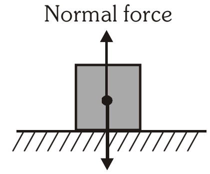
8. FORCE & NLM

- **Force :** A force can be defined as 'a push or a pull exerted on an object that can cause the object to speed up, slow down, or change direction as it moves or it can change its shape and size'.
  - An interaction of one object with another object results in a force between the two objects i.e., to apply force at least two objects are required.
  - The effect of a force depends on both magnitude and direction, thus, force is a vector quantity. A force vector points in the direction of the force, and its length is proportional to the magnitude of the force.
  - Forces applied on an object in the same direction add to one another. If two forces act in the opposite directions on an object, the net force acting on it is the difference between the two forces.
  - **Unit of force :** SI unit - Newton ; c.g.s unit - Dyne **1 N = 10^5 dynes**
- **Net force :** If many forces are acting simultaneously on an object, the effect on the object is due to the net force acting on it. The combination of all the forces acting on an object is called net force. The net force acting on an object is also referred as the total force, the resultant force, or the unbalanced force acting on the object.
- **Contact force :** It is a force that is exerted only when two objects are touching.

  Examples :
  - **Muscular Force :** The force resulting due to the action of muscles is known as the muscular force.
  - **Friction :** Friction is a force that resists motion. Friction is found everywhere in every material i.e., solids, liquids and gases.
  - **Tension :** Tension is a force exerted by string, ropes, fibres, and cables when they are pulled.
  - **Normal force :** The force perpendicular to the surfaces of the objects in contact is called normal force.



- **Non-contact force :** It is a force that one object exerts on another when they are not touching. Examples :
  - **Magnetic force :** The force exerted by a magnet on a piece of iron or on an another magnet is called magnetic force. Like (or similar) poles repel while unlike (or opposite) poles attract.
  - **Electrostatic force :** The force exerted by a charged body on another charged body or uncharged body is known as electrostatic force. Like charges repel and unlike charges attract.
  - **Gravitational force :** The attractive force between two objects that have mass is called **gravitational force**. Force of gravity is always attractive in nature and pulls objects toward each other. A gravitational attraction exists between you and every object in the universe that has mass.
- **Balanced forces :** If the resultant of all forces acting on a body is zero, the forces are called 'balanced forces'.
  - If the forces are balanced, this means the acceleration of the object is zero and its velocity remains constant. That is, the object either remains at rest or continues to move with constant velocity.
  - When forces on an object are balanced, the object is said to be in **equilibrium**. This means, it has zero acceleration which includes, the state of rest as well as, the state of uniform motion.
  - **The equilibrium rule :** For any object or system of objects in equilibrium, the sum of the forces acting equals zero. In mathematical form, $\sum F = 0$.
- **Unbalanced forces :** If the resultant of all forces acting on a body is not zero, the forces are called 'unbalanced forces'.
  - In this case, the acceleration of the object is not zero and its velocity changes. That is, unbalanced force changes the state of rest or the state of uniform motion of the object.
- **Inertia :** It is 'the natural tendency of an object to remain at rest or in motion at a constant speed along a straight line'. It is the tendency of an object to resist any attempt to change its velocity.
  - The mass of an object is a quantitative measure of inertia. More the mass, more will be the inertia of an object and vice-versa.
  - Inertia of an object can be of three types :

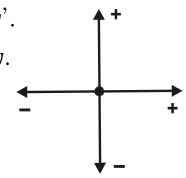
    Inertia of rest : The tendency of an object to remain at rest. This means an object at rest remains at rest until a sufficiently large external force is applied on it.

Inertia of motion : The tendency of an object to remain in the state of uniform motion. This means an object in uniform motion continues to move uniformly until an external force is applied on it.

Inertia of direction : The tendency of an object to maintain its direction. This means an object moving in a particular direction continues to move in that until an external force is applied to change it.

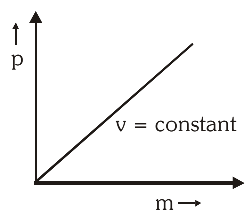
- **Newton's first law of motion (Galileo's law of inertia) :** 'Every object continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it'.

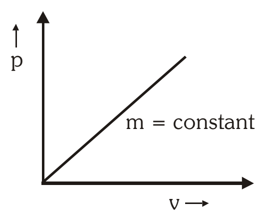
- **Linear momentum (or momentum) :** It is the product of the mass (m) & velocity (v). $\boxed{p = mv}$

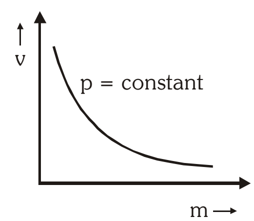


Sign convention for momentum

- Linear momentum is a vector quantity. Its direction is 'the direction along the velocity'.
- The linear momentum of a particle is directly proportional to (i) its mass (ii) its velocity.
- **Unit of linear momentum :** SI unit : kg m/s or kg m s^{-1} or Newton-second (N-s)
  c.g.s. unit : g cm/s or g cm s^{-1} or Dyne-second
- Linear momentum can be positive or negative depending on its direction.
- For a given velocity, the momentum is directly proportional to the mass of the object $(p \propto m)$. If a car and a truck have same velocity, then, the momentum of truck is more than the momentum of car as the mass of a truck is greater than the mass of a car.
- For a given mass, the momentum is directly proportional to the velocity of the object $(p \propto v)$. If two bodies with same masses move with different velocities then, the body having more velocity will have more momentum.
- For a given momentum, the velocity is inversely proportional to the mass of the object $(v \propto 1/m)$. If a car and a truck have same momentum, the velocity of car will be more than the velocity of truck as the mass of a car is smaller than the mass of a truck.







- When an object is moving along a circular path, its velocity is tangential to the circular path hence, its momentum is also tangential to the circular path.

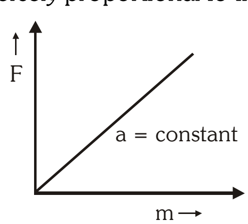
- **Newton's second law of motion :** 'The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts'. Mathematically, it can be represented as,

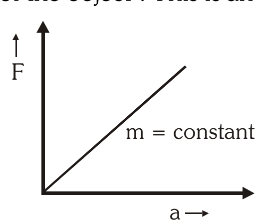
$$\boxed{F = ma = \frac{p_2 - p_1}{t} = \frac{m(v-u)}{t}}$$

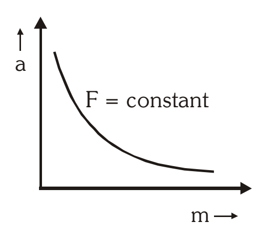
- If force is constant i.e., F = ma = constant, then, the acceleration produced in the body is inversely proportional to its mass, i.e, $a \propto 1/m$. This means, if same force F is applied to masses m_1 and m_2 and the resulting accelerations in them are a_1 and a_2 respectively, then, $m_1a_1 = m_2a_2$

  or $\boxed{\dfrac{a_2}{a_1} = \dfrac{m_1}{m_2}}$

- When an external non-zero net force acts on an object, the object accelerates in the direction of the net force. The magnitude of the acceleration is directly proportional to the magnitude of the net force and inversely proportional to the mass of the object'. This is an another statement of Newton's second law.





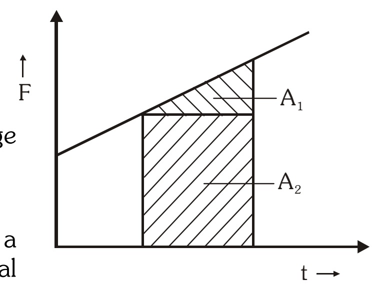


- 1 newton is the amount of force that produces an acceleration of 1 m s^{-2} in an object of 1 kg mass. Similarly, 1 dyne is the amount of force that produces an acceleration of 1 cm s^{-2} in an object of 1 g mass.
- Force is necessary for changing the direction of momentum, even if its magnitude is constant. We can feel this while rotating a stone in a horizontal circle with uniform speed by means of a string.
- Force, $F = \Delta p/t$, this means for a given change in momentum, the force is inversely proportional to the time interval in which this change takes place. Thus, for the same change in momentum brought about in a shorter time needs a greater applied force and vice-versa. For example, an experienced cricketer while catching a cricket ball, allows a longer time for his hands to stop the ball. He moves his hands backward in the act of catching the ball. As the time for catching increases, the force with which the ball hurts his hand decreases. As a result, his hands are not injured.

■ **Impulse (J) :** The product of force and time is called 'impulse'. It is also the change in momentum of the body. It is a vector quantity.

$$\boxed{J = F \times t = \Delta p = p_2 - p_1 = m(v - u)}$$

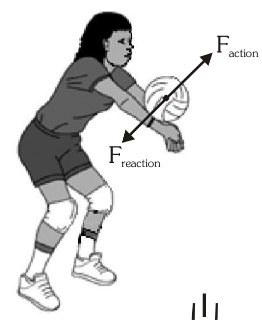
- A large force acting for a short time that produces a significant change in momentum is called an **impulsive force**.
- Area under the force-time graph gives impulse (see adjoining fig.).



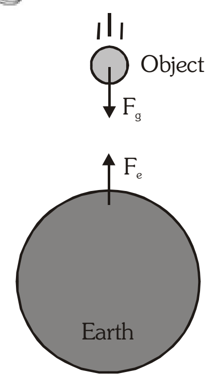
Impulse = $A_1 + A_2$

■ **Newton's third law of motion :** Whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body'. '**To every action, there is always an equal and opposite reaction**'.

- **Forces always exist in pairs :** When two objects interact, two forces will always be involved. One force is the action force and the other is the reaction force.
- Consider a pair of bodies A and B. According to the Newton's third law, $\mathbf{F_{AB} = -F_{BA}}$
  Where, F_{AB} = force on A due to B and F_{BA}= force on B due to A
- Though action-reaction pair are equal in magnitude and opposite in direction but the reaction force always acts on a different object than the action force. Thus, these forces do not cancel out each other. Hence, there can be an acceleration in an object. For example, a volleyball player while bumping the ball (see figure), the action force is the upward force that the player exerts on the ball. The reaction force is the downward force that the ball exerts on the player's arms. Due to the upward action force, the ball accelerates upward. (The player's arms also accelerate downward but we hardly notice it as mass of the player is quite large).



- **Newton's third law is applicable to non-contact forces also.** For example, the Earth pulls an object downwards due to gravity (see fig.). The object also exert the same force on the Earth but in upward direction. But, we hardly see the effect of the stone on the Earth because the acceleration of Earth is negligible due to its huge mass.



- Even though the action and reaction forces are always equal in magnitude, these forces may not produce accelerations of equal magnitudes. This is because each force acts on a different object that may have a different masses.
- **Some important examples of Newton's third law of motion :**
  - When we strike a nail using a hammer to fix in a board, the hammer exerts a downward force on the nail, and the nail exerts an equal an upward force on the hammer.
  - While walking (or running) on a road, we push the road below backwards and the road exerts an equal and opposite reaction force on our feet to make us move forward.

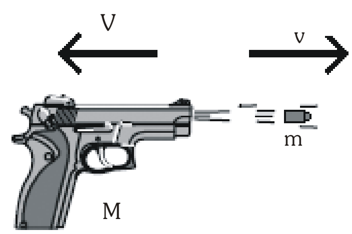
- When a gun is fired, it exerts a forward force on the bullet. The bullet exerts an equal and opposite reaction force on the gun. This results in the recoil of the gun. Since the gun has a much greater mass than the bullet, the acceleration of the gun is much less than the acceleration of the bullet.
- When a sailor jumps out of a rowing boat, as the sailor jumps forward, the force on the boat moves it backwards.
- An inflated balloon recoils when air is expelled from it. When the air is expelled leftward, the balloon accelerates rightward.
- **Rocket Propulsion :** In a rocket engine, the highly combustible fuel burns at a tremendous rate. The rocket exerts a downward (or backward) force on the exhaust gas and thus, the exhaust gas exert an equal upward (or forward) force on the rocket.

■ **The normal force :** A force that acts on a surface in a direction perpendicular to the surface is called 'normal force'.

- Like every force, a normal force is one half of an action-reaction pair, so it is often called a 'normal reaction force'.

■ **Conservation of momentum :** 'When the net external force on a system of objects is zero, the total momentum of the system remains constant'.

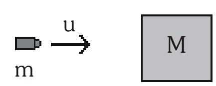
Initial momentum = 0



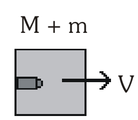
Final momentum = mv – MV = 0

- The total momentum of an isolated system of objects remains constant.
- The term '**collision**' is used to represent the event of two particles coming together for a short time and thereby producing 'impulsive forces' on each other. These forces are assumed to be much greater than any external forces present because they act for a very short time interval.
- Momentum is conserved for all types of collisions that take place in real world in the absence of any external force.
- Rocket propulsion or the recoil of gun are based on law of conservation of momentum as well as Newton's third law. This is because the law of conservation of momentum is derived using Newton's third law.
- **Solving problems on conservation of momentum :**
  - **Recoil of a gun :** Initial momentum = Final momentum

    or $0 = MV - mv$ or $\boxed{V = \frac{m}{M}v}$ (see fig.)



Initial momentum = $m \times u + M \times 0 = mu$



Final momentum = $(M+m)V$

  - A bullet is fired on a wooden block and it gets embedded in it, after that they move together with a common velocity (see fig.).

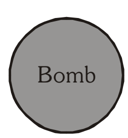
    Initial momentum = Final momentum

    or $mu = (M + m)V$ or $\boxed{V = \frac{mu}{M+m}}$

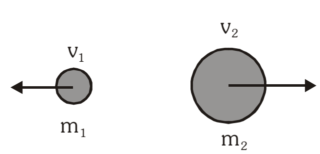
  - A bomb of mass M explodes in two parts having masses m_1 and m_2 (see fig.).

    Final momentum = initial momentum

    or $m_2v_2 - m_1v_1 = 0$ or $\mathbf{m_2v_2 = m_1v_1}$

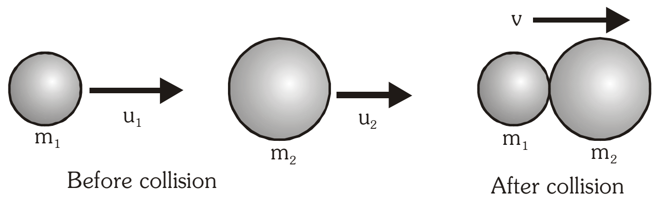


Initial velocity, u = 0
Mass of bomb = M
Initial momentum = $M \times 0 = 0$
(Before explosion)



Final momentum = $m_2v_2 - m_1v_1$
(After explosion)

- Two objects having masses m_1 and m_2 moving with velocities u_1 and u_2 along a straight line collide head-on, stick together, and move with a common velocity v after the collision.

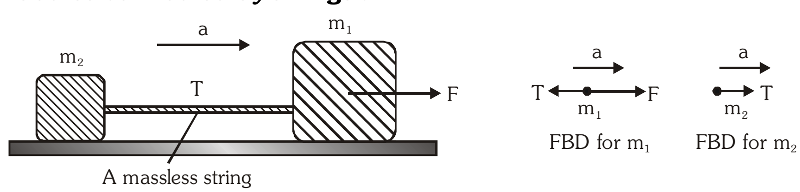


Initial momentum = Final momentum

or $m_1u_1 + m_2u_2 = m_1v + m_2v$ or $\boxed{v = \dfrac{m_1u_1 + m_2u_2}{m_1 + m_2}}$

Tension in the strings :

- Strings are assumed to be inextensible i.e., they cannot be stretched. Due to this assumption 'acceleration of masses connected through a string is always same. They are assumed to be massless unless it is mentioned. Due to this assumption 'tension in the string is same every where'.
- The direction of tension at body (or a point) is always outward along the string i.e., away from the body along the string. A tension always have pulling action.
- **Motion of bodies connected by strings :**

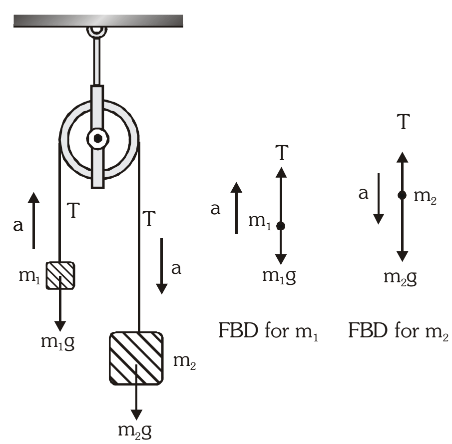


- $\boxed{a = \dfrac{F}{m_1 + m_2}}$ $\boxed{T = \dfrac{m_2F}{m_1 + m_2}}$

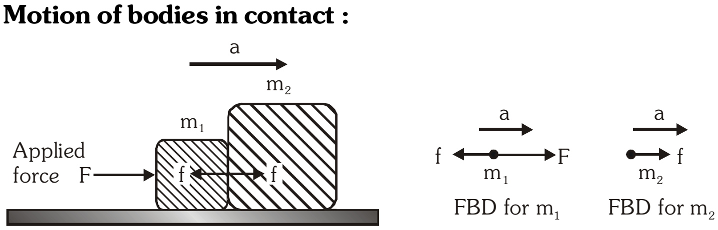
- **Motion of bodies connected by string passing over a light pulley (Atwood's Machine) :**

- $\boxed{a = \dfrac{(m_2 - m_1)g}{(m_2 + m_1)}}$

- $\boxed{T = \dfrac{2m_1m_2g}{m_1 + m_2}}$



- **Motion of bodies in contact :**



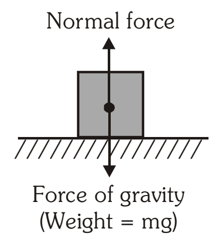
- $\boxed{a = \dfrac{F}{m_1 + m_2}}$ $\boxed{f = \dfrac{m_2F}{m_1 + m_2}}$

- **Weight of an object in a lift :** A weighing machine measures the normal force not the 'true weight'.
  - When the lift is at rest or in uniform motion, apparent weight, i.e., **W = mg** [Apparent weight = true weight]
  - When the lift is moving up with uniform acceleration a, apparent weight, i.e., **W' = m(a + g)** [Apparent weight > true weight]
  - When the lift is moving down with uniform acceleration a, apparent weight, i.e., **W'' = m(g – a)** [Apparent weight < true weight]
  - Suppose the rope of the lift breaks, then it will fall freely under gravity i.e., a = g. In this situation, apparent weight, W'' = m(g – g) = 0. That is, the weighing machine will read zero weight.
- **Friction :** It is a force that opposes the movement between two surfaces in contact.
  - The magnitude of the friction force depends on the types of surfaces in contact. The frictional force is usually larger on the rough surfaces and smaller on the smooth surfaces.
  - Friction is always parallel to the surface in contact.
  - Friction depends on both of the surfaces in contact, therefore, the value of friction is different for different pairs of surfaces.
  - If an object is allowed to move on a surface then, more the distance travelled by the object on the surface, less will be the friction between them and vice-versa.
  - Friction is caused by the irregularities on the two surfaces in contact.
  - There are many kinds of friction that exist in different media :
    - **Static friction :** It exists when two surfaces try to move across each other but not enough force is applied to cause motion.
    - **Sliding friction :** It exists when two surfaces slide across each other.
    - **Rolling friction :** It exists when one object rolls over another object.
    - **Air friction (air resistance) :** It exists when air moves around an object.
    - **Viscous friction :** It exists when objects move through water or other liquids.
  - Force of friction increases if the two surfaces are pressed harder. The greater the force pressing the two surfaces together, the greater will be the force of friction between them.
  - **Friction increases with weight :** For a heavy object, the weight is quite large, therefore, the force between the object and the floor is also large. Thus, the friction force between them is large.
  - For hard contact surfaces, the force of friction does not depend on the 'area of contact' between the two surfaces. But, it is not true if the surfaces are wet, or if they are soft. Rubber is soft as compared to the surface of a road. The friction between rubber and surface of road also depends on how much rubber is contacting with the surface of road. Thus, wide tires (made of rubber) have more friction than narrow tires.
- **Static friction (f_s) :** It is the force exerted on an object at rest that prevents the object from sliding.
  - The direction of static friction is opposite to the applied force. Also, it acts in a direction opposite to the direction in which an object tends to move.
  - The maximum value of static friction is called the **starting friction** or **limiting friction**. It is the amount of force that must be overcome to make a stationary object start moving.

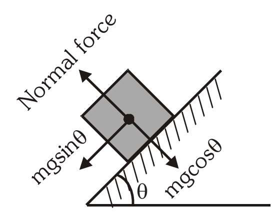
- The law of static friction may be written as, $\boxed{f_s \le \mu_s N}$

  Where, μ_s = coefficient of static friction, which depends only on the nature of surfaces in contact ; N = normal force (or normal reaction)

- Normal force on a horizontal plane is exactly equal to the weight of the body while on an inclined plane it is smaller than the weight of the body that depends of the angle of the inclined plane (see fig.).



Normal force = weight = mg



Normal force = mgcosθ

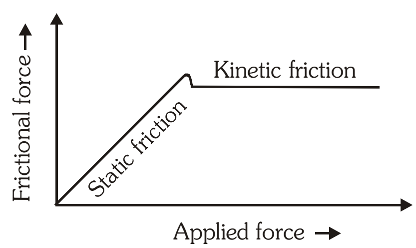
- Limiting (maximum) value of static friction is given by, $\mathbf{f_L = \mu_s N}$. If the applied force F exceeds f_L , the body begins to slide on the surface.
- If applied force F is less than f_L, then, $\mathbf{F = f_s}$

■ **Sliding friction (or kinetic friction) (f_k) :** It is the force exerted on an object in motion that opposes the motion of the object as it slides on another object.

- Sliding or kinetic friction is smaller than the limiting value of static friction. This is because it takes more force to break the interlocking between two surfaces than it does to keep them sliding once they are already moving.
- Kinetic friction, like static friction, is also found to be independent of the area of contact. Further, it is nearly independent of the velocity of the body.
- The law of kinetic friction may be written as, $\boxed{f_k = \mu_k N}$

  Where μ_k is the coefficient of kinetic friction, which depends only on the nature of surfaces in contact.

- $\boxed{\mu_s > \mu_k}$, μ_s or μ_k have no units as they are ratio of two forces.
- Note that it is not motion, but relative motion that the frictional force opposes.



Variation of friction with applied force

■ **Rolling friction :** The rolling motion of the wheel is a combination of both spin (rotational) motion and linear (translation) motion.

- Rolling reduces the friction significantly.
- When one body rolls over the surface of another body, the resistance (opposition) to its motion is called the **rolling friction**.
- Since the rolling friction is smaller than the sliding friction, sliding is replaced in most machines by rolling by the use of ball bearings.

■ **Fluid friction :** The force of friction exerted by the fluids on the objects moving through them is called fluid friction.

- Factors that affects fluid friction :
  - The speed of the object in the fluid. The faster an object moves in a fluid, the greater is the fluid friction acting on it.
  - The shape of the object moving in the fluid. For example, a piece of paper crumpled into a ball falls faster than a flat piece of paper falls.
  - The nature of the fluid. For example, an object moving with certain speed experiences a greater friction in water than experienced in air.

- **Friction is a necessary evil :** Friction is often undesirable, it causes wear of machine parts, engines, soles of shoes, etc. But, it is useful in many cases. For example,
  - Walking on the road is not possible without static friction.
  - **Friction is useful for brakes and tyres :** The brakes on a bicycle create friction between two rubber brake pads and the rim of the wheel. Friction between the brake pads and the rim slows down or stops the bicycle. Friction is also necessary to make vehicles go on the road. Without friction the vehicle's tyres would not grip the road.
- **Friction changes energy of motion into heat energy**. Rubbing hands together quickly can make them warmer on a cold day.
- **Increasing friction :** Grooving the soles of shoes increases friction between the feet and the ground
  - Treads on tyres increases friction on pavement (road surface) in dry as well as wet conditions.

Multiple choice questions

1. A person sitting in a moving car is at rest with respect to
(1) a tree on the ground
(2) a cyclist on the road
(3) a building on the roadside
(4) the car

2. The motion of the wheel of a cycle is
(1) rotatory
(2) rectilinear
(3) translatory and rotatory
(4) None of these

3. A man has to go 50 m due north, 40 m due east and 20 m due south to reach a field. His displacement from his house to the field is,
(1) 110 m (2) $20\sqrt{5}$ m
(3) 75 m (4) 50 m

4. The numerical ratio of displacement to distance for a moving object is
(1) always less than 1 (2) always equal to 1
(3) always more than 1 (4) equal or less than 1

5. A monkey is moving on circular path of radius 80 m. If the monkey starts at one end of the diameter and reaches the other end, the displacement and the distance covered by the monkey are respectively,
(1) 160 m ; 160 m (2) 160 m ; 80π m
(3) 0 m ; 80π m (4) 160 m ; 160π m

6. In which of the following cases of motions, the distance moved and the magnitude of displacement are equal ?
(1) If the car is moving on straight road
(2) If the car is moving in circular path
(3) The pendulum is moving to and fro
(4) The earth is revolving around the Sun

7. A body moved from one end to another end along a curved path of a quarter circle. The ratio of distance to displacement is
(1) $\frac{\pi}{2\sqrt{2}}$ (2) $\frac{2\sqrt{2}}{\pi}$
(3) $\frac{\sqrt{2}}{\pi}$ (4) $\frac{\pi}{\sqrt{2}}$

8. A ball is thrown up with a certain velocity. It attains a height of 40 m and comes back to the thrower, then
(1) total distance covered by it is 40 m
(2) total displacement covered by it is 80 m
(3) total displacement is zero
(4) total distance covered by it is zero

9. A body moves on three quarters of a circle of radius r. The displacement and distance travelled by it are
(1) displacement = r, distance = 3r
(2) displacement = $\sqrt{2}$r , distance = $\frac{3\pi r}{2}$
(3) distance = 2r, displacement = $\frac{3\pi r}{2}$
(4) displacement = 0, distance = $\frac{3\pi r}{2}$

10. For the motion on a straight line path with constant acceleration, the ratio of the magnitude of the displacement to the distance covered is
(1) = 1 (2) ≥ 1
(3) ≤ 1 (4) < 1

11. A body moves along the circumference of a circular track. It returns back to its starting point after completing the circular track twice. If the radius of the track is R, the ratio of displacement to the distance covered by the body will be
(1) 0 (2) 8πR
(3) $\sqrt{3R}$ (4) $\frac{p}{R}$

12. A particle is travelling with a constant speed. This means that
(1) Its position remains constant as time passes
(2) It covers equal distances is equal time intervals
(3) Its acceleration is zero
(4) It does not change its direction of motion

13. A boy runs for 10 min at a uniform speed of 9 km/h. At what speed should he run for the next 20 min so that the average speed comes to 12 km/h ?
(1) 13.5 km/h (2) 10.2 km/h
(3) 8.2 km/h (4) 7.72 km/h

14. A car moves at a speed of 60 km/hr for 50 km and 80 km/hr for the next 50 km. What is average speed (in km/hr) of car for the journey of 100 km ?

(1) 68.6 (2) 70

(3) 75 (4) 72.6

15. A train moving on linear way travels a distance 'D' at constant velocity of 30 km/h, then it travels in opposite direction with same distance and reaches at original station at a constant velocity of 45 km/h. What is the average speed of train ?

(1) 36 km/h (2) 10 km/h

(3) 0 (4) 75 km/h

16. An object travels 16 m in 4 seconds, then another 16m in 2 seconds. Its average speed is

(1) 6 m/sec (2) 5 m/sec

(3) 8 m/sec (4) 5.3 m/sec

17. The rate of change of displacement with time is

(1) speed (2) acceleration

(3) retardation (4) velocity

18. A car travels a distance A to B at a speed of 40 km/hr and returns to A at a speed of 30 km/hr. The average velocity (in km/hr) for the whole journey is,

(1) 34.3 (2) 0 (3) 35 (4) 36.3

19. A passenger travels along a straight line with velocity v_1 for first half time and with velocity v_2 for next half time, then the mean velocity v is given by,

(1) $v = \sqrt{\frac{v_2}{v_1}}$ (2) $v = \sqrt{v_1 v_2}$

(3) $v = \frac{2v_1 v_2}{v_1 + v_2}$ (4) $v = \frac{v_1 + v_2}{2}$

20. A car travels $\frac{1}{3}$rd distance on a straight road with a velocity of 10 km/hr, next $\frac{1}{3}$rd with velocity 20 km/hr and the last $\frac{1}{3}$rd with velocity 60 km/hr. What is the average velocity of the car in the whole journey?

(1) 4 km/hr (2) 6 km/hr

(3) 12 km/hr (4) 18 km/hr

21. A cyclist moving on a circular track of radius 40 m completes half revolution in 40 seconds. Its average velocity is

(1) 2π m/sec (2) 2 m/sec

(3) 4π m/sec (4) 4 m/sec

22. A quantity has a value of – 6.0 m/s. It may be the

(1) Speed of a particle

(2) Velocity of a particle

(3) Acceleration of a particle

(4) Position of a particle

23. An insect moves along the sides of a wall of dimensions 12 m $\times$5 m starting from one corner and reaches the diagonally opposite corner. If the insect takes 2 s for its motion then find the ratio of average speed to average velocity of insect.

(1) 15 : 4 (2) 1 : 1 (3) 12 : 7 (4) 17 : 13

24. When the distance travelled by an object is directly proportional to the time, it is said to travel with

(1) constant acceleration (2) uniform velocity

(3) zero velocity (4) constant speed

25. The rate of change of velocity with time is

(1) Speed (2) Displacement

(3) Distance (4) Acceleration

26. A bus decreases its speed from 80 km/hr to 60 km/hr in 5 sec. The acceleration of the bus is

(1) 2.1 m/s^2 (2) – 3.4 m/s^2

(3) – 1.1 m/s^2 (4) 3.2 m/s^2

27. The CGS unit of acceleration is

(1) m/s^2 (2) m/s (3) cm/min^2 (4) cm/s^2

28. Which of the following is not a vector quantity?

(1) Retardation

(2) Acceleration due to gravity

(3) Average speed

(4) Displacement

29. A rubber ball dropped from a certain height is an example of

(1) non-uniform acceleration

(2) uniform retardation

(3) uniform speed

(4) non-uniform speed

30. If the displacement of an object is proportional to square of time, then the object moves with

(1) uniform velocity

(2) uniform acceleration

(3) increasing acceleration

(4) decreasing acceleration

31. If the velocity of a body does not change, its acceleration is
(1) zero (2) infinite
(3) unity (4) none of these

32. A body whose speed is constant
(1) has a constant velocity
(2) might be accelerated
(3) must be accelerated
(4) cannot be accelerated

33. When the brakes are applied on a moving cycle, the directions of velocity and acceleration are
(1) opposite (2) same
(3) perpendicular (4) not related

34. The velocity acquired by a body moving with uniform acceleration is 20 m/s in first 2 sec and 40 m/s in first 4 sec. The initial velocity of the body is
(1) 40 m/s (2) 20 m/s
(3) 10 m/s (4) 0 m/s

35. A car starts from rest and moves along the x-axis with constant acceleration 5 m s^{-2} for 8 seconds. If it then continues with constant velocity, what distance will the car cover in 12 seconds since it started from rest ?
(1) 160 m (2) 200 m
(3) 320 m (4) 400 m

36. A person travelling at 43.2 km/hr applies the brakes giving a deceleration of 12 m/s^2 to his bike. The distance it travels before coming to rest is
(1) 12 m (2) 4 m
(3) 6 m (4) 9 m

37. A bullet going with speed 150 m/s enters in a concrete wall and penetrates a distance of 15 cm before coming to rest. The retardation that offered by the wall is
(1) 15×10^4 m/s^2 (2) 7.5×10^4 m/s^2
(3) 3.75×10^4 m/s^2 (4) 30×10^4 m/s^2

38. A particle moving with a uniform acceleration travels 24 m and 64 m in the first two consecutive intervals of 4 sec each. Its initial velocity (in m/s) is
(1) 1 (2) 10
(3) 5 (4) 2

39. A particle experiences a constant acceleration for 20 sec after starting from rest. If it travels a distance S_1 in the first 10 sec and a distance S_2 in the next 10 sec, then
(1) $S_1 = S_2$ (2) $S_1 = S_2/3$
(3) $S_1 = S_2/2$ (4) $S_1 = S_2/4$

40. A body starts from rest and accelerates uniformly. Ratio of distances travelled in one, two and three seconds of its motion is
(1) 1 : 3 : 5 (2) 1 : 4 : 9
(3) 1 : 2 : 3 (4) 9 : 4 : 1

41. A body covers 200 cm in the first 2 sec and 220 cm in next 4 sec. What is the velocity of the body at the end of 7th second?
(1) 40 cm/sec (2) 20 cm/sec
(3) 10 cm/sec (4) 5 cm/sec

42. A body moving along a straight line at 20 m/sec undergoes an acceleration of 4 m/sec^2. After two seconds its speed will be :
(1) 12 m/sec (2) 28 m/sec
(3) 72 m/sec (4) 20 m/sec

43. Average velocity of an object is equal to the mean of its initial and final velocities if the acceleration is
(1) variable (2) uniform
(3) both of the above (4) Can't be said

44. A body starts from rest and moves with uniform acceleration for 2s. It then decelerates uniformly for 3s and stops. If deceleration is 4 ms^{-2}, the acceleration of the body is _______ ms^{-2}.
(1) 10 (2) 8.7 (3) 4 (4) 6

45. In the equation of motion : $s = at + bt^2$, the units of a and b are respectively.
(1) m/s^2, m/s^2 (2) m/s, m/s^2
(3) m/s^2, m/s^3 (4) m/s, m/s^3

46. A body travels a distance of 20 m in the 7th second and 24 m in 9th second. The distance travelled by it in the 15th second is,
(1) 36 m (2) 32 m (3) 42 m (4) 44 m

47. A particle starts from rest and moves with uniform acceleration. Then the ratio of distance covered in n^{th} sec. to that in n sec. is
(1) $\frac{n^2}{2n+1}$ (2) $\frac{2n-1}{n^2}$
(3) $\frac{n^2}{2n-1}$ (4) $\frac{2n+1}{n^2}$

48. The initial velocity of a particle is 10 m/sec and its retardation is 2 m/sec^2. The distance moved by the particle in 5th sec of its motion is :
(1) 31 m (2) 52 m (3) 1 m (4) 1 cm

49. A heavy ball falls freely, starting from rest. Between t = 3 s and t = 4 s, it travels a distance of (g = 9.8 m/s^2)

(1) 4.9 m (2) 9.8 m

(3) 29.4 m (4) 34.3 m

50. A stone is dropped from the top of a tower. If it travels 34.3 m in the last second before it reaches the ground, find the height of the tower (g = 9.8 m/s^2)

(1) 39.2 m (2) 58.8 m

(3) 78.4 m (4) 98 m

51. A body starting from rest and moving with a constant acceleration covers a distance S_1 in the 4th second and a distance S_2 in the 6th second. The ratio S_1/S_2 is

(1) 2/3 (2) 4/9 (3) 6/11 (4) 7/11

52. A body with an initial velocity of 3 m/s moves with an acceleration of 2 m/s^2, then the distance travelled in the 4th second is

(1) 10 m (2) 6 m (3) 7 m (4) 28 m

53. A stone is dropped into a well in which the level of water is h, below the top of the well. If v is velocity of sound, then time T after which the splash is heard is equal to

(1) $\frac{2h}{v}$ (2) $\sqrt{\frac{2h}{v}}+\frac{h}{g}$

(3) $\sqrt{\frac{2h}{g}}+\frac{h}{v}$ (4) $\sqrt{\frac{h}{2g}}+\frac{2h}{v}$

54. If two bodies of different masses m_1 and m_2 are dropped from different heights h_1 and h_2, then ratio of the time taken by the two to drop through these distances is

(1) $h_1 : h_2$ (2) h_2/h_1

(3) $\sqrt{h_1} : \sqrt{h_2}$ (4) $h_1^2 : h_2^2$

55. A stone is thrown vertically upward with an initial velocity u from the top of a tower, reaches the ground with a velocity 3u. The height of the tower is

(1) $\frac{3u^2}{g}$ (2) $\frac{4u^2}{g}$ (3) $\frac{6u^2}{g}$ (4) $\frac{9u^2}{g}$

56. Acceleration of a body projected upwards with a certain velocity is

(1) 9.8 m/s^2 (2) – 9.8 m/s^2

(3) zero (4) insufficient data

57. A body is dropped from the top of a tower and reaches the ground in 3 sec. Then the height of the tower is :

(1) 44.1 m (2) 40.2 m

(3) 62.3 m (4) None of these

58. A body is projected up with an initial velocity of 10 m/sec. It will return to its starting point after:

(1) 6 seconds (2) 10 seconds

(3) 2 seconds (4) 2 hours

59. At the maximum height of a body thrown vertically up

(1) Velocity is not zero but acceleration is zero

(2) Acceleration is not zero but velocity is zero

(3) Both acceleration and velocity are zero

(4) Both acceleration and velocity are not zero

60. A ball is thrown vertically upwards with a velocity of 49 m/s. The maximum height to which it rises and the total time it takes to return to the surface of the earth are respectively (g = 9.8 m/s^2),

(1) 100 m ; 4 s (2) 110.5 m ; 6 s

(3) 150 m ; 5 s (4) 122.5 m ; 10 s

61. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking g = 10 m/s^2, what is the net displacement and the total distance covered by the stone when it returns to earth ?

(1) 0 m ; 150 m

(2) 0 m ; 160 m

(3) 75 m ; 150 m

(4) 80 m ; 160 m

62. A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of 25 m/s. When and where the two stones will meet ? (Take, g = 10 m/s^2)

(1) The stones will meet at a height of 20 m above the ground after 4 s

(2) The stones will meet at a height of 16 m above the ground after 4 s

(3) The stones will meet at a height of 24 m above the ground after 6 s

(4) The stones will meet at a height of 18 m above the ground after 3 s

63. An object is thrown vertically upward at 35 m/s. Taking g = 10 m/s^2, the velocity of the object 5 s later is

(1) 15 m/s down (2) 7.0 m/s up

(3) 15 m/s up (4) 85 m/s down

64. A stone is released from a balloon that is descending at a constant speed of 10 m/s. Neglecting air resistance, after 20 s the speed of the stone is (g = 9.8 m/s^2)

(1) 2160 m/s (2) 1760 m/s

(3) 206 m/s (4) 196 m/s

65. A stone is dropped from the top of a tower 500 m high into a pond of water at the base of the tower. When is the splash heard at the top ? Given, g = 10 ms^{-2} ; speed of sound = 340 m/s.

(1) 11.47 s (2) 10 s

(3) 13.5 s (4) 15.42 s

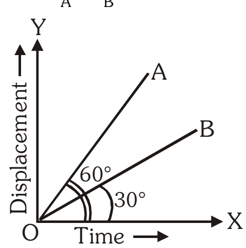
66. If the time of fall of two objects are in the ratio 1 : 2, find the ratio of the heights from which they fall.

(1) 1: 2 (2) 2: 1 (3) 1: 4 (4) 4: 1

67. Two bodies are held separated by 9.8 m vertically one above the other. They are released simultaneously to fall freely under gravity. After 2 s the distance between them is

(1) 4.9 m (2) 19.6 m (3) 9.8 m (4) 39.2 m

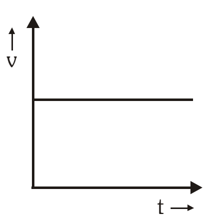
68. From the position time graph for two particles A and B is shown below. Graph A and graph B are making angles 60^0 and 30^0 with the time axis. The ratio of velocities $v_A : v_B$ is



(1) 1 : 1 (2) 3 : 1

(3) $\sqrt{3} : 1$ (4) 1 : 3

69. From the given v – t graph, it can be inferred that the object is



(1) in uniform motion

(2) at rest

(3) in non-uniform motion

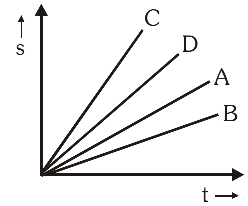
(4) moving with uniform acceleration

70. Area under a v – t graph represents a physical quantity which has the unit

(1) m^2 (2) m

(3) m^3 (4) m s^{-1}

71. Four cars A, B, C and D are moving on a levelled road. Their distance versus time graphs are shown in fig.. Choose the correct statement



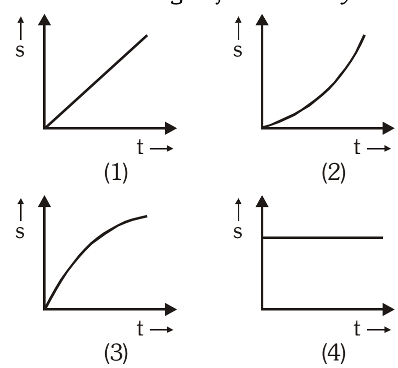
(1) Car A is faster than car D.

(2) Car B is the slowest.

(3) Car D is faster than car C.

(4) Car C is the slowest.

72. Which of the following figures represents uniform motion of a moving object correctly?

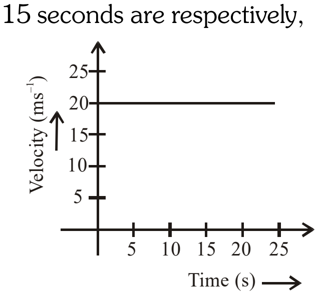


73. Slope of a velocity – time graph gives

(1) the distance (2) the displacement

(3) the acceleration (4) the speed

74. The velocity-time graph shows the motion of a cyclist. Its acceleration and the distance covered by the cyclist in 15 seconds are respectively,



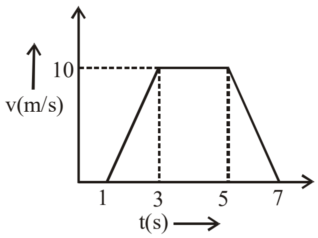
(1) 1.33 m/s^2 ; 150 m

(2) 0 m/s^2 ; 150 m

(3) 1.33 m/s^2 ; 300 m

(4) 0 m/s^2 ; 300 m

75. A particle moves according to given velocity-time graph. Then, the ratio of distance travelled in last 2 seconds to the total distance travelled is



(1) 1/4 (2) 1/2

(3) 1/8 (4) 1/6

76. The velocity of a body increases for sometime, then remains constant and then decreases until it comes to rest. When velocity is plotted against time the fig. obtained is :

(1) triangle

(2) trapezium

(3) circle

(4) None of the above

77. The area under the acceleration-time graph represents :

(1) change in velocity (2) speed

(3) velocity (4) acceleration

78. When a graph between one quantity versus another results in a straight line with positive slope, the quantities are

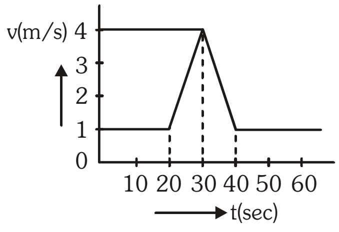
(1) directly proportional

(2) both constant

(3) inversely proportional

(4) zero

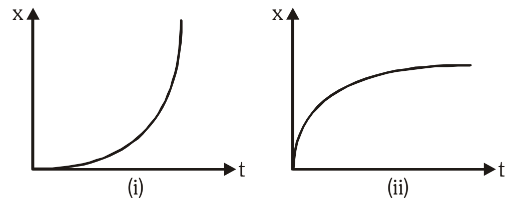
79. Velocity time (v – t) graph for a moving object is shown in the figure. Total displacement of the object during the time interval when there is non-zero acceleration and retardation is



(1) 60 m (2) 50 m

(3) 30 m (4) 40 m

80. Figures (i) and (ii) below show the displacement-time graphs of two particles moving along the x-axis. We can say that



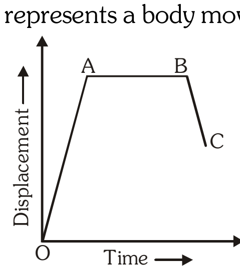
(1) Both the particles are having a uniformly accelerated motion

(2) Both the particles are having a uniformly retarded motion

(3) Particle (i) is having a uniformly accelerated motion while particle (ii) is having a uniformly retarded motion

(4) Particle (i) is having a uniformly retarded motion while particle (ii) is having a uniformly accelerated motion

81. In fig, BC represents a body moving



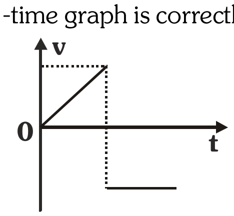
(1) Backward with uniform velocity

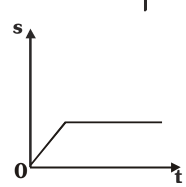
(2) Forward with uniform velocity

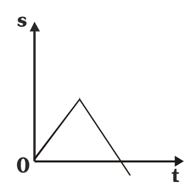
(3) Backward with non-uniform velocity

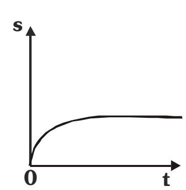
(4) Forward with non-uniform velocity

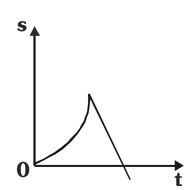
82. The velocity-time graph for a particle moving along x-axis is shown in the figure. The corresponding displacement -time graph is correctly shown by



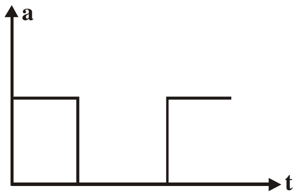
(1) 

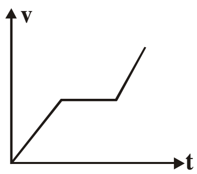
(2) 

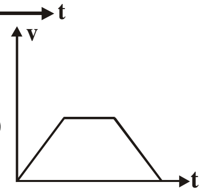
(3) 

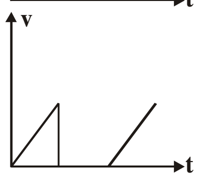
(4) 

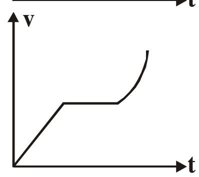
83. Which of the following graphs would probably show the velocity plotted against time graph for a body whose acceleration-time graph is shown in the figure?



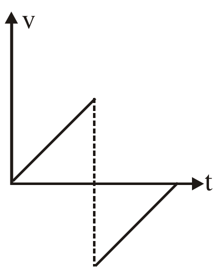
(1) 

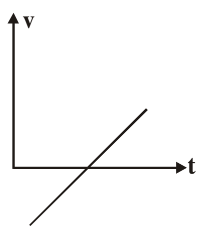
(2) 

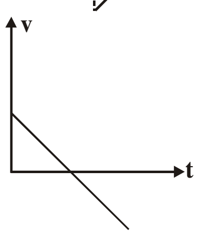
(3) 

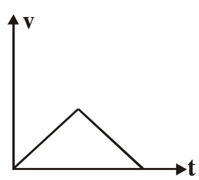
(4) 

84. The velocity-time graph of a body falling from rest under gravity and rebounding from a solid surface is represented by which of the following graphs?

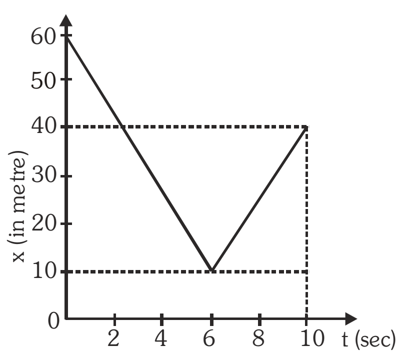
(1) 

(2) 

(3) 

(4) 

85. The fig. shows the displacement-time graph of a particle moving on a straight line path. What is the average velocity of the particle over 10 seconds ?



(1) 2 ms^{-1} (2) 4 ms^{-1} (3) 6 ms^{-1} (4) 8 ms^{-1}

86. Suppose a boy is enjoying a ride on a merry-go-round which is moving with a constant speed of 10 m s^{-1}. It implies that the boy is

(1) at rest

(2) moving with no acceleration

(3) in accelerated motion

(4) moving with uniform velocity

87. The constant quantity in a uniform circular motion is

(1) linear speed (2) centripetal force

(3) acceleration (4) momentum

88. Two cars of masses m_1 and m_2 are moving along the circular paths of radius r_1 and r_2 respectively. The speeds are such that they complete one round at the same time. The ratio of angular speeds of two cars is

(1) $m_1 : m_2$ (2) $r_1 : r_2$

(3) 1 : 1 (4) $m_1r_1 : m_2r_2$

89. A wheel is of diameter 1m. If it makes 30 revolutions/sec., then the linear speed (in m/s) of a point on its circumference is

(1) 30π (2) π (3) 60π (4) $\pi/2$

90. The angular velocity (in rad/hr) of the earth's rotation about its axis is

(1) $12/\pi$ (2) $\pi/12$

(3) $48/\pi$ (4) $\pi/24$

91. An aeroplane revolves in a horizontal circle above the surface of the earth with a uniform speed of 100 km/hr. The change in velocity (in km/hr) after completing 1/2 revolution is

(1) 200 (2) 150

(3) 300 (4) 400

92. In uniform circular motion

(1) acceleration & velocity both remain constant

(2) acceleration & speed both remain constant

(3) acceleration & velocity both keep on changing

(4) acceleration constant but speed changes

93. Angular velocity of minute hand of a watch is

(1) $\pi/3600$ rad/s (2) $\pi/1800$ rad/s

(3) $\pi/7200$ rad/s (4) $\pi/900$ rad/s

94. The ratio of angular speed of hour's hand and second's hand of a clock is

(1) 1 : 1 (2) 1 : 60

(3) 1 : 720 (4) 1 : 3600

95. The angular speed (in rad/s) of a fly wheel making 120 revolutions/minute is

(1) 2π (2) 8π (3) π (4) 4π

96. A particle is moving in a horizontal circle with constant speed. It has constant

(1) Velocity (2) Acceleration

(3) Kinetic energy (4) Displacement

97. The earth's radius is 6400 km. It makes one rotation about its own axis in 24 hrs. The centripetal acceleration of a point on its equator is nearly

(1) 340 cm/s^2 (2) 34 cm/s^2

(3) 3.4 cm/s^2 (4) 0.34 cm/s^2

98. The acceleration of a point on the rim of flywheel 1 m in diameter, if it makes 1200 revolutions per minute is

(1) $8\pi^2$ m/s^2 (2) 80 π^2 m/s^2

(3) 800 π^2 m/s^2 (4) none of these

99. A particle revolves in a circular path. The acceleration of the particle is :

(1) along the tangent

(2) zero

(3) along the radius

(4) None of these

100. Which equation is used to find out the speed of object moving in uniform circular motion ?

(1) $\frac{\pi r}{T}$ (2) $\frac{\pi r}{2T}$

(3) $\frac{2\pi r}{T}$ (4) $\frac{2\pi r}{(T/2)}$

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	3	4	4	2	1	1	3	2	1	1	2	1	1	1	4	4	2	4	
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	2	4	4	4	3	4	3	4	2	1	2	1	4	3	3	2	1	2	
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	2	2	4	2	1	2	3	4	3	4	1	3	3	2	2	1	3	2	
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	1	1	3	1	3	3	2	1	2	2	1	3	4	1	2	1	1	2	
Que.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	1	4	1	1	1	3	1	3	1	2	1	3	2	3	4	3	3	3	3	