a large block of wood of mass M which is at rest. If the bullet gets stuck in the block, the final velocity of the system is

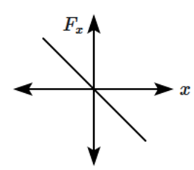
(A) $\left(\frac{M}{m+M}\right)v$ (B) $\left(\frac{m+M}{m}\right)v$ (C) $\left(\frac{m}{m+M}\right)v$ (D) $\left(\frac{m+M}{M}\right)v$

19. The restoring force of a spring with a block attached to the free end of the spring is represented by

(A)


(B)


(C)


(D)


20. A body is initially at rest. It undergoes one-dimensional motion with constant acceleration. The power delivered to it at time t is proportional to

(A) $t^{1/2}$ (B) t (C) $t^{3/2}$ (D) t^2

FILL IN THE BLANKS:

(conservative, kinetic energy, power, scalar product, constant, zero)

1. Work is ____________ of force and displacement.
2. When work done is zero, then the speed of a body remains ____________.
3. The total mechanical energy of a system is conserved if the forces doing work on it are ____________.
4. In an inelastic collision, the _________ does not remain constant.
5. The rate of doing work is called ____________.

TWO MARK QUESTIONS:

1. Mention the necessary conditions for work done.
2. State the conditions under which no work is done. OR Write the conditions for zero work-done.
3. Under what conditions the work done by a force is maximum and minimum?
4. Can acceleration be produced without doing any work? Give example.
5. Write the SI unit and dimensional formula of work.
6. What are conservative and non-conservative forces? Give example.
7. Mention the SI unit of energy and write its dimensional formula.
8. Name the types of mechanical energy.
9. Define kinetic energy of a body. Give examples.
10. Define potential energy. Give examples.
11. State and explain force law for the spring.
12. What is a spring constant of a spring? Give its SI unit.
13. Draw a graph of variation of kinetic energy and potential energy of a block attached to a vibrating spring which obeys Hooke's law.
14. Mention the different forms of energy.
15. What is the unit of electrical energy? Express it in joules.
16. Which physical quantity is measured in HP? Express it in SI units.
17. Write the SI unit and dimensional formula of power.
18. Show that $P = \vec{F} \cdot \vec{v}$, where the symbols have their usual meaning.
19. Mention the types of collisions.
20. What is elastic collision? Give examples.
21. What is inelastic collision? Give examples.
22. Distinguish between elastic collision and inelastic collision.
23. A constant force of 8 N is applied to a body which displaces it through a distance of 9 m in the direction of the applied force. Find the work done by the force. **[72 J]**
24. An object of mass 10 kg is moving with speed 5 m/s. Estimate the kinetic energy associated with the object. **[125 J]**

THREE MARK QUESTIONS:

1. Show that the work done is equal to the scalar product of force and displacement vectors.
2. What is meant by positive work, negative work and zero work? Give examples of case.
3. Derive an expression for the work done by a variable force graphically.
4. Distinguish between conservative and non-conservative forces with an example for each.
5. State and prove work-energy theorem for a constant force.
6. Derive an expression for gravitational potential energy
7. Derive the expression for the potential energy of a spring.
8. Show that kinetic energy of the object on reaching the ground dropped from a certain height is equal to its gravitational potential energy at the initial height.
9. State and prove the law of conservation of mechanical energy.
10. A force $\vec{F} = (5\hat{\imath} + 3\hat{\jmath} + 2\hat{k})$ N is applied over a particle which displaces it from its origin to the point $\vec{r} = (2\hat{\imath} - \hat{\jmath})$ m. Calculate the work done on the particle **[7 J]**
11. A man pushes a roller with a force of 50 N through a distance of 20 m. Calculate the work done if the handle of the roller is inclined at an angle of 60^0 with the ground. **[500 J]**

FIVE MARK QUESTIONS:

1. State and prove work-energy theorem for a variable force.
2. Derive an expression for the potential energy of an elastic stretched spring.
3. Show that the spring force is conservative.
4. Show that the total mechanical energy of a freely falling body under gravity is conserved.
5. Derive expressions for the velocities of colliding particle after the collision in one dimensional elastic collision. Discuss special cases.
6. Derive an expression for the loss of kinetic energy when a moving particle collides with another particle at rest in a completely inelastic collision in one dimension.
7. A body of mass 0.5 kg travels in a straight line with velocity $v = 5\,x^{3/2}$ ms^{-1}. What is the work done by the net force during its displacement from x = 0 to x = 2 m? **[50 J]**
8. A bullet of mass 100 gm is fired from a gun with a velocity of 432 kmph. It strikes a wooden plank and emerges out in 0.01 sec with a velocity of 144 kmph. Calculate the work done by the bullet in penetrating wooden plank and thickness of wooden plank. **[640 J, 0.8 m]**
9. A bullet of mass 0.012 kg and horizontal speed 70 ms^{-1} strike a block of wood of mass 0.4 kg and instantly comes to rest with respect to the block. The block is suspended from the ceiling by means of thin wires. Calculate the height to which the block rises. **[0.2123 m]**
10. A rain drop of mass 1 g falling from a height 1 km hits the ground at a speed 50 ms^{-1}. Calculate the (i) work done by the gravitational force and (ii) work done by the unknown resistive force.
    Given, g = 9.8 ms^{-2} **[9.8 J, 8.55 J]**
11. A pump on the ground floor of a building can pump up water to fill a tank of volume 30 m^3 in 15 min. If the tank is 40 m above the ground, and the efficiency of the pump is 30%, how much electric power is consumed by the pump? **[43.56 W]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	**C**	**A**	**D**	**C**	**C**	**B**	**B**	**C**	**B**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	**A**	**B**	**D**	**B**	**C**	**A**	**C**	**D**	**B**

ANSWERS TO FIBS:

1. scalar product 2. constant 3. conservative 4. kinetic energy 5. Power

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6. SYSTEM OF PARTICLES AND ROTATIONAL MOTION

MULTIPLE CHOICE QUESTIONS:

1. **What do we call a body in which the distances between all particles remain constant, even when subjected to external force?**
   (A) Elastic body (B) Plastic body (C) Rigid body (C) Fluid body

2. **A moving Radium nucleus decays into Radon and an alpha particle. The two particles produced during decay move in different directions. What is the direction of motion of the centre of mass after decay?**
(A) The centre of mass moves along the original path.
(B) The centre of mass moves along with Radon because Radon is heaver
(C) The centre of mass moves along with alpha particle because alpha particle moves faster.
(D) When radium splits in to two then no more center of mass.

3. **What is the vector product of two parallel vectors $\vec{A}$ and $\vec{B}$?**
(A) AB (B) zero (C) 1 (D) A.B

4. **$\vec{A}$ and $\vec{B}$ are two non zero vectors. If $\vec{A}.\vec{B} = 0$, then what is the angle between $\vec{A}$ and $\vec{B}$?**
(A) zero (B) 90^0 (C) 180^0 (D) 2π rad

5. **A body rotates with a constant angular momentum. Then**
(A) Torque is zero (C) Torque is maximum
(B) Torque is minimum (D) Torque is independent of angular momentum

6. **The relation between linear velocity and angular velocity of a rotating body is**
(A) $\vec{v} = \vec{\omega} \times \vec{r}$ (B) $\vec{v} = \vec{r} \times \vec{\omega}$ (C) $v = r\omega^2$ (D) $v = \omega r^2$

7. **The physical quantity which is equal to (torque)×(angular displacement) is _______**
(A) Angular velocity (B) Work
(C) Angular momentum (D) Angular acceleration

8. **What is the angle between $\vec{a} \times \vec{b}$ and $\vec{b} \times \vec{a}$?**
(A) Zero (B) 90^0 (C) 180^0 (D) 2π rad

9. **Write the dimension of angular momentum $\vec{L}$.**
(A) $[M^1L^2T^{-1}]$ (B) $[M^1L^{-2}T^1]$ (C) $[M^{-1}L^2T^{-1}]$ (D) $[M^{-2}L^2T^{-1}]$

10. **SI unit of torque is**
(A) rad s^{-1} (B) Nm^{-1} (C) js^{-1} (D) Nm

11. **A point on the body about which the gravitational torque is zero is called**
(A) center of body (B) center of gravity (C) geometrical center (D) central force

12. **Name the physical quantity which is equal to $\sum_1^n m_i r_i^2$**
(A) Angular velocity (B) Work (C) Moment of inertia (D) Inertia

13. **Some dancers performing a pirouette on the toes of one foot. They employ the principle of conservation of**
(A) linear momentum (B) angular momentum (C) Mass (D) torque

14. **The kinetic energy of a rotating body is, KE =**
(A) $\frac{1}{2}kx^2$ (B) $\frac{1}{2}mv^2$ (C) $\frac{1}{2}I\omega^2$ (D) Iω

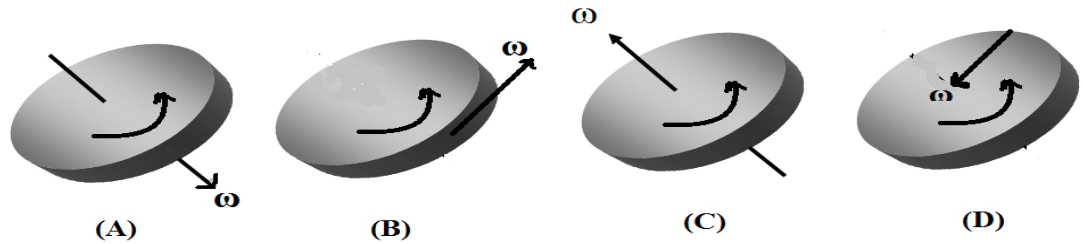
15. **A pair of equal and opposite forces with different lines of action produces**
(A) Rotation without translation (C) Both Translation and rotation
(C) Translation without rotation (D) Neither translation nor rotation

16. **A seesaw is balanced with a child on each end. What happens if one child moves closer to the fulcrum?**
(A) The sea saw will remain balanced. (B) The side where the child moved will go down.
(C) The side where the child moved will go up
(D) The seesaw will start rotating faster.

17. **Two boys are sitting on a seesaw balanced around its fulcrum. Boy A weighs 20kg and sits 2 meters away from the fulcrum. Boy B weighs 40kg and sits 1 meter away from the fulcrum. Why is the seesaw balanced?**
(A) The sum of weights is equal to zero.

(B) The weight of boy A is greater than boy B.
(C) The sum of moments around the fulcrum is equal to zero.
(D) Both (A) and (B) are correct.

18. Choose the correct diagram which shows the direction of angular velocity of a rotating disc.



19. Some regular objects are listed in column I and their moments of inertia are listed in column II. Identify the correct match.

COLUMN I	COLUMN II
(i) Solid sphere along any diameter	(a) MR^2
(ii) Thin circular disc at its center a, perpendicular to its plane	(b) $\frac{2MR^2}{5}$
(iii) Hollow cylinder along its axis	**(c)** $\frac{MR^2}{2}$

(A) (i) – (a), (ii) – (b), (iii) – (c)
(B) (i) – (b), (ii) – (c), (iii) – (a)
(C) (i) – (c), (ii) – (b), (iii) – (a)
(D) (i) – (a), (ii) – (c), (iii) – (b)

20. STATEMENT 1: A girl sits on a swivel chair. When she brings her arms closer to the body, the angular speed of rotation increases.
STATEMENT 2: In the absence of friction and external torque, the angular momentum of a system is conserved.

(A) Both the statements are correct. STATEMENT 2 is the correct explanation for the STATEMENT 1.
(B) Both the statements are correct. STATEMENT 2 is not the correct explanation for the STATEMENT 1.
(C) STATEMENT 1 is correct. STATEMENT 2 is wrong.
(D) STATEMENT 2 is correct. STATEMENT 1 is wrong.

FILL IN THE BLANKS:

[moment of force, radius of gyration, power, moment of inertia, angular acceleration, work]

1. The physical quantity which is equal to the time rate of change of angular momentum is………..
2. The ……….. of a body about an axis may be defined as the distance from the axis of a mass point where mass is equal to the mass of the whole body and whose moment of inertia is equal to the moment of inertia of the body about the axis.
3. The …………. of a body is directly proportional to the applied torque and inversely proportional to moment of inertia.
4. The rotational analogue of mass in linear motion is ……………..
5. The …………. required to rotate a body with an angular velocity ω is $\tau\omega$, where τ is the torque.

TWO MARK QUESTIONS:

1. What is the pure translational motion? Give one example
2. What is the pure rotational motion? Give one example
3. Give an example for a body whose centre of mass lies (i) inside the body and (ii) outside the body
4. What is mechanical advantage of a lever? The mechanical advantage of a lever is greater than one. What does it mean?
5. Define vector product of two vectors. Give an example.
6. Define moment of force. Write the expression for it.
7. Mention the two factors on which torque of a rotating body depends.
8. Define angular momentum. Write the expression for it.
9. Write the dimension and SI unit of angular momentum.
10. State and explain the principle of conservation of angular momentum.
11. Write any two examples for conservation of angular momentum.
12. Define moment of inertia of a particle. Write its SI unit.
13. Mention two factors on which moment of inertia of a rigid body depends.
14. Define couple. Give the expression for moment of couple.
15. Give two examples for couple.
16. State the principle of moments. What is mechanical advantage?
17. Give the general conditions of equilibrium of a rigid body.
18. Why a flywheel is used in engines of vehicles?
19. What are the factors on which the moment of inertia of a body depends?
20. To maintain a rotor at a uniform angular speed of $200 rads^{-1}$, an engine needs to transmit a torque of 180Nm. What is the power required by the engine? **[3600 W]**

THREE MARK QUESTIONS:

1. Write three kinematic equations of rotational motion of a body with a uniform angular acceleration and explain the terms.
2. What is the rotational analogue for the equation dw = Fdx? Prove that the power $P = \tau\omega$
3. Write the relation between angular momentum and moment of inertia. Prove that the torque $\tau = I\alpha$
4. Distinguish between vector product and scalar product of two vectors. Give one example for each.
5. Explain the principles of moments for a lever.
6. Obtain the relation between linear velocity and angular velocity of a rotating body.
7. Derive the expression for kinetic energy of a rotating body.
8. Two particles of masses 2kg and 4kg located at 2m and 4m, respectively, from the origin along x axis. Find the coordinate of center of mass. **[3.33m from origin]**
9. Find the torque of a force $2\hat{\imath} - 3\hat{\jmath} + 4\hat{k}$ about the origin. The force acts on a particle whose position vector is $\hat{\imath} + \hat{\jmath} - \hat{k}$. **[$\hat{\boldsymbol{\imath}} - 6\hat{\boldsymbol{\jmath}} - 5\hat{\boldsymbol{k}}$]**
10. A meter stick is balanced on a knife edge at its centre. When two Coins, each of mass 5g are put on the top of the other at 12.0cm mark, the stick is found to be balanced at 45.0cm. What is the mass of the meter stick? **[66 g]**

FIVE MARK QUESTIONS:

1. Show that torque is equal to rate of change of angular momentum of a particle.
2. Define centre of mass. Assuming the expression for velocity of centre of mass show that the centre of mass moves as if all the mass of the system is concentrated at the centre of mass and all the external forces were applied were applied at that point.
3. Find the centre of mass of three particles at the vertices of an equilateral triangle. The masses of the particles are 100 g, 150 g and 200 g respectively. Each side of the equilateral triangle is 0.5 m long. **[$X = \frac{5}{18} m, Y = \frac{1}{3\sqrt{3}} m$]**
4. A rope of negligible mass is wound round a hollow cylinder of mass 3kg and radius 40cm. What is the angular acceleration of the cylinder if the rope is pulled with a force of 30N? What is the linear acceleration of the rope? Assume that there is no slipping. **[12Nm,25rads^{-1},750ms^{-2}]**
5. A solid cylinder of mass 20 kg rotates about its axis with angular speed 100rads^{-1}. The radius of the cylinder is 0.25m. What is the kinetic energy associated with the rotation of the cylinder? What is the magnitude of angular momentum of the cylinder about its axis? **[3125J, 62.5kgm^{2}s^{-1}]**
6. The angular speed of a motor wheel is increased from 1200 rpm to 3120 rpm in 16 seconds. (i) What is its angular acceleration, assuming the acceleration to be uniform? (ii) How many revolutions does the engine make during this time? **[4π rads^{-1}, 576 rotations]**
7. A flywheel of mass 10 kg and diameter 0.4m rotating at 120 rpm has its speed increased to 720 rpm in 8 seconds. Find the torque acting on the flywheel. **[12.6Nm]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10
C	A	B	B	A	A	B	C	A	D
11	12	13	14	15	16	17	18	19	20
B	C	B	C	A	C	C	C	B	A

ANSWER TO FIBS:

1. moment of force 2. radius of gyration 3. angular acceleration 4. moment of inertia 5. power

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7. GRAVITATION

MULTIPLE CHOICE QUESTIONS:

1. **Name the astronomer who proposed the geocentric model of the planetary system.**
   (A) Aryabhatta (B) Nicolas Tesla (C) Ptolemy (D) Kepler
2. **In 'Heliocentric theory' of planetary system, …………… is the center.**
   (A) Earth (B) Moon (C) Sun (D) Jupiter
3. **The SI unit of universal gravitational constant (G) is :**
   (A) N m^{2}kg^{-1} (B) N m^{2}kg^{-2} (C) N m kg^{-2} (D) N m^{2}kg^{-3}

4. The dimension of universal gravitational constant (G) is

(A) $[M^1L^3T^2]$ (B) $[M^{-1}L^{-3}T^{-2}]$ (C) $[M^1L^{-3}T^{-2}]$ (D) $[M^{-1}L^3T^{-2}]$

5. The correct form of Newton's law of gravitation in vector form is(symbols have usual meaning)

(A) $\vec{F} = G\frac{m_1 m_2}{r^2}\hat{r}$ (B) $\vec{F} = -G\frac{m_1 m_2}{r^2}\hat{r}$ (C) $\vec{F} = G\frac{m_1 m_2}{r^3}\hat{r}$ (D) $\vec{F} = -G\frac{m_1 m_2}{r^3}\hat{r}$

6. Which of the following quantity is conserved according to Kepler's law of areas?

(A) Linear momentum (B) Angular momentum

(C) Potential energy (D) Kinetic energy

7. When the earth is closer to the sun, earth

(A) moves faster (B) moves with same speed.

(C) moves slower (D) moves with constant acceleration.

8. Which experiment led to the determination of universal gravitational constant?

(A) Cavendish's experiment (B) Kepler's experiment

(C) Newton's experiment (D) Galileo's experiment

9. What is the value of universal gravitational constant in SI units?

(A) 6.67×10^{-11} N m^2kg^{-2} (B) 9.8 ms^{-2} (C) 6400km (D) 11.2km/s

10. The value of time period of revolution of moon around earth is

(A) one year (B) one month (C) 27.3days (D) 27.3month

11. Which statement best describes Newton's law of gravitation?

(A) It applies only to objects on earth

(B) It is limited to interactions between planets

(C) It is applicable to all objects with mass in the universe.

(D) It only applies to celestial bodies like stars and planets.

12. The acceleration due to gravity due to a hollow spherical shell of uniform density at a point inside it is

(A) $9.8ms^{-2}$ (B) same as its value at the surface

(C) zero (D) more than its value at the surface

13. The acceleration due to gravity at a large height h from the surface of earth is given by

(A) $g = \frac{GM}{R^2}$ (B) $g(h) = g\left(1 - \frac{h}{R}\right)$

(C) $g(h) = g\left(1 - \frac{2h}{R}\right)$ (D) $g(h) = \frac{GM}{(R+h)^2}$

14. The work required to bring a particle of unit mass from infinity to the given point is called

(A) gravitational potential (B) gravitational constant

(C) gravitational potential energy (D) gravitational kinetic energy.

15. Who was the author of the book Mathematical Principles of Natural Philosophy (Principia)?

(A) Johannes Kepler (B) Albert Einstein (C) Isaac Newton (D) Galileo Galilei

16. The escape speed for an object of mass 'm' from the surface of earth is 11.2km/s. The minimum speed required for an object of mass '2m' to escape the gravitational influence of the earth is

(A) 44.8km/s (B) 33.6km/s (C) 22.4km/s (D) 11.2km/s

17. STATEMENT-1: When two objects of different masses are dropped simultaneously from the same height; they will reach the earth's surface at the same time. (neglect the air resistance)

STATEMENT- 2: The acceleration due to gravity is independent of the mass of the object.

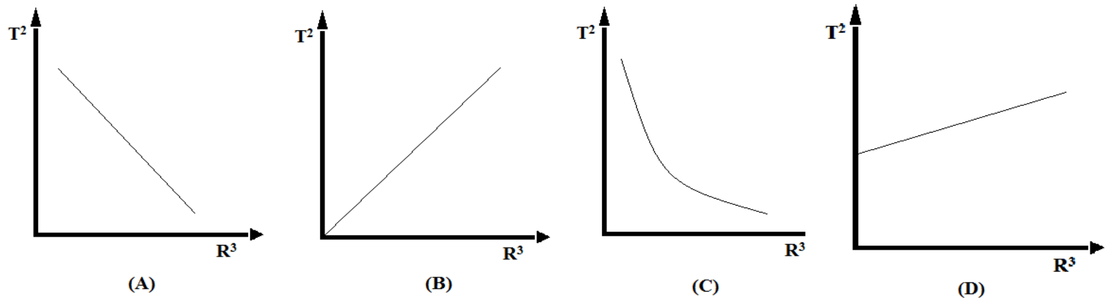
(A) Both the statements are correct. STATEMENT-2 is the correct explanation for the STATEMENT-1.

(B) Both the statements are correct. STATEMENT-2 is not the correct explanation for the STATEMENT-1.

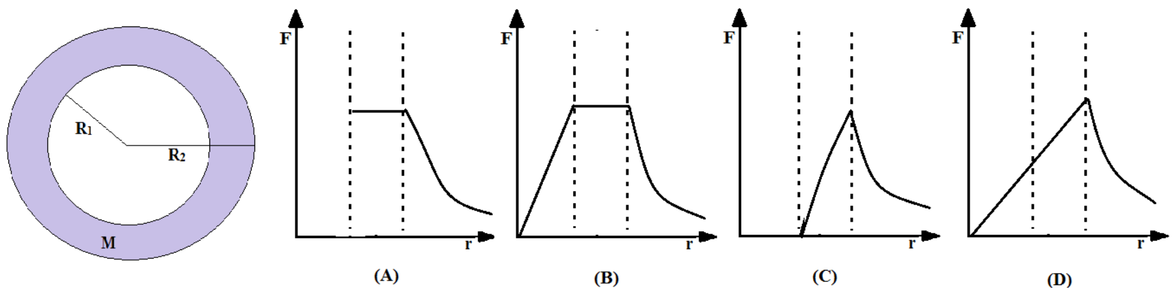
(C) STATEMENT-1 is correct. STATEMENT-2 is wrong.

(D) STATEMENT-2 is correct. STATEMENT-1 is wrong.

18. **The time period of a planet is T and its distance from the sun is R. which one of the following graphs represents correct relation between T^2 and R^3.**



19. **The thickness of a spherical shell of mass M is R_2-R_1. The force exerted by this shell on an object of mass m located at a distance r varies like,**



20. **A satellite is orbiting in an orbit of radius R_E+h, its kinetic energy is KE, potential energy is PE and total energy is E. Choose the correct relation**

(A) E = KE (B) PE = 2E (C) PE = 2KE (D) PE = – KE

FILL IN THE BLANKS:

[minimum, maximum, zero, energy, time period, linear momentum]

1. The acceleration due to gravity is ……………. at the surface of the earth.
2. The gravitational potential due to earth at a very large distance is …………
3. The ……………… of revolution of planet Saturn around the sun is more than that of the planet Jupiter.
4. When an object is moving under the influence of gravity, …………is not conserved.
5. The ………… of any orbiting satellite is negative because it is bound to the earth by gravitational force.

TWO MARK QUESTIONS:

1. Moon has no atmosphere. Why?
2. Define gravitational potential energy of a body. Give an expression for it.
3. State and explain Newton's law of gravitation.
4. What is escape speed? Give its value in the case of earth.
5. Define orbital speed of a satellite around the earth. Write the expression for it.
6. Why does an object weigh more at the surface of earth than at any point inside the earth?
7. What is a satellite? Name the natural satellite of earth.
8. Give any two applications of artificial satellites.
9. The both radius and mass of a planet are two times that of the earth's values. Calculate the acceleration due to gravity on the surface of that planet. **[$4.9 ms^{-2}$]**
10. The radius of the earth is **R_E**. Find the depth at which the acceleration due to gravity is half the acceleration due to gravity at the surface of the earth. **[$d = R_E/2$]**

THREE MARK QUESTIONS:

1. State Kepler's laws of planetary motion.
2. Derive the relationship between g and G. **OR**
   Derive the expression for acceleration due to gravity at a point on the surface of earth.
3. Assuming the expression for orbital velocity of a satellite at height h, derive an expression for its time period.
4. The acceleration due to gravity on Moon is 1.7 ms^{-2} and its radius is 0.27 times the radius of the Earth. Calculate the ratio of mass of the Earth to the mass of the Moon. **[79]**
5. Mass of earth is 80 times that of moon and the radius of earth is 4 times that of moon. If the acceleration due to gravity on earth is 9.8 m/s^2, calculate its value on the surface of the moon. **[1.96** m/s^2**]**
6. The escape velocity on earth is 11.2 km/s. Find the escape velocity on a planet whose radius is two times that of earth and mass is three times that of earth.
7. A Saturn year is 29.5 times earth year. How far is Saturn from sun if earth is 1.5×10^8 km from the sun? **[1.43×10^{12}m]**
8. An earth satellite is in a circular orbit at a height of 200 km above the earth's surface. If the radius of earth is 6400 km, find the orbit velocity. **[7.8km/s]**
9. A rocket is fired from the earth towards the sun. At what distance from the earth's centre is the gravitational force on the rocket zero? Mass of the sun=2×10^{30}kg, mass of the earth = 6×10^{24} kg. Neglect the effect of other planets etc. (orbital radius = 1.5×10^{11}m). **[2.6×10^8m]**

FIVE MARK QUESTIONS:

1. Derive the expression for acceleration due to gravity at a point above the surface of the earth.
2. Derive the expression for acceleration due to gravity at a point below the surface of the earth.
3. Derive the expression for gravitational potential energy of a particle at a point due to the earth.
4. Obtain the expression for escape speed for an object from the surface of earth.
5. Derive the expression for orbital speed of a satellite around the earth.
6. Obtain the expression for energy of an orbiting satellite.
7. State Kepler's law of area for a planet and show that the law of areas follows from the law of conservation of angular momentum.
8. Describe Cavendish's experiment to determine the value of gravitational constant G.
9. Assuming the earth to be a sphere of uniform mass density, how much would a body weighs at a depth equal to half the radius of the earth if it weighs 250N on the surface of earth? What will the weight of the same body at the centre of the earth? **[125N, zero]**
10. Find the acceleration due to gravity at a height of 400km above the earth's surface. Given: Radius of the earth = 6400km. g = 9.8 ms^{-2} **[8.575ms^{-2}]**
11. A body weights 63N on the surface of the earth. What is the gravitational force on it due to the earth at a height equal to half the radius of the earth? **[28N]**
12. A rocket is fired vertically upwards with a speed of 5kms^{-1} from the earth's surface. How far the earth does the rocket go before returning to earth. (Mass of earth = 6×10^{24} kg, Mean radius of the earth = 6.4×10^6 m, G = 6.67×10^{-11} N m^2 kg^{-2}) **[h = 1.6×10^6m]**
13. The size of the planet is same as that of the Earth. Its mass is 4 times that of Earth. An object of mass 2kg is placed at height of 2m from the surface of the planet. Find the potential energy of the object related to the surface of the planet. (g = 10 ms^{-2} on the surface of the earth). **[160J]**
14. Calculate the orbital velocity and period of revolution of an artificial satellite of earth moving at an altitude of 200 km. The radius of earth is 6400 km and mass of earth is 6×10^{24} kg. **[7.78kms^{-1}, 1.43h]**
15. The escape speed of a projectile on the surface is 11.2 km/s. A body is projected with thrice this speed what is the speed of the body far away from the earth? Ignore the pressure of sun and other planets. **[v_f = 31.68 km/s]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10
C	C	B	D	B	B	A	A	A	C
11	12	13	14	15	16	17	18	19	20
C	C	D	A	C	D	A	B	D	B

ANSWERS TO FIBS:

1. maximum, 2. zero, 3.time period, 4. linear momentum, 4. energy

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8. MECHANICAL PROPERTIES OF SOLIDS

MULTIPLE CHOICE QUESTIONS:

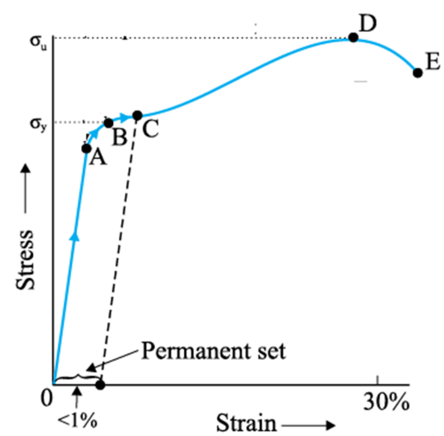
1. The breaking stress of a wire depends upon:

(A) length of the wire (B) the radius of the wire
(C) the material of the wire (D) shape of the area of cross-section of the wire.

2. The SI unit and the dimensional formula for modulus of elasticity are:

(A) Pa, $[ML^2T^{-2}]$ (B) Nm^{-2}, $[ML^{-1}T^{-2}]$ (C) Pa, $[ML^1T^{-2}]$ (D) N, $[ML^{-1}T^{-2}]$

3. The following table lists several points relates to the given stress-strain curve and the corresponding names. Match column – I with correct option among column – II.



Column – I	Column – II
(a) Point A	(p) Measure of ductility of the material
(b) Point B	(q) Proportionality limit
(c) Point E	(r) Fracture point
(d) Region DE	(s) Yield Point

(A) (a) → (q), (b) → (s), (c) → (r), (d) → (p)
(B) (a) → (s), (b) → (q), (c) → (r), (d) → (p)
(C) (a) → (q), (b) → (s), (c) → (p), (d) → (r)
(D) (a) → (s), (b) → (q), (c) → (p), (d) → (r)

4. The stress that changes the volume of the object without changing its shape is:

(A) compressive stress (B) tensile stress
(C) shear stress (D) hydraulic stress

5. After what point on the stress – strain curve for a metal, does the strain keeps increasing even by a reduced applied force?

(A) Yield point (B) Ultimate tensile strength
(C) Fracture point (D) Proportional limit

6. **Consider the following statement:**

<u>STATEMENT – I:</u> Steel is preferred over copper and aluminium in structural designs.

<u>STATEMENT – II:</u> Steel is more elastic than copper and aluminium as its Young's modulus is greater than that for copper and aluminium.

Among the given two statements:

(A) Both statements are correct and statement – II is the correct reason for statement – I.

(B) Both statements are correct but statement – II is not a correct reason for statement – I.

(C) Statement – I is correct but statement – II is wrong.

(D) Both statements are wrong.

7. **The approximate relationship between Young's modulus and rigidity modulus is:**

(A) $G \approx \frac{Y}{2}$ (B) $Y \approx \frac{G}{3}$ (C) $G \approx \frac{Y}{3}$ (D) $Y \approx \frac{G}{2}$

8. **Which one of the following correctly represents the general relationship between bulk moduli (*B*) of solids, liquids and gases?**

(A) $B_{solids} < B_{liquids} < B_{gases}$ (B) $B_{solids} > B_{liquids} = B_{gases}$

(C) $B_{solids} = B_{liquids} > B_{gases}$ (D) $B_{solids} > B_{liquids} > B_{gases}$

9. **The Young's modulus of a perfect rigid body is:**

(A) zero (B) infinite (C) 0.5 Pa (D) negative

10. **If σ is the stress in a stretched wire and ε is the corresponding strain, the elastic energy density in the wire is given by:**

(A) $u = \frac{1}{4}\sigma\varepsilon$ (B) $u = \frac{1}{2}\sigma^2\varepsilon$ (C) $u = \frac{1}{2}\sigma\varepsilon^2$ (D) $u = \frac{1}{2}\sigma\varepsilon$

11. **Consider the following statement:**

<u>STATEMENT – I:</u> To avoid buckling of beams, load-bearing bars of I – section are used.

<u>STATEMENT – II:</u> Bars of I – shape provide large load bearing surface and good strength with less weight.

Among the given two statements:

(A) Both statements are correct and statement – II is the correct.

(B) Statement – II is correct but statement – I is wrong

(C) Statement – I is correct but statement – II is wrong.

(D) Both statements are wrong.

12. **Within proportionality limit, the slope of stress – strain curve gives:**

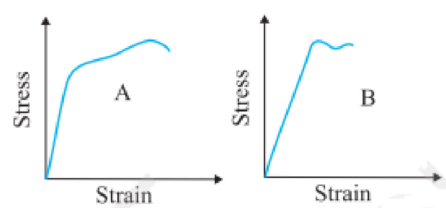
(A) Modulus of elasticity

(B) Compressibility

(C) Ultimate tensile stress

(D) Reciprocal of modulus of elasticity

13. **The stress-strain graphs for materials A and B are shown in the figure.**



The graphs are drawn to the same scale. Then:

(A) Material B has greater Young's modulus

(B) Material A is more brittle.

(C) Material A is stronger than B

(D) Both materials are equally ductile.

14. **Which one of the following statements is wrong?**
    (A) The stretching of a coil is determined by its shear modulus.
    (B) The Young's modulus of rubber is greater than that of steel.
    (C) When a spring is stretched by applying a load to one of its free ends, both longitudinal and shear strains are produced in the spring.
    (D) Poisson's ratio is the ratio of lateral strain to the longitudinal strain.
15. **The maximum load a wire can withstand without breaking, when its length is reduced to half of its original length, will**
    (A) doubled (B) half (C) four times (D) remain same

FILL IN THE BLANKS:

(*Poisson ratio, Young's modulus, Shear modulus, Compressibility, Bulk modulus*)

1. The ratio between longitudinal stress and longitudinal strain is called ___________.
2. ____________ is the shear stress per unit shear strain.
3. Lateral strain = ____________ × Longitudinal strain.
4. The reciprocal of bulk modulus is called _____________.

TWO MARK QUESTIONS:

1. What do you mean by elasticity and plasticity?
2. Give one example each for elastic and plastic substance.
3. Define stress. Mention its SI unit.
4. Define strain. What is its unit?
5. State and explain Hooke's law.
6. Define (i) compressive stress and (ii) tensile stress.
7. Define (i) shearing stress and (ii) hydraulic stress.
8. Define longitudinal strain. Write the expression for it.
9. Define shearing strain. Write an expression for it.
10. Define volume strain. Write an expression for it.
11. What is yield point? Define yield strength of a material.
12. What are elastomers? Give an example.
13. Draw stress – strain curve for an elastomer.
14. Write the expression for Young`s modulus. Explain the terms.
15. Write the expression for rigidity modulus of the material. Explain the terms.
16. Mention the expression for bulk modulus of the material. Explain the terms.
17. Write two application of elastic behavior of the material.
18. Define compressibility. Mention its SI unit.
19. Define Poisson ratio. Give an example for it.
20. Write the expression for the buckling sag of a beam that is supported at its two ends and is loaded at the center. Explain the terms.
21. A steel rod of area of cross section 3.14×10^{-4} m^2 is stretched by a force of 100 kN. Calculate the stress acting on the rod. **[3.2×10^8 Pa]**
22. Calculate the fractional change in the volume of glass sphere when subjected to a hydraulic pressure of 1.013×10^6 Nm^{-2}. (Bulk modulus of glass is 3.7×10^{10} Nm^{-2}) **[0.0027%]**
23. The bulk modulus of a material is 2×10^9 Pa. What is its compressibility? **[5×10^{-10} Pa^{-1}]**

THREE MARK QUESTIONS:

1. Draw typical stress – strain graph for copper. Represent yield point, elastic limit and fracture point.
2. Define (i) Young's modulus (ii) Rigidity modulus and (iii) Bulk modulus.

3. Derive an expression for elastic potential energy in a stretched wire.
4. A steel rod of radius 10 mm and length 2 m is stretched by a force of 100 kN along its length. The elongation in the wire is 3.2 mm. Find the stress and Young's modulus of the material of the rod. **[3.2×10^8 Pa, 2×10^{11} Pa]**
5. The upper face of a cube of edge 1m moves through a distance of 1 mm relative to the lower fixed surface under action of a tangential force 1.5×10^8 N. Calculate tangential stress and rigidity modulus. **[150 MPa, 150 GPa]**
6. A square lead slab of side 50 cm and thickness 10 cm subjected to shearing force of 9×10^4 N. How much will the upper edge be displaced? Shear modulus of lead =5.6 GPa. **[0.16 mm]**
7. When a rubber ball is taken in deep of 100 m in sea its volume is decrease by 0.1% due to hydraulic stress. If the density of seawater is 1000 kgm^{-3}, calculate the bulk modulus and compressibility of the rubber. **[9.8×10^8 Pa, 10^{-9} Pa^{-1}]**
8. A steel wire of length 5 m and cross section 3×10^{-5} m^2 stretched by the same amount as copper of length 3.7 m and cross section 4×10^{-5} m^2 under given load. Find the ratio of Young's modulus of steel to that of copper. **[1.8]**
9. The average depth of Indian Ocean is about 3000 m. Calculate the fractional compression, $\Delta V/V$, of water at the bottom of the ocean, given that the bulk modulus of water is 2.2×10^9 N m^{-2}. (Take $g = 10$ m s^{-2}) **[1.36%]**
10. A steel cable with a radius of 1.5 cm supports a chairlift at a ski area. If the maximum stress is not to exceed 10^8 N m^{-2}, what is the maximum load the cable can support? **[0.71 Kn]**
11. A rigid bar of mass 15 kg is supported symmetrically by three wires each 2.0 m long. Those at each end are of copper and the middle one is of iron. Determine the ratios of their diameters if each is to have the same tension. (Young's modulus for iron and copper are 190 GPa and 110 GPa respectively) **[1.31]**
12. Determine the volume contraction of a solid copper cube, 10 cm on an edge, when subjected to a hydraulic pressure of 7.0×10^6 Pa. **[– 0.05 cm^3]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
C	**B**	**A**	**D**	**B**	**A**	**C**	**D**
9	**10**	**11**	**12**	**13**	**14**	**15**	
B	**D**	**A**	**A**	**C**	**B**	**D**	

ANSWERS TO FIBS:

1. Young's modulus; 2. shear modulus; 3. poisson ratio; 4. compressibility

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9. MECHANICAL PROPERTIES OF FLUIDS

MULTIPLE CHOICE QUESTIONS:

1. **Which one of the following statements is wrong?**
   (A) Solids have a definite shape while liquids and gases do not have definite shape.
   (B) The volume of any substance depends on the pressure acting on it.
   (C) Solids and liquids have lower compressibility when compared to gases.
   (D) When compared to solids, fluids offer large shear stress.
2. **Consider the following two statements:**
   STATEMENT – I: A sharp needle when pressed against our skin pierces it.
   STATEMENT – II: Smaller the area on which the force acts, greater is the pressure.
   Between the above two statements:
   (A) Both statements are correct and statement – II is the correct reason for statement – I.
   (B) Both statements are correct but statement – II is not a correct reason for statement – I.
   (C) Statement – I is correct but statement – II is wrong.
   (D) Both statements are wrong.
3. **The pressure in a fluid at rest is the same at all points if they are at the same height. This is the statement of:**
   (A) Bernoulli's principle (B) Pascal's law
   (C) Stoke's law (D) Hooke's law
4. **If the area of cross-section of a tube of flow decreases, then the rate of flow of the fluid through it:**
   (A) increases (B) remains constant
   (C) decreases (D) may increase or decrease
5. **When a tank is open to the atmosphere, the speed of efflux is given by (symbols have usual meanings):**
   (A) $v = \sqrt{2gh}$ (B) $v = \sqrt{gh}$ (C) $v = \sqrt{\frac{2h}{g}}$ (D) $v = \sqrt{\frac{gh}{2}}$
6. **Dynamic lift due to spinning is called:**
   (A) Pascal's law (B) Magnus effect (C) surface tension (D) viscosity
7. **For a given fluid in laminar flow, at a particular temperature, the shearing stress is:**
   (A) directly proportional to strain (B) directly proportional to $(\text{strain})^2$
   (C) directly proportional to strain rate (D) inversely proportional to strain rate
8. **When an rain drop falls through the atmosphere from a large height:**
   (A) the net force on it remains constant (B) the net force on it decreases as it falls
   (C) the net force on it increases as it falls (D) the drop undergoes continuous retardation
9. **Consider the following two statements:**
   STATEMENT – I: No two streamlines can cross each other.
   STATEMENT – II: If two streamlines intersect, an oncoming fluid particle can go either one way or the other and the flow would not be steady.
   Between the above two statements:
   (A) Both statements are correct and statement – II is the correct reason for statement – I.
   (B) Both statements are correct but statement – II is not a correct reason for statement – I.
   (C) Statement – I is correct but statement – II is wrong.
   (D) Both statements are wrong.

10. SI unit and dimensional formula for surface tension is:

(A) N m^{-1}, $[ML^{-1}T^{-2}]$ (B) N m, $[MT^{-2}]$ (C) N m^{-1}, $[MT^{-2}]$ (D) J m^2, $[MT^{-2}]$

11. Let θ be the angle of contact between a liquid drop and a solid surface. Then:

(A) The liquid wets the surface if $\theta > 90°$ (B) The liquid wets the surface if $\theta = 90°$

(C) The liquid wets the surface if $\theta < 90°$ (D) The liquid does not wet the surface if $\theta > 90°$

12. Which one of the following statements is correct?

(A) Hydrostatic pressure is a vector quantity.

(B) Surface tension of a liquid is independent of the area of the surface.

(C) Water with detergent dissolved in it should has large angles of contact.

(D) Liquids like water, alcohol are more viscous than blood, glycerine, etc.

13. Bernoulli's principle is:

(A) the law of conservation of energy for an incompressible, non-viscous fluid.

(B) the law of conservation of energy for an compressible, viscous fluid.

(C) the law of conservation of mass for an incompressible, non-viscous fluid.

(D) the law of conservation of momentum for an incompressible, non-viscous fluid.

14. The principle behind continuity equation for flow of incompressible fluids is:

(A) the law of conservation of energy (B) the law of conservation of momentum

(C) the law of conservation of mass (D) Pascal's law

15. As the temperature of a water inside a glass capillary tube increases, the height of water in the capillary tube (neglect the thermal expansions):

(A) increases (B) decreases

(C) remains the same (D) may increase or decrease

FILL IN THE BLANKS

(*turbulent, hydraulic lift, viscosity, dynamic lift, surface tension, open tube manometer*)

1. Drops and bubbles are spherical because of their____________ property.
2. With increase in temperature, __________ of gases increases.
3. Beyond a limiting value, called critical speed, this flow of a fluid becomes __________.
4. The force that acts on a body, such as airplane wing, by virtue of its motion through a fluid is called________.
5. A _________ works on the principle of Pascal's law.

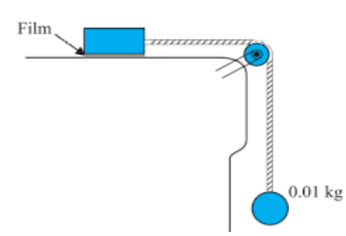
TWO MARK QUESTIONS:

1. What are fluids? Give an example.
2. Define pressure. Write its unit.
3. Define (i) density and (ii) relative density.
4. Write the equation for gauge pressure and explain the terms.
5. Write the expression for absolute pressure and explain the terms.
6. State and explain Pascal's law.
7. Mention any two factors on which pressure inside a fluid depends.
8. Write the conversion factors of (i) 1 torr and (ii) 1 bar into pascals.
9. In what fields the units torr and bar are used to measure pressure?
10. What is the use of a (i) mercury barometer and (ii) open tube manometer?
11. Write any two applications of Pascal's law.
12. What is streamline motion? Give an example
13. What is turbulent motion? Give an example.
14. What are the limitations of Bernoulli's equation?

15. Write any two applications of Bernoulli's principle.
16. What are (i) Dynamic lift and (ii) Magnus effect?
17. What is viscosity? Write the expression for coefficient of viscosity.
18. Write the SI unit and dimensional formula for coefficient of viscosity.
19. State Stoke's law. Write the expression for the viscous drag force on a spherical object moving through a fluid.
20. What are the factors on which drag force on an object moving through a fluid depends?
21. Define the terms (i) surface energy and (ii) surface tension.
22. (i) Why are drops and bubbles spherical in shape?
    (ii) Why are detergents used as wetting agents?
23. Write the expression for capillary rise inside a capillary tube. Explain the terms.
24. Mention the expressions for excess pressure inside (i) a drop and (ii) a bubble.
25. The two thighbones (femurs), each of cross-sectional area 10 cm^2 support the upper part of a human body of mass 40 kg. Estimate the average pressure sustained by the femurs. **[2×10^5 Pa]**
26. A 50 kg girl wearing high heel shoes balances on a single heel. The heel is circular with a diameter 1.0 cm. What is the pressure exerted by the heel on the horizontal floor? **[6.24 MPa]**
27. What is the pressure on a swimmer 10 m below the surface of a lake? **[Nearly 2 atm]**
28. The density of the atmosphere at sea level is 1.29 kg/m^3. Assume that it does not change with altitude. Then how high would the atmosphere extend? **[8 km]**
29. The terminal velocity of a copper ball of radius 2.0 mm falling through a tank of oil is 6.5 cm s^{-1}. Compute the viscosity of the oil. Density of oil is 1.5×10^3 kg m^{-3}, density of copper is 8.9×10^3 kg m^{-3}. **[0.99 kg m^{-1} s^{-1}]**
30. What is the excess pressure inside the drop of mercury of radius 3.00 mm at room temperature? Surface tension of mercury at that temperature (20°C) is 0.465 N m^{-1}. The atmospheric pressure is 1.01×10^5 Pa. **[310 N m^{-2}]**

THREE MARK QUESTIONS:

1. Derive an expression for gauge pressure inside a static fluid.
2. Derive the equation of continuity. What is the significance of the equation?
3. Obtain the expression for the terminal velocity of a small sphere falling through a fluid.
4. Derive the expression for excess pressure inside a drop.
5. At a depth of 1000 m in an ocean (a) What is the absolute pressure? (b) What is the gauge pressure? (c) Find force acting on the window of area 20 cm × 20 cm of a submarine at this depth, the interior of which is maintained at sea level atmospheric pressure. (Given: The Density of seawater is 1.03×10^3 kgm^{-3} and $g = 10$ ms^{-2}) **[(a) 104.01×10^5 Pa, (b) 103×10^5 Pa and (c) 4.12×10^5 N]**
6. Two syringes of different cross-sections (without needles) filled with water are connected with a tightly fitted rubber tube filled with water. Diameters of the smaller piston and larger piston are 1.0 cm and 3.0 cm respectively. (a) Find the force exerted on the larger piston when a force of 10 N is applied to the smaller piston. (b) If the smaller piston is pushed in through 6.0 cm, how much does the larger piston move out? **[90 N, 0.67 cm]**
7. In a car-lift compressed air exerts a force F_1 on a small piston having a radius of 5.0 cm. This pressure is transmitted to a second piston of radius 15 cm. If the mass of the car to be lifted is 1350 kg, calculate F_1. What is the pressure necessary to accomplish this task? ($g = 9.8$ ms^{-2}). **[1.5 kN, 1.9×10^5 Pa]**
8. A metal block of area 0.10 m^2 is connected to a 0.010 kg mass via a string that passes over an ideal pulley (considered massless and frictionless), as in figure. A liquid with a film thickness of 0.30 mm is placed between the block and the table. When released the block moves to the right with a constant speed of 0.085 m s^{-1}. Find the coefficient of viscosity of the liquid. **[3.46×10^{-3} Pa s]**



9. A U-tube contains water and methylated spirit separated by mercury. The mercury columns in the two arms are in level with 10.0 cm of water in one arm and 12.5 cm of spirit in the other. What is the relative density (also called specific gravity) of spirit? **[0.8]**
10. A U-shaped wire is dipped in a soap solution, and removed. The thin soap film formed between the wire and the light slider supports a weight of 1.5×10^{-2} N (which includes the small weight of the slider). The length of the slider is 30 cm. What is the surface tension of the film? **[2.5×10^{-2} N m^{-1}]**

FIVE MARK QUESTIONS:

1. State and prove Bernoulli's principle.
2. What is capillarity? Arrive at the expression for capillary rise inside a capillary tube.
3. In a test experiment on a model aeroplane in a wind tunnel, the flow speeds on the upper and lower surfaces of the wing are 70 m s^{-1}and 63 m s^{-1} respectively. What is the lift on the wing if its area is 2.5 m^2? Take the density of air to be 1.3 kg m^{-3}. **[1.5×10^3 N]**
4. The cylindrical tube of a spray pump has a cross-section of 8.0 cm^2 one end of which has 40 fine holes each of diameter 1.0 mm. If the liquid flow inside the tube is 1.5 m min^{-1}, what is the speed of ejection of the liquid through the holes? **[0.637 m s^{-1}]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8
D	A	C	B	A	B	C	B
9	10	11	12	13	14	15	
A	C	C	B	A	C	A	

ANSWERS TO FIBS:

1. surface tension; 2. viscosity; 3. turbulent; 4. dynamic lift; 5. hydraulic lift

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10. THERMAL PROPERTIES OF MATTER

MULTIPLE CHOICE QUESTIONS:

1. **Absolute zero (0 *K*) is that temperature at which**
(A) Matter ceases to exist (B) Ice melts and water freezes
(C) Volume and pressure of a gas becomes zero (D) None of these
2. **The temperature at which same value of measurement in Celsius and Fahrenheit scale is**
(A) 0^0 (B) 100^0 (C) 40^0 (D) - 40^0
3. **Relation between coefficient of linear expansion(α_L), coefficient of area expansion(α_A) and coefficient of volume expansion(α_V) is**
(A) $\alpha_L = \alpha_A$ and $\alpha_V = \alpha_L$ (B) $2\alpha_L = \alpha_A$ and $\alpha_V = 3\alpha_L$
(C) $\alpha_L = 2\alpha_A$ and $3\alpha_V = \alpha_L$ (D) $3\alpha_L = \alpha_A$ and $\alpha_V = 2\alpha_L$

4. 5 litre of benzene weighs

(A) more in summer than in winter (B) more in winter than in summer
(C) equal in winter and summer (D) more in rainy season.

5. Water has maximum density at

(A) 0^0C (B) 32^0C (C) -4^0C (D) 4^0C

6. Water is used to cool radiators of engine because

(A) of its lower density (B) it is easily available
(C) it is cheap (D)it has high specific heat.

7. At atmospheric pressure, the water boils at 100^0C. if pressure is reduced, it will boil at

(A) higher temperature (B) lower temperature
(C) at the same temperature (D) at critical temperature.

8. For cooking the food which of the following type of utensil is most suitable

(A) high specific heat and low conductivity. (B) high specific heat and high conductivity.
(C) low specific heat and low conductivity. (D) low specific heat and high conductivity

9. Two thin blankets keep more hotness than one blanket of thickness equal to these two. The reason is

(A) Their surface area increases
(B) A layer of air is formed between these two blankets, which is bad conductor
(C) These have more wool
(D) They absorb more heat from outside.

10. In order that the heat flows from one part of a solid to another part, what is required

(A) Uniform density (B) Density gradient
(C) Temperature gradient (D) Uniform temperature

11. The layers of atmosphere are heated through

(A) conduction (B) convection (C) radiation (D) both (B) and (C)

12. The fastest mode of heat transfer is

(A) conduction (B) convection (C) radiation (D) both (A) and (C)

13. The temperature of stars determined by

(A) Stefan's law (B) Wein's displacement law
(C) Kirchhoff's law (D) Newton's law.

14. The spectral energy distribution of star is maximum at twice temperature as that of sun. The total energy radiated by star is

(A) twice as that of the sun (B)same as that of the sun
(C) sixteen times as that of the sun (D) one sixteenth of sun.

15. Equal masses of two liquids are filled in two similar calorimeters. The rate of cooling will

(A) depend on the nature of the liquids
(B) depend on the specific heats of liquids
(C) be same for both the liquids
(D) depend on the mass of the liquids.

16. In cold countries, water pipes sometimes burst, because

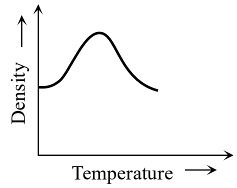
(A) Water expands on freezing
(B) When water freezes, pressure increases
(C) pipes expand
(D) when water freezes, it takes heat from pipes

17. A container contains hot water at $100°C$. If in time T_1 temperature falls to $80°C$ in time T_2 temperature falls to $60°C$ from $80°C$, then

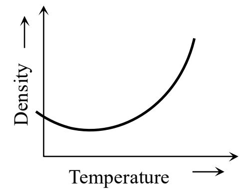
(A) $T_1 = T_2$ (B) $T_1 > T_2$ (C) $T_1 < T_2$ (D)None

18. The variation of density of water with temperature is represented by the

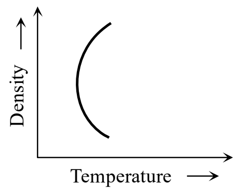
(A)



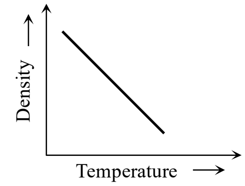
(B)



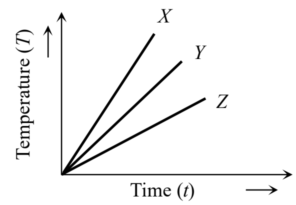
(C)



(D)



19. Which of the substances *A*, *B* or *C* has the highest specific heat ? The temperature *vs* time graph is shown

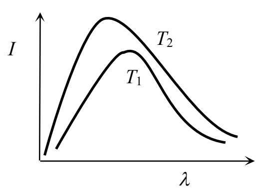


(A) X (B) Y

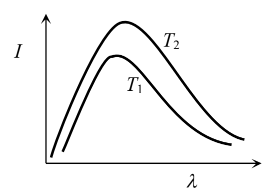
(C) Z (D) all have equal specific heat

20. Shown below are the energy emitted by black body curves at temperatures T_1 and T_2 ($T_2 > T_1$). Which of the following plots is correct

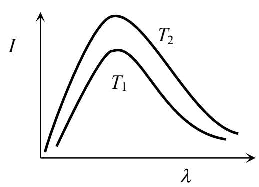
(A)



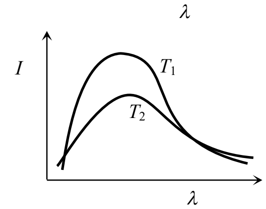
(B)



(C)



(D)



FILL IN THE BLANKS:

(temperature, regelation, trade wind, calorimeter, sea breeze, sublimation)

1. __________ is the device used for measuring the quantity of heat.
2. The ____________ of the solid during melting remains same.
3. The phenomenon in which refreezing of ice when pressure is removed is called ________.
4. The process of change of state directly from solid to vapour is known as_________.
5. The steady wind blowing from North-East to equator, near the surface of earth is called __________.

TWO MARK QUESTIONS:

1. Write any two differences between heat and temperature.
2. What are two fixed points on a temperature scale?
3. Draw a graph of Fahrenheit temperature versus Celsius temperature.
4. State and explain Boyle's law.
5. State and explain Charle's law at constant pressure.
6. Draw a graph of pressure versus temperature for low density gases indicates the same absolute zero temperature.
7. Define co-efficient of linear expansion of a solid. Mention its SI unit.

8. Explain the meaning of the statement "the coefficient of linear expansion of silver is 0.000019 per kelvin.
9. Define co-efficient of volume expansion of a solid. Write the expression for it.
10. What is meant by anomalous expansion of water?
11. Explain the variation of volume of 1kg of water with temperature graphically.
12. At what temperature, the density of water is maximum? Mention the highest value of density of water.
13. Name any two substances which neither expand nor contract on heating.
14. Define heat capacity of a substance. Write its SI unit.
15. Define specific heat capacity of a substance. Write its SI unit.
16. Define (i) molar specific heat of a gas at constant volume and (ii) molar specific heat at constant pressure.
17. C_p is always greater than C_v. Why?
18. Mention the factors on which molar specific heats depend.
19. State and explain the principle of calorimetry.
20. Define the terms (i) melting and (ii) fusion.
21. Define the terms (i) vaporisation and (ii) sublimation.
22. Define the terms (i) melting point and (ii) normal melting point.
23. What is regelation? Mention one of its practical applications.
24. Explain the possibility of ice skating.
25. Define the terms (i) boiling point and (ii) normal boiling point of a liquid.
26. Define latent heat of substance. Give its SI unit.
27. Define the terms (i) latent heat of fusion and (ii) latent heat of vapourisation.
28. Define coefficient of thermal conductivity. Mention its SI unit.
29. Why a metal bar does feel much colder than a wooden block on a cold day?
30. What are the values of thermal conductivity of a
    (i) a perfect heat conductor and (ii) a perfect heat insulator.
31. Mention the types of convection.
32. Distinguish between conduction and convection.
33. State and explain Stefan-Boltzmann law of radiation.
34. State and explain Wein's displacement law of radiation.
35. State and explain Newton's law of cooling.
36. Convert 100^0 F into degree Celsius scale.

THREE MARK QUESTIONS:

1. Derive an ideal gas equation by using gas laws.
2. Write a note on absolute scale of temperature.
3. Mention the different types of thermal expansion.
4. Derive $\alpha_v = \frac{1}{T}$ for an ideal gas, where the symbols have their usual meaning.
5. Show that $\alpha_v = 3\,\alpha_l$, where the symbols have their usual meaning.
6. Mention three factors on which heat flow by conduction in a bar depends.
7. Mention any three properties of thermal radiation.
8. A metal bar measures 50 cm at 0^0C and 50.048 cm at 80^0C. Find the coefficient of linear expansion of the metal. **[$1.2 \times 10^{-5}\ /^0C$]**
9. Calculate the change in volume of an iron block 10 cm × 20 cm × 5 cm if its temperature is raised from 10^0C to 40^0C. Given coefficient of volume expansion of iron = $3.6 \times 10^{-5}\ /^0C$. **[1.08 cm^3]**
10. The two molar specific heats of a gas are 29.11J/mol/K. Calculate the universal gas constant. **[8.32 J/mol/K]**
11. The temperature of a furnace is 2500 K, find the heat radiated by it per second per square metre of its surface. Stefan's constant = $5.7 \times 10^{-8} Wm^{-2}K^{-4}$. **[2.23×10^6J]**

FIVE MARK QUESTIONS:

1. State and explain the laws of thermal conductivity.
2. Obtain the relation $\log_e (T_2 - T_1) = Kt + C$ by using Newton's law of cooling where the symbols have their usual meaning.
3. A blacksmith fixes iron ring on the rim of wooden wheel of a bullock cart. The diameter of the rim and the iron ring are 5.243 m and 5.231 m respectively at 27 ^{0}C. To what temperature should the ring be heated so as to fit the rim of the wheel? Given $\alpha = 1.2 \times 10^{-5}\ K^{-1}$. **[218^0 C]**
4. 0.2 kg of copper heated to 100^{0}C is dropped into 0.1 kg of water at 30^{0}C contained in copper calorimeter of mass 0.2 kg. If the specific heat of copper is 418 $Jkg^{-1}K^{-1}$ and that of water is 4200 $Jkg^{-1}K^{-1}$, find the maximum temperature attained by water. **[40^0 C]**
5. A drilling machine of 5kW is used to drill a hole in the block of copper of mass 4.0kg. Calculate the rise in temperature of the block in 5 minutes if 75% of the energy is used in heating the block. Given specific heat of copper = 0.385 $J\ g^{-1}\ {}^0C^{-1}$. **[730.52^0 C]**
6. A metal cylinder 0.628 m long and 0.04 m in diameter has one end in boiling water at 100^{0}C and the other end in melting ice. The coefficient of thermal conductivity of the metal is 378 $Wm^{-1}K^{-1}$. Latent heat of ice is $3.36 \times 10^5 Jkg^{-1}$. Find the mass of ice that melts in one hour. **[0.81 kg]**
7. A liquid takes 10 minutes to cool from 70^0 C to 50^0 C. How much time will it take to cool from 60^0 C to 40^0 C? The temperature of the surrounding is 20^0 C. **[13.33 minutes]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	**D**	**B**	**B**	**D**	**D**	**B**	**D**	**B**	**C**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	**C**	**B**	**C**	**B**	**A**	**C**	**A**	**A**	**A**

ANSWERS FOR FIBS:

1. calorimeter 2. temperature 3. regelation 4. sublimation 5. trade wind

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11. THERMODYNAMICS

MULTIPLE CHOICE QUESTIONS

1. **When two systems are in thermal equilibrium, the quantity which remains same in the two system is**
   (A) volume (B) pressure (C) temperature (D) density
2. **Temperature is a measurement of coldness or hotness of an object. This definition is based on**
   (A) Zeroth law of thermodynamics (B) First law of thermodynamics
   (C) Second law of thermodynamics (D) Newton's law of cooling
3. **The internal energy of an ideal gas depends on**
   (A) specific volume (B) pressure (C) density (D) temperature

4. The first law of thermodynamics is concerned with the conservation of

(A) Momentum (B)Energy (C)Mass (D) Temperature

5. The state of a thermodynamic system is represented by

(A) Pressure only (B) Volume only

(C) Pressure, volume and temperature (D) Number of moles

6. If a system undergoes contraction of volume then the work done by the system will be

(A) Zero (B)Negligible (C) Negative (D) Positive

7. In an isothermal expansion

(A) Internal energy remains unchanged

(B) Internal energy of the gas decreases

(C) Internal energy of the gas increases

(D) Average KE of gas molecule decreases

8. If a cylinder containing a gas at high pressure explodes, the gas undergoes

(A) Reversible adiabatic change and fall of temperature

(B) Reversible adiabatic change and rise of temperature

(C) Irreversible adiabatic change and fall of temperature

(D) Irreversible adiabatic change and rise of temperature

9. The work done in an adiabatic change in a gas depends only on

(A) Change in temperature (B) Change is volume

(C) Change in pressure (D) both (B) and (C)

10. $\Delta U + \Delta W = 0$ **is valid for**

(A) Adiabatic process (B) Isothermal process

(C) Isobaric process (D) Isochoric process

11. The work done in which of the following processes is zero

(A) Isothermal process (B) Adiabatic process

(C) Isochoric process (D) Isobaric process

12. For a reversible process, necessary condition is

(A) In the whole cycle of the system, the loss of any type of heat energy should be zero

(B) That the process should be too fast

(C) That the process should be slow so that the working substance should remain in thermal and mechanical equilibrium with the surroundings

(D) The loss of energy should be zero and it should be quasistatic

13. "Heat cannot by itself flow from a body at lower temperature to a body at higher temperature" is a statement or consequence of

(A) Second law of thermodynamics

(B) Conservation of momentum

(C) Conservation of mass

(D) First law of thermodynamics

14. For an isothermal expansion of a perfect gas, the value of $\frac{\Delta P}{P}$ **is equal**

(A) $-\gamma^{1/2}\frac{\Delta V}{V}$ (B) $-\frac{\Delta V}{V}$ (C) $-\gamma\frac{\Delta V}{V}$ (D) $-\gamma^2\frac{\Delta V}{V}$

15. Efficiency of Carnot engine is 100% if

(A) $T_2 = 273$ K (B) $T_2 = 0$ K (C) $T_1 = 273$ K (D) $T_1 = 0$ K

16. In an adiabatic process, the state of a gas is changed from $P_1, V_1, T_1,$ **to** P_2, V_2, T_2**. Which of the following relation is correct?**

(A) $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$ (B) $P_1V_1^{\gamma-1} = P_2V_2^{\gamma-1}$ (C) $T_1P_1^{\gamma} = T_2P_2^{\gamma}$ (D) $T_1V_1^{\gamma} = T_2V_2^{\gamma}$

17. Match the following:

The amount of work done per mole in

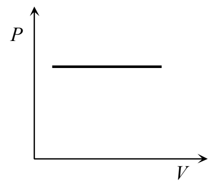
(a) an isothermal process	**(i) $R(T_2 - T_1)$**
(b) an adiabatic process	**(ii)** $RT \log_e \frac{V_2}{V_1}$
(c) an isobaric process	**(iii)** $\frac{R}{\gamma - 1}(T_2 - T_1)$

(A) (a) - (i), (b) - (ii), (c) - (iii)   (B) (a) - (ii), (b) - (iii), (c) - (i)

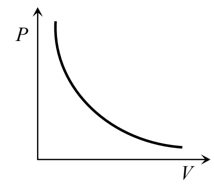
(C) (a) - (iii), (b) - (ii), (c) - (i)   (D) (a) - (i), (b) - (iii), (c) - (ii)

18. Which of the accompanying-*PV*, diagrams best represents an isothermal process

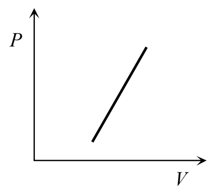
(A)



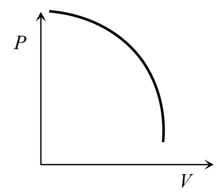
(B)



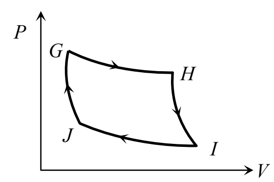
(C)



(D)



19. Carnot cycle (reversible) of a gas represented by a Pressure-Volume curve is in the diagram. Consider the following statements



I .Area *GHIJ* = Work done on the gas

II. Area *GHIJ* = Net heat absorbed

III.Change in the internal energy in cycle = 0

which of these are correct

(A) I only   (B) II only   (C) II and III   (D) I, II and III

20. An ideal heat engine working between temperature T_1 and T_2 has an efficiency η, the new efficiency if both the source and sink temperature are doubled, will be

(A) $\frac{\eta}{2}$ (B) η (C) 2η (D) 3η

FILL IN THE BLANKS:

(isothermal expansion, internal energy, isochoric, temperature, zero, adiabatic expansion)

1. Zeroth law of thermodynamics defines the concept of __________.
2. The work done by the gas in adiabatic process is equals the decrease in its _________.
3. In an ___________ process work done by the gas is zero.
4. The change in internal energy of a system in a cyclic process is __________.
5. The first operation involved in a Carnot cycle is ____________.

TWO MARK QUESTIONS:

1. Define the terms (i) thermodynamic system and (ii) surrounding.
2. When is a system said to be in the state of thermodynamic equilibrium? Explain with example.
3. Define the terms (i) adiabatic wall and (ii) diathermic wall.
4. State and explain zeroth law of thermodynamics.
5. Who formulated zeroth law of thermodynamics? Mention its significance.
6. What is the nature of internal energy of an ideal gas? Explain.
7. State and explain first law of thermodynamics.

8. Show the variation of specific heat capacity of water with temperature graphically.
9. Name the thermodynamic variables defined by (i) zeroth law and (ii) first law of thermodynamics.
10. What are thermodynamic state variables. Give an example.
11. Define the terms (i) equilibrium state and (ii) equation of state.
12. Mention the types thermodynamic state variables.
13. What is an isothermal process? Give an example.
14. What do you mean by adiabatic process? Give an example.
15. What is isobaric process? Give an example.
16. What is isochoric process? Give an example.
17. Write the expression for work done by a gas in an isochoric process and explain the terms.
18. Write Kelvin-Planck statement and Clausius statement of second law of thermodynamics.
19. Define reversible process. Give an example.
20. Define irreversible process. Give an example.
21. Mention any two causes of irreversibility of a thermodynamic process.
22. State Carnot's theorem.

THREE MARK QUESTIONS:

1. Classify thermodynamic system by the nature of transfer of heat.
2. Define thermal equilibrium. How it is attained.
3. Define internal energy of a system. Explain.
4. State sign conventions used in the measurement of heat, work and internal energy.
5. Show that first law of thermodynamics $\Delta Q = \Delta U + \Delta W$ for an ideal gas.
6. Distinguish between extensive and intensive variables. Give an example of each.
7. What is thermodynamic process? Mention its different types.
8. 10 litre of air at 17^0C and 76cm of mercury pressure is compressed isothermally to a volume of 0.5 litre. Calculate the final pressure. **[1520cm of mercury]**
9. A cylinder with a movable piston contains 3 moles of hydrogen at STP. The walls of the cylinder are made of heat insulator and the piston is insulated by having a pile of sand on it. By what factor does the pressure of the gas increases if the gas is compressed to half its original volume? **[2.64]**
10. Calculate the efficiency of a Carnot engine operating between 127^0C and 27^0C. **[0.25]**

FIVE MARK QUESTIONS:

1. Using first law of thermodynamics, arrive at the relation Cp –Cv = R.
2. Derive an expression for work done by the gas in an isothermal process.
3. Obtain the expression for work done by the gas in adiabatic process.
4. Explain the different stages of Carnot's cycle with P-V diagram.
5. Show that for a Carnot's engine, the efficiency of the engine $\eta = 1 - \frac{T2}{T1}$ where $T_2 < T_1$.
6. A geyser heats water flowing at the rate of 2 litres per minute from a temperature of 30^0C to 80^0C. If the geyser operates on a gas burner, what is the rate of consumption of the fuel if the heat of combustion is 4×10^4 Jg^{-1}? Given density of water = 1000kgm^{-3} and specific heat of water = 4200$Jkg^{-1}K^{-1}$. **[$1.75 \times 10^{-4} kgs^{-1}$]**
7. 1g of water at 373K is converted into steam at the same temperature at normal pressure. The volume of $1cm^3$ of water becomes 1671 cm^3 on boiling. Calculate the change in internal energy of the system if the heat of vaporisation is 540 $calg^{-1}$. **[499.5 cal]**
8. Two moles of an ideal gas, kept at a constant temperature of 27^0C is compressed from 2 litre to 0.5 litre. Calculate the work done in the process. **[6.914×10^3 J]**
9. A work of 146 kJ is performed in order to compress 1 kmol of a gas adiabatically and in this process the temperature of the gas increases by 7^0C. What is the value of γ of the gas? **[1.4]**
10. Calculate the efficiency of a Carnot engine working between 100^0C and 400^0C. If it absorbs 200 J per cycle from the source, calculate the heat rejected to the sink in one cycle. **[110.85 J]**

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	**A**	**D**	**B**	**C**	**C**	**A**	**C**	**A**	**A**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	**D**	**A**	**B**	**B**	**A**	**B**	**B**	**C**	**B**

ANSWERS TO FIBS:

1. temperature 2. internal energy 3. isochoric 4. zero 5. isothermal expansion

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12. KINETIC THEORY

MULTIPLE CHOICE QUESTIONS:

1. Every gas (real gas) behaves as an ideal gas

(A) At high temperature and low pressure (B) At low temperature and high pressure

(C) At normal temperature and pressure (D) None of the above

2. Two gases of equal mass are in thermal equilibrium. If P_a, P_b and V_a and V_b are their respective pressures and volumes, then which relation is true

(A) $P_a \neq P_b; V_a = V_b$ (B) $P_a = P_b; V_a \neq V_b$ (C) $\frac{P_a}{V_a} = \frac{P_b}{V_b}$ (D) $P_a V_a = P_b V_b$

3. In the relation $\mu = \frac{PV}{RT}$, μ is

(A) Number of molecules (B)Atomic number (C) Mass number (D)Number of moles

4. Molecules of a gas behave like

(A) Inelastic rigid sphere (B) Perfectly elastic non-rigid sphere

(C) Perfectly elastic rigid sphere (D) Inelastic non-rigid sphere

5. When volume of system is increased two times and temperature is decreased half of its initial temperature, then pressure becomes

(A) 2 times (B) 4 times (C) $\frac{1}{4}$ times (D) $\frac{1}{2}$ times

6. Relationship between $P, V,$ and E for a gas is

(A) $P = \frac{3}{2}EV$ (B) $V = \frac{2}{3}EP$ (C) $PV = \frac{3}{2}E$ (D) $PV = \frac{2}{3}E$

7. The *r.m.s.* velocity will be greater for

(A) Hydrogen (B) Oxygen

(C) Equal for both (D) Nothing is definite

8. The root mean square velocity of a gas molecule of mass *m* at a given temperature is proportional to

(A) m^0 (B) m (C) $\sqrt{m}$ (D) $\frac{1}{\sqrt{m}}$

9. A monoatomic gas molecule has

(A) Three degrees of freedom (B) Four degrees of freedom

(C) Five degrees of freedom (D) Six degrees of freedom

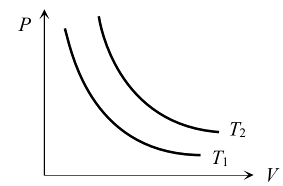
10. **The specific heat of an ideal gas is**
(A) Proportional to T (B) Proportional to T^2 (C) Proportional to T^3 (D) Independent of T

11. **If the molecular weight of two gases are M_1 and M_1, then at a temperature the ratio of root mean square velocity v_1 and v_2 is**
(A) $\sqrt{\frac{M_1}{M_2}}$ (B) $\sqrt{\frac{M_2}{M_1}}$ (C) $\sqrt{\frac{M_1+M_2}{M_1-M_2}}$ (D) $\sqrt{\frac{M_1-M_2}{M_1+M_2}}$

12. **Molar specific heat at constant volume is C_V for a monoatomic gas is**
(A) $\frac{3}{2}R$ (B) $\frac{5}{2}R$ (C) $3R$ (D) $2R$

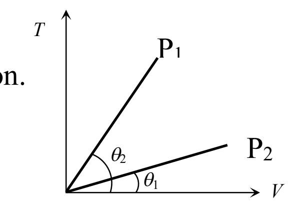
13. **A box contains n molecules of a gas. How will the pressure of the gas be effected, if the number of molecules is made $2n$**
(A) Pressure will decrease (B) Pressure will remain unchanged
(C) Pressure will be doubled (D) Pressure will become three times

14. **The adjoining figure shows graph of pressure and volume of a gas at two temperatures T_1 and T_2.**



Which of the following interferences is correct
(A) $T_1 > T_2$ (B) $T_1 = T_2$
(C) $T_1 < T_2$ (D) No interference can be drawn

15. **The figure shows the volume V versus temperature T graphs for a certain mass of a perfect gas at**
two constant pressures of P_1 and P_2. What interference can you draw from the graphs
(A) $P_1 > P_2$ (B) $P_1 < P_2$
(C) $P_1 = P_2$ (D) No interference can be drawn due to insufficient information.



FILL IN THE BLANKS:

(isochoric, zero, internal energy, isothermal expansion, temperature, heat)

1. According to ___________ law 'equal volumes of all gases at equal temperatures and pressure have the same number of molecules'.
2. The kinetic energy of a molecule is proportional to the ________ of the gas.
3. In equilibrium, the total energy is equally distributed in all possible energy modes, with each mode having an average energy is equal to $\frac{1}{2}k_BT$ is known as law of ____________.
4. The degrees of freedom of a diatomic gas is ________.
5. The average distance a molecule can travel without colliding is called___________.

TWO MARK QUESTIONS:

1. State and explain Avogadro's hypothesis.
2. Show that behaviour of real gases approach ideal gas at low pressure and high temperature graphically.
3. Mention the expression for average kinetic energy of a gas molecule in terms of its absolute temperature.
4. Find the value of the ratio of specific heats for monoatomic gas molecule.
5. Find the value of the ratio of specific heats for rigid diatomic gas molecule.
6. Write the expression for the ratio of specific heats for polyatomic gas molecule.
7. Mention the factors on which the mean free path of a gas molecule depends.

THREE MARK QUESTIONS:

1. State any three postulates of kinetic theory of ideal gases.
2. Define rms speed of gas molecules. Obtain the expression for rms speed of a gas molecule on the basis of kinetic interpretation of temperature.
3. State and explain the law of equipartition of energy of a gas.
4. Show that the specific heat capacity of solids $C = 3R$.
5. Calculate rms speed of oxygen molecule at 27° C, atomic weight of oxygen is 16.[483.5ms^{-1}]
6. Derive the expression for pressure of an ideal gas as P = $\frac{1}{3}$ nm$\bar{v}^2$.

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
A	**D**	**D**	**C**	**C**	**D**	**A**	**D**
9	**10**	**11**	**12**	**13**	**14**	**15**	
A	**D**	**B**	**A**	**C**	**C**	**A**	

ANSWERS TO FIBS:

1. Avogadro's 2. absolute temperature 3. equipartition of energy 4. five 5. mean free path

****

13. OSCILLATIONS

MULTIPLE CHOICE QUESTIONS:

1. **The function of time which is not periodic among the following is**
   (A) sin ωt (B) cos ωt (C) $e^{-\omega t}$ (D) sin ωt + cos ωt
2. **Maximum acceleration of a particle executing SHM is (in usual symbols)**
   (A) $-\omega^2$ A (B) $-\omega^2$ x (C) +ωA (D) $+\omega^2$ x
3. **Uniform circular motion can be seen as SHM because**
   (A) circular motion is oscillatory motion
   (B) SHM motions and circular motions are periodic in nature
   (C) projection of circular motion on its diameter executes SHM
   (D) None of these
4. **The restoring force acting on the particle executing SHM is**
   (A) directed in the same direction as the displacement
   (B) inversely proportional to displacement
   (C) directly proportional to displacement
   (D) independent of displacement
5. **Velocity and displacement of a body executing simple harmonic motion**
   (A) are in phase (B) out of phase
   (C) have phase difference of 90^0 (D) have phase difference of 45^0
6. **If simple harmonic motion is represented by x = A cos (ωt + ϕ), then ϕ is**
   (A) Displacement (B) Amplitude (C) Angular frequency (D) Phase constant
7. **Which of the following will produce oscillatory vibration**
   (A) Musical instruments (B) The membranes of drums
   (C) Diaphragms of telephone (D) All of the above

8. The external forces acting on a body in periodic motion at equilibrium position is

(A) maximum (B) can't say (C) Zero (D) 200N

9. In SHM, Force is directed towards the

(A) Opposite position (B) Mean Position (C) Extreme position (D) Origin Position

10. An Oscillating body comes to rest because

(A) it gets tired (B) its energy is very less
(C) of the damping due to friction (D) external force acts along it

11. Any material medium is a collection of a large number of ____________ which manifest themselves as waves

(A) electrons (B) Atoms (C) Coupled oscillators (D) molecules

12. The period of vibration of a quartz crystal is

(A) 10^{-6} s (B) 10^{-8} s (C) 10^{-10} s (D) 10^{-14} s

13. The period of Halley's Comet is

(A) 12 years (B) 76 years (C) 24 years (D) 48 years

14. The quantities which characterize SHM are

(A) Amplitude, Angular velocity, Phase angle
(B) Wavelength, Linear Displacement, Angular Displacement
(C) Frequency, Linear Velocity, time taken
(D) None of these

15. The maximum displacement of a body is called ______________

(A) Amplitude (B) Velocity (C) frequency (D) phase angle

16. Both kinetic energy and potential energy peak ________during each period of SHM

(A) once (B) twice (C) thrice (D) four times

17. The two forces acting on bob of simple pendulum are

(A) Frictional force and Force due to gravity (B) Tension in the string and Force due to gravity
(C) Frictional force and Tension in the string (D) Electrical force and Gravitational force

18. A boy is continuously bouncing a ball between his hands and the ground. Motion of the ball is

(A) Both simple harmonic and periodic (B) Only periodic and not simple harmonic
(C) Only simple harmonic not periodic (D) Neither simple harmonic nor periodic

19. Among the following which is the characteristic of simple harmonic motion

(A) It is periodic in nature
(B) The time period of oscillation and frequency depend on amplitude of vibration.
(C) Acceleration is directed away from mean position
(D) It is non – oscillatory motion.

20. Planets rotate about their own axis and revolve around Sun, their motion is

(A) Periodic and Oscillatory (B) not periodic and not oscillatory
(C) Periodic but not Oscillatory (D) Simple Harmonic Motion

21. The following statements related to periodic motion
Statement – I: Every oscillatory motion is periodic
Statement – II: Every periodic motion is always oscillatory

(A) I is true but II is false. (B) Both I and II are true
(C) II is true but I is false (D) Both I and II are false

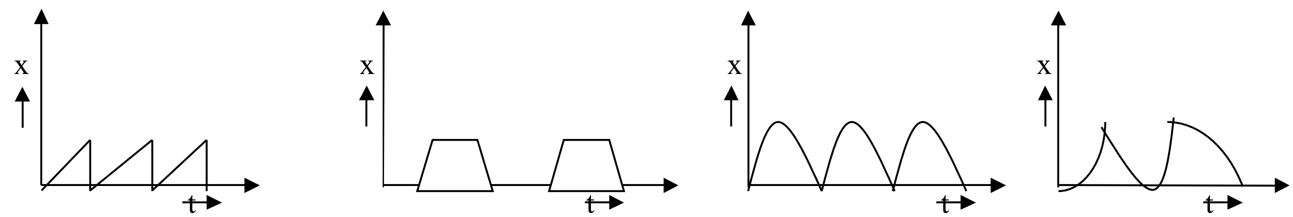
22. The Column-I is the type of motion and column-II is its example. Identify the correct match.

Type of Motion	Examples
(i) Linear motion	**(a) Orbital motion of planet**
(ii) Projectile motion	**(b) Pendulum of wall clock**
(iii) Circular motion	**(c) Ants orderly moving in a line**
(iv) Oscillatory motion	**(d) A ball thrown upward**

(A) (i) - (a), (ii) - (b), (iii) - (c), (iv) - (d) (B) (i) - (b), (ii) - (c), (iii) - (d), (iv) - (a)
(C) (i) - (c), (ii) - (d), (iii) - (a), (iv) - (b) (D) (i) - (c), (ii) - (d), (iii) - (b), (iv) - (a)

23. In the graph, identify which is not periodic motion

(A) (B) (C) (D)



24. Identify the correct statements

(i) If frequency is high, then we call oscillation
(ii) If frequency is small, then we call vibration
(iii) If frequency is high, then we call vibration
(iv) If frequency is small, then we call oscillation

(A) (i) & (ii) (B) (iii) & (iv) (C) (ii) & (iv) (D) (i) & (iii)

25. Examples of displacement variables are

(i) The voltage across capacitor in AC
(ii) Pressure variation during the sound propagation
(iii) The changing electric and magnetic field in light wave
(iv) Oscillating simple pendulum

(A) (i), (ii) & (iii) (B) (ii), (iii) & (iv) (C) (ii) & (iv) (D) All of these

FILL IN THE BLANKS:

(time period, maximum, 1 m, minimum, 1s, infinity)

1. The length of second's pendulum is ______________
2. The kinetic energy of a simple pendulum at extreme position is _______________
3. The reciprocal of frequency is _____________________
4. The potential energy of a simple pendulum at extreme position is _______________.
5. The number of oscillations for ________ is called frequency.

TWO MARK QUESTIONS:

1. What is periodic motion? Give an example
2. Define simple harmonic motion. Give an example
3. Write any two characteristics of SHM
4. Write the equation for displacement of a particle of a simple harmonic wave. Explain the terms
5. Draw displacement-time graph of a particle executing SHM
6. Define the terms a) period b) frequency of periodic motion
7. Define phase of a particle. In which quantities it is expressed?
8. Write the expression for time period of oscillations of simple pendulum and explain the terms used
9. Mention the expression for the period of oscillation of a spring and explain the terms.
10. At which position is the acceleration of the particle executing SHM is maximum and minimum.
11. On an average a human heart is found to beat 75times in a minute. Calculate its frequency and period. **[υ = 1.25 Hz, T = 0.8 s]**
12. The displacement of an oscillating particle varies with time according to the equation $x = 2 \cos (0.5\pi t)$, where x is in metre and time is in second. Calculate (i) amplitude of oscillation and (ii) time period of oscillation **[A = 2m, T = 4s]**
13. The maximum velocity of a particle executing SHM is 4.4 ms^{-1} with its amplitude 7 mm. What is the period of oscillation? **[T = 0.01 s]**

THREE MARKS QUESTIONS:

1. Draw graphical representation of variation of potential energy and kinetic energy of a particle and total energy of a particle in SHM as a function of displacement.
2. Show that acceleration $a = -\omega^2 x$ by assuming equation for displacement of SHM.
3. Represent graphically displacement, velocity and acceleration with respect to time of particle under SHM.

FIVE MARK QUESTIONS:

1. Derive the expression for the kinetic energy and potential energy and total energy of harmonic oscillator.
2. Arrive at an expression for the time period of simple pendulum.
3. a) What is an initial phase or epoch? (1)
   b) At what position is the velocity of particle executing SHM (i) maximum and (ii) minimum? (2)
   c) State and explain force law of SHM (2)
4. A body oscillates with SHM, according to the equation $x = 5 \cos(2\pi t + \pi/4)$ at $t = 1.5$s where x in meter and t is in second. Calculate displacement, speed and acceleration of the body.
   [$x = -3.535$ m, $v = 22.22$ ms^{-1}, $a = 139.56$ ms^{-2}]
5. If a particle executing SHM is given by the equation $y = 2\sin(314t)$ in m. Calculate amplitude, frequency and maximum velocity of particle? **[$A = 2$ m, $\upsilon = 50$ Hz, $v_{max} = 628$ ms^{-1}]**
6. A block of mass 1kg is fastened to a spring. The spring has a spring constant of 50 Nm^{-1}. The block is pulled to a distance x = 10cm from its equilibrium position at x = 0 on a frictionless surface from rest at t = 0 and is released. Calculate (i) angular frequency of oscillations of the block and (ii) the maximum speed with which the block crosses the mean position. **[$\omega = 7.07$ rad^{-1}, $v_{max} = 0.707$ ms^{-1}]**
7. A mass of 0.2 kg is suspended from a fixed point by a light spring. The spring is extended by 0.02 m from the equilibrium position. The mass is then pulled down by 0.03 m and released. Find the time period and maximum kinetic energy of the mass (Given: g = 9.8 ms^{-2}) **[T = 0.284 s, $K_{max} = 0.044$J]**
8. A spring compressed by 0.2 m develops a restoring force of 25 N. When a body of mass 5kg is placed over it, calculate (i) force constant of the spring (ii) elongation of the spring under the weight of the body (iii) period of oscillation if the body is disturbed (Given: g = 9.8 ms^{-2})
   [k = 125 Nm^{-1}, $x_{max} = 0.392$ m, T = 1.256 s]
9. A body suspended from a spring balance, when displaced and released, oscillates with a period of 0.6 s. What is the weight of the body? (Given: Spring constant of the spring = 2450 Nm^{-1}, g = 9.8ms^{-2})
   [W = 219.128 N]
10. A body executes SHM along the Y-axis its displacement varies with time according to the equation $y = 1.5 \sin(100\pi t)$, where y is in metre and t is in second. Calculate a) amplitude b) period, c) frequency of motion of the particle d) maximum velocity and maximum acceleration of the particle.
    [A =1.5 m, T = 0.02 s, υ = 50 Hz, v_{max} = 471 rads^{-1}, a_{max} = 147894 rads^{-2}]

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
C	**A**	**C**	**C**	**C**	**D**	**D**	**C**	**B**
10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
C	**C**	**A**	**B**	**A**	**A**	**B**	**B**	**B**
19	**20**	**21**	**22**	**23**	**24**	**25**		
A	**C**	**A**	**C**	**D**	**B**	**D**		

ANSWERS TO FIBS:

1. 1m 2. minimum 3. time period 4. maximum 5. 1s

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14. WAVES

MULTIPLE CHOICE QUESTIONS:

1. **Select a wrong statement: When a wave travels in a medium**
   (A) Disturbance is carried from one point to another
   (B) Energy is carried from one point to another
   (C) Particle travel from one point to another
   (D) All particle vibrate with same period.
2. **Sound waves is a**
   (A) mechanical wave (B) non-mechanical wave (C) transverse wave (D) electromagnetic wave
3. **Electromagnetic waves**
   (A) do not carry energy (B) do not require any medium for propagation
   (C) require a medium for propagation (D) cannot travel in vacuum
4. **What is common with X-rays, Infrared waves, ultraviolet waves?**
   (A) All have same frequency (B) All have same wavelength
   (C) All travel with same speed in vacuum (D) All are mechanical waves
5. **Transverse waves**
   (A) travel in the form of compressions and rarefactions
   (B) travel in the form of crests and troughs
   (C) travel with direction of particle velocity and wave velocity parallel to each other
   (D) Do not carry energy
6. **Longitudinal waves**
   (A) travel in the form of compressions and rarefactions
   (B) travel in the form of crests and troughs
   (C) travel with direction of particle velocity and wave velocity perpendicular to each other
   (D) Do not carry energy
7. **Mechanical transverse waves can propagate only in**
   (A) gases (B) gases and liquids
   (C) medium with shear modulus of elasticity (D) vacuum
8. **Capillary waves are produced due to**
   (A) surface tension of water (B) anomalous expansion of water
   (C) Gravitational pull (D) viscosity of water
9. **Waves in an ocean are**
   (A) purely longitudinal (B) purely transverse
   (C) combination of both longitudinal and transverse
   (D) neither longitudinal nor transverse
10. **Type of waves produced in a cylinder containing a liquid by moving its piston back and forth is**
    (A) Longitudinal (B) transverse (C) non mechanical (D) electromagnetic
11. **Phase difference between two particles in a wave separated by a distance of $\lambda/2$ is**
    (A) π (B) $\pi/2$ (C) 2π (D) $\pi/4$
12. **The quantity which do not change, when sound enters from one medium to another is**
    (A) wavelength (B) Speed (C) frequency (D) amplitude
13. **Velocity of a transverse wave in a stretched wire depends on**
    (A) tension in the wire (B) mass per unit length of the wire
    (C) radius of the wire (D) All of the above
14. **According to Newton when a longitudinal wave travel in a gas, changes in pressure and volume are**
    (A) isothermal (B) adiabatic (C) isochoric (D) isobaric

15. Velocity of sound in a gas does not change with

(A) change density of the medium (B) change in humidity
(C) change in temperature (D) change in pressure

16. Distance between the node and nearest antinode in a stationary wave is

(A) λ (B) $\lambda/2$ (C) 2λ (D) $\lambda/4$

17. In a closed pipe, open end is always

(A) a node (B) an antinode
(C) either node or antinode (D) neither node nor antinode

18. An open pipe always vibrates in

(A) only odd harmonics (B) only even harmonics (C) all harmonics (D) none of these

19. A stretched wire vibrates in

(A) only odd harmonics (B) only even harmonics (C) all harmonics (D) none of these

20. A closed pipe always vibrates in

(A) only odd harmonics (B) only even harmonics (C) all harmonics (D) none of these

21. Energy is not carried by

(A) Longitudinal progressive wave (B) Transverse progressive wave
(C) Electromagnetic wave (D) Stationary wave

22. Air column present in an open pipe is vibrating in fundamental mode. It contains

(A) a node and an antinode (B) a node and two antinodes
(C) two nodes and an antinode (D) two nodes and two antinodes

23. Which of the following statements is true for wave motion?

(A) Mechanical transverse waves can propagate through all medium
(B) Longitudinal waves can propagate through solids only
(C) Mechanical transverse waves can propagate through solids only
(D) Longitudinal waves can propagate through a vaccum

24. The minimum distance between two consecutive points having zero phase difference is

(A) $\lambda/3$ (B) $\lambda/2$ (C) $\lambda/4$ (D) λ

25. To demonstrate the phenomenon of beats we need

(A) Two sources which produces waves of nearly same frequency
(B) Two sources which produces waves of exactly same frequency
(C) Two sources which produces waves of exactly same wavelength
(D) Two sources which produces waves of exactly same frequency and constant phase difference

26. The speed of sound in a medium depends upon

(A) its elasticity as well as its inertia (B) its elasticity but not its inertia
(C) its inertia but not its elasticity (D) neither its elasticity nor its inertia.

FILL IN THE BLANKS:

(sound, light, decreases, resonance, increases, zero, energy)

1. Nodes are the points at which amplitude is _______________ .
2. _____________ waves cannot travel through vacuum.
3. In case of waves, _______________ is transferred from one point to another.
4. As temperature decreases, the velocity of sound __________________ by Laplace correction.
5. If the external frequency is close to one of the natural frequency then system attains __________ condition.

TWO MARK QUESTIONS:

1. Mention any two applications of beats
2. Distinguish between mechanical and non-mechanical waves.

3. What are beats? What is the principle of beats?
4. Mention the relation between wave frequency, wavelength and wave velocity.
5. The wave has wavelength 2 m and frequency 0.5 Hz. Calculate the velocity of wave **[$v = 1\ ms^{-1}$]**
6. What is the wavelength of the wave traveling with velocity 3 ms^{-1} having time period 0.5 s? **[$\lambda = 1.5$ m]**

THREE MARK QUESTIONS:

1. Write Newton's formula for speed of sound in air. Explain why and how Laplace modified Newton's formula of speed of sound
2. Distinguish between longitudinal and transverse waves
3. A steel wire has a length of 12m and a mass of 2.1kg. What should be the tension in the wire so that the speed of a transverse wave on the wire equals the speed of sound in dry air at 20^0 C is 343 ms^{-1} **[2.06×10^4 N]**
4. A steel rod 100 cm long is clamped at its middle. The fundamental frequency of longitudinal vibrations of the rod is given to be 2.53 Hz. What is the speed of sound in steel? **[$v = 5.06 \times 10^3\ ms^{-1}$]**

FIVE MARK QUESTIONS:

1. What is a closed pipe? Show that the overtones in a closed pipe are odd harmonics of the fundamental.
2. What is an open pipe? Show that the overtones in an open pipe are all harmonics of the fundamental.
3. a) Distinguish between stationary wave and progressive wave. (3)
   b) What harmonics are present in stretched string? (1)
   c) Write the expression for velocity of waves on stretched string with terms explained. (2)
4. a) What is a progressive wave? (1)
   b) Write an equation representing it and explain its terms? (2)
   c) Write any two characteristics of progressive wave (2)
5. A wave travelling along a string is described by $y(x, t) = 0.005 \sin(80x - 3t)$ in which the numerical constants are in SI units. Calculate: a) amplitude b) the wavelength, c) the period and frequency of wave d) calculate the displacement y of the wave at a distance x = 30 cm and t = 20 s? **[$A = 0.005$ m, $\lambda = 7.85 \times 10^{-2}$m, $T = 2.09$ s, $\upsilon = 0.48$ Hz, $y = -0.0029$ m]**
6. A pipe 30 cm long is open at both ends. Which harmonic mode of the pipe is resonates at 1.1 kHz source? Will resonance with the same source be observed if one end of the pipe is closed? Given: velocity of sound in air = 330 ms^{-1}. **[υ_2 = 1.1kHz for second harmonic it resonates, no resonance will be observed for one end of pipe is closed]**
7. A progressive wave is represented as $y = 1.2 \sin \pi(2t/5 - x/4)$, where x and y are in meter and t is in second. Determine the amplitude, period and speed of the wave **[$A = 1.2$ m, $T = 5$ s, $v = 1.6\ ms^{-1}$]**
8. A string of mass 4 kg is under the tension of 1500 N, the length of the stretched string is 10 m. If a transverse jerk is struck at one end of the string, how long does the disturbance take to reach the other end? **[$v = 61.23\ ms^{-1}$, $t = 0.163$ s]**
9. The equation of a sinusoidal wave travelling along negative x-axis is $y = 0.4 \sin 10\pi(3t + 2x)$, where x and y are in meter and t is in seconds. Calculate the amplitude, wavelength, frequency and velocity of the wave. **[$A = 0.4$ m, $\lambda = 10$ m, $\upsilon = 15$ Hz, $v = 150\ ms^{-1}$]**
10. When a progressive wave travels through a medium the displacement of the particle is given by $y = 0.05 \sin 2\pi(2t - 0.01x)$, where x and y are in meter and t in seconds. Calculate a) wavelength b) frequency c) phase difference between two particle at 10 m apart.

    [$\lambda = 100$ m, $\upsilon = 2$ Hz, $\phi = 0.628$ rad]

ANSWERS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
C	**A**	**B**	**C**	**B**	**A**	**C**	**A**	**C**
10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
A	**A**	**C**	**D**	**A**	**D**	**D**	**B**	**C**
19	**20**	**21**	**22**	**23**	**24**	**25**	**26**	
C	**A**	**D**	**B**	**C**	**D**	**A**	**A**	

ANSWERS TO FIBS:

1. zero   2. sound   3. energy   4. decreases   5. resonance

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