

Chapter 4

Dynamics II

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Short Questions

1. Why is a long spanner used to open or tighten nuts of a vehicle's tyre? While tightening a small nut, an extra-long wrench is not suitable. Why?

Answer:

A long spanner is used to open or tighten large nuts because it provides greater torque due to the increased length of the lever arm. This makes it easier to apply sufficient force to loosen or tighten the nuts.

For small nuts, an extra-long wrench is not suitable because it may generate excessive torque, potentially damaging the nut or the threads.

2. Why are door knobs fixed at the edge of the door? What will happen if the door knob is at the middle of the door?

Answer:

Door knobs are fixed at the edge of the door to maximize the torque produced when opening or closing the door. Placing the knob further from the hinge increases the lever arm, making it easier to apply force.

If the knob were at the middle of the door, the lever arm would be shorter, requiring more force to open or close the door.

3. If you drop a feather and a bowling ball from the same height, which one will reach the terminal velocity first? Which one of them will hit the ground first?

Answer:

The feather will reach terminal velocity first because it has a much larger surface area relative to its mass, causing greater air resistance.

The bowling ball will hit the ground first because its terminal velocity is much higher, and it is less affected by air resistance.

4. Why do ice skates effortlessly slide on ice, while your shoes cause skidding?

Answer:

Ice skates have thin, sharp blades that exert high pressure on the ice, melting a thin layer beneath them. This creates a lubricating layer of water that allows effortless sliding. Shoes, on the other hand, have a larger surface area, creating more friction and preventing smooth sliding.

5. Explain why it's easier to push a car on flat tyres than inflated ones. What happens to the frictional force between the tyres and the road?

Answer:

It's easier to push a car on flat tyres because the contact area between the tyres and the road increases, reducing the pressure. This decrease in pressure reduces the frictional force required to move the car. In contrast, inflated tyres have a smaller contact area, increasing the frictional force.

6. When standing on a crowded school bus, which stance would provide better stability and prevent you from being pushed over: legs joined or legs spread apart?

Answer:

Standing with legs spread apart provides better stability. This stance increases the base of support and lowers the center of gravity, which helps in maintaining balance and resisting external forces, such as a push or the motion of the bus.

7. Why is a moving bicycle easier to balance? Relate this to the principles of rotational motion.

Answer:

A moving bicycle is easier to balance because the wheels are in rotational motion, creating angular momentum. According to the principles of rotational motion, angular momentum resists changes in the orientation of the rotation axis, thus stabilizing the bicycle and making it less likely to tip over.

8. Why is a pencil standing on its tip unstable, and what factors affect the stability of an object balanced on a point?

Answer:

A pencil standing on its tip is unstable because its center of gravity is high, and its base of support (the tip) is very small. Stability is affected by the height of the center of gravity (lower is more stable), the size of the base of support (larger is more stable), and the distribution of mass (wider and more evenly distributed mass increases stability).

9. While driving, what happens if the driver takes the curve too fast? How does centripetal force play a role in keeping the car from skidding off the road?

Answer:

If a driver takes a curve too fast, the required centripetal force to keep the car in a curved path may exceed the available frictional force between the tires and the road. This can result in skidding. Centripetal force, provided mainly by the frictional force, keeps the car moving in a circular path. If the speed is too high, the frictional force may not suffice, causing the car to lose traction and skid.

10. Consider a situation where you swing a ball connected to a string in a circle. How does the tension in the string vary as the ball moves across different points in its circular path, and what forces are involved?

Answer:

The tension in the string provides the centripetal force required to keep the ball in a circular path. At the top of the circular path, the tension in the string is less because it combines with the gravitational force acting downward. At the bottom of the path, the tension is greater because it must counteract both the gravitational force and provide the centripetal force. The forces involved are tension, gravity, and the centripetal force.

11. Why is it important for communication satellites in geostationary orbit to maintain a specific speed?

Answer:

Communication satellites in geostationary orbit need to maintain a specific speed to match the Earth's rotational speed. This ensures they remain stationary relative to a fixed point on Earth's surface, which is crucial for providing consistent communication and broadcasting services. If the speed deviates, the satellite's position would shift, disrupting communication.

Long Questions

1. Differentiate between like and unlike parallel forces.

Like Parallel Forces

- **Definition:** Like parallel forces are forces that act in the same direction along parallel lines.
- **Resultant Force:** The resultant force is the sum of all individual forces and acts in the same direction.
- **Formula:** $F_R = F_1 + F_2 + F_3 + \dots$
- **Examples:**
 1. Two people pushing a cart in the same direction.
 2. The gravitational force acting downward on multiple objects stacked together.

Unlike Parallel Forces

- **Definition:** Unlike parallel forces are forces that act in opposite directions along parallel lines.
- **Resultant Force:** The resultant force is the difference between the magnitudes of the forces, and its direction is the same as the larger force.
- **Formula:** $F_R = F_1 - F_2$, where $F_1 > F_2$
- **Examples:**
 1. A tug of war where two teams pull a rope in opposite directions.
 2. A box being pushed from opposite sides by two people applying unequal forces.

Key Differences:

Aspect	Like Parallel Forces	Unlike Parallel Forces
Direction	Same	Opposite
Resultant Force	Sum of forces	Difference of forces
Example	Pushing a cart together	Tug of war with unequal pulls

2. What is the moment of force or torque? On what factors does it depend? Write its mathematical formula.

Moment of Force (Torque)

- **Definition:** Torque, or moment of force, is the rotational effect of a force applied at a distance from the axis of rotation.
- **Formula:** $\tau = F \cdot d$, where:
 - τ = Torque (Nm)
 - F = Force (N)
 - d = Distance from the axis of rotation (m)

- ddd = Perpendicular distance from the axis of rotation (m).

Factors Affecting Torque

1. **Magnitude of Force:** Greater the force, higher the torque.
2. **Perpendicular Distance:** Torque increases as the distance from the axis of rotation increases.

Examples:

1. Turning a door handle: The force applied farther from the hinge creates more torque.
2. Using a wrench: A longer wrench increases the torque applied to a bolt.

Applications in Real Life

- Torque is used in machines like levers, pulleys, and gears.
- Engineers calculate torque to design vehicles, turbines, and other mechanical systems.

3. Define center of mass. What is the effect of mass distribution in a body on its center of mass?

Center of Mass

- **Definition:** The center of mass of an object is the point where its entire mass can be considered concentrated for the purpose of analyzing motion.
- **Formula:** For a system of particles:

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

$$x_{cm} = \sum m_i x_i$$
, where:
 - m_i = Mass of each particle,
 - x_i = Position of each particle.

Effect of Mass Distribution

1. **Symmetrical Distribution:** If the mass is evenly distributed, the center of mass lies at the geometric center of the object.
Example: A uniform sphere has its center of mass at its center.
2. **Asymmetrical Distribution:** If the mass is unevenly distributed, the center of mass shifts toward the heavier side.
Example: A hammer's center of mass is closer to the heavier metal head than the wooden handle.

Applications in Daily Life

1. In designing vehicles, the center of mass is kept low for stability.
2. Athletes use the concept of center of mass for balance in gymnastics and high jumps.

4. How can you find the center of gravity of an irregular-shaped thin sheet of plastic?

Center of Gravity

- **Definition:** The center of gravity is the point where the entire weight of an object is considered to act.

Procedure to Find Center of Gravity of an Irregular Object

1. **Suspend the Object:** Hang the sheet from any one point. The center of gravity lies along the vertical line from the suspension point.
2. **Mark the Line:** Use a plumb line to trace the vertical line on the sheet.
3. **Repeat the Process:** Suspend the object from another point and draw the vertical line.
4. **Intersection Point:** The intersection of the two lines is the center of gravity.

Applications in Real Life

1. Determining the balance point of vehicles and machinery.
2. Designing stable structures like bridges and tall buildings.

5. What is equilibrium? Describe the conditions of equilibrium. State and explain the principle of moments.

Equilibrium

- **Definition:** An object is in equilibrium if it is at rest or moving with uniform velocity, and all the forces and torques acting on it are balanced.

Conditions for Equilibrium

1. **Translational Equilibrium:** The net force acting on the object must be zero:
 $\sum F_x = 0$, $\sum F_y = 0$
2. **Rotational Equilibrium:** The net torque acting on the object must be zero:
 $\sum \tau = 0$

Principle of Moments

- **Statement:** For an object in rotational equilibrium, the sum of clockwise moments equals the sum of anticlockwise moments:
 $\sum \tau_{\text{clockwise}} = \sum \tau_{\text{anticlockwise}}$

Examples:

1. A balanced seesaw: The weights on both sides create equal and opposite moments.
2. A suspended beam: The forces at both ends balance the weight in the middle.

Applications:

- Used in designing cranes, bridges, and levers.
- Ensures stability in construction and machinery.

6. Propose how the stability of an object can be improved. Illustrate the applications of stability in real life.

Definition of Stability

Stability refers to the ability of an object to maintain its position or return to its original position after being disturbed.

How Stability Can Be Improved

1. **Lowering the Center of Gravity:**

- The lower the center of gravity, the more stable the object becomes.
Example: Sports cars have a low center of gravity for better handling.

2. **Increasing the Base Area:**

- A larger base area improves stability by distributing weight more evenly.
Example: Tripods used for cameras have wide legs to increase stability.

3. **Adding Weight to the Base:**

- Adding weight at the base lowers the center of gravity and enhances stability.
Example: High-rise cranes have heavy counterweights at their bases.

4. **Aligning the Center of Gravity and Base:**

- Keeping the center of gravity directly above the base prevents toppling.
Example: Tightrope walkers carry long poles to adjust their center of gravity.

Applications in Real Life

1. **Construction:** Skyscrapers are designed with wide bases and low centers of gravity to withstand strong winds and earthquakes.
2. **Furniture Design:** Chairs and tables are designed with wide legs for stability.
3. **Sports:** Athletes maintain low centers of gravity in activities like wrestling and skiing to avoid falling.

7. Define force of friction. What causes friction? What are the advantages and disadvantages of friction? Explain with examples.

Definition of Friction

Friction is the resistive force that opposes the motion of an object when it comes in contact with another surface.

Causes of Friction

1. **Surface Roughness:** Microscopic irregularities on surfaces interlock and resist motion.
2. **Nature of Materials:** Some materials, like rubber, create more friction than others, like ice.
3. **Normal Force:** The greater the force pressing two surfaces together, the higher the friction.

Advantages of Friction

1. **Walking and Driving:** Friction between shoes and the ground allows walking, and between tyres and the road enables driving.
2. **Holding Objects:** Friction helps grip objects like tools or handles.
3. **Stopping Motion:** Brakes in vehicles rely on friction to stop motion.

Disadvantages of Friction

1. **Energy Loss:** Friction converts useful energy into heat, reducing efficiency.
Example: Engine parts lose energy due to friction.
2. **Wear and Tear:** Continuous friction causes damage to moving parts.
Example: Tyres wear out over time.
3. **Slows Motion:** Friction opposes motion, making it harder to move objects.

Examples in Daily Life

1. Writing with a pencil relies on friction between the pencil tip and paper.
2. Sliding a box across a floor requires overcoming friction.

8. Compare rolling friction and sliding friction. How are they different in terms of contact surfaces, motion, and forces involved? Explain with examples.

Definition of Rolling Friction

Rolling friction occurs when an object rolls over a surface.

Definition of Sliding Friction

Sliding friction occurs when an object slides over a surface.

Differences Between Rolling and Sliding Friction

Aspect	Rolling Friction	Sliding Friction
Contact Surface	Smaller area of contact	Larger area of contact
Force Required	Requires less force	Requires more force
Motion	Smooth and continuous	Irregular and resistive
Energy Loss	Lower energy loss	Higher energy loss

Examples

1. **Rolling Friction:**
 - Wheels on a car reduce friction, making it easier to move.
2. **Sliding Friction:**
 - Pushing a heavy box across the floor involves sliding friction.

Applications

1. **Rolling Friction:** Used in vehicles, conveyor belts, and bearings to improve efficiency.

2. **Sliding Friction:** Applied in activities like braking, where more resistance is needed to stop motion.
-

9. Analyze the dynamics of an object reaching terminal velocity.

Definition of Terminal Velocity

Terminal velocity is the constant speed achieved by an object when the downward force of gravity is balanced by the upward drag force (air resistance).

Dynamics of Terminal Velocity

1. Initial Stage:

- The object accelerates due to gravity.
- The velocity increases, causing air resistance to increase.

2. Intermediate Stage:

- As the object's speed increases, the upward air resistance grows until it equals the downward gravitational force.

3. Terminal Velocity Stage:

- At this point, net force acting on the object becomes zero.
- The object continues to fall at a constant speed without further acceleration.

Factors Affecting Terminal Velocity

1. **Mass of the Object:** Heavier objects have higher terminal velocities.
2. **Surface Area:** Larger surface areas experience more air resistance, reducing terminal velocity.
3. **Shape of the Object:** Streamlined shapes reduce drag, increasing terminal velocity.

Examples in Real Life

1. **Skydivers:** Before deploying a parachute, skydivers reach terminal velocity. The parachute increases air resistance, lowering terminal velocity.
 2. **Raindrops:** Terminal velocity prevents raindrops from causing damage when they hit the ground.
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10. Define centripetal force. Describe the motion of a body in a circular path under the action of centripetal force.

Definition of Centripetal Force

Centripetal force is the force directed toward the center of a circular path that keeps an object moving in a curved trajectory.

Formula:

$$F_c = \frac{mv^2}{r}$$

Where:

- F_c = Centripetal force,
- m = Mass of the object,
- v = Velocity,
- r = Radius of the circle.

Motion in a Circular Path

1. Direction of Force:

- Centripetal force always acts toward the center of the circle, perpendicular to the object's velocity.

2. Velocity:

- The velocity of the object is tangential to the circular path.

3. Acceleration:

- The object undergoes centripetal acceleration, changing its direction of motion while maintaining constant speed.

Examples of Centripetal Force

1. **Planetary Motion:** Gravity acts as the centripetal force, keeping planets in orbit around the Sun.
2. **Car on a Curved Road:** Friction between tyres and the road provides the centripetal force required to make the turn.
3. **Swinging a Ball:** The tension in the string provides the centripetal force.

11. Define centripetal force. Describe the motion of a body in a circular path under the action of centripetal force.

Definition of Centripetal Force:

Centripetal force is the force that acts on an object moving in a circular path and is always directed toward the center of the circle. It keeps the object in circular motion by continuously changing its direction.

Explanation of Circular Motion:

When a body moves in a circle, it has a tendency to move in a straight line due to inertia (Newton's first law). However, the centripetal force pulls the object toward the center of the circle, preventing it from flying outward. This inward force causes the object to follow a curved (circular) path.

For example:

- When you swing a ball tied to a string in a circle, the tension in the string provides the centripetal force.
 - If the string breaks, the ball flies off tangentially because there is no centripetal force to keep it in the circular path.
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12. Identify different sources of centripetal force in real-life examples.

Sources of Centripetal Force:

1. **Friction:** Friction between the tires and the road provides the centripetal force when a car takes a turn.
2. **Tension:** Tension in a string provides centripetal force for a ball swung in a circular motion.
3. **Gravitational Force:** Gravity provides the centripetal force that keeps planets orbiting the Sun or the Moon orbiting the Earth.
4. **Normal Force:** The force exerted by the walls of a rotating ride (like a Ferris wheel) acts as centripetal force for the riders.

Explanation with Examples:

- **Driving Around a Curve:** When a car turns, the friction between the tires and the road prevents it from sliding outward. This friction acts as the centripetal force, keeping the car on the curved path.
- **Orbiting Satellites:** For a satellite orbiting Earth, the gravitational pull acts as the centripetal force, keeping the satellite in orbit.
- **Swinging a Pendulum:** When you swing a pendulum, the tension in the string acts as the centripetal force.

13. Define orbital velocity. How do scientists use the concept of orbital speed to launch satellites into specific orbits? What factors influence the chosen speed?

Definition of Orbital Velocity:

Orbital velocity is the minimum speed needed for an object to stay in orbit around a planet or star without falling back due to gravity.

Explanation:

When a satellite is launched, it is given enough speed to counteract the pull of Earth's gravity. This speed ensures that the satellite keeps falling toward Earth but never reaches it because Earth's surface curves away. As a result, the satellite remains in orbit.

Formula for Orbital Velocity:

$$v = \sqrt{\frac{GM}{r}}$$

Where:

- G = Gravitational constant
- M = Mass of the planet
- r = Radius of the orbit (distance from the center of the planet to the satellite)

How Scientists Use Orbital Speed:

- Scientists calculate the required speed for the satellite based on the desired orbit (e.g., low Earth orbit, geostationary orbit).

- The satellite is launched at this speed to ensure it enters and stays in the orbit without falling back to Earth or escaping into space.

Factors Influencing Orbital Speed:

1. **Height of Orbit:** A satellite closer to Earth requires higher orbital velocity, while one farther away requires lower speed.
2. **Mass of the Planet:** Heavier planets exert stronger gravitational forces, requiring higher orbital velocities.
3. **Type of Orbit:** Geostationary satellites (used for communication) need a specific speed and altitude to match Earth's rotation.

Example:

For a geostationary satellite, it is launched at a height of about 35,786 km above Earth's surface with a velocity that matches Earth's rotational speed. This ensures it stays fixed above a specific location on Earth.

Extera Short Questions (Topic Wise)

4.1 Forces on Bodies

1. **What is force, and how does it affect the motion of a body?**

Force is a push or pull acting on a body. It can change the speed, direction, or shape of the body.

2. **What happens to a body when balanced and unbalanced forces act on it?**

Balanced forces keep a body at rest or in uniform motion, while unbalanced forces cause a change in motion or acceleration.

3. **How does Newton's first law relate to forces on bodies?**

Newton's first law states that an object remains at rest or in uniform motion unless acted upon by an external force.

4. **What are contact and non-contact forces? Provide examples.**

Contact forces require physical touch (e.g., friction, tension), while non-contact forces act without touch (e.g., gravity, magnetic force).

4.2 Moment of a Force

1. **What is the moment of a force?**

The moment of a force is the turning effect produced by a force acting at a distance from a pivot point.

2. **How is the moment of a force calculated?**

It is calculated using the formula:

$$\text{Moment} = \text{Force} \times \text{Perpendicular Distance from Pivot}$$
$$\text{Moment} = \text{Force} \times \text{Perpendicular Distance from Pivot}$$

3. **What is the difference between clockwise and anticlockwise moments?**

Clockwise moments turn objects in a clockwise direction, while anticlockwise moments turn them in the opposite direction.

4. **Give real-life examples of moments of force.**

Examples include opening a door, using a wrench to tighten a bolt, or a seesaw in a playground.

4.3 Center of Mass

1. **What is the center of mass of a body?**

The center of mass is the point where the entire mass of an object appears to act.

2. **How is the center of mass determined for symmetrical objects?**

For symmetrical objects, the center of mass lies at their geometric center.

3. **Why is the center of mass important for stability?**

A lower center of mass increases stability, while a higher one makes objects less stable.

4. **What happens if the center of mass is outside the base of an object?**

The object will tip over if its center of mass is outside its base of support.

4.4 Equilibrium

1. **What is equilibrium in physics?**

Equilibrium is when an object is at rest or moving with constant velocity, with no net force acting on it.

2. **What are the two types of equilibrium?**

Static equilibrium (object at rest) and dynamic equilibrium (object moving at constant velocity).

3. **What is the role of forces in maintaining equilibrium?**

For equilibrium, the sum of all forces and torques acting on an object must be zero.

4. **How is equilibrium used in real life?**

Examples include a balanced weighing scale and a person standing still without falling.

4.5 Stability

1. **What does stability mean in physics?**

Stability refers to an object's ability to maintain its position and resist tipping over.

2. **How does the base of support affect stability?**

A wider base of support increases an object's stability.

3. **What is the relationship between the center of gravity and stability?**

A lower center of gravity makes an object more stable, while a higher one reduces stability.

4. **How can stability be improved in vehicles?**

Stability can be improved by lowering the center of gravity and widening the base of the vehicle.

4.6 Friction

1. **What is friction?**

Friction is the force that resists motion between two surfaces in contact.

2. **What are the types of friction?**

Static friction (prevents motion), sliding friction (resists sliding), rolling friction (resists rolling), and fluid friction (resists motion in liquids or gases).

3. **How can friction be reduced?**

Friction can be reduced by using lubricants, polishing surfaces, or adding wheels.

4. **What are the advantages of friction?**

Friction allows walking, holding objects, and stopping vehicles using brakes.

4.7 Centripetal Force

1. **What is centripetal force?**

Centripetal force is the inward force that keeps an object moving in a circular path.

2. **Why is centripetal force necessary for circular motion?**
Without centripetal force, an object would move in a straight line due to inertia.
 3. **What happens if centripetal force is removed during circular motion?**
The object will leave the circular path and move tangentially.
 4. **What are the sources of centripetal force in real life?**
Examples include gravitational force for planetary orbits and tension in a string during circular motion.
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4.8 Orbital Motion

1. **What is orbital motion?**
Orbital motion is the movement of an object around another due to gravitational attraction.
 2. **How does gravity affect orbital motion?**
Gravity acts as the centripetal force, keeping the object in orbit.
 3. **What happens if a satellite's speed is too low or too high?**
If too low, the satellite will fall back to Earth. If too high, it will escape into space.
 4. **Why do satellites need specific orbital velocity?**
To maintain a stable orbit without falling back to Earth or escaping its gravity.
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4.9 Planetary Data

1. **What is planetary data, and why is it important?**
Planetary data includes information about planets' sizes, masses, and orbits, essential for studying celestial mechanics.
2. **How do planets maintain their orbits around the Sun?**
The Sun's gravity provides the centripetal force needed to keep planets in orbit.
3. **Why are some planets rocky and others gas giants?**
Planets close to the Sun are rocky due to high temperatures, while those farther away are gas giants because of lower temperatures and their ability to retain gases.
4. **What factors affect the orbital speed of planets?**
Distance from the Sun and the mass of the planet influence orbital speed. Closer planets orbit faster due to stronger gravitational pull.

Extera Long Questions (Topic Wise)

1. Explain the types of forces acting on bodies with examples from real life.

Forces on Bodies

Forces can act on a body in different ways, influencing its state of motion, rest, or shape. They are categorized as follows:

1. Contact Forces:

Forces that require physical contact between two objects.

○ Examples:

1. **Friction:** A force resisting motion when two surfaces interact (e.g., pushing a box).
2. **Normal Force:** The support force exerted by a surface perpendicular to an object (e.g., a book resting on a table).
3. **Tension:** The pulling force in a rope or string (e.g., a hanging object).

2. Non-Contact Forces:

Forces that act over a distance without direct contact.

○ Examples:

1. **Gravitational Force:** Attraction between masses (e.g., Earth's gravity pulling objects downward).
2. **Electrostatic Force:** Force between charged particles (e.g., static electricity).
3. **Magnetic Force:** Force between magnets or moving charges (e.g., magnetic attraction in a compass).

Applications in Real Life:

- Contact forces are used in machines like levers and pulleys.
- Non-contact forces are essential in understanding planetary motion and electromagnetism.

2. Define the moment of a force. What factors affect the moment of force? Explain its applications in daily life.

Definition of Moment of Force

The moment of a force, or torque, is the turning effect of a force applied at a distance from the axis of rotation.

Formula:

$$\text{Torque}(\tau) = F \cdot d \quad \text{Torque}(\tau) = F \cdot d$$

Where:

- F = Force (N)
- d = Perpendicular distance from the axis of rotation (m).

Factors Affecting the Moment of Force:

1. **Magnitude of the Force:** Larger forces produce greater torque.
2. **Distance from the Axis:** Increasing the distance amplifies the turning effect.

Applications in Daily Life:

1. **Opening a Door:** Applying force farther from the hinge requires less effort.
2. **Using a Wrench:** Longer wrenches increase torque, making it easier to tighten or loosen bolts.
3. **Balancing Seesaws:** Adjusting the position of people on a seesaw creates balanced torque for equilibrium.

3. What is the center of mass? Discuss its importance in designing stable structures and vehicles.

Definition of Center of Mass

The center of mass is the point at which the entire mass of an object can be considered concentrated for analysis of motion.

Formula:

For a system of particles:

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i} \quad x_{cm} = \frac{\sum m_i x_i}{\sum m_i}$$

Importance in Designing Stable Structures:

1. **Lowering the Center of Mass:** Structures with a low center of mass are more stable and less likely to topple.
 - **Example:** Skyscrapers are designed with heavy foundations to lower the center of mass.
2. **Even Distribution of Mass:** Ensures uniform load distribution to prevent collapse.
 - **Example:** Bridges are built with symmetrical mass distribution.

Importance in Vehicles:

1. **Improving Stability:** Lowering the center of mass in vehicles reduces the risk of toppling during turns.
 - **Example:** Sports cars have low centers of gravity for better handling.
2. **Balance in Motion:** Maintaining a proper center of mass enhances safety and performance.
 - **Example:** Trucks with loads balanced near the center of mass prevent tipping.

4. Explain equilibrium and the conditions for equilibrium. State the types of equilibrium with examples.

Definition of Equilibrium

An object is in equilibrium when the net force and net torque acting on it are zero.

Conditions for Equilibrium:

1. Translational Equilibrium:

- The sum of all forces in horizontal ($\sum F_x$) and vertical ($\sum F_y$) directions must be zero.

2. Rotational Equilibrium:

- The sum of all torques ($\sum \tau$) must be zero.

Types of Equilibrium:

1. Static Equilibrium: The object is at rest.

- **Example:** A book resting on a table.

2. Dynamic Equilibrium: The object is in uniform motion.

- **Example:** A car moving at constant velocity.

Applications:

1. **Construction:** Buildings are designed to ensure forces and moments balance, preventing collapse.
2. **Engineering:** Machines like cranes use equilibrium principles to maintain stability.

5. Describe the concept of stability and how it is influenced by the center of gravity and base area.

Definition of Stability

Stability is an object's ability to return to its original position after being disturbed.

Factors Affecting Stability:

1. Center of Gravity:

- Lowering the center of gravity increases stability.

Example: Wide-based furniture is more stable because the center of gravity is closer to the ground.

2. Base Area:

- A wider base area enhances stability by distributing the load more evenly.

Example: Tripods are designed with wide legs for stability.

3. Weight Distribution:

- Properly distributed weight reduces the risk of toppling.

Example: Heavy vehicles have counterweights for balance.

Applications in Real Life:

1. **Buildings:** Skyscrapers are designed with stable foundations.
2. **Sports:** Wrestlers lower their center of gravity to resist being toppled.

6. What is centripetal force? Discuss its role in orbital motion and explain how it helps maintain planetary orbits.

Definition of Centripetal Force

Centripetal force is the inward force that keeps an object moving in a circular path.

Formula:

$$F_c = \frac{mv^2}{r}$$

Where:

- F_c = Centripetal force (N)
- m = Mass (kg)
- v = Velocity (m/s)
- r = Radius of the circular path (m).

Role in Orbital Motion:

1. **Maintaining Circular Path:** Centripetal force prevents objects from flying off their circular orbits.
2. **Balancing Forces:** For planets, gravitational force provides the necessary centripetal force to maintain their orbits.

Applications:

1. **Satellites:** Centripetal force ensures satellites stay in orbit around Earth.
2. **Vehicles on Curves:** Friction provides centripetal force for vehicles taking turns on roads.

Examples:

1. **Earth's Orbit Around the Sun:** The Sun's gravity acts as a centripetal force, keeping Earth in its orbit.
2. **Swinging a Ball:** The tension in the string provides centripetal force for circular motion.

MCQs Based on Dynamics Topics

1. What is the turning effect of a force called?

[Moment] | Force | Torque | Work

2. Which force keeps a satellite in orbit?

Magnetic force | [Centripetal force] | Friction | Normal force

3. What happens if the center of mass is outside the base of an object?

It becomes more stable | [It tips over] | It rotates | It stays balanced

4. What is the role of gravity in orbital motion?

Provides friction | [Acts as centripetal force] | Reduces speed | Stops motion

5. Which is NOT a type of friction?

Static friction | Sliding friction | Fluid friction | [Orbital friction]

6. What increases the stability of an object?

[Lower center of gravity] | Higher center of gravity | Smaller base | Less mass

7. What is the formula for calculating moment of a force?

[Force $\times$ Distance] | Force + Distance | Force $\div$ Distance | Force - Distance

8. What is a condition for an object to be in equilibrium?

[Zero net force] | Constant speed | Changing direction | Decreasing acceleration

9. Which force opposes motion between surfaces?

[Friction] | Gravity | Normal force | Tension

10. What is the minimum speed required for a satellite to stay in orbit?

[Orbital velocity] | Terminal velocity | Escape velocity | Critical velocity

11. What determines the strength of gravitational force on a planet?

[Mass of the planet] | Distance from the Sun | Atmosphere | Rotation speed

12. What type of motion requires centripetal force?

Linear motion | [Circular motion] | Random motion | Oscillatory motion

13. What happens to an object in circular motion if centripetal force is removed?

It stops | [It moves tangentially] | It accelerates | It spins faster

14. Which object has the center of mass at its geometric center?

[Uniform sphere] | Irregular body | Leaning tower | Pendulum

15. What is the SI unit of force?

[Newton] | Joule | Watt | Pascal

16. What is a balanced force?

[Zero net force] | Constant acceleration | Unequal forces | Rotational force

17. What is the direction of centripetal force?

[Toward the center] | Away from the center | Parallel to motion | Perpendicular to motion

18. Which force keeps a car moving on a curved path?

[Friction] | Gravity | Air resistance | Tension

19. What is the moment of a force dependent on?

[Force and distance] | Speed and time | Mass and velocity | Pressure and volume

20. What is the effect of increasing the base of support?

[Increases stability] | Decreases stability | No effect | Reduces friction

21. Which force is responsible for planets orbiting the Sun?

[Gravitational force] | Magnetic force | Frictional force | Electric force

22. What is the center of mass?

[Point where mass is concentrated] | Point of rotation | Point of highest force | Point of equilibrium

23. How does friction benefit walking?

[Prevents slipping] | Reduces effort | Speeds up motion | Balances weight

24. What is an example of static friction?

[Holding a book] | Sliding a box | Rolling a ball | Air resistance

25. Which factor does not affect stability?

Shape of object | [Color of object] | Base area | Center of gravity

26. What happens to an object at terminal velocity?

[Net force is zero] | Acceleration increases | Speed decreases | Gravitational force stops

27. What type of friction occurs when a ball rolls?

[Rolling friction] | Static friction | Sliding friction | Fluid friction

28. What is the main factor for determining orbital velocity?

[Height of orbit] | Shape of object | Temperature | Color

29. What is the relationship between speed and centripetal force?

[Higher speed requires more centripetal force] | Higher speed reduces centripetal force | No effect | Speed changes direction

30. Why are gas giants farther from the Sun?

[Lower temperature] | Stronger gravity | Closer to other stars | Slower rotation