CHAPTER 1: UNITS & MEASUREMENT

1. Assuming that the mass (m) of the largest stone that can be moved by a flowing river depends only upon the velocity v, the density ρ of water and the acceleration due to gravity g. Show that m varies, with the sixth power of the velocity of the flow.
2. 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 $\propto \sqrt{\frac{\rho r^3}{\sigma}}$.
3. Liquid is flowing steadily through a pipe. Assume that the volume of the liquid flowing out per second depends on (a) the coefficient of velocity 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 is 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 $[\mathrm{ML^{-1}T^{-1}}]$. Deduce by the method of dimensions, the formula for the volume of the liquid flowing out per second.
4. The factors affecting the tgime period of a simple pendulum are mass, length and the acceleration due to gravity. Deduce a relation for the time period of a simple pendulum.
5. The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m and 2.01 cm repectively. Calculate the surface area and volume of the sheet to correct significant figures.
6. Deduce by the method of dimensions, an expression for the energy of a body executing S.H.M. assuming tha thte energy of the body depends upon (a) the mass m (b) the frequency v and (c) the amplitude of vibration a.
7. To determine acceleration due to gravity, the time of 20 oscillations of a simple pendulum of length 100 cm was observed to be 40 s. Calculate the value of g and maximum percentage error in the measured value of g.
8. By using the method of dimensions, check the accuracy of the following formula :

   $T = \frac{rh\rho g}{2\cos\theta}$, where T is the surface tension, h is the height of the liquid in a capillary tube, ρ is the density of the liquid, g is the acceleration due to gravity, θ is the angle of contact, and r is the radius of the capillary tube.
9. The radius of curvature of a concave mirror measure by spherometer is given by R = $\frac{l^2}{6h} + \frac{h}{2}$. The values of l and h are 4 cm and 0.065 cm respectively, Compute the error in measurement of radius of curvature.
10. A physical quantity P is related to four observables, a, b, c and d as follows :

    P = $\frac{a^3b^2}{\sqrt{c}d}$

    The percentage errors of measurement in a, b, c and d are 1%, 3%, 4% and 2% respectively. What is the percentage error in the quantity P? If the value of P calculated using the given relation turns out to be 3.763, to what value should the result be rounded off?
11. The measured value of length, breath and of a block of wood along with maximum permissible errors are expressed as follows :

    l = 12.08 $\pm$ 0.01 cm, b = 10.12 $\pm$ 0.01 cm, h = 5.62 $\pm$ 0.01 cm.

    Calculate the percentage error in the volume of the block.
12. Reynold's number $\mathrm{N_R}$(a dimensionless quantity) determines the condition of laminar flow of a viscous liquid through a pipe. $\mathrm{N_R}$ is a function of the density of the liquid 'r', its average speed is 'v' and the coefficient of viscosity of the liquid is 'h'. If $\mathrm{N_R}$ is given directly proportional to 'd')the diameter of the pipe), show from dimensional consideration that $\mathrm{N_R} \propto \frac{d\rho v}{\eta}$ the unit of 'η' in SI system is kg $\mathrm{m^{-1}\ s^{-1}}$.
13. A planet moves around the sun in a circular orbit. The time period of revolution T of the planet depends on
    i. Radius of the orbit (R)
    ii. Mass of the sun M

iii.Gravitational constant G

Show dimensionally that $T^2 \propto R^3$

14. Experiments show that the frequency (n) of a turning fork depends upon the length (l) of the prong, the density (d) and the Young's modulus (Y) of its material. From dimensional consideration, find a possible relation for the frequency of the turning fork.
15. The density ρ of a piece of metal of a mass m and volume V is given by the formula ρ = $\frac{m}{V}$; If m = 375.32 $\pm$ 0.01 g, and V = 136.41 $\pm$ 0.01 cm^3

    Find % error in ρ.

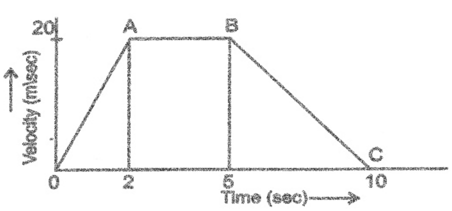
Chapter : 2 Kinematics

1. Derive the three equations of motion by calculus method. Express conditions under which they can be used.
2. (a) With the help of a simple case of an object moving with constant velocity show that the area under velocity show that the area under velocity-time cure represents the displacement over a given time interval.

   (b) Establish the relation

   $x = v_0 t + \frac{1}{2}at^2$ graphically.

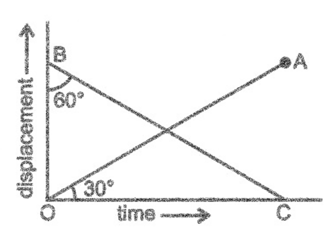
   (c) A car moving with a speed of 126 km/h is brought to a stop within a distance of 200 m. Calculate the retardation of the car and the time required to stop it.
3. Draw velocity-time graph of uniformly accelerated motion in one dimension. From the velocity time graph of uniform accelerated motion, deduce the equation of motion in distance and time.
4. A point object is thrown vertically upwards at such a speed that it returns to the thrower after 6 second. 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.
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.
6. A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one-tenth of its speed. Plot the speed-time graph of its motion between t = 0 to 12 s.
7. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 kmh^{-1} in the direction A to B notices that a bus goes past him every 18 minutes in the direction of the motion, and every 6 minutes in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road?
8. An electron travelling with a speed of $5 \times 10^3\ \mathrm{ms}^{-1}$ passes through an electric field with an acceleration of $10^{12}\mathrm{ms}^{-2}$. How long will it take for the electron to double its velocity?
9. The velocity-time graph of an object moving along a straight line in as shown.

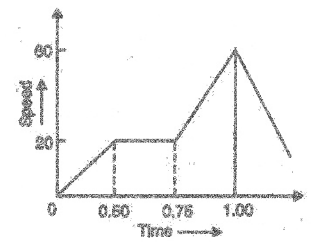
   Calculate distance covered by object between :

   i. t = 0 to t = 5 sec.

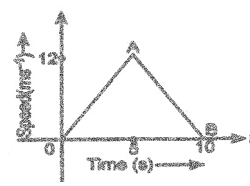
   ii. t = 0 to t = 10 sec.
10. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 kmh^{-1} in the same direction, with A ahead of B. The driver of B desires to overtake A and accelerates by 1 ms^{-1}. If, after 50 s, the guard of B just brushes past driver of A, calculate the original distance between the two trains.
11. A highway motorist travels at a constant velocity of 45 kmh^{-1} in a 30 kmh^{-1} zone. A motor-cyclist police officer has been watching from behind a bill board and at the same moment the speeding motorist passes the bill board, the police officer accelerates uniformly from rest to overtake her. If the acceleration of the police officer is 10 kmh^{-2}, how long does he take to reach the motorist?



12. The displacement-time graph of two bodies P and Q are represented by OA and BC respectively. What is the ratio of velocities of P and Q?
    $\angle OBC = 60^0$ and $\angle AOC = 30^0$.
13. A train moves from one station to another in two hours time. Its speed during the motion is shown in the graph. Determine the maximum acceleration during the journey. Also calculate the distance covered during the time interval from 0.75 to 1 hour.



14. A car moving with a speed of 50 kmh^{-1} can be stopped by brakes after at least 6 m. What will be the minimum stopping distance, if the same car is moving at a speed of 100 kmh^{-1}?
15. A car moving along a straight highway with speed of 126 kmh^{-1} is brought to a stop within a distance of 200 m. What is the retardation of the car (assumed uniform) and how long does it take for the car to stop?
16. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km/hr. Finding the market closed, he instantly turns, and walks back home with a speed of 7.5 km/hr. What is the (a) magnitude of average velocity and (b) average speed of the man over the interval of time (i) $0 - 30$ minutes (ii) $0 - 50$ minutes (iii) $0 - 40$ minutes?
17. The speed-time graph of a particle moving along a fixed direction is shown here. Obatin the distance travelled by the particle between (a) t = 0 to 10 s, (b) t = 2 to 6 s. What is the average speed of the particle over the intervals in (a) and (b)?



18. A body is moving with a uniform acceleration. Its velocity after 5 seconds is 25 m/s and after 8 seconds is 34 m/s. Calculate the distance it will cover in 10th second.
19. A body is projected horizontally from the top of a building of height h. Velocity of projection is u. Find :
    i. the time it will take to reach the ground.
    ii. horizontal distance from foot of building where it will strike the ground.
    iii. Velocity with which the body reach the ground.
20. Prove the following :
    a) For two angles of projection θ and (90 – θ) with the same velocity v,
       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 $tan^{-1}(4)$.
21. 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. the 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 (90^o – θ).
22. A projectile shot at an angle of 60^o 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.
23. A cricket ball is thrown at a speed of 28 m/s in a direction 30^o 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 point of projection to the point where the ball returns to the same level.

24. State parallelogram law of vector addition. Show that resultant of two vectors A and B inclined at an angle θ is $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$.
25. A passenger arriving in a new town whishes to go from the station to a hotel located 10 km away on a straight road from the station. A dishonest cabman takes him along a circular path 23 km long and reaches the hotel in 28 min. What is (a) the average speed of the taxi, (b) the magnitude of average velocity? Are the two equal ?
26. Show that range of projection of a projectile for two angles of a projection α and β is same where $\alpha + \beta = 90^o$.
27. Define the terms resultant or equivalent of two forces. Two forces F_1 and F_2 acting at an angle θ on a body simultaneously have a resultant F. Show that $\theta = \cos -1\ [(F^2 - F_1^2 - F_2^2)/2F_1F_2]$

Chapter 3 Newton's Law of Motion

1. 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 and force experienced.
2. (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 limiting friction.
3. Consider a mass $'m'$ attatched t a string of length $'l'$ performing vertical circle. Find an expression for the
   i. velocity at any point,
   ii. tension at any point,
   iii. velocity minimum at the lower-mass point for a vertical circle.
4. What do you understand by friction? Discuss about static friction, limiting friction, kinetic friction and rolling friction.
5. Derive expression for velocity of a car on a banked circular road having coefficient of frictions. Hence write the expression for optimum velocity.
6. State Newton's Second Law of motion. Prove that second law is the real law of motion.
   Explain :
   i. Why are ball bearings used in machinery?
   ii. Why does a horse have to apply more force to start a cart than to keep it moving?
   iii. What is the need for banking the tracks?
   iv. State two advantages and two disadvantages of friction.
7. An aircraft executes a horizontal loop at a speed of 720 km/hr with its wings banked at 15°. What is the radius of the loop?
8. A rocket with a lift off mass 20,000 kg is blasted upwards with an initial acceleration of 5.0 ms^{-2}. Calculate the initial thrust (force) of the blast.
9. A cyclist goes round a circular track of 440 metres length in 20 seconds. Find the angle that the cycle makes with the vertical.
10. A body of mass 0.4 kg moving with a constant speed of 10 ms^{-1} to the north is subjected to a constant force of 8 N directed towards the south for 30 s. Take, the instant the force is applied to be t = 0 and the position of the particle at that time to be x = 0, predict its position at t = 5 s, 25 s, and 100 s.
11. A 70 kg man stands in contact against the wall of a 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 to man to remain stuck to the wall (without falling), when the floor is suddenly removed?

12. A truck starts from rest and accelerates uniformly at 2.0 $\mathrm{m\ s^{-2}}$. At t = 10 s, a stone is dropped by a person standing on the top of the truck (6 m high from the ground). What are the (a) velocity, and (b) acceleration of the stone at t = 11 s? (Neglect air resistance).
13. A shell of mass 0.020 kg is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 $\mathrm{m\ s^{-1}}$, what is the recoil speed of the gun?
14. A stone $'m'$ tied to the end of a string is whirled round in a circle of radius r with a speed ω in a horizontal plane. If the speed of the stone is increased beyond the maximum permissible value, and the string breaks suddenly, which of the following correctly describes the trajectory of the stone after the string breaks :
    (a) The stone moves radially outwards.
    (b) The stone flies off tangentially from the instant the string breaks.
    (c) The stone flies off at an angle with the tangent whose magnitude depends on the speed of the particle?
15. A train runs along an unbanked circular track of radius 30 m at a speed of 54 km/h. The mass of the train is 10^6 kg. What provides the centripetal force required for this purpose – The engine or the rails? What is the angle of banking required to prevent wearing out of the rail?
16. A money of mass 40 kg climbs on a rope which can stand a maximum tension on 600 N. In which of the following cases will the rope break : the monkey
    (a) climbs up with an acceleration of 6 $\mathrm{m\ s^{-2}}$
    (b) climbs down with an acceleration of 4 $\mathrm{m\ s^{-2}}$
    (c) climbs up with a an acceleration of 4 $\mathrm{m\ s^{-1}}$
    (d) falls down the rope nearly freely under gravity?
    (Ignore the mass of the rope.)