SHORT ANSWER QUESTIONS

3.1 State second law of motion in case of rotation.

Ans. The torque (τ) acting on a body is equal to the product of its moment of inertia (I) and its angular acceleration (α).

Explanation:

$$\boxed{\tau = I\alpha}$$

This law ($\tau = I\alpha$) is the rotational analogue of Newton's second law (F = ma).

In rotational motion torque play same role as force in linear motion.

3.2 What Is the effect of changing the position of a diver while diving in the pool?

Ans. The diver changes his body position to get ***extra somersaults***.

Explanation:

$$I_1\omega_1 = I_2\omega_2 \qquad \boxed{I \propto \frac{1}{\omega}}$$

Greater the moment of inertia (I) means lesser angular velocity (ω) and vice versa.

Extended body = $(I\uparrow), (\omega\downarrow)$

Tucked body = $(I\downarrow), (\omega\uparrow)$

When a diver lifts off from the diving board, his legs and arms are full extended. The moment of inertia (I_1) is large and angular velocity (ω_1) is small. When the legs and arms of the diver are in closed tuck position, moment of inertia(I_2) is reduced and angular velocity (ω_2) will increase to ***conserve the angular momentum***.

3.3 How do we get butter from the milk?

Ans. Centrifuge is used to separate cream from milk.

Reason:

In Centrifuge machine, milk is whirled rapidly. Since milk is a mixture of light and heavy particles.

Milk is placed in the centrifuge drum and the drum spins at high speed.

Due to centrifugal force:

- Heavier part (like **skimmed milk**) moves outward.
- Lighter part (like **cream**) stays closer to the center.

The machine **collects cream** and milk separately.

3.4 Mass is a measure of inertia in linear motion. What is its analogue in rotational motion? Describe briefly.

Ans. Moment of inertia(I) is the analogue of mass in rotational motion

Explanation:

F = ma (For linear motion)

$\tau = I\alpha$ (For angular motion)

- Just like mass resists changes in an object's straight-line motion, moment of inertia resists changes in an object's rotational motion.
- It depends on mass and also how that mass is distributed relative to the axis of rotation.

3.5 Why is it harder for a car to take turn at higher speed than at lower speed?

Ans. It is harder for a car to take turn at high-speed to needs more centripetal force.

Reason:

While turning a car requires centripetal-force, given by

$$\boxed{F_C = \frac{mv^2}{r}}$$

At higher speed, the term v^2 has large value, so more force is needed to make the car turn. If there isn't enough friction to provide this force, the car can slip or skid.

That's why making turns becomes more difficult at higher speed due to need of greater centripetal force.

3.6 What are the benefits of using rear wheels of heavy vehicles consisted of double tyres?

Ans. Heavy vehicles with double tires having ***benefits***.

- Providing greater frictional force to meet the centripetal force requirement for turning.
- Using more tyres spreads the weight over a larger **contact area, which reduces the pressure** on the road $\left(p = \frac{F}{A}\right)$.
- Double wheels provide greater stability, especially for uneven roads.

3.7 When a moving car turns around a corner to the left, in what direction do the occupants tend to fall? Explain briefly.

Ans. When a moving car turns left, the occupants tend to fall to the right (outward).

Reason:

- When the car changes direction to the left, the bodies of the occupants continue moving in a straight line due to inertia (Newton's first law). As the car turns left, the bodies tend to continue in a straight line, so they tend to shift to the right relative to the car.

3.8 Why is the acceleration of a body moving uniformly in a circle, directed towards the centre?

Ans. The acceleration is directed towards the centre because it is caused by the **centripetal force**, which always acts towards the centre.

Reason:

In uniform circular motion, acceleration arises as the object's velocity vector changes direction. The force that causes this change in direction is known as the **centripetal force.**

The centripetal acceleration which is always points towards the centre of the circle, given by

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

This inward acceleration is necessary to keep the body moving along a circular path.

3.9 How does an astronaut feel weightlessness while orbiting from the Earth in a space-ship?

Ans. The astronaut feels weightless because they are in free fall.

Reason:

- Both the spacecraft and astronaut accelerate toward earth at the same acceleration equal to g.
- This means normal force is zero so they are not experiencing a net force pushing them against a floor or seat This leads to the sensation of **weightlessness** They are "falling" towards the Earth, and the curvature of the path is **matched with the curvature of Earth,** so, they never actually hit the ground.

CONSTRUCTED RESPONSE QUESTIONS

3.1 If angular velocity of different particles of a rigid body is constant, will the linear velocity of these particles also constant?

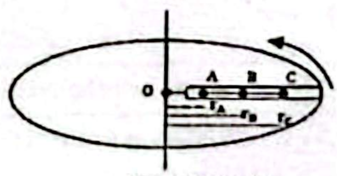
Ans. No, the linear velocity of different particles is not constant.

Explanation:

$$\boxed{v = \omega r}$$

The linear velocity of a particle depends on its distance (r) from the axis of rotation.

Since different particles are at different distances (r), have different linear velocities, even though ω is constant.



$\omega_A = \omega_B = \omega_C$ = constant

$v_A < v_B < v_C$

3.2 A loaf of bread is lying on rotating plate. A crow takes away the loaf of bread and the plates rotation increase. Why?

Ans. The plate's rotation increases due to conservation of angular momentum.

Explanation:

$$I_1\omega_1 = I_2\omega_2 \qquad (I) \propto \frac{1}{(\omega)}$$

Where (I) is the moment of inertia and ω is the angular velocity.

When the crow takes away the loaf, Thus, the moment of inertia decreases (i.e., $I = mr^2$), the angular velocity must increase to maintain that constant angular momentum.

3.3 Why do we tumble when we take the sharp turn with large speed?

Ans. We tumble due to inertia and insufficient centripetal force.

Explanation:

$$\left(F_c = \frac{mv^2}{r}\right)$$

At high speeds, turning requires a **large centripetal force** to change direction.

If the **frictional force** (which provides the centripetal force) is **not enough**, the body can't turn effectively.

Due to **inertia** (Newton's 1st Law), the body wants to keep moving **in a straight line.**

This causes the person to **lose balance and tumble outward** from the turn.

3.4 What will be time period of a simple pendulum in an artificial satellite?

Ans. The time period of a simple pendulum in an artificial satellite will **be infinite.**

Reason:

In an artificial satellite, objects are in free fall, experiencing weightlessness (i.e., $g_{eff} = 0$).

The time period of simple pendulum is

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}} = 2\pi\sqrt{\frac{l}{0}}$$

$$\boxed{T = \infty}$$

The time period becomes infinite. So, without gravity, the pendulum cannot oscillate.

3.5 Is the motion of a satellite in its orbit, uniform or accelerated?

Ans. The motion of a satellite is accelerated.

Explanation:

During the motion of a satellite in its orbit, the speed is constant in orbit, but the direction changes continuously.

Hence, the satellite experiences centripetal acceleration:

$$\left(a_c = \frac{v^2}{r}\right)$$

Hence, this type of accelerated motion due to the changing direction of velocity.

3.6 What are the advantages that radian has been preferred as SI unit over degree?

Ans. Radian is preferred because it's dimensionless and relates arc length to radius.

Explanation:

- It is a pure ratio (arc length/radius), hence dimensionless
- Making it easier to use in mathematical equations While degrees adds extra conversion steps, which makes formulas more complex.
- In rotational motion, these formations hold true only when angles are in radians:

$$\boxed{S = r\theta}$$

3.7 In uniform circular motion, what are the average velocity and average acceleration for one revolution? Explain.

Ans. The average velocity and average acceleration over one complete revolution are zero.

Explanation:

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}} = \frac{0}{t} = 0$$

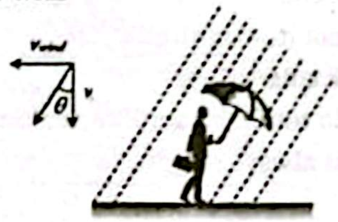
In one complete revolution, the displacement is zero.

$$\text{Average acceleration} = \frac{\text{Change in velocity}}{\text{time}} = \frac{0}{t} = 0$$

The change in velocity for one revolution is zero, because initial and final velocities are the same.

3.8 In a rainstorm with a strong wind, what determines the best position to hold an umbrella?

Ans. The best position to hold an umbrella in direction of the relative velocity of rain with respect to the person.



Explanation:

$\vec{v}_{rain}$ = Velocity of rain vertically downward

$\vec{v}_{wind}$ = Horizontal wind velocity

Then the relative velocity of rain is

$$\vec{v}_{rel} = \vec{v}_{rain} + \vec{v}_{wind}$$

So, the best position to hold an umbrella during a windy rainstorm is to tilt it against the wind, so it blocks the rain coming at some angle.

3.9 A ball is just supported by a string without breaking, If it is whirled in a vertical circle, it breaks. Explain why,

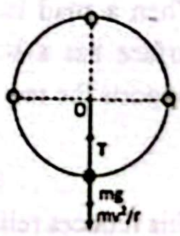
Ans. The string breaks at lower point in a vertical circle due to maximum tension.

Explanation:

When the ball is hanging, the tension (T) in the string is equal to the weight of the ball (*mg*).

$$\boxed{T = mg}$$

When the ball is whirled in a vertical circle, at the lowest point, the string must provide both the weight of the ball and the centripetal force to keep it in circular motion.



The tension (*T*) becomes

$$\boxed{T_{Bottom} = mg + \frac{mv^2}{r}}$$

This tension may exceed the string's strength, cause to break.

3.10 How the centripetal force supplied in the following cases:

(a) A satellite orbiting around the Earth.

(b) A car taking a turn on a level road.

(c) A stone whirled in a circle by means of a string.

Ans. (a) A satellite orbiting around the Earth.

Centripetal force in provided by the gravitational attraction between the earth and the satellite.

According to Newton's law of gravitation

$$\boxed{F = \frac{GMm}{r^2}}$$

(b) A car taking a turn on a level road.

Centripetal force is supplied by the frictional force between the tyres of the car and the road surface.

$$F_{friction} = \mu N = \mu mg$$

(c) A stone whirled in a circle by means of a string.

Tension in the string provides the required centripetal force

$$\boxed{T = \frac{mv^2}{r}}$$