

Chapter No 3

Dynamics I

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Short Questions

1. When a monkey jumps off a stationary car, he may fly off the motorcycle and driver in the car. Why?

Ans:

This happens because of inertia. Inertia is the tendency of an object to resist changes in its state of motion. When the monkey jumps, his body tends to stay in motion due to inertia, causing him to continue in the same direction and speed as the motorcycle or car he jumped from.

2. Why are tree branches shaken, and the leaves are detached?

Ans:

When a branch is shaken, the branch experiences motion while the leaves tend to remain at rest due to inertia. This difference in motion causes the leaves to detach from the branch and fall to the ground.

3. Illustrate Newton's first law of motion on the stationary loaded bicycle.

Ans:

Newton's first law of motion states that an object remains at rest or in uniform motion unless acted upon by an external force. A stationary loaded bicycle remains at rest because no external unbalanced force is acting on it to change its state.

4. Action and reaction forces are equal but opposite in direction. Are these forces always acting in pairs? Do they cancel out?

Ans:

Yes, action and reaction forces always occur in pairs according to Newton's third law of motion. They do not cancel out because they act on different objects. For example, when you push a wall, the wall pushes back with an equal and opposite force.

5. A person slips on a slippery floor. Why?

Ans:

A person slips on a slippery floor because there is very little friction between the surface of the floor and their feet. Friction provides the grip necessary to maintain balance, and its absence leads to slipping.

6. A man standing on the ice throws his bag. He wants to move out of this area. He throws his bag in the opposite direction. Why?

Ans:

When the man throws the bag in one direction, the bag exerts an equal and opposite force on the man, pushing him in the opposite direction. This is an application of Newton's third law of motion.

7. Why are cricket gloves padded with foam?

Ans:

Cricket gloves are padded with foam to reduce the impact force when the ball hits the hands. The foam increases the time of contact between the ball and the hands, reducing the force exerted on the hands as per the equation $F = \frac{\Delta P}{\Delta t}$ or $F \Delta t = \Delta P$.

8. Why are astronauts considered weightless on the moon? What about mass?

Ans:

Astronauts are considered weightless on the moon because the gravitational force acting on them is much weaker than on Earth. However, their mass remains the same because mass is independent of gravity.

9. When Ronaldo kicks the ball, both Earth and ball attract each other with the same magnitude of force. Why then does the ball move towards Earth and not the Earth?

Ans:

According to Newton's third law, the force exerted by the Earth on the ball is equal and opposite to the force exerted by the ball on the Earth. However, the Earth's mass is so large compared to the ball that the acceleration of the Earth is negligible, while the ball accelerates significantly.

10. Why then does the ball move toward the Earth and not the Earth toward the ball?

Ans:

According to Newton's third law of motion, every action has an equal and opposite reaction. When the ball is kicked, it exerts a force on the Earth, and the Earth exerts an equal and opposite force on the ball.

The ball moves toward the Earth because the mass of the Earth is significantly larger than the mass of the ball. From Newton's second law ($F = ma$), acceleration (a) is inversely proportional to mass (m). The Earth's mass is so immense that its acceleration due to the ball's force is negligible, while the ball, having much less mass, accelerates noticeably toward the Earth.

This is why we observe the ball moving toward the Earth, but not the Earth moving toward the ball.

Long Questions

1. State the first law of motion. Explain with the help of examples. Why is it called the law of inertia?

Newton's First Law of Motion

Newton's first law states:

"An object remains at rest or in uniform motion in a straight line unless acted upon by an external unbalanced force."

This law emphasizes that objects do not change their state of motion unless influenced by a force.

Explanation

- **At Rest:** If no force acts on an object at rest, it will stay at rest.
- **In Motion:** If an object is already moving and no external force acts on it, it will keep moving in a straight line at a constant speed.

Why It Is Called the Law of Inertia

The law describes the property of inertia, which is the tendency of objects to resist changes in their motion. Larger objects (with more mass) have greater inertia.

Examples in Daily Life

1. **At Rest:** A stationary football will not move unless kicked.
2. **In Motion:** When a car suddenly stops, passengers tend to move forward because of their inertia.

Importance of the Law

This law helps us understand why seatbelts are necessary in cars (to counter the effect of inertia) and why heavy objects require more force to move.

2. Define inertia. Why is it important to have knowledge of inertia in daily life? Elaborate your answer with examples.

Definition of Inertia

Inertia is the property of an object to resist changes in its state of rest or motion. It depends on the mass of the object—greater mass means greater inertia.

Importance of Inertia in Daily Life

1. **Safety in Vehicles:**
 - When a vehicle stops suddenly, passengers continue to move forward due to inertia. Seatbelts help protect them by providing a counter-force.
2. **Handling Heavy Objects:**
 - A heavier object (e.g., a loaded truck) is harder to start or stop because it has more inertia than a lighter object (e.g., a bicycle).
3. **Games and Sports:**

- In cricket, a fast-moving ball has high inertia, making it harder to catch. Gloves reduce the force of impact.

Examples in Daily Life

1. A book remains stationary on a table unless pushed.
2. A rolling ball stops only when friction or another force acts on it.
3. Clothes are dried by spinning in a washing machine. The water continues to move outward due to inertia while the clothes stay inside.

3. State and prove Newton's second law of motion. Deduce Newton's second law of motion from its first law.

Newton's Second Law of Motion

The second law states:

"The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass."

Formula: $F = ma$, where:

- F = Force (N)
- m = Mass (kg)
- a = Acceleration (m/s^2)

Proof

1. The rate of change of momentum is given by $p = mv$, where v is velocity.
2. Differentiating p with respect to time t : $F = \frac{\Delta p}{\Delta t} = \frac{m \Delta v}{\Delta t}$.
3. Substituting $\Delta p = m \Delta v$: $F = m \cdot a$.

Special Case (Deriving the First Law)

If $F = 0$, then $a = 0$. This means no change in motion, so the object remains at rest or in uniform motion. This is Newton's First Law.

Examples

1. Pushing a cart requires more force for greater acceleration.
2. A heavier object accelerates slower than a lighter object under the same force.

4. State Newton's third law of motion. Explain with examples from daily life.

Newton's Third Law of Motion

This law states:

"For every action, there is an equal and opposite reaction."

Explanation

When one object exerts a force on another, the second object exerts an equal force in the opposite direction. These forces act on different objects.

Examples in Daily Life

1. Walking:

- While walking, your foot pushes the ground backward, and the ground pushes you forward with an equal force.

2. Swimming:

- A swimmer pushes water backward, and the water pushes the swimmer forward.

3. Rocket Propulsion:

- Exhaust gases are ejected downward, and the rocket moves upward due to the reaction force.

4. Jumping:

- When you jump, you push the ground downward, and the ground pushes you upward.

Applications

This law is used in the design of propulsion systems, bridges, and vehicles.

5. State the limitations of Newton's laws of motion.

Limitations of Newton's Laws

1. Inertial Frames Only:

- Newton's laws are valid only in inertial (non-accelerating) frames of reference. They fail in accelerating or rotating frames unless modified with fictitious forces.

2. High Speeds:

- At speeds close to the speed of light, Newton's laws are replaced by Einstein's theory of relativity.

3. Microscopic Scale:

- At atomic and subatomic levels, quantum mechanics governs the

motion instead of Newton's laws. Newton's laws are not sufficient to describe the behavior of particles like electrons.

4. Strong Gravitational Fields:

- Newton's laws cannot accurately describe motion in strong gravitational fields (e.g., near a black hole). In such cases, Einstein's general theory of relativity is needed.

Examples Highlighting Limitations

1. Non-Inertial Frames:

- A person sitting in a car taking a sharp turn feels pushed outward. This "centrifugal force" is not explained by Newton's laws without adding fictitious forces.

2. Relativistic Speeds:

- Objects moving near the speed of light (e.g., particles in a collider) do not follow Newtonian mechanics.

Conclusion

While Newton's laws are fundamental, they have limitations and are supplemented by modern physics in specific cases.

6. Differentiate with examples between contact and non-contact forces. Also, explain fundamental forces and the role of Dr. Abdus Salam in unifying two fundamental forces.

Contact Forces

Contact forces arise when two objects physically touch each other.

Examples:

1. **Friction:** Resists motion between surfaces in contact.
2. **Tension:** A pulling force in a rope or cable.
3. **Normal Force:** The force exerted by a surface perpendicular to an object resting on it.

Non-Contact Forces

Non-contact forces act over a distance without physical contact.

Examples:

1. **Gravitational Force:** Attraction between two masses.
2. **Electrostatic Force:** Force between charged particles.
3. **Magnetic Force:** Force between magnets or moving charges.

Fundamental Forces in Nature

There are four fundamental forces:

1. **Gravitational Force:** Acts between masses; weakest but has an infinite range.
2. **Electromagnetic Force:** Acts between charged particles; responsible for electricity and magnetism.
3. **Strong Nuclear Force:** Binds protons and neutrons in an atomic nucleus; strongest but very short-ranged.
4. **Weak Nuclear Force:** Responsible for radioactive decay; short-ranged and weaker than the strong force.

Role of Dr. Abdus Salam

Dr. Abdus Salam, a Pakistani physicist, played a pivotal role in unifying the weak nuclear force and electromagnetic force into a single framework called the **Electroweak Theory**. This achievement earned him the Nobel Prize in Physics in 1979.

7. Represent the forces acting on a body using free-body diagrams.

Definition of Free-Body Diagram (FBD)

A free-body diagram is a graphical representation of all the forces acting on an object. It simplifies the analysis of forces in a system.

Steps to Draw an FBD

1. **Identify the Object:** Choose the body to analyze.
2. **Represent the Object:** Use a simple shape, like a dot or box.
3. **Draw Forces as Arrows:** Represent each force acting on the object with an arrow pointing in the correct direction.
4. **Label Forces:** Clearly label all forces, including their type (e.g., gravitational, normal, frictional).

Example

For a block sliding down an inclined plane:

- **Weight (WWW):** Acts vertically downward.
- **Normal Force (NNN):** Perpendicular to the inclined plane.
- **Friction (fff):** Opposes motion along the plane.

Applications

FBDs are used in engineering, physics, and mechanics to solve problems involving motion, equilibrium, and dynamics.

8. Define momentum. What is its formula and unit? Is it a scalar or vector quantity? Show that units of momentum, Ns and $\text{kg}\cdot\text{m/s}$, are equal.

Definition of Momentum

Momentum is the quantity of motion possessed by a moving object. It depends on both mass and velocity.

Formula: $p = mv$, where:

- p = Momentum ($\text{kg}\cdot\text{m/s}$)
- m = Mass (kg)
- v = Velocity (m/s)

Nature of Momentum

Momentum is a vector quantity because it has both magnitude and direction (same as velocity).

Unit of Momentum

- Standard unit: $\text{kg}\cdot\text{m/s}$
- Alternate unit: Ns (Newton-second)

Equivalence of Units:

1. Force (FFF) = mamama, so $F = m \cdot \Delta v / \Delta t$ $F = m \cdot \frac{\Delta v}{\Delta t}$ $F = m \cdot \Delta v / \Delta t$.
2. Rearrange: $F \cdot \Delta t = m \cdot \Delta v$ $F \cdot \Delta t = m \cdot \Delta v$ $F \cdot \Delta t = m \cdot \Delta v$.
3. The left-hand side (Ns) equals the right-hand side (kg·m/s).

Examples of Momentum

1. A moving truck has more momentum than a car due to its larger mass.
2. A bullet, despite its small mass, has high momentum due to its high velocity.

9. Differentiate between mass and weight of a body.

Mass

1. **Definition:** The amount of matter in an object.
2. **Nature:** Scalar quantity (no direction).
3. **Unit:** Kilogram (kg).
4. **Effect of Gravity:** Independent of gravity; remains constant everywhere.
Example: A 10 kg object on Earth has the same mass on the Moon.

Weight

1. **Definition:** The force exerted by gravity on an object.
2. **Formula:** $W = mg$ $W = mg$, where $g = 9.8 \text{ m/s}^2$ $g = 9.8 \text{ m/s}^2$ on Earth.
3. **Nature:** Vector quantity (has direction).
4. **Unit:** Newton (N).
5. **Effect of Gravity:** Varies with location (different on Earth and Moon).
Example: A 10 kg object weighs 98 N on Earth but only 16 N on the Moon ($g_{\text{Moon}} = 1.6 \text{ m/s}^2$).

Key Differences

1. Mass is intrinsic to the object, while weight depends on the gravitational field.
2. Mass is constant, but weight changes with gravity.

10. What are gravitational field and gravitational field strength? Explain.

Gravitational Field

A gravitational field is a region in space around a mass where another mass experiences a gravitational force. It is a vector field that represents the influence of gravity exerted by a mass.

Definition:

The gravitational field exists around any object with mass and decreases with distance.

Example:

The Earth has a gravitational field that pulls objects toward its center.

Gravitational Field Strength (g)

Gravitational field strength is the force per unit mass experienced by an object placed in a gravitational field.

Formula: $g = \frac{F}{m}$ or $F = mg$, where:

- F = Gravitational force (N),
- m = Mass of the object (kg).

Unit:

The SI unit of g is N/kg or m/s^2 .

Earth's Gravitational Field Strength:

On Earth, g is approximately 9.8 m/s^2 .

Explanation:

The gravitational field strength depends on the mass of the object creating the field and the distance from it. For Earth:

$$g = \frac{GM}{R^2}$$

Where:

- G = Gravitational constant,
- M = Mass of the Earth,
- R = Distance from the Earth's center.

Example in Daily Life:

1. A ball falls to the ground due to Earth's gravitational field.
2. Satellites orbit Earth because of the gravitational field.

11. Justify and illustrate the use of electronic balances to measure mass.

Electronic Balance

An electronic balance is a device used to measure the mass of an object accurately by converting gravitational force into an electronic signal.

How It Works

1. When an object is placed on the balance, its weight (gravitational force) is measured.
2. The balance calculates the mass using the formula $W = mg$, where g is the gravitational field strength.
3. It then displays the mass on the screen.

Illustration of Use

Steps:

1. Place the electronic balance on a flat surface.
2. Calibrate it to zero.
3. Place the object on the balance.

- The displayed value is the mass of the object.

Advantages:

- High accuracy and precision.
- Easy to use.
- Can measure very small masses, such as in laboratories.

Example in Daily Life:

- Measuring ingredients in cooking.
- Weighing chemicals in scientific experiments.
- Determining the mass of metals in jewelry shops.

12. State and prove Newton's second law of motion in terms of momentum.

Newton's Second Law of Motion in Terms of Momentum

The second law states that the rate of change of momentum of an object is directly proportional to the applied force and takes place in the direction of the force.

Mathematical Formulation:

Force (FFF) is given by:

$$F = \frac{\Delta p}{\Delta t} \quad F = \frac{\Delta p}{\Delta t}$$

Where:

- $p = mv$ is momentum,
- $\Delta p = p_{\text{final}} - p_{\text{initial}}$
- t = Time interval.

Proof:

- Momentum is defined as $p = mv$.
- Differentiating p :

$$F = \frac{d}{dt}(mv) = m \frac{dv}{dt} = m \cdot a$$
- Assuming mass (m) is constant:

$$F = m \cdot \frac{dv}{dt} = m \cdot a$$
- Since $\frac{dv}{dt} = a$ (acceleration), we get:

$$F = ma$$

Special Case for Momentum Conservation

If $F = 0$, then $\frac{\Delta p}{\Delta t} = 0$, meaning momentum is conserved.

Examples in Daily Life:

- A moving car's momentum increases as it accelerates due to the force applied by the engine.
- A cricket ball changes momentum when hit by a bat.

13. Define isolated system. State the law of conservation of linear momentum. Explain with an example.

Isolated System

An isolated system is a system in which no external force acts on the objects within it. The total momentum of the system remains constant.

Law of Conservation of Linear Momentum

The law states:

"In an isolated system, the total linear momentum before an event is equal to the total linear momentum after the event, provided no external force acts on it."

Mathematical Formulation:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Where:

- m_1, m_2 = Masses of the objects,
- u_1, u_2 = Initial velocities,
- v_1, v_2 = Final velocities.

Example:

Collision of Two Balls

1. Before collision:

- Ball A (mass = 2 kg, velocity = 5 m/s).
- Ball B (mass = 3 kg, velocity = 0 m/s).

Total initial momentum: $(2 \cdot 5) + (3 \cdot 0) = 10 \text{ kg} \cdot \text{m/s}$

2. After collision:

- Ball A moves at 2 m/s, Ball B moves at 2 m/s.

Total final momentum: $(2 \cdot 2) + (3 \cdot 2) = 10 \text{ kg} \cdot \text{m/s}$

Explanation:

The total momentum is conserved, demonstrating the law.

Numerical Response Questions

1. A boy is holding a book of mass 2 kg. How much force is he applying on the book? If he moves it up with acceleration of 3 m/s^2 , how much should he apply total force on the book?

Solution:

Force applied to hold the book (Weight of the book):

$$F = mg = 2 \times 9.8 = 19.6 \text{ N}$$

Total force when lifting with acceleration:

$$F_{\text{total}} = m(g + a) = 2 \times (9.8 + 3) = 25.6 \text{ N}$$

2. A girl of mass 30 kg is running with velocity of 4 m/s. Find her momentum.

Solution:

Momentum (p) is given by:

$$p = mv = 30 \times 4 = 120 \text{ kg}\cdot\text{m/s}$$

3. A 2 kg steel ball is moving with speed of 15 m/s. It hits with bulk of sand and comes to rest in 0.2 second. Find force applied by sand bulk on the ball.

Solution:

Force (F) is given by:

$$F = (m\Delta v) / \Delta t$$

Initial velocity (u) = 15 m/s, Final velocity (v) = 0 m/s

$$\Delta v = v - u = 0 - 15 = -15 \text{ m/s}$$

$$F = (2 \times -15) / 0.2 = -150 \text{ N}$$

The negative sign indicates the force opposes motion. Force = 150 N

4. A 100 grams bullet is fired from 5 kg gun. Muzzle velocity of bullet is 20 m/s. Find recoil velocity of the gun.

Solution:

Using conservation of momentum:

$$m_{\text{bullet}} \times v_{\text{bullet}} = m_{\text{gun}} \times v_{\text{gun}}$$

$$0.1 \times 20 = 5 \times v_{\text{gun}}$$

$$v_{\text{gun}} = (0.1 \times 20) / 5 = 0.4 \text{ m/s}$$

5. A robotic car of 15 kg is moving with 25 m/s. Brakes are applied to stop it. Brakes apply constant force of 50 N. How long does the car take to stop?

Solution:

Force (F) = ma, so $a = F / m$

$$a = 50 / 15 = 3.33 \text{ m/s}^2$$

Time to stop (t):

$$v = u + at$$

$$0 = 25 - 3.33 \times t$$

$$t = 25 / 3.33 \approx 7.5 \text{ seconds}$$

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Extera Short Questions (Topic Wise)

3.1 Force

1. **What is force? Write its SI unit.**

Force is a push or pull acting on an object to change its state of motion or shape. Its SI unit is the Newton (NNN).

2. **State two effects of force.**

- Force can change the speed of an object.
- Force can change the direction of motion of an object.

3. **What is a balanced force? Give an example.**

Balanced forces are forces acting on an object that cancel each other out, resulting in no change in motion.

Example: A book resting on a table experiences balanced forces from gravity and the table's normal force.

4. **What is an unbalanced force? How does it affect motion?**

Unbalanced forces are forces that do not cancel each other out, causing a change in the object's state of motion.

Example: Pushing a stationary box causes it to move.

3.2 Newton's Laws of Motion

1. **State Newton's First Law of Motion. Why is it also called the law of inertia?**

Newton's First Law states that an object will remain at rest or in uniform motion unless acted upon by an external force. It is called the law of inertia because it describes an object's resistance to changes in its motion.

2. **Explain Newton's Second Law of Motion with its mathematical expression.**

Newton's Second Law states that the force acting on an object is equal to the product of its mass and acceleration:

$$F = ma$$

3. **Give an example of Newton's Third Law of Motion.**

When you jump off a boat, you push the boat backward (action), and the boat pushes you forward (reaction).

4. **How do Newton's laws apply to a rocket launch?**

The rocket exerts a downward force on exhaust gases (action), and the gases push the rocket upward with an equal force (reaction).

3.3 Mass and Weight

1. **Define mass and weight. How are they different?**

- Mass is the amount of matter in an object, measured in kilograms (kgkgkg).
- Weight is the force due to gravity acting on an object, measured in Newtons (NNN).

2. **What is the relationship between mass and weight?**

$W = mg$, where W is weight, m is mass, and g is the gravitational field strength (9.8 m/s^2 on Earth).

3. **Why does weight change on different planets, but mass remains the same?**

Weight depends on the gravitational field strength, which varies between planets, while mass is constant and independent of gravity.

4. **What are the SI units of mass and weight?**

The SI unit of mass is kilograms (kg), and the SI unit of weight is Newtons (N).

3.4 Gravitational Field

1. **What is a gravitational field? Write its unit.**

A gravitational field is a region where a mass experiences a force due to gravity. Its unit is N/kg or m/s^2 .

2. **What factors affect the strength of a gravitational field?**

- The mass of the object creating the field.
- The distance from the object.

3. **State the formula for gravitational field strength.**

$g = \frac{F}{m}$, where F is the gravitational force, and m is the mass of the object.

4. **Why does gravitational field strength decrease with distance?**

The gravitational field strength decreases with the square of the distance from the mass, as described by $g = \frac{GM}{r^2}$.

3.5 Momentum

1. **Define momentum and write its formula.**

Momentum is the quantity of motion possessed by a moving object. Its formula is $p = mv$, where p is momentum, m is mass, and v is velocity.

2. **State the SI unit of momentum. Is it a scalar or vector quantity?**

The SI unit of momentum is $\text{kg} \cdot \text{m/s}$. It is a vector quantity because it has both magnitude and direction.

3. **What is the law of conservation of momentum?**

The total momentum of an isolated system remains constant before and after a collision, provided no external force acts on it.

4. **How is momentum used in sports?**

Momentum helps players control and transfer motion, such as hitting a cricket ball with a bat or catching a football.

5. **Give an example of momentum conservation in daily life.**

When two ice skaters push away from each other, their combined momentum remains constant.

Long Question (Topic Wise)

1. Explain the concept of force. Define balanced and unbalanced forces with examples. Discuss their effects in detail.

Definition of Force

Force is a push or pull acting on an object to change its state of rest, motion, or shape. It is a vector quantity, meaning it has both magnitude and direction. The SI unit of force is the Newton (N).

Balanced Forces

Balanced forces occur when two or more forces acting on an object cancel each other out, resulting in no net force.

Example: A book resting on a table experiences a downward gravitational force and an upward normal force of equal magnitude, keeping it stationary.

Effects of Balanced Forces

- The object remains at rest or in uniform motion.
- No change in the object's shape or motion occurs.

Unbalanced Forces

Unbalanced forces occur when the net force acting on an object is non-zero. This causes a change in the object's state of motion or shape.

Example: Pushing a stationary box causes it to move in the direction of the applied force.

Effects of Unbalanced Forces

- Changes the object's speed (acceleration or deceleration).
- Changes the object's direction.
- Can deform the object (change its shape).

Daily Life Applications

1. Driving a car: Applying the brakes creates unbalanced forces that slow down the car.
2. Tug of war: The team applying greater force wins because the forces are unbalanced.

2. State and explain Newton's three laws of motion with examples from daily life.

Newton's First Law of Motion

"An object remains at rest or in uniform motion in a straight line unless acted upon by an external unbalanced force."

This is also called the law of inertia.

Example:

- A soccer ball remains stationary until a player kicks it.
- Passengers in a moving bus continue forward when the bus stops suddenly due to inertia.

Newton's Second Law of Motion

"The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass."

Formula: $F = ma$, where:

- F = Force,
- m = Mass,
- a = Acceleration.

Example:

- A heavier cart requires more force to push compared to a lighter one.

Newton's Third Law of Motion

"For every action, there is an equal and opposite reaction."

Example:

- When a swimmer pushes water backward, the water pushes the swimmer forward.
- A rocket launches upward because gases are expelled downward with an equal and opposite force.

Applications

1. Newton's laws help in designing vehicles, machines, and structures.
2. They explain natural phenomena like walking, swimming, and flying.

3. Define mass and weight. Explain their differences with examples. Discuss the relationship between them and why weight changes on different planets.

Definition of Mass

Mass is the amount of matter in an object. It is a scalar quantity and does not depend on gravity. The SI unit of mass is the kilogram (kg).

Definition of Weight

Weight is the force exerted by gravity on an object. It is a vector quantity and depends on the gravitational field strength.

Formula: $W = mg$, where:

- W = Weight,
- m = Mass,
- g = Gravitational field strength (9.8 m/s^2 on Earth).
The SI unit of weight is the Newton (N).

Differences Between Mass and Weight

1. **Mass:** Constant everywhere, independent of gravity.
Weight: Changes depending on the gravitational field.
2. **Mass:** Measured in kg.
Weight: Measured in N.

Examples

- A 10 kg object on Earth weighs 98 N, but on the Moon, where $g = 1.6 \text{ m/s}^2$, it weighs only 16 N.

Why Weight Changes on Different Planets

Weight depends on the gravitational field strength, which varies across planets. For example, Jupiter has stronger gravity than Earth, so objects weigh more there.

4. Explain gravitational field and gravitational field strength. Derive the formula for gravitational field strength and discuss its importance in daily life.

Gravitational Field

A gravitational field is a region in space around a mass where another mass experiences a gravitational force.

Gravitational Field Strength (g)

Gravitational field strength is the force experienced by a unit mass in the gravitational field.

Formula: $g = \frac{F}{m}$, where:

- F = Gravitational force,
- m = Mass of the object.

Derivation

Using Newton's law of gravitation:

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

Substitute F into $g = \frac{F}{m}$:

$$g = \frac{GM}{r^2}$$

Where:

- G = Gravitational constant,
- M = Mass of the planet,
- r = Distance from the planet's center.

Importance in Daily Life

1. Explains why objects fall toward Earth.
2. Helps in calculating satellite orbits.
3. Used in designing buildings to withstand gravitational forces.

5. Define momentum. Explain the law of conservation of momentum with examples.

Definition of Momentum

Momentum is the product of an object's mass and velocity. It measures the quantity of motion in an object.

Formula: $p = mv$, where:

- p = Momentum,

- mmm = Mass,
- vvv = Velocity.

Law of Conservation of Momentum

The total momentum of an isolated system remains constant before and after an event, provided no external force acts on it.

Formula:

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Where:

- m_1, m_2 = Masses of the objects,
- u_1, u_2 = Initial velocities,
- v_1, v_2 = Final velocities.

Example:

In a collision between two balls:

- Before collision: Ball A has momentum $p_A = m_1u_1$, and Ball B has $p_B = m_2u_2$.
- After collision: Total momentum remains the same ($p_A + p_B = p_A' + p_B'$).

Applications in Daily Life

1. A bullet fired from a gun demonstrates conservation of momentum: the forward momentum of the bullet equals the backward momentum of the gun.
2. Rockets launch by expelling exhaust gases downward, conserving momentum.

MCQs

1. What is the SI unit of force?

- a) Newton b) Joule c) Pascal d) Watt

Answer: a) Newton

2. Force is a:

- a) Scalar quantity b) Vector quantity c) Both scalar and vector d) None of the above

Answer: b) Vector quantity

3. Which of the following can a force change?

- a) Mass b) Shape c) Volume d) Color

Answer: b) Shape

4. Balanced forces result in:

- a) Acceleration b) Change in direction c) No change in motion d) Increased speed

Answer: c) No change in motion

5. Unbalanced forces cause:

- a) Change in speed or direction b) Static motion c) No movement d) No effect

Answer: a) Change in speed or direction

6. Newton's First Law is also known as the law of:

- a) Momentum b) Inertia c) Action and Reaction d) Energy Conservation

Answer: b) Inertia

7. Which of the following is an example of Newton's Second Law of Motion?

- a) A ball rolling on the ground stops due to friction. b) Pushing a heavy cart requires more force than pushing a lighter cart. c) A swimmer pushes water backward to move forward. d) A book resting on a table.

Answer: b) Pushing a heavy cart requires more force than pushing a lighter cart.

8. The formula for Newton's Second Law is:

- a) $F = ma$ b) $F = m/v$ c) $F = mv$ d) $F = m + a$

Answer: a) $F = ma$

9. Newton's Third Law states:

- a) Force is directly proportional to acceleration. b) For every action, there is an equal and opposite reaction. c) An object remains at rest unless acted upon by an external force. d) Momentum is conserved.

Answer: b) For every action, there is an equal and opposite reaction.

10. A rocket launching upward is an example of:

- a) Newton's First Law b) Newton's Second Law c) Newton's Third Law d) Law of Gravitation

Answer: c) Newton's Third Law

11. Mass is measured in:

- a) Newtons b) Kilograms c) Meters d) Pascals

Answer: b) Kilograms

12. Weight is defined as:

- a) The force due to gravity acting on an object. b) The quantity of matter in an object. c) The volume of an object. d) The density of an object.

Answer: a) The force due to gravity acting on an object.

13. The formula for weight is:

- a) $W = mv$ b) $W = mg$ c) $W = m/g$ d) $W = ma$

Answer: b) $W = mg$

14. Which of the following is constant everywhere?

- a) Mass b) Weight c) Gravitational force d) Velocity

Answer: a) Mass

15. Weight depends on:

- a) Shape b) Gravity c) Volume d) Temperature

Answer: b) Gravity

16. A gravitational field is defined as:

- a) A force that repels objects. b) A region where a mass experiences a gravitational force. c) A region of magnetic influence. d) A field where mass is constant.

Answer: b) A region where a mass experiences a gravitational force.

17. The SI unit of gravitational field strength is:

- a) Joule b) Newton per kilogram (N/kg) c) Pascal d) Kilogram

Answer: b) Newton per kilogram (N/kg)

18. Gravitational field strength depends on:

- a) The shape of the object. b) The distance from the mass creating the field. c) The temperature of the environment. d) The volume of the object.

Answer: b) The distance from the mass creating the field.

19. Which of the following is true about the gravitational field strength on Earth?

a) It is the same everywhere. b) It increases with altitude. c) It decreases with altitude. d) It is zero at the poles.

Answer: c) It decreases with altitude.

20. The formula for gravitational field strength is:

a) $g = GM/r$ b) $g = GM/r^2$ c) $g = M/r^2$ d) $g = GM$

Answer: b) $g = GM/r^2$

21. Momentum is given by the formula:

a) $p = mv$ b) $p = ma$ c) $p = m/v$ d) $p = v/m$

Answer: a) $p = mv$

22. The SI unit of momentum is:

a) Joule b) Newton-second (Ns) c) Newton per meter d) Pascal

Answer: b) Newton-second (Ns)

23. Momentum is a:

a) Scalar quantity b) Vector quantity c) Constant quantity d) Derived unit

Answer: b) Vector quantity

24. What does the law of conservation of momentum state?

a) Momentum is never lost. b) The total momentum of an isolated system is conserved. c) Momentum depends on gravity. d) Momentum is always constant.

Answer: b) The total momentum of an isolated system is conserved.

25. Which of the following is an example of momentum conservation?

a) A car accelerating on a highway. b) Two billiard balls colliding and transferring motion. c) A pendulum swinging back and forth. d) Water flowing in a river.

Answer: b) Two billiard balls colliding and transferring motion.