Chapter 1. Unite and measurement

Q.1 Define the following :

(i) Astronomical Unit (ii) Light Year (iii) Parsec.

Q.2 Write the dimensions of

(i) Linear density (ii) Power (iii) Impulse (iv) Velocity Gradient
(v) Mass per unit area (vi) kinetic energy (vii) Angular Acceleration
(viii) Couple (ix) Moment of force (x) Work done.

Q.3 A book with many printing errors contains four different formulae for the displacement y of a particle undergoing a certain periodic motion:

(i) $y = a\sin\frac{2\pi t}{T}$ (ii) $y = a\sin vt$

(iii) $y = (a/T)\sin(t/a)$ (iv) $y = \left(a\sqrt{2}\right)(\sin 2\pi t/T + \cos 2\pi/T)$

Where $a =$ maximum displacement of the particle, $\upsilon =$ speed of the particle, $\mathrm{T} =$ time period of motion. Rule out the wrong formulae on dimensional grounds.

Q.4 Rule out or accept the following formulae for kinetic energy on the basis of dimensional arguments.

(i) $k = 3/16m\upsilon^2$ (ii) $k = \frac{1}{2}m\upsilon^2 + ma$ (iii) $k = \frac{1}{2}m\upsilon^2$

Q.5 A physical quantity Q is given by $Q = \frac{A^2.B^{\frac{3}{2}}}{C^{+4}D^{\frac{1}{2}}}$ The percentage error in A, B, C, D are 1%, 2%, 4%, 2% respectively. Find the percentage error in Q.

Q.6 The time of oscillation (t) of a small drop of liquid under surface tension depends upon the density ρ, radius r and surface tension (σ).

Prove dimensionally that $t \propto \sqrt{\frac{\rho r^3}{\sigma}}$.

Q.7 Liquid is flowing steadily through a pipe. Assume that the volume of the liquid flowing out per second depends on (a) the coefficient of viscosity of the liquid (η) (b) the radius of the pipe (r) and (c) the pressure gradient along the pipe (Pressure gradient is drop in pressure per unit length of the pipe, and equal to P/l, where P is the difference between the ends of the pipe and l is the length of the pipe). The dimensions of viscosity is $\left[ML^{-1}T^{-1}\right]$. Deduce by the method of dimensions the formula for the volume of the liquid flowing out per second.

Q.8 The length, breadth and thickness of a rectangular sheet of metal are 4.234m, 1.005m and 2.01 cm respectively. Calculate the surface area and volume of the sheet to correct significant figures.

Q.9 Reynoid's number N_R (a dimensionless quantity) determines the condition of laminar flow of a viscous liquid through a pipe. N_R is a function of the density of the liquid 'r', its average speed is $'\upsilon'$ and the coefficient of viscosity of the liquid is $'h'$. If N_R is given

directly proportional to $'d'$(the diameter of the pipe), show from dimensional consideration that $N_R \propto \frac{d\rho\upsilon}{\eta}$ the unit of $'\eta'$ in S.I. system is kg $m^{-1}s^{-1}$.

Q.10 if two resistances of values $R_1 = (2.0 \pm 0.1)\Omega$ and $R_2 = (12.3 \pm 0.2)\Omega$ are put (i) in parallel and (ii) in series, find the error in the equivalent resistance.

Q.11 The force experienced by a mass moving with a uniform speed υ in a circular path of radius r experiences a force which depends on its mass, speed and radius. Prove that the relation is $f = \frac{m\upsilon^2}{r}$.

Q.12 The viscous force 'F' acting on a body of 'r' moving with a velocity $'\upsilon'$ in a medium of coefficient of viscosity $'\eta'$ is given by $f = 6\pi\eta r\upsilon$. Check the correctness of the formula.

Chapter 2. Motion in a straight line

Q.1 Derive the three equations of motion by calculus method. Express conditions under which they can be used.

Q.2 (a) With the help of a simple case of an object moving with constan velocity show that the area under velocity- time curve represents the displacement over a given time interval.

(b) Establish he relation $x = \upsilon_o t + \frac{1}{2}at^2$ graphically.

(c) A car moving with a speed of 126 km/h is brought to a stop within a distance of 200m.

Calculate the retardation of he car and the time required to stop it.

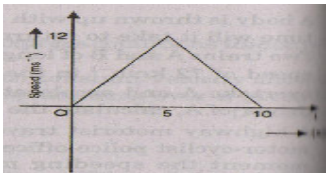
Q.3 Draw velocity- time graph of uniformly accelerated motion in one dimension. From the velocity time graph of uniform accelerated motion deduce the equations of motion in distance and time.

Q.4 A point object is thrown vertically upwards at such a speed that it returns to the thrower after 6 seconds. With what speed was it thrown up and how high did it rise ?Plot speed time graph for the object and use it to find the distance travelled by it in the last second of its journey.

Q.5 Derive an equation for the distance covered by a uniformly accelerated body in n^{th} second of its motion. A body travels half its total path in the last second of its fall from rest. Calculate the time of its fall.

Q.6 The speed –time graph of a particle moving along a fixed direction is shown here. Obtain the distance travelled by the particle between $(a)\, t = 0$ to $s, (b)\, t = 2$ to 6 s.

What is the average speed of the particle over the intervals in (a) and (b)?



Q.7 A body is moving with a uniform acceleration. Its velocity after 5 second is 25 m/s and after 8 seconds is 34 m/s. Calculate the distance it will cover in 10th second.

Q.8 A train starts from a station P with a uniform acceleration a_1 for the some distance and then goes with the uniform retardation a_2 for the some more distance to come to rest at the statio

Q.9 The distance between the stations P and Q is 4 km and train takes 4 minutes to complete this journey. If the accelerations are in km per min^2. Show that $\frac{1}{a_1}+\frac{1}{a_2}=2$.

Q.10 Find the displacement and distance travelled by a body in 10 seconds, using the $\upsilon - t$ graph given.

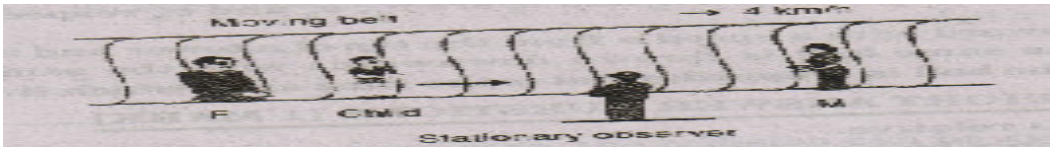
Q.11 on a long horizontal moving belt, a child runs to and for with a speed 9 km h^{-1} (with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of 4 km h^{-1} . For an observer on a stationary platform outside, what is the

(a) speed of the child running in the direction of motion of the belt?

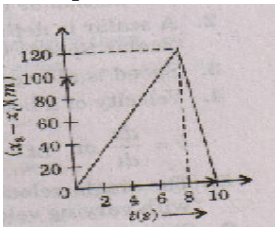
(b) speed of the child running opposite to the direction of motion of the belt ?

(c) time taken by the child in (a) and (b) ?

Which of the answers alter if motion is viewed by one of the parents?



Q.12 Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speed of 15 m s^{-1}and 30 m s^{-1}. Verify whether the graph shown, correctly represents the time variation of the relative position of the second stone with respect to the first. Neglect air resistance and assume that the stones do not rebound after hitting the ground. Take $g=10$ m s^{-2} . Give the equations for the linear and curved parts of the plot.



Q.13 A body starts from rest and accelerates with α from some time and decelerates with β to come to rest. If t is the total time taken find the

(i) Maximum velocity attained, (ii) Distance travelled in the time $'t'$.

Q.14 The driver of a train moving with a speed υ_1 sights a train at a distance d ahead of him on the same track moving in the same direction, with a slower speed υ_2. Show that if $d > \frac{(\upsilon_1-\upsilon_2)^2}{2a}$ the collision between them is avoided.

Q.15 A point moves with a deceleration $a\sqrt{\upsilon}$ in a straight line. (α is a constant). At time $t=0$, the velocity is υ_0. What distance it traverses before it comes to rest. What will be the time consumed ?

Q.16 A train is moving with a constant acceleration. If u and υ are the velocities of the fron and back portions, as they cross a point, find the velocity with which the middle point of the train cross the same point.

Q.17 A particle moves in a straight line such that its displacement at any time is, $s^2 = t^2 + 1$. Find

(i) velocity (ii) acceleration as a function of s.

Q.18 In a car race, car A takes a time t seconds les than the car B and passes the finishing point with a velocity υ more than that of the car B. If the cars starts from rest and travel with constant acceleration a_1 and a_2 respectively, show that $\upsilon = t\sqrt{a_1 a_2}$.

Q.19 If x, y and z are distances moved by a particle moving with a constant acceleration during l^{th}, m^{th} and n^{th} second of its motion respectively, Show that, $x(m-n)+y(n-l)+z(l-m)=0$.

Q.20 The acceleration experienced by boat, after its engine is cut off is given by, $\frac{d\upsilon}{dt} = -K\upsilon^3$, where K is a constant .If υ_0 is the magnitude of velocity at cut off $(t=0)$, find the magnitude of the velocity at a time t after the cut off.

Q.21 A particle moves with uniform acceleration in a straight line. If the average velocities in three successive time intervals, t_1, t_2 and t_3 are υ_1, υ_2 and υ_3 respectively. Find the ratio of $(\upsilon_2 - \upsilon_1)$ and $(\upsilon_3 - \upsilon_2)$.

Q.22 A ball is thrown upward with a speed υ from the top of a tower and it reaches the ground after time t_1. If the same ball is thrown downwards with the same speed u, the time taken is t_2. When the ball is dropped, what is the time after which it reaches the ground ?

Chapter 3. <u>Motion in a plan</u>

Q.1 Distinguish between a uniform and non- uniform circular motion, For a uniform circular motion find the centripetal acceleration. If the speed is variable in circular path, give the net acceleration.

Q.2 a body is projected with a velocity u at an angle θ with the horizontal. Derive relations for (i) Path followed, (ii) Maximum height, (iii) time of flight, (iv) Range of projectile, (v) Maximum range.

Q.3 State the law of parallelogram of vectors. Find the magnitude and direction of the resultant of two vectors $\vec{A}$ and $\vec{B}$.

Q.4 Prove the following :

(a) For two angles is same of projection θ and $(90-\theta)$ with same velocity υ,

(i) Range is same, (ii) Heights are in the ratio $\tan^2\theta : 1$.

(b) If the range and maximum height are equal, the angle of projection is $\tan^4(4)$.

Q.5 A projectile is fired at an angle θ with the horizontal.

(a) Show that its trajectory is a parabola.

(b) Obtain expression for

(i) the maximum height attained. (ii) the time of its flight and (iii) he horizontal range

(c) At what value of θ is the horizontal range maximum ?

(d) Prove that, for a given velocity of projection, the horizontal range is same for θ and $\left(90^o - \theta\right)$.

Q.6 A projectile shot at an angle of 60° above the horizontal ground strikes a vertical wall 30 m away at a point 15 m above the ground. Find the speed with which the projectile was launched and the speed with which it strikes the wall.

Q.7 Define projectile. Show that the path of projectile is parabola. Find the angle of projection at which the horizontal range and maximum height o the projectile are equal.

Q.8 Establish the following vector inequalities geometrically or otherwise.

(a) $\left|\vec{a}+\vec{b}\right| \le \left|\vec{a}\right| + \left|\vec{b}\right|$ (b) $\left|\vec{a}-\vec{b}\right| \le \left|\vec{a}\right| + \left|\vec{b}\right|$ (c) $\left|\vec{a}+\vec{b}\right| \ge \left|\left|\vec{a}\right| - \left|\vec{b}\right|\right|$ (d) $\left|\vec{a}-\vec{b}\right| \ge \left|\left|\vec{a}\right| - \left|\vec{b}\right|\right|$

Q.9 Prove that the vectors $\left(\hat{i}+2\hat{j}+3\hat{k}\right)$ and $\left(2\hat{i}-\hat{j}\right)$ are perpendicular to each other.

Q.10 If $\vec{A} = \left(-2\hat{i}+3\hat{j}-3\hat{k}\right)$ and $\vec{B} = 3\hat{i}-4\hat{j}+5\hat{k}$ find $\vec{A}\times\vec{B}$ and $\vec{A}.\vec{B}$.

Q.11 Determine λ such that : $\vec{A} = 2\hat{i}+\lambda\hat{j}+\hat{k}$; $\vec{B} = 4\hat{i}-2\hat{j}-2\hat{k}$ are perpendicular to each other.

Q.12 Rain is falling vertically with a speed of 30 ms^{-1}. A woman rides a bicycle with a speed of 10 ms^{-1} in the north to south direction. What is the direction in which she should hold her umbrella ?

Q.13 A string can withstand a tension of 25 N. What is the greatest speed at which a body of mass 1 kg can be whirled in a horizontal circle using a 1m length of the string ?

Q.14 $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axes respectively. (i) What is the magnitude and direction of the vectors $\hat{i}+\hat{j}$ and $\hat{i}-\hat{j}$? (ii) What are the components of a vectors $\vec{A} = 2\hat{i}+3\hat{j}$ along the directions of $\hat{i}+\hat{j}$ and $\hat{i}-\hat{j}$?

Q.15 A shell bursts on contact with the ground and the fragments fly in all distance that a speeds upto 39.2 m/s. Show that a man 78.4 m away is in danger for $4\sqrt{2}$ seconds.

Q.16 The position of a particle is given by $r = 3.0t\hat{i} - 2.0t^2\hat{j} + 4.0\hat{k}$ m where t is in seconds and the coefficients have the proper units for r to be in meters.

(a) Find υ and a of the particle.

(b) What is the magnitude and direction of velocity of the particle at $t = 2s$?

Q.17 A particle starts from the origin at $t = 0s$ with a velocity of $10.0\,\hat{j}$ m/s and moves in the x - y plane with a constant acceleration of $\left(8.0\hat{i}+2.0\hat{j}\right)$ ms^{-2}.

(a) At what time will the x - co-ordinate of the particles be 16 m? What is the y - co-ordinate of the particle at that time ?

(b) What is the speed of the particle at the time?

Q.18 On a certain day rain was falling vertically with a speed of 30 ms^{-1}. In which direction should a girl waiting at a bus stop turn her umbrella ? Explain with labeled diagram.

Q.19 A cricket ball is thrown at a speed of 28 m/s in a direction 30° above the horizontal. Calculate : (a) the maximum height (b) the time taken by the ball to return to the same

level (c) the horizontal distance from the thrower to the point where the ball returns to the same level.

Q.20 On an open ground, a motorist follows a track that turns to his left by an angle of 60° after every 500 m. Starting from a given turn, specify the displacement of the motorist at the third, sixth and eighth turns. Compare the magnitude of the displacement with the total path length covered by the motorist in each case.

Q.21 A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 s, what is the magnitude and direction of acceleration of the stone?

Q.22 An aircraft executes a horizontal loop of radius 1.00 km with a steady speed of 900 km/h. Compare its centripetal acceleration with the acceleration due to gravity.

Q.23 An aircraft is flying at a height of 3400 m above the ground. If the angle subtended at a ground observation pount by the aircraft positions 10.0 s apart is 30°, what is speed of the aircraft ?

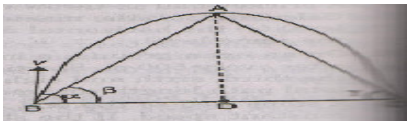
Q.24 A cyclist is riding with a speed of 27 km/h. As he approaches a circular turn on the road of radius 80 m, he applies brakes and reduces his speed at the constant rate of 0.50 m/s every second. What is the magnitude and direction of the net acceleration of the cyclist on the circular turn ?

Q.25 The total speed V_1 of a projectile at its greatest height is $\sqrt{\frac{6}{7}}$ of its speed V_2 when it is at half its greatest height. Show that the angle of projections 30°.

Q.26 A base- ball is hit at an angle 45° and at a height of 0.9 m. The ball travels a total distance of 120 m. What is the initial velocity of the ball? What is the height of the ball above a 3 m fence 100 m from where the ball is hit ?

Q.27 A motorcycle stunt rider will jump a 100 m wide row of cars. The launch ramp is 30° and 9.0 m high. The land ramp is also 30° and 6 m high. Find the minimum speed for the launch.

Q.28 A particle is projected with a speed at an angle α to the horizontal from the end B of the horizontal base BC of a triangle ABC. It rises to the vertex A and after just grazing it, falls down to reach point C- of the base BC. If the base angles of the triangle are β and γ, show that 4 $\cot\alpha = \cot\beta + \cot\gamma$.



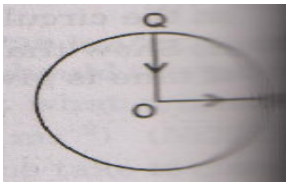
Q.29 The kinetic energy associated with a mass m moving in a circular path is given by K.E. = as^2 where a is a constant and s is the distance travelled. Find the accelerations associated with the body.

Q.30 A body is suspended by a string of length 1m and is projected horizontally with velocity 4 m/s. Calculate the tangential and radial accelerations when the string rises by 60° from its initial position. Also find the difference in velocity.

Q.31 The acceleration associated with a mass 'm' moving in a circular path is to be found. It is given that the velocity at any instant is $\upsilon = Krt$, where K is a constant. Classify the motion and find acceleration.

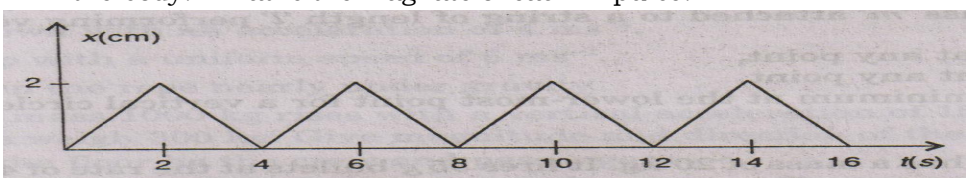
Q.32 A body falling freely from a height H hits an inclined plane in its path at a height h. Due to the impact,(elastic) the direction of the velocity of the body becomes horizontal. Find h/H, so that the body takes maximum time to reach the ground.

Q.33 A cyclist starts from the centre O of a circular park of radius 1 km, reaches the edge of the park, then cycles along the circumference and returns to the centre QO as shown. If the round trip takes 10 min, what is the (a) net displacement, (b) average velocity and (c) average speed of the cyclist.



Chapter 4. Law of motion

Q.1 Figure shows the position time graph of a body of mass 0.04 kg. Suggest physical context for this motion. What is the time between two consecutive impulses received by the body? What is the magnate of each impulse?



Q.2 Discuss how the principle of conservation of momentum is used in the launching of rockets. Deduce an expression for,
(i) velocity at any instant and (ii) acceleration of the rocket.

Q.3 (i) Define friction.
(ii) Show that kinetic friction is less than the static friction.
(iii) Establish that static friction is a self-adjustable force.
(iv) Write the basic laws of static friction.

Q.4 Consider a mass 'm' attached to a string of length 'l' performing vertical circle. Find an expression for
(i) Velocity at any point, (ii) Tension at any point,
(iii) Velocity minimum at the lower-most point for a vertical circle.

Q.5 A machine gun has a mass of 20 kg. It fires g bullets at the rate of 400 bullets per second with a speed of 400 ms^{-1} . What force must be applied to the gun to keep it in position?

Q.6 Weights of 50 g and 40 g are connected by a string passing over a smooth pulley. If the system travels 2.18 m in the first 2 seconds, find the value of g.

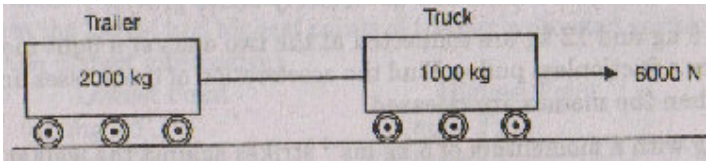
Q.7 A hammer of mass 1 kg moving with a speed of 6 ms^{-1} strikes a wall and comes to rest in 0.1 s. Calculate.
(i) the impulse of force. (ii) the retardation of the hammer, and
(iii) the retarding force that stops the hammer.

Q.8 A man weight 70 kg. He stands on a weighing scale in a lift which is moving.
(a) upward with a uniform speed of 10 ms^{-1}.
(b) downward with a uniform acceleration of ms^{-2} .
(c) upwards with a uniform acceleration of 5 ms^{-2}.
What would be the reading on the scale in each case ? What would be the reading if the lift mechanism failed, and it hurtled down freely under gravity ?

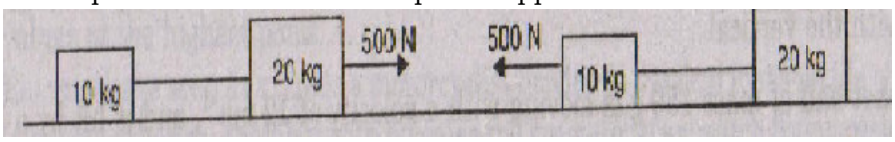
Q.9 A monkey of mass 40 kg climbs on a rope which can stand a maximum tension of 600 N. In which of the following cases will the rope break. The monkey :

(a) climbs up with an acceleration of 6 ms^{-2}.
(b) Climbs down with an acceleration of 4 ms^{-2}.
(c) Climbs up with a uniform speed of 5 ms^{-1}.
(d) Falls down the rope nearly under gravity. [Take g = 10 ms^{-2}]

Q.10 A truck of mass 1000 kg is pulling a trailer of mass 2000 kg as shown. The retarding(frictional) force on the truck is 500 N and that on the trailer is 1000 N. The truck engine exert a force of 6000 N. Calculate;
(i) the acceleration of the truck and the trailer, and
(ii) he tension in the connecting rope.

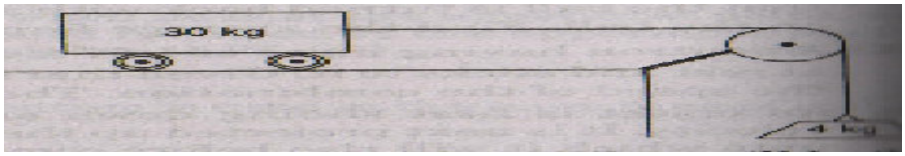


Q.11 A horizontal force of 500 N pulls two masses 10kg and 20 kg(lying on a frctionless table) connected by a lightest string as shown. What is the tension in the string? Does the answer depend on which mass the pull is applied ?

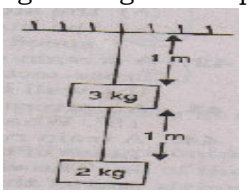


Q.12 Compute the acceleration of the block and trolley system as shown. If the coefficient of kinetic friction between the trolley and the surface is 0.04, what is the tension in the string ?

[Take g = 10 ms^{-2}]

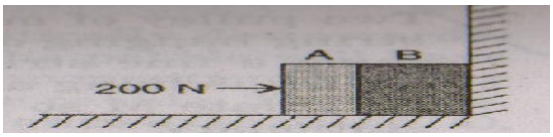


Q.13 Two blocks 3 kg and 2 kg are suspended from a rigid support by two inextensible wire, each of length 1 m and having linear mass density 0.2 kg/m. Find the tension at the mid-point of each ire as the arrangement gets an upward acceleration of 2 m/s^2.

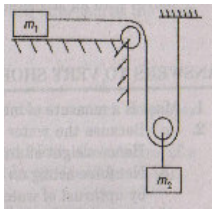


Q.14 A money of mass 40 kg climbs on a rope which can stand a maximum tenson on 60 N. In which of the following cases will the rope break : the money
(a) climbs up with an acceleration of 6 m s^{-2}
(b) climbs down with an acceleration of 4 m s^{-2}
(c) climbs up with a uniform speed of 5 m s^{-1}
(d) falls down the rope nearly freely under gravity ?

Q.15 Two bodies A and B of mass 5 kg and 10 kg in contact with each other rest on a table against a rigid. The coefficient of friction between the bodies and the table is 0.15. A force of 200 n is applied horizontally to A. what are (a) the reaction of the partition (b) the action- reaction forces between A and B ? What happens when the wall is removed ? Does the answer to (b) change, when the bodies are in motion ? Ignore the difference between μ_s and μ_k.



Q.16 Find the acceleration of he two masses.



Q.17 A body of mass m rests on a rough horizontal surface. Find the minimum force required to be applied to move the body ? Given that the direction of application of force is $\theta = \tan^{-1}(\mu)$.

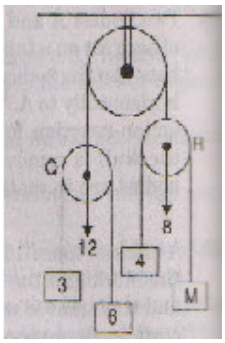
Q.18 A uniform rope of length l and mass m is hung from a support. What is the tension at a distance x from the free end ?

Q.19 Apiece of uniform sting hangs vertically, so that its free end just touches the horizontal surface of a table. If the upper end is released, show that at any instant during fall of the string, the total force on the surface is three times the weight of that part of the string which is lying on the surface.

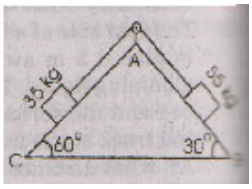
Q.20 A string of length l passes over a pulley. Two monkey of equal masses hold the two free ends and starts climbing up. Find the time in which they will meet each if the motion is with (i) constant velocity u (ii) uniform acceleration 'α'.

Q.21 Starting from rest, a mass m slides down an inclined plane (θ) in a time n times the time taken to slide down the same length in the absence of friction. Find the frictional coefficient of the surface.

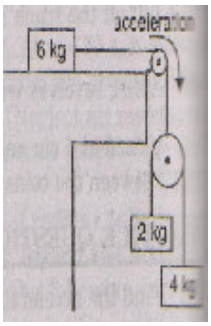
Q.22 Two pulley of masses 12 kg and 8 kg are connected by a fine string hanging over a fixed pulley as shown. Over the latter is hung a fine string with masses 4 kg and m. Over the 12 kg pulley is hung another fine string with masses 3 kg and 6 kg. Calculate M so that the string over the fixed pulley remains stationary.



Q23. Two blocks connected by an inextensible string passing over a light frictionless pulley rest on two smooth inclined planes as shown. Determine the acceleration of the blocks and the tension in the string. Assume the strings to be massless.



Q.24 One end of a string is attached to a 6 kg mass on a smooth horizontal table. The string passes the edge of the table, and to its other end is attached a light smooth pulley. Over this pulley passes another string to the ends of which are attached masses of 4 kg and 2 kg respectively as shown. Show that the 6 kg mass moves with an acceleration of $\frac{8g}{17}$.



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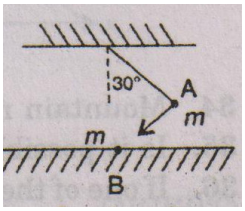
Chapter 5. <u>Work, Energy and Power</u>

Q.1 The bob A of a pendulum released from 30° to the vertical hits another bob b of the same mass at test on a table as shown in the figure. How high does he bobs and assume the collision to be elastic.

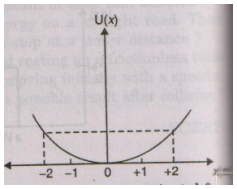


Q.2 A body of mass 2 kg initially at rest moves under the action of an applied horizontal force of 7 N on a table with co-efficient of kinetic friction = 0.1. Calculate the

(a) work done by the applied force in 10 s.
(b) work done by the friction in 10 s.
(c) work done by the net force on the body in 10 s.

(d) change in kinetic energy of the body in 10 s and interpret your result.

Q.3 The potential energy function for a particle executing linear SHM is given by $U(x)=\frac{1}{2}kx^2$, where k is the force constant of the oscillator. $k=\frac{1}{2}Nm^{-1}$ the graph of $U(x)$ versus x is as shown. Show that particle of total energy 1J moving under this potential must "turn back" when it reaches $x=\pm 2$ m.



Q.4 A body of mass 'M' at rest is struck by a body of 'm'. Show that the fraction of K.E. of mass m transferred to the struck particle is $\frac{4mM}{(n+M)^2}$.

Q.5 State if each of the following statements is true or false. Give reasons for your answer.

(a) In an elastic collision of two bodies, the momentum and energy of each body is conserved.

(b) Total energy of a system is always conserved, no matter what internal and external forces on the body are present.

(c) Work done in the motion of a body over a closed loop is zero for every force in nature.

(d) In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system.

Q.6 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

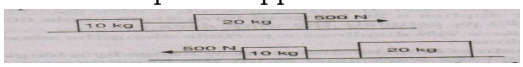
(i) $t^{1/2}$ (ii) t (iii) $t^{3/2}$ (iv) t^2

Q.7 A body of moving unidirectional under the influence of a source of constant power. Its displacement in time t is proportional to

(i) $t^{1/2}$ (ii) t (iii) $t^{3/2}$ (iv) t^2

Q.8 A stone of mass 2 kg is attached to a string 3 m long and is whirled in a horizontal circle. The string can withstand a maximum tension 2.5 kgwt. Calculate maximum velocity of revolution that can be given to the stone without breaking the string.

Q.9 A horizontal force of 500 N pulls two masses 10 kg and 20 kg(lying on a frictionless table) connected by a light string. What is the tension in the string ? Does the answer depend on which mass the pull in applied ?



Q.10 What are conservative and Non-conservative forces. Explain with example.

Q.11 State and prove work-energy theorem.

Q.12 Derive an expression for the velocity of the two masses m_1 and m_2 moving with speeds u_1 and u_2 undergoing elastic collision in one dimension.

Q.13 A mass m moving with a speed u collides with a similar mass m at rest, elastically and obliquely. Prove that they will move in directions making an angle $\frac{\pi}{2}$ with each other.

Q.14 What is a conservative force ? Prove that gravitational force is conservative, while frictional force is non-conservative.

Q.15 A mass is dropped from a height h on to a floor with coefficient of restitution $'e'$. Find

(i) the height to which, it will go after n collisions.

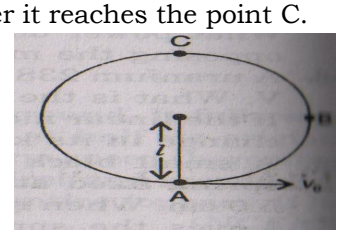
(ii) the velocity after $'n'$ collisions with the floor.

(iii) the time taken till the nth collision.

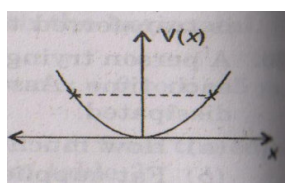
Q.16 A body constrained to move along z-axis of a co-ordinate system is subject to a constant force $\vec{F}$ given by $\vec{F}=\left(-\hat{i}+2\hat{j}+3\hat{k}\right)$ where $\hat{i},\hat{j},\hat{k}$ are unit vectors along x, y, z-axis of the system respectively. What is the work done by this force in moving the body a distance of 4 m along z-axis ?

Q.17 If the energy of a body increases by 300% by what percentage does its momentum increase ?

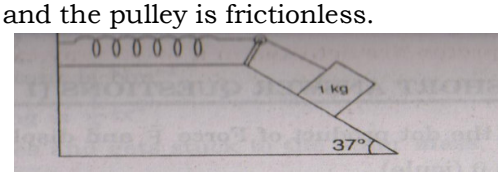
Q.18 A bob of mass m is suspended by a light string of length l. It is imparted a horizontal velocity υ_o at the lowest point A such that it completes a semi-circular trajectory in the vertical plane with the string becoming slack only on reaching the top-most point C. This is shown in the figure. Obtain an expression. For (i) υ_o (ii) the speed at point B and C, (iii) the ratio of the kinetic energies $\left(\frac{K_B}{K_C}\right)$ at B and . Comment on the nature of the trajectory of the bob after it reaches the point C.



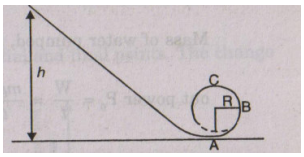
Q.19 The potential energy function for a particle executing linear simple harmonic motion is given by $V(x)=\frac{kx^2}{2}$, where k is the force constant of the oscillator. For $k=0.5\,Nm^{-1}$, the graph of $V(x)$ versus x is shown in figure. Show that a particle of total energy 1J moving under this potential must 'turn back' when it reaches $x=\pm 2$ m.



Q.20 A 1kg block situated on a rough incline is connected to a spring of spring constant 100 N m^{-1} as shown in figure. The block is released from rest with the spring in the unstreatched position. The block moves 10 cm down the incline before coming to rest, Find the coefficient of friction between the block and the incline. Assume that the spring has a negligible mass and the pulley is frictionless.



Q.21 From what height above the bottom of the loop must the mass m start in order to just make it around the loop. What is the velocity of the car at A and at point B ?



Q22. A pendulum with string of length 1 m with a bob of mass 1 kg is held horizontally and set free. At the lowermost point it hits a 0.3 kg block placed on a horizontal surface of frictional coefficient $u = 0.25$. If the collision is elastic, how far will the mass travel to come to rest ?

Q.23 Two masses A and b of m and 2m kg respectively are placed on a smooth floor connected by a spring. A third body C of mass m moving with a velocity υ_0 collides elastically. At a time t_0 after the collision, the velocity of A and B is same. The compression in the spring is x_0. Find

(i) the velocity of A and B at t_0 (ii) the spring constant.

Q.24 A mass m is placed on a platform from a height h. The platform is attached to a spring whose other end is fixed to the ground. Find the compression in the spring, if the spring constant is K.

Q.25 A pendulum bob mass 4 Kg is attached to a string (1 m) which can bear a maximum tension of 46 N. When it is allowed to move, what is the maximum height to which it can go up ?

Chapter 6. Rotational Motion

Q.1 A cylinder of length 20 cm and radius 10 cm is rotating about its central axis at an angular speed of 100 rad/s. What tangential force will stop the cylinder at a uniform rate in 10 seconds ? The moment of inertia of the cylinder about its axis of rotation is 0.8 kg m^2.

Q.2 A mass m is allowed to roll down an inclined plane (θ). If the height vertical is h, find

(i) acceleration along the inclined plane. (ii) velocity down the plan.

Q.3 (i) Define Moment of inertia. Write the parallel and perpendicular axis theorem.

(ii) Derive an expression for moment for inertia of a disc of radius r, mass m about an axis along its diameter.

Q.4 (a) Obtain an expression for moment of inertia of uniform circular disc about an axis perpendicular to the plane of disc and passing through its centre.

(b) Three point masses of 1 kg, 2 kg and 3 kg lie at (1,2), $(0,-1)$ and $(2,-3)$ respectively. Calculate the co-ordinates of centre of mass of the system.

Q.5 Calculate the moment of inertia of a cylinder of length, $l = 150$ cm, radius, $r = 5$ cm, density, $\rho = 88\,\text{cm}^{-3}$ about the axis of the cylinder.

Q.6 A sphere of a radius 10 cm weighs 1 kg, calculate the moment of inertia.

(i) about the diameter (ii) about the tangent.

Q.7 Three point masses of 1 kg, 2 kg and 3 kg lie at (1,2), $(0,-1)$ and $(2,-3)$ respectively. Calculate the co-ordinates of the centre of mass of the system.

Q.8 In the HCl molecule the separation between the nuclei of the two atoms is about 1.27 $\overset{o}{A}$ $\left(1\overset{o}{A} = 10^{-10}\text{ m}\right)$. Find the approximate location of the CM of the molecule, given that a

chlorine atom is about 35.5 times as massive as a hydrogen atom and nearly all the mass of an atom is concentrated in its nucleus.

Q.9 From a uniform circular disc of diameter d, a circular hole of diameter $d/6$ and having its centre at a distance of $d/4$ from the centre of the disc is scooped out. Find the centre of mass of the remaining portion.

Q.10 Two particles of mass 2 kg and 1 kg are moving along the same line with speeds 2ms and 5 m/s respectively. What is the speed of the centre of mass of the system if both the particles are moving(a) in same direction (b) in opposite direction?

Q.11 To maintain a rotor at a uniform angular speed of 200 rad s^{-1}, an engine needs to transmit a torque of 180 Nm. What is the power required by the engine ?

[**Note :** uniform angular velocity in the absence of friction implies zero torque. In practice, applied torque is needed to counter frictional torque]. Assume that the engine is 100% efficient.

Q.12 A solid cylinder of mass 20 kg rotates about its axis with angular speed 100 rad s^{-1}. The radius of the cylinder is 0.25 m What is the KE. Associated with the rotation of the cylinder ? What is the magnitude of angular momentum of the cylinder about its axis ?

Q.13 A solid cylinder of mass 20 kg and radius 0.12 m rotating with initial angular speed of 125 rad s^{-1} is placed lightly (*i.e.*, without any translational push) on a horizontal table with coefficient of kinetic friction $\mu_k = 0.15$, between the cylinder and the table.

(a) After how long does the cylinder starts rolling ?

(b) What is the initial (i) translational energy (ii) rotational energy and (iii) total energy of the cylinder ?

(c) After rolling begins, what is (i) translational energy (ii) rotational energy and (iii) total energy

(d) Where does the difference in energies (total) disappear ?

Q.14 (a) A child stands at the centre of a turntable with his two arms outstretched. The turntable is set rotating with an angular speed of 40 rev/min. How much is the angular speed of the child if he folds his hands back and there by reduces his moment of inertia to 2/5 times the initial value? Assume that the turntable rotates without friction.

(b) show that the child's new kinetic energy of rotation is more than initial kinetic energy of rotation. How do you account for this increase in kinetic energy ?

Q.15 A cylinder of mass 10 kg and radius 15 cm is rolling perfectly on a plane of inclination 30°. The co-efficient of static friction $\mu_s = 0.25$.

(a) How much is the force friction acting on the cylinder ?

(b) What is the work done against friction during rolling ?

(c) If the inclination θ of the plane is increased, at what value of θ does the cylinder begin to skid, and not roll perfectly?

Q.16 A uniform sphere of radius r made of material of density ρ exerts a force of F_1 on a mass m at a distance $3r$ from its centre. If a sphere of radius $r/4$ centred at $r/2$ from the original centre is removed, what will be the force on the mass ?

Q.17 A uniform toy of constant density ρ is made by fixing a cone over a hemispherical base (radius-r). For equilibrium, prove that the maximum height possible is $\sqrt{3}\,r$ with the cone.

Q.18 A tube of length l is filled with a liquid if density ρ. Find the force experienced at one of its edge if rotated about the other edge with an angular velocity ω.

Q.19 A uniform bar if length $6a$ and 8m lies on a smooth horizontal surface. Two point masses m and $2m$ moving in the same plane with speeds 2υ and υ respectively strike at a and $2a$ and stick to the rod. Find

(i) moment of Inerita of the system after the collision.

(ii) Angular momentum associated

(iii) Angular velocity, just after the collision.

Q.20 a uniform disc of mass M and radius R, starts off with sliding motion with a velocity υ_0 at $t=0$. After t_0 seconds, it starts purely rolling motion. Find he velocity of its centre of mass at t_0. If μ is the coefficient of friction, find the work done as a function of time against the friction.

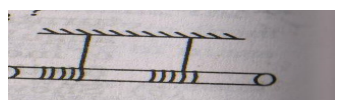
Q.21 Two masses M_1 and M_2 are separated by a distance r. Find the moment of inertia of this arrangement about an axis passing through the centre of mass and perpendicular to the line joining them.

Q.22 A rod of length l and mass M held vertically is let go down, without slipping at the point of contact. What is the velocity of the top end at the time of touching the ground ?

Q.23 A pulley of radius R and mass M has an inextensible string placed over it. Two masses m_1 and m_2 $(m_2 > m_1)$ are attached to the free ends of the string ? Find (i) The acceleration of the system (ii) Tension in the string.

Q.24 A uniform rod of length $1m$ is accelerated $(2m/s^2)$ horizontally by the application of two forces F_1 and F_2.The mass of the rod is -2 kg. If the Force F_1 acts at the top edge of the rod and F_2 acts at a distance 25 cm from the lower edge in the opposite direction and the acceleration is found to be in the direction of F_2 , find the forces F_1 and F_2 ?

Q.25 A solid cylinder of mass M and radius R is held at rest in a horizontal position. Two strings are wound round the cylinder. As the string gets un-wond, find the tension in the string and acceleration in the cylinder.



Chapter 7. Gravitation

Q.1 The value of acceleration due to gravity at the moon is $\frac{1}{6}$th of the value of g at the surface of the earth, and the diameter of the moon is $\frac{1}{4}$th of the diameter of the earth. Compare the ratio of the escape velocities.

Q.2 If the earth has a mass nine times and radius twice that of the planet Mars, calculate the maximum velocity required by a rocket to pull out of the gravitational force of Mars. Given escape velocity on the surface of earth is 112.2 km/sec.

Q.3 What happens to a body when it is projected vertically upwards from the surface of the earth with a speed of 11200 m/s, and Why ? Compare escape speeds for two planets of masses M and 4M and radii 2R and R respectively.

Q.4 A body weighs 90 kgf on the surface of earth. How much will it weigh on the surface of a planet whose mass is $\frac{1}{9}$ and radius $\frac{1}{2}$ that of earth ?

Q.5 The escape velocity υ of a body depends upon :

(i) the acceleration due to gravity 'g' of the planet.
(ii) the radius of the planet 'R'.
Establish dimensionally the relationship between them.

Q.6 State Newton's law of Gravitation. Find the percentage decrease in the weight of the body when taken to a height of 16 km. above the surface of the earth. Radius of the earth is 6400 km.

Q.7 Define gravitational field strength. Which of the planet of the solar system has the greatest gravitational filed strength ? What is the gravitational filed strength of a planet where the weight of 60 kg Astronaut is 300 N ?

Q.8 Discuss how torque on a extended rigid body is, $\vec{\tau} = \vec{r} \times \overrightarrow{Mg}$ if n finite masses exist in it.

Q.9 Estimate the acceleration due to gravity at any point on the surface of earth, due to its rotation. How this value changes from the equator to the poles?

Q.10 Derive a relation for work done in a gravitational filed. Using is (i) find potential difference between a pair of points. (ii) express whether gravitational force is conservative or non- conservative.

Q.11 State Kepler's laws on planetary motion. Explain the way the three laws can be proved.

Q.12 What is the difference between gravitational potential and gravitational potential energy. Derive an expression for gravitational potential energy of body.

Q.13 Explain the variation of 'g' with (i) shape of Earth ; (ii) rotation of Earth and prove that the weight of body remains unchanged at the poles of Earth.

Q.14 Obtain an expression for the escape velocity of an object of mass m from the surface of a planet of mass M and radius R. For planet earth, velocity is known to have a value of 11.2 km/s. How fast will an object be moving when at infinity if it is launched with a speed of 22.4 km/s from the surface of earth ?

Q.15 What is the gravitational field at a point distance $x, (x < R)$ from the centre of a uniform sphere of density ρ ? Using this result find the gravitational field at any point inside a spherical shell ?

Q.16 Two masses m_1 and m_2 are infinite distance apart. When they approach and come to a separation r, what is the relative velocity ?

Q.17 Two stars of masses M and 16m are separated by a distance 10α. Their radii are respectively a and $2a$. What should be the initial velocity with which a mass m be fired, from larger star to land on the smaller.

Q.18 Two satellites S_1 and S_2 revolve around a planet in coplanar circular orbits in the same sense. Their periods (hrs) of revolution are in the ratio 1 : 8. The radius of the orbit of S_1 is 10^4 km. When S_2 is closest to S_1 find

(i) the speed of S_2 relative to S_1.

(ii) the angular speed of S_2 as observed by an astronaut in S_1.

Q.19 A planet of mass M is moving in an elliptical orbit with sun of mass M_s at its focus. If the perihelion and aphelion are r and R respectively, what is the angular momentum of the planet relative to the Sun ?

Q.20 A solid sphere of radius $\frac{R}{2}$ is cut from solid sphere of radius R, to form a cavity. The density of the material of the sphere is ρ. A mass placed at a distance 2.5 R from the centre of the cavity. What will be gravitational attraction on m ?

Q.21 In a gravitational filed $-\frac{K}{r}$, where K is a constant and r is the distance. If the gravitational potential at $r = r_0$ is V_0, then what is the expression for the gravitational potential V?

Q.22 An infinite number of point masses each equal to m are placed at $x = 1, 2, 4, 8, ...$ Estimate the gravitational energy on a mass m at origin ?

Q.23 A stone of mass 1 kg tied to a light string of length $l = \frac{10}{3}$ m is whirling in a circular path in vertical plane. If the ratio of the maximum to minimum tension in the string is 4 find the sped of the stone at the lowest and highest points?

Chapter 8. Mechanical Properties of Solids

Q.1 When the pressure on a sphere is increased by 80 atmospheres then its volumes decreases by 0.01%. Find the bulk modulus of elasticity of the material of sphere.

Q.2 A wire is replaced by another wire of same length and material but of twice diameter:
(i) What will be the effect on the increase in its length under a given load ?
(ii) What will be the effect on the maximum load which it can bear?

Q.3 The breaking force for a wire is F. What will be the breaking forces for :
(i) two parallel wires of this size and (ii) for a single wire of double thickness ?

Q.4 Why does a cycle tube burst in summer ?

Q.5 Why is steel more elastic than rubber ?

Q.6 A spherical ball contracts in volume by 0.01% when subjected to a normal uniform pressure of two atmospheres. What is the bulk modulus of its material in C. G. S. units ?

Q.7 Explain the terms: Young's modulus of elasticity and elastic fatigue.

Q.8 The Young's modulus of a wire of length L and radius r is Y. If the length is reduced to L/2 and radius $r/2$ what will be its Young's modulus?

Q.9 The Young's modulus of a wire of length L and radius r is Y. If the length is reduced to L/2 and radius $r/4$. What will be its Young's modulus?

Q.10 A metal bar of length L and area of cross-section A, is rigidly clamped between two walls. The Young's modulus of its material is y and the coefficient of linear expansion is α. The bar is heated so that its temperature is increased from 0^oC. Find the force exerted at the ends of he bar.

Q.11 A spring balance reads 10 kg when a bucket of water is suspended from it. What is the reading on the spring balance when :
(i) an ice cube of mass 1.5 kg is put into the bucket;
(ii) an iron pieces of mass 7.8 kg suspended by another string is immersed with half its volume inside the water in the bucket(Relative density if iron =7.8) ?

Q.12 A wire of length l and area of cross-section A is stretched by the application of a force. If the Young's modulus is Y, what is the work done per unit volume?

Q.13 (i) Write the Hooke's law.
(ii) A steel wire of length 4 m and diameter 5 mm is stretched by 5 kg-wt. Find the increase in its length, if the young's modulus of steel wire is 2.4×10^{-12} dyne cm^{-2}.

Q.14 (i) prove that the work done in stretching a wire $= 1/2 \times \text{tension} \times \text{extension}$.
(ii) prove that the work done per unit volume in stretching a wire for every type of strain $= 1/2 \times \text{stress} \times \text{strain}$.

Q.15 The Stress- Strain graph for a metal wire is shown in the figure upto the point E. The wire returns to its original state O along the curve EPO when it is gradually unloaded. Point B corresponds to the fracture of the wire:

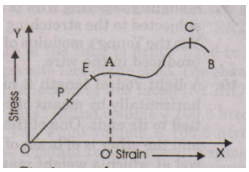
(i) Upto what point of the curve is Hooke's law obeyed ?

(ii) Which point on the curve corresponds to the elastic limit or yield point of the wire ?

(iii) Indicate the elastic and plastic regions of the Stress-Strain graph.

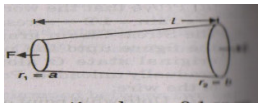
(iv) Describe what happens when the wire is loaded upto a stress corresponding to the point A on the graph, and then unloaded gradually. In particular explain the dotted cure.

(v) What is peculiar about the portion of the Stress-Strain graph from C to B ? Upto what stress can the wire be subjected without causing fracture ?

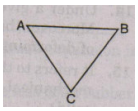


Q.16 Describe stress- strain relationship for a loaded steel wire and hence explain the terms Elastic limit, yield point, tensile strength.

Q.17 A slightly tapering wire of length l and end radii a and b is subjected to the stretching forces F and as shown in fig. If Y is the Young's modulus of the wire, calculate the extension produced in the wire.



Q.18 A wire of radius r stretched without strain along a straight line is lightly fixed at A and B. [AB = l]. What is the tension when it is pulled into the shape ACB. Young's modulus is Y.



Q.19 A stone of mass 0.5 kg is attached to one end of a 0.8 m long alumimium wire of 0.7 mm diameter and suspended vertically. The stone is now rotated in a horizontal plane at a rate such that the wire makes an angle of 85° with the vertical. Find the increase in length of the wire. $Y_{al} = 7\times10^{10}$ N/m².

Q.20 Two rods of different materials but of equal cross –section and length (1 m each) are joined to make a rod of length 2 m. The metal of one rod has coefficient of linear expansion $10^{-5}/^{o}C$ and Young's modulus $3\times10^{10} N/m^2$. The other metal has these values $2\times20^{-5}/^{o}C$ and $10^{10} N/m^2$ respectively. How much pressure must be applied to the ends of the composite rod to prevent units expansion when the temperature is raised by 100°C ? What will be the separate lengths of the two rods at the new temperature ?

Chapter 9. Mechanical Properties of Fluids

Q.1 Two liquids of equal mass and different densities ρ_1 and ρ_2 are mixed, what is the density of the mixture?

Q.2 If two liquids of equal volume and densities ρ_1 and ρ_2 are mixed, what is the equivalent density?

Q.3 how does viscous force differ from normal friction ?

Q.4 Surface tension of all lubricating oils and pants is kept low. Why ?

Q.5 the diameter of ball A is twice of that of b. What will be the ratio of their terminal velocities in water ?

Q.6 What do you understand by Reynolds's number ?

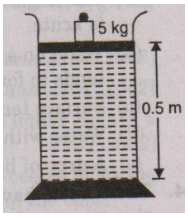
Q.7 Explain why

(i) the blood pressure in humans is greater at the feet than at the brain

(ii) Atmospheric pressure at a height of about 6 km deceases to nearly half of its value at the sea level, through the height of the atmosphere is more than 100 km

(iii) Hydrostatic pressure is a scalar quantity even though pressure is force divided by area.

Q.8 A cylindrical jar of cross-sectional area 0.01 m^2 is filled with water to a height of 50 cm (adjoining figure). It carries a tight fitting piston of negligible mass. Calculate the pressure at the bottom of the jar when a mass of 5 kg is placed on the piston.



Q.9 What are the limitations of Bernoulli's theorem.

Q.10 A hydraulic automobile lift is designed to lift cars with maximum mass of 300 kg. The area of cross section of the piston carrying the load is 425 cm^2. What maximum pressure would the smaller piston have to bear?

Q.11 Explain why

(a) The angle of contact of mercury with glass is obtuse, while that of water with glass is acute.

(b) Water on a clean glass surface tends to spread out while mercury on the same surface tends to form drops. (Put differently, water wets glass while mercury does not.)

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

(d) Water with detergent dissolved in it should have small angles of contact.

(e) A drop of liquid under no external forces is always spherical in shape

Q.12 Ice floats in water with about nine tenth of its volume submerged. What is the fractional volume submerged for an iceberg floating on a fresh water lake of a (hypothetical) planet whose gravity is en times that of the earth?

Q.13 Two capillaries of same length and radius in the ratio of 1 : 2 are connected in series and a liquid flows through this system under streamline conditions. If the pressure across the two extreme ends of combination is 1 m of water, what is the pressure difference across the (i) first capillary (ii) second capillary?

Q.14 Two vessels of the same size are at the same temperature. One of them holds 1 kg of H_2 gas and the other holds 1 kg of N_2 gas :

Q.15 A U-tube contains water and methylated spirit separated by mercury. The mercury columns in the two arms are in level with10.0 cm of water in one arm and 12.5 cm of spirit in the other. What is the specific gravity of spirit ?

Q.16 Water flows through a horizontal pipe of which the cross-section is not constant. The pressure is 1 cm of mercury where the velocity is 0.35 m/s. Find the pressure at a point where the velocity is 0.65 m/sec.

Q.17 When a drop of mercury (radius R) is split into n similar drops, what is the change in surface energy ? [σ -surface tension of mercury]

Q.18 What is meant by the term Coefficients of Viscosity ? State Stoke's law. Define terminal velocity and find an expression for the terminal velocity in case of a sphere falling through a viscous liquid such as glycerin.

Q.19 Explain why

(a) To keep a piece of paper horizontal, you should blow over, not under, it

(b) When we try to close a water tap with our fingers, fast jets of water gush through the openings between our fingers

(c)The size of the needle of a syringe controls flow rate better than the thumb pressure exerted by a doctor while administering an injection.

(d) A fluid flowing out of a small hole in a vessel results in a backward thrust on the vessel.

(e) A spinning cricket ball in air does not follow a parabolic trajectory.

Q.20 (a) State and prove Archimedes' principle.

(b) What would be pressure inside a small air bubble of 0.1 mm radius situated just below the surface of water ? Surface tension of water 72×10^{-3} N/m and atmospheric pressure is 1.1×10^{5} N/m^2.

Q.21 State and prove Bernoulli's theorem.

Q.22 Define angle of contact of a liquid with a solid surface. On what factors does it depend ? Derive an expression for the rise of a liquid in a capillary tube of uniform diameter.

Q.23 Prove that velocity of efflux of an ideal liquid through an orifice is equal to the velocity attained by a freely falling body from te surface of the liquid to the orifice. Also find he horizontal range in terms of height. When is this range maximum ?

Q.24 (i) What is the phenomenon of capillarity ? Derive an expression for the rise of liquid in a capillary tube

(ii) What will happen if the length of the capillary tube is smaller than the height to which the liquid rises? Explain briefly.

Q.25 (i) State and Prove Bernoulli's theorem.

(ii) A cylindrical vessel of uniform cross section contains liquid upto a height 'H'. At a depth $'h' = H/2$ below the free surface of the liquid there is an orifice. Using Bernoulli's theorem find the velocity of efflux of liquid.

Q.26 State Bernoulli's theorem.

Water is flowing with a speed of 2 m/s in a horizontal pipe with cross sectional area decreasing from 2×10^{-2} m^2 to 0.01 m^2 at pressure 4×10^{4} Pa. What will be the pressure at smaller cross section?

Chapter 10. Thermal Properties of Matter

Q.1 What is the shift in the colour of light when the temperature increases ?

Q.2 A slab consists of two parallel layers of two different materials of the same thickness, having thermal conductivities $K_1$and K_2. What is the equivalent thermal conductivity of the slab?

Q.3 Give dimensions of Solar Constant and Water equivalent.

Q.4 Distinguish the radiation and convection methods of heat transfer.

Q.5 Define tripe point of water. Why is it unique?

Q.6 Calculate the heat of combustion of coal, when 10 gm of coal, on burning raises the temperature of the mixture.

Q.7 2 kg water at 80°C is mixed with 3 kg water at 20°C. Assuming no heat losses, find the final temperature of the mixture.

Q.8 a body of mass 6 kg is floating in a liquid with 2/3 of its volume inside the liquid. Find (i) buoyant force acting on the body, and (ii) ratio between the density of body and density of liquid. Take g = $10ms^{-2}$.

Q.9 What are the basic requirements of a cooking utensil in respect of :
(a) specific heat (b) thermal conductivity

Q.10 What is convection current? How does it form land and sea breeze ?

Q.11 Two rods of the same area of cross-section, but of lengths l_1 and l_2 and conductivities K_1 and K_2 are joined in series. Show that the combination is equivalent of a material of conductivity. $K = \dfrac{l_1 + l_2}{\left(\dfrac{l_1}{K_1}\right) + \left(\dfrac{l_2}{K_2}\right)}$.

Q.12 State Stefan's law and Newton's law of cooling. How do you deduce the latter from the former ?

Q.13 Two bodies A and B at temperatures 327°C and 127°C respectively are placed in an evacuated enclosure maintained at a temperature of 27°C compare their rates of cooling.

Q.14 In a room, where the temperature is 30°C, a body cools from 61°C to 59°C in 4 minutes What time will the body take to cool from 51°C to 49°C in the same room ?

Q.15 A body cools from 80°C to 50°C in 5 minutes. Calculate the time it takes to cool from 60°C to 30°C. The temperature of the surrounding is 20°C.

Q.16 Answer the following questions based on the P-T phase diagram of CO_2.
(a) CO_2 at 1 atm pressure and temperature −60°C is compressed isothermally. Does it go through a liquid phase ?
(b) What happen when CO_2 at 4 atm pressure is cooled from room temperature at constant pressure.
(c) Describe qualitatively the changes in a given mass of solid CO_2 at 10 atm pressure and temperature −65°C as it is heated up to room temperature at constant pressure.
(d) CO_2 is heated to a temperature 70°C and compressed isothermally. What changes in its properties do you except to observe ?

Chapter 11. Thermodynamics

Q.1 What is the value of γ for a gas having $'n'$ degrees of freedom ?

Q.2 If on giving 40 Joule of heat to a system, work done on the system is 10 Joule. What will ne the change in internal energy of the system ?

Q.3 A cloudy night is hotter than a clear sky night. Why ?

Q.4 Put a piece of chalk into water. The chalk will emit bubbles in all directions. Explain.

Q.5 Which of the two will increase the pressure more – an adiabatic or an isothermal process in reducing the volume to 50% ?

Q.6 What are the limitations of the first law of thermodynamics ?

Q.7 Prove for an adiabatic process : (i) $TV^{\gamma-1} =$ constant, (ii) $P^{1-\gamma}T^{\gamma} =$ constant.

Q.8 A Carnot's engine whose sink is at a temperature of 300 K has an efficiency of 40%. By how much should the temperature of the source be increased so as increase the efficiency to 60% ?

Q.9 What is meant by the term 'Molar specific heat' of a gas ? the molar specific heat of hydrogen in the value of molar specific heat of hydrogen decreases to the value typical of monoatomic gases (3/2)R while at higher temperatures, it tends to the value (7/2) R. Explain.

Q.10 (i) Why a gas has two principal specific heats ?
(ii) Which one is greater and why ?

(iii) Of what significance is the difference between these two specific heats and their ratio ?

Q.11 Define molar specific heat capacities at constant volume and pressure. Considering theromodynamical process in a cylinder with parameters P,V and t, derive the Mayer's relation.

Q.12 Define degrees of freedom. How will you account for the five degrees of freedom in a diatomic molecule ? Using the idea of equi- partition of energy, find the value of γ for the same.

Q.13 A gas undergoes reduction in volume (i) adiabatically, (ii) isothermally. Find the work done in the process.

Q.14 Explain how Carnot explained that a cyclic reversible process be carried out to realize an engine ?

Q.15 Explain how Carnot's cycle works with the heat flow diagram ? Using the same, explain the working of a refrigerator. Also give its coefficient of performance.

Q.16 Use a PV diagram to explain various stages of a Carnot engine and show how this diagram gives the net work done by the Carnot engine per cycle.

Q.17 (a) Explain briefly the working principle of a refrigerator and obtain an expression for its coefficient of performance.

(b) A refrigerator has to transfer 263 J of heat second from temperature—10°C to 25°C. Calculate the average power consumed assuming no energy loss in the process.

Q.18 (a) In a Carnot engine temperature of sink is increased. What will happen to its efficiency ?

(b) A carnot engine absorbs 1000J of heat from a reservoir at 127°C and rejects 600J of heat during each cycle. Calculate the

(i) efficiency of engine. (ii) temperature of the sink.

(iii) amount of the useful work done during each cycle.

Chapter 12. Kinetic Theory

Q.1 The velocities of three molecules are $3\upsilon, 4\upsilon$ and 5υ. Calculate their roots mean square velocity.

Q.2 Oxygen and hydrogen are at the same temperature T. What is the ratio of kinrtic energies of oxygen molecule and hydrogen molecule when oxygen is 16 times heavier than hydrogen?

Q.3 The absolute temperature of the gas is increased 3 times. What will be the increase in root mean square velocity of the gas molecules ?

Q.4 Explain the concept of absolute zero of temperature on the basis of kinetic theory of gases.

Q.5 When pressure increases by 1%, what is the percentage decrease in the volume of a gas, if Boyle's law is obeyed ?

Q.6 Explain the phenomenon of evaporation on the basis of kinetic theory.

Q.7 Estimate the fraction of molecular volume to the actual volume occupied by Oxygen gas at STP. Given the radius of Oxygen molecule as 3A.

Q.8 Find the temperature at which root mean square velocity of a gas is half of its value of 0°C, pressure remaining constant.

Q.9 Calculate the r.m.s velocity of oxygen molecule at 27°C, atomic weigh of oxygen is 16.

Q.10 Calculate the molecular K.E. of 1 gram of Helium (Molecular weight 4) at 127°C. Given $R = 8.31$ j mol^{-1} K^{-1}.

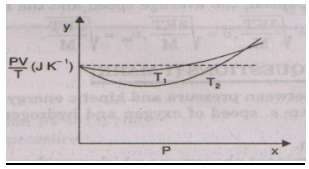
Q.11 Prove that the average kinetic energy of a molecule of an ideal gas is directly proportional to the absolute temperature of the gas.

Q.12 Figure show plot of PV/T versus P for 1.00×10^{-3} kg of oxygen gas at two different temperatures.

(a) What does the dotted plot signify ?

(b) Which is true : $T_1 > T_2$ or $T_1 < T_2$?

(c) What is the value o PV/T where the curves meet on the y -axis ?



(d) if we obtained similar plots for 1.00×10^{-3} kg of hydrogen, would we get the same value of PV/T at the point where the curves meet on the y-axis ? If not, what mass of hydrogen yields the same value of PV/T (for low pressure high temperature region of the plot) ? (Molecular mass of H_2 = 2.02 u, of O_2 = 32.0 u, R = 8.31J mol^{-1} K^{-1}).

Q.13 Three vessels of equal capacity have gases at the same temperature and pressure. The first vessel contains neon (monatomic), the second contains chlorine (diatomic), and the third contains uranium hexafluoride (polyatomic). Do the vessels contain equal number of respective molecules ? Is the root mean square speed of molecules the sane in the three cases ? If not, in which case in υ_{rms} the largest ?

Q.14 Derive an expression for pressure of a gas in a container. Using it, relate K.E. with pressure.

Q.15 (a) Define an adiabatic process. Derive an expression for work done during an adiabatic process.

(b) A Carnot engine operates between 500K and 400 K. If it absorbs 6×10^5 cal heat at higher temperature, how much work per cycle per cycle can the engine perform ?

Chapter 13. Oscillarations

Q.1 Will a pendulum gain or lose time when taken to the top of a mountain?

Q.2 Two simple pendulum of equal length cross each other at mean position. What is their phase difference ?

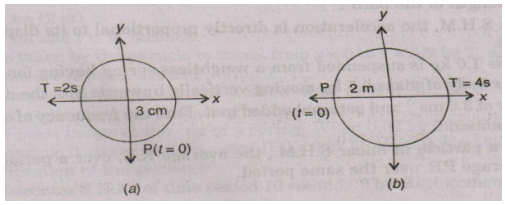
Q.3 A spring of constant K is cut into two equal parts. What is the spring constant of each part ?

Q.4 What do you mean by resonance in oscillation ?

Q.5 A girl swinging suddenly stands up on the swing. What is the influence on the time period and frequency ?

Q.6 The bob of a simple pendulum is a ball full of water. If a fine hole is made in the bottom of the ball, what will be its effect on the time period of the pendulum ?

Q.7 Figure correspond to two circular motions. The radius of the circle, the period of revolution, the initial position, and the sense of revolution (i.e., clockwise or anti-clockwise) are indicated on each figure. Obtain the corresponding simple harmonic motions of the x-projection of the radius vector of the revolving particle P, in each case.

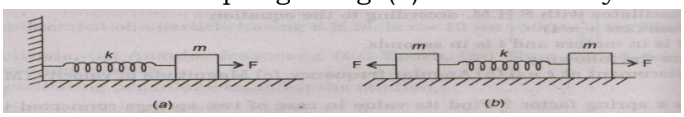


Q.8 If $y = a\sin\omega t + b\cos\omega t$, does it represent S.H.M ? What is the amplitude of motion ? what is the length of the path?

Q.9 A body of mass 1.0 kg is suspended from a weightless spring having force constant 600 Nm^{-1}. Another body of mass 0.5 kg moving vertically upwards hits the suspended body with a velocity of 3.0 ms^{-1} and gets embedded in it. Find the frequency of oscillations and amplitude of motion.

Q.10 For a particle in SHM, the displacement x of the particle as a function of time t is given as $x = A\sin(2\pi t)$. Here x is in cm and t is in seconds. Let the time taken by the particle to travel from $x = 0$ to $x = A/2$ be T_1 and the time taken to travel from $x = A/2$ to $x = A$ be T_2. Find T_1/T_2.

Q.11 Figure (a) shows a spring of force constant k clamped rigidly at one end and a mass m attached to its free end. A force F applied at the free end stretches the spring. Figure (b) shows the same spring with both end free and attached to a mass m at either end. Each end of the spring in Fig. (b) is stretched by the same force F.



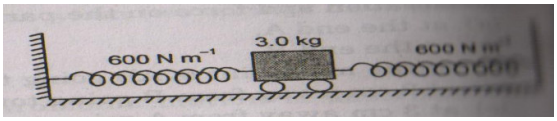
(a) What is the maximum extension of the spring in the two cases ?

(b) If the mass in Fig. (a) and the masses in Fig. (b) are released, what is the period of oscillation in each case ?

Q.12 Find the total energy of the particle executing S.H.M. and show graphically the variation of P.E. and K.E. with time in S.H.M. What is the frequency of these energies with respect to the frequency of the particle executing S.H.M.

Q.13 A particle is executing S.H.M. If V_1 and V_2 are the speeds of the particle at distance x_1 and x_2 from the equilibrium position, show that the frequency of oscillations $f = \frac{1}{2\pi}\left(\frac{V_1^2 - V_2^2}{x_2^2 - x_1^2}\right)^{1/2}$.

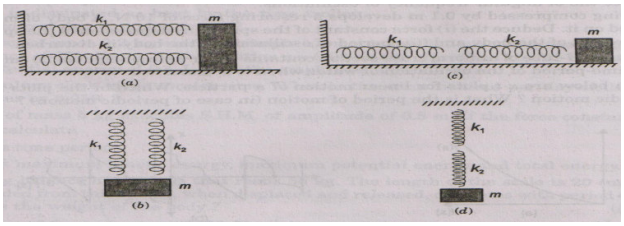
Q.14 A trolley of mass 3.0 kg, as shown in Figure, is connected to two springs, each of spring constant 600 Nm^{-1}. If the trolley is displaced from its equilibrium position by 5.0 cm and released, what is (a) the period of ensuring oscillations, and (b) the maximum speed of the trolley ? How much energy is dissipated as heat by the time trolley comes to rest due damping forces ?



Q.15 A cylindrical piece of cork of base area A and height h floats in a liquid of density ρ_r The cork is depressed slightly and then released . Show that the cork oscillates up and down simple harmonically with a period $T = 2\pi\sqrt{\frac{h\rho}{\rho_l g}}$ where ρ is the density of cork.(Ignore damping due to viscosity of the liquid).

Q.16 It the earth were a homogeneous sphere and a straight hole bored in it through its centre, show that if a body were dropped into the hole it would execute a simple harmonic motion. Also find its time period.

Q.17 Figure below show shows four different spring arrangements. If the mass in each arrangement is displaced from its equilibrium position and released, what is the resulting frequency of vibration in each case ? Neglect the mass of the spring. [Figs. (a) and (b) represent an arrangement of springs in parallel, and (c) and (d) represent 'spring in series']



Q.18 Answer the following questions :

(a) Time period of a particle in S.H.M. depends on the force constant k and mass m of a the particle. $T = 2\pi\sqrt{\frac{m}{k}}$. A simple pendulum executes S.H.M. approximately. Why then is the time period of a pendulum independent of the mass of the pendulum ?

(b) The motion of a simple pendulum is approximately simple harmonic for small angle oscillations. For larger angles of oscillation, a more involved analysis shows that T is greater than $2\pi\sqrt{\frac{l}{g}}$. Think of a qualitative argument to appreciate this result.

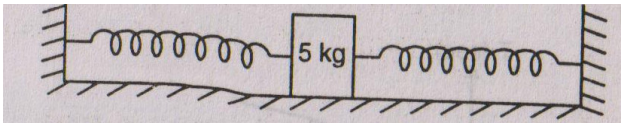
(c) A man with a wristwatch on his hand falls the top of a tower. Does the watch give correct time during the free fall ?

(d) What is the frequency of oscillation of a simple pendulum mounted in a cabin that is freely falling under gravity ?

Q.19 A mass of 5 kg is connected to two identical spring each of spring constant 500 N/m as shown in the figure. If the trolley is displaced by 5 cm on any one side and released, what is :

(i) time period. (ii) maximum speed of oscillation.

(iii) energy lost due to the damping force ?



Q.20 A particles oscillating simple harmonically has velocities υ_1 and υ_2 at positions x_1 and x_2. Find the frequency of its oscillation.

Q.21 A person weighing 50 kg stands on a platform oscillating up and down with a frequency of 2 s^{-1}, displacing to a maximum of 5 cm. What will be the weight, (i) maximum (ii) minimum, felt by the person ?

Q.22 A frictionless ball of mass m fitted at the neck of an air chamber of volume V is pressed inside to displace by x. What is the time period of the oscillation ?Given : B is the bulk modulus and A is the cross-sectional area of the neck.

Q.23 Two masses m_1 and m_2 are suspended together by a massless spring (K). When the masses are in equilibrium, m_1 is removed without disturbing the system. Find the angular frequency and amplitude of oscillation of m_2.

Q.24 A thin rod of length l and area of cross-section A is pivoted at its lowest point P inside stationary homogeneous and non-viscous liquid. The rod is free to rotate in a vertical

plane about a horizontal axis through P. The density d_1 of the material is smaller than the density d_2 of the liquid. The rod is displaced by an angle θ from its equilibrium position and released. Show that the motion will be simple harmonic and determine its angular frequency.

Chapter 14. Waves

Q.1 What is the difference a tone and a note ?

Q.2 What is the nature of waves produced in a tuning fork ?

Q.3 What do you mean by the Overtones ?

Q.4 What type of mechanical waves do you expect to exits in (a) vacuum (b) air (c) inside the water (d) rock (e) on the surface of water ?

Q.5 Examine whether the following functions of Y represent a travelling wave.

(i) $(x-\upsilon t)^2$, (ii) $\dfrac{1}{x+\upsilon t}$.

Q.6 The intensity maxima due to two interfering waves of equal amplitude $a_1 = a_2 = a$ is $4a^2$.Does this violate the law of conservation of energy ? Justify.

Q.7 The equation for the transverse wave on a string is $y = 4\sin 2\pi\left(\dfrac{t}{0.05} - \dfrac{x}{50}\right)$ with length expressed in cm and time in second. Calculate the wave velocity and maximum particle velocity.

Q.8 Explain why (or how) :

(a) in a sound wave, a displacement node is a pressure antinode and vice versa,

(b) bats can ascertain distances, directions, nature and sizes of the obstacles without any "eyes",

(c) a violin note and sitar note may have the same frequency, yet we can distinguish between the two notes,

(d) solids can support both longitudinal and transverse waves, but only longitudinal waves can propagate in gases, and

(e) the shape of a pulse gets distorted during propagation in a dispersive medium.

Q.9 Prove dimensionally, that the velocity of transverse waves in a string $\sqrt{\dfrac{T}{\mu}}$,where T is the tension and μ is the mass of unit length.

Q.10 For the travelling harmonic wave $y = 2.0\cos 2\pi(10t - 0.080x + 0.35)$,where x and y are in cm and t in s. What is the phase difference between oscillatory motion at two points separated by a distance of (i) 4 m, (ii) 0.5 m, (iii) $\lambda/2$, (iv) $3\lambda/4$.

Q.11 Show that in the case of a closed organ pipe, the ratio of the frequencies of the harmonics is 1 : 3 : 5 : 7.

Q.12 A policeman on duty detects a drop of 15% in the pitch of the horn of a motor car as it crosses him. If the velocity of sound is 330 m/sec calculate the speed of the car.

Q.13 Use the formula $\upsilon = \sqrt{\dfrac{\gamma P}{\rho}}$ to explain why the speed of sound in air

(a) is independent of pressure, (b) increases with temperature,

(c) increases with humidity

Q.14 What are stationary waves? How are they formed in strings ? Draw the various modes of vibration in them.

Q.15 Explain how stationary waves are formed in open and closed pipes. Compare the first three harmonics produced in them.

Q.16 What is meant by beats ? Discuss graphical method of formation of beats.

Q.17 (i) What are beats ? Name the basic phenomenon due to which beats are produced.

(ii) Two sources of sound are producing waves of frequency n_1 and n_2, where $(n_1 - n_2)$ is small, show mathematically that the beat frequency is $(n_1 - n_2)$.

Q.18 An incident wave and a reflected wave are represent by

$$\xi_1 = a \sin \frac{2\pi}{\lambda}(vt - x) \text{ and } \xi_2 = a \sin \frac{2\pi}{\lambda}(vt + x)$$

Derive the equation of the stationary wave, and calculate the position of the nodes and antinodes.

Q.19 Discuss Newton's formula for the velocity of longitudinal waves in air. What correction was applied by Laplace and why ?

Q.20 A simple harmonic wave is expressed by equation : $y = 7 \times 10^{-6} \sin\left(800\pi t - \frac{\pi}{42.5} x\right)$ where y and x are in cm. and t in seconds. Calculate the following :

(i) amplitude (ii) frequency (iii) wavelength (iv) wave velocity and

(v) Phase difference between two particles separated by 17.0 cm.