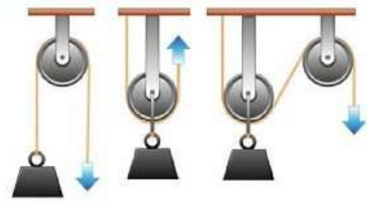
CHAPTER 3 DYNAMICS



3.1 CONCEPT OF FORCE
TYPES OF FORCES
3.2 FUNDAMENTAL FORCES

3.3 FORCE IN A FREE- BODY DIAGRAMS

SHORT QUESTIONS

Q.1 Define dynamics.

Ans:

<u>DYNAMICS</u>

<u>Definition</u>:

"Dynamics is concerned with the forces that produce change in the motions of bodies.**"**

OR

"The branch of mechanics that deals with the study of motion of an object and the cause of its motion is called dynamics**"**.

Q.2 Define force? Write its formula and unit.

Ans:

<u>FORCE</u>

<u>Definition</u>:

"A force is a push or a pull that starts stops or changes the magnitude and direction of velocity of a body.**"**

<u>Formula</u>:

$F = ma$

<u>Quantity</u>:

A force is a vector quantity.

<u>Unit</u>:

S.I unit of force is newton(N)

$1N = 1kg \times 1ms^{-2}$

<u>Definition of newton</u>:

"One newton is the force that produces an acceleration of $1ms^{-2}$ in a body of mass1kg.**"**

<u>Examples</u>:

- We can open the door either by pushing or pulling the door.
- A man pushes the cart. The push may move the cart or change the direction of its motion or may stop the moving cart.
- A batsman changes the direction of a moving ball by pushing it with his bat.

Figure: <u>Functions of Force</u>

Q.3 Define net Force.

Ans:

<u>NET FORCE</u>

<u>Definition</u>:

"The resultant of all the forces acting on the body is called Net Force.**"**

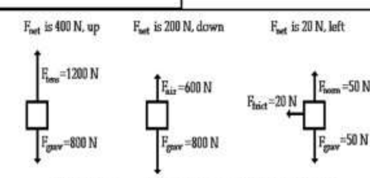


Figure: <u>Concept of Net Force</u>

TYPES OF FORCE

LONG QUESTION

Q.1 Define force and discuss the types of forces.

<u>FORCE</u>

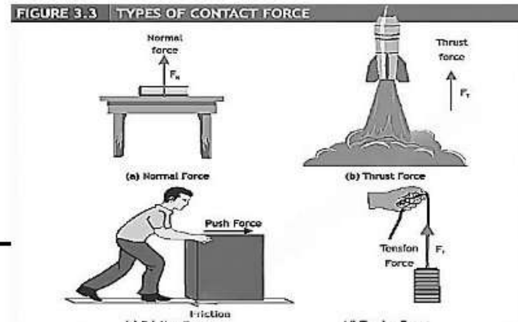
Definition:
"A force is a push or a pull that starts stops or changes the magnitude and direction of velocity of a body.**"**

Formula:
F = ma
Quantity:
A force is a vector quantity.
Unit:
S.I unit of force is newton(N)
$1N = 1kg \times 1m/s^2$
Definition of newton:
"One newton is the force that produces an acceleration of $1m/s^2$ in a body of mass1kg.**"**
Examples:
- We can open the door either by pushing or pulling the door.
- A man pushes the cart. The push may move the cart or change the direction of its motion or may stop the moving cart.
- A batsman changes the direction of a moving ball by pushing it with his bat.


Figure: Functions of Force

TYPES OF FORCES:
Forces are broadly classified as contact and non-contact forces.

A. CONTACT FORCES:
Definition:
"The force acting between two objects that are in physical contact are termed as contact forces."
Example
In cricket a batter hitting a cricket ball (Figure 3.2) is a contact force since there is physical contact in between the bat and the ball.
Normal Force:
Definition:
"A force perpendicular to the contact surface that keeps objects from passing through each other is called the normal force and is represented as F. (In geometry, normal means perpendicular)."
Example:
The book lying on table, the force perpendicular to the table is normal force .
Thrust Force:
Definition:
"The force that propels a flying machine in the direction of motion is termed as thrust.
Example:
Engines produce thrust, the thrust of engine of car cause it to accelerate.
Friction force:
Definition:
"Force that resist the relative motion of solid surfaces, fluid layers, and material elements in contact and sliding against each other is called friction. Friction on an object acts in a direction



opposite to the direction of the object's motion or attempted motion."

Example:

Air resistance is also a frictional force which occurs between air and an object. It is the force that the object experiences as it passes through the air. It is a kind of the drag force which resists the motion of a body with fluid.

Tension Force:

Definition:

"The forces exerted by two or more physical objects that are in contact, through string, rope, cable or spring, we call such force as tension."

Example:

Tension keeps spider web together consists of numerous fine strands that pull on one another. The tension in cord attached to a string.

Elastic Forces:

Definition:

"The forces that an object exerts to resist a change in its shape are called elastic forces; they arise from forces between the particles in the material."

Example:

When force is applied to a spring or rubber band it will stretch and at same time resists being stretched. It must be noted that the tension is the elastic only during extension not compression.

Drag:

The drag force is the resistant force caused by the motion of a body throughafluid.Itactsoppositetotherelativemotionofanyobjectmovingwith respect to surrounding fluid.

Air Resistance:

It is the resistance (opposition) offered by air when an object falls through it.

B. NON-CONTACT FORCES:

Introduction:

Have you seen magnets exerting push or pull on other magnets at some distance? The force which acts at a distance, without any physical contact between bodies is termed as non-contact force. This force acts even if the objects involved are not touching, also termed as action at a distance force.

Gravitational Force:

Definition:

"The attractive force between two objects with mass is called gravitational force."

Example:

The force experienced by moon because of earth.

Electrostatic Force:

Definition:

An attractive or repulsive force experienced by charged objects is called electrostatic force.

Example:

The attractive force between a positively charged nucleus and negatively charged electron.

Magnetic Force:

Definition:

An attractive or repulsive force experienced between magnetic poles is called magnetic force.

Example:

The repulsive force between the two North poles of magnets.

Strong and Weak Nuclear Forces:

These are also non-contact forces acting between the subatomic particles. We will study these forces in the next section.

FUNDAMENTAL FORCES IN NATURE

LONG QUESTIONS

Q.2 Discuss difference types of fundamental of forces.

FUNDAMENTAL FORCES

Introduction:

There are many different types of forces around us, but physicists have classified forces into only four categories based on how objects interact with one another. The four fundamental forces of nature are the gravitational force, the electromagnetic force, the strong nuclear force, and the weak nuclear force. Physicists have classified all forces that exist as one of these four fundamental forces. Physicists explain these fundamental forces through exchange particles.

A. Strong Nuclear Force:

The strong nuclear force is the strongest of all the fundamental forces. It keeps the positively charged protons tightly packed in the nucleus of an atom, by overcoming the repulsion between them. The exchange particles of strong force are called points, with other heavy particles.

B. Electromagnetic Force:

The electromagnetic force act between electric charges. It includes both electric forces and magnetic forces. The electromagnetic force can exert either an attraction or a repulsion, so on average, the forces tend to cancel each other out and its effect is not observed. The electromagnetic force is mediated by a massless particle known as a photon. The massless nature of the photon makes the effective range infinite, even though the strength of the force decreases rapidly as the distance between the objects increases.

C. Gravitational Force:

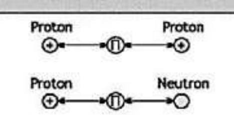
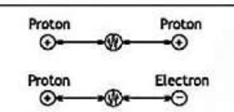
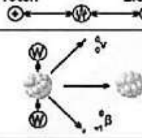
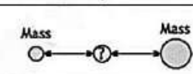
The gravitational force, or the force of gravity, is the force of attraction between all objects in the universe. Gravity is by far the weakest of the four fundamental forces (with least relative strength), the force of gravity between two objects is noticed only if at least one of the objects has a large mass such as stars, planets, and moons. It holds them together and controls their motions in the same way that it controls the motion of falling objects here on Earth. Gravitational force is theorized to be an exchange force with a massless mediating particle 'graviton'. The massless nature of the graviton allows gravity to have infinite range similar to the electromagnetic force. However, the graviton is the only exchange particle not detected yet.

D. Weak Nuclear force:

The weak nuclear force is very weak, 10 000 times weaker than the strong nuclear force and has the shortest range of any of the fundamental forces. Despite this, the weak nuclear force plays a major role in the structure of the universe. It is an exchange force mediated by the exchange of three different particles called vector bosons.

The weak nuclear force is responsible for radioactive decay. Specifically, the weak force changes the flavor (type) of an elementary particle called a quark. When this process occurs, a neutron in the nucleus transforms into a proton. For years physicists have sought to show that the four basic forces are simply different manifestations of the same

TABLE 3.1: FUNDAMENTAL FORCES IN NATURE

Fundamental Force	Range (metre)	Relative strength	Function	Exchange Particles
Strong Force	10^{-15} (diameter of proton)	1		Pions (Π) or others)
Electromagnetic Force	infinite	7.3×10^{-3}		Photons (massles)
Weak Force	10^{-17}	10^{-6}		W^+, W^-, Z_0 (vector bosons)
Gravitational Force	Infinite	6×10^{-39}		graviton (not yet detected)

fundamental force. The most successful attempt at such a unification is the electroweak theory, proposed during the late 1960_s by Abdus Salam (Pakistani physicist), Steven Weinberg, and Sheldon Lee Glashow.
This theory, which incorporates quantum electrodynamics (the quantum field theory of electromagnetism), treats the electromagnetic and weak forces as two aspects of a more-basic electroweak force that is transmitted by four carrier particles, the so-called gauge bosons.
One of these carrier particles is the photon of electromagnetism, while the other three-the electrically charged W^+ and W^- particles and the neutral Z_0, particle-are associated with the weak force. Unlike the photon, these weak gauge bosons are massive, and it is the mass of these carrier particles that severely limits the effective range of the weak force.

Unification of Weak Nuclear and Electromagnetic Forces:

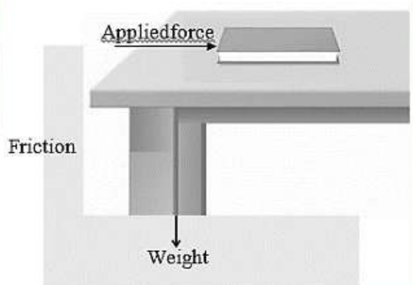
A Pakistani scientist Dr. Abdus Salam along with Sheldon Glashow and Steven Weinberg were awarded in 1979 Nobel Prize in Physics for their contributions to the unification of the weak nuclear force and electromagnetic force as electroweak force. Although these two forces appear to be different in everyday phenomena, but the theory models them as two different aspects of the same force. Its effects are observed for the interactions taking place at very high energy.

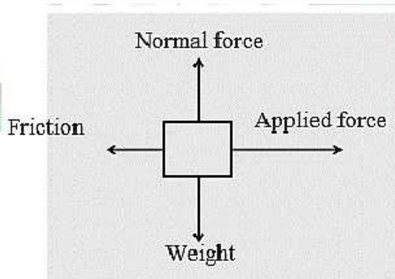
FORCE IN A FREE- BODY DIAGRAMS

Q.3 Draw the difference forces diagrams.

FORCES DIAGRAMS

External forces acting on an object may include friction, gravity, normal force, drag, tension in a string or a human force due to pushing or pulling.





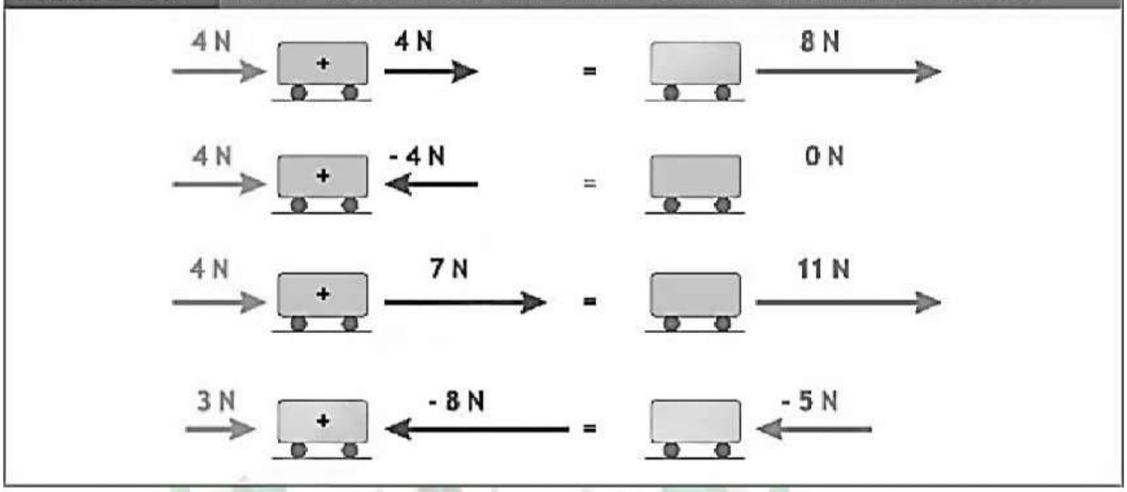
Suppose a book is pushed over the surface of a table top as shown in Fig.3.8(a). Then how can we represent the forces acting on the body using free-body diagram?
Free-body diagrams are used to show the relative magnitudes and directions of all the forces acting on an object in a given situation. In other words, a free-body diagram is a special example of the vector diagrams.
Usually, the object is represented by a box and the force arrows are drawn outward from the centre of the box in the directions of forces as shown in Fig.3.8(b). The length of a force arrow (line) reflects the magnitude of the force and the arrow head indicates the direction in which the force acts. Each force is labeled to indicate the exact type of force.

FREE-BODY DIAGRAMS AND RESULTANT (NET) FORCES

To study the effects of forces acting on any object, we can apply the skill of drawing force diagrams. Since force is a vector quantity, the vector sum of all the forces acting on an object is the resultant force. The resultant force can also be called the net force. These two terms can be used interchangeably. They will be represented by the same symbol, '$\vec{F}_{net}$', in this text.

The net force or resultant force can be obtained by simply adding forces. A resultant force is a single force that has the same effect as the combined effect of all the forces to be added. Forces are vector quantities which require both magnitude with proper unit as well as direction for its complete description. Therefore, it is required that we should draw the forces to a common scale as vectors (arrow diagrams). Simply add the magnitudes of vectors in case of like parallel forces and subtract the magnitudes of vectors in case of unlike parallel forces. Few examples are shown in the figure 3.7.

FIGURE 3.7 NET FORCE FOR LIKE AND UNLIKE PARALLEL FORCES



However, we cannot make such algebraic addition of vectors when vectors are making certain angle. In such cases we draw vectors on a coordinate axis and then according to the same scale we can add them by head to tail rule of vector addition.

MULTIPLE CHOICE QUESTIONS

1. **The characteristic of a body due to which it tends to retain its state of rest or of uniform motion is known as:**
(A) Weight (B) Force
(C) Inertia (D) Momentum

2. **The agency which changes or tends to change the state of rest or of uniform motion of a body:**
(A) Weight (B) Force
(C) Inertia (D) Momentum

3. **A metal wire, of initial length 1000mm, extends by 4mm when a load of 2N is added to it. What is the length of the wire when a further 3N is added, assuming that the wire does not extend beyond the limit of proportionality?**
(A) 1006 mm (B) 1008 mm
(C) 1010 mm (D) 1012 mm

4. **The diagram shows three forces acting on a block.**

Which additional force will produce a resultant force of 3N to the left?
(A) 3 N to the left (B) 6 N to the right

(C) 9 N to the left | (D) 13 N to the right

5. **SI unit of force is:**
(A) Kilogram | (B) Dynes
(C) newton | (D) Pound

6. **An object has a mass of 15 kg. it is pushed horizontally by a force of 40N. The frictional force is 10N. What is the acceleration of the object.**
(A) 0.50 m/s^2 | (B) 1.5 m/s^2
(C) 2.0 m/s^2 | (D) 2.7 m/s^2

7. **1 N = ?**
(A) $kgms^{-2}$ | (B) $kgms^{-1}$
(C) kgm^2s^{-1} | (D) kg^2ms^{-2}

8. **Net force is the**
(A) resultant force | (B) centripetal force
(C) centrifugal force | (D) All of these

SHORT QUESTIONS

Q.1 What do you know about scientist Newton?

Ans: Sir Isaac Newton was born in Lincolnshire on January 4, 1643. The name of his famous book is "Principia Mathematica".

Q.2 Who was Dr. Abdus Salam?

Ans: A Pakistani scientist Dr. Abdus Salam along with Sheldon Glashow and Steven Weinberg were awarded in 1979 Nobel Prize in Physics for their contributions to the unification of the weak nuclear force and electromagnetic force as electroweak force. Although the set a forces appear to be different in everyday phenomena, but the theory models them as two different aspects of the same force. Its effects are observed for the interactions taking place at very high energy.

3.4 NEWTON'S LAWS OF MOTION
NEWTON'S FIRST LAWS OF MOTION
NEWTON'S SECOND LAWS OF MOTION
NEWTON'S THIRD LAWS OF MOTION
LIMITATIONS OF NEWTON'S LAWS OF MOTION

LONG QUESTIONS

Q.1 State and Explain Newton's First law of motion.

Ans:

NEWTON'S FIRST LAW OF MOTION

Introduction:

First law of motion deals with bodies which are either at rest or moving with uniform speed in a straight line. It means it deals with bodies on which no net force acts. Furthermore, in 1686 English Scientist Sir. Isaac Newton (1642-1727) presented his three laws of motion in a book Philosophiae Naturalis Principia Mathematica (English: Principles of Natural Mathematics). This book is considered as the greatest scientific work ever written.

In a soccer game, players kick the ball to each other. When a player kicks the ball, the kick is an unbalanced force. It sends the ball in a new direction with a new speed. What keeps the ball rolling? To answer we have to look into statement of newton's first law of motion.

Statement:

Newton's First Law of Motion states that:

"If the net external force acting on an object is zero, the object will maintain its state of rest or uniform motion (constant velocity).**"**

Explanation for Rest:

It means that in absence of external net force, an object at rest, it will remain at rest; While an object in motion will continue to move with constant velocity (no change in velocity or no acceleration). Mathematically,

$\vec{F}_{net} = 0$ then $\Delta\vec{v} = 0$ or $\vec{a} = 0$

Example:

A book lying on a table remains at rest as long as no net force acts on it.

Science tidbit

An external force is an applied force, applied on to the object or system. There are also internal forces. For example, suppose the object is a train and you are a passenger traveling inside it. You can push (apply a force) on the floor or the walls of cabin, but this has no effect on the train's velocity because your push is an internal force.

Explanation For Motion:

Object in motion would continue to move in a straight line for ever. However, on the Earth, it is difficult to observe an object in a state of uniform motion, because of presence of forces (like gravity and friction), which continually retard motion of the objects. But in free space, where there is no friction and negligible gravitational attraction, an object initially in motion maintains a constant velocity.

FIGURE 3.9 NEWTON'S FIRST LAW OF MOTION

Example:

An object can continue to move when the unbalanced forces are removed. For example, when a soccer ball is kicked, it experiences an unbalanced force. The ball keeps rolling on the ground until another unbalanced force alters its movement as shown in figure 3.9.

Law of Inertia:

Since Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as **law of inertia.**

First law of motion specifies that there is a natural tendency of an object to remain in a state of rest or in uniform motion in a straight line termed as inertia. Does all objects have equal tendency to resist its state of rest or uniform motion? Absolutely not, the object with more mass (the measure of the amount of matter in a body) has greater resistance to change (inertia), is the reason why it is difficult to move massive objects. Mass is a quantity that is dependent on inertia (the greater the mass of an object, the greater its inertia, and vice versa).

Example:

Newton's first law of motion is applied when we ride standing in the aisle of a bus holding a pole as shown in figure 3.10 (a). As the bus begins to move, we tend to remain at rest, therefore we feel a push to back (as our lower body start moving with the bus, but the upper part of body maintains the state of inertia). The same principle is again at work when the bus start to slow down or stops, we feel to move forward due to inertia as shown in the figure 3.10 (b).

FIGURE 3.10 INERTIA AND SUDDEN MOTION OF BUS

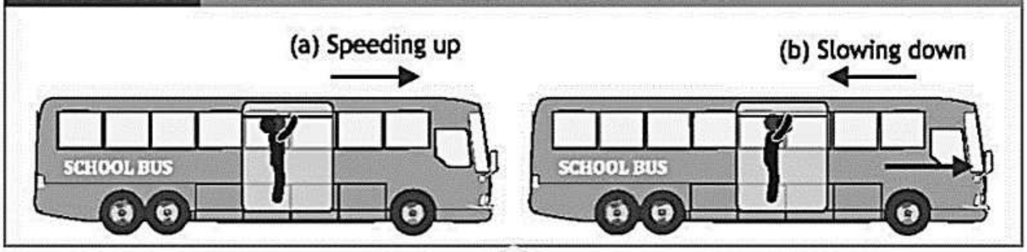
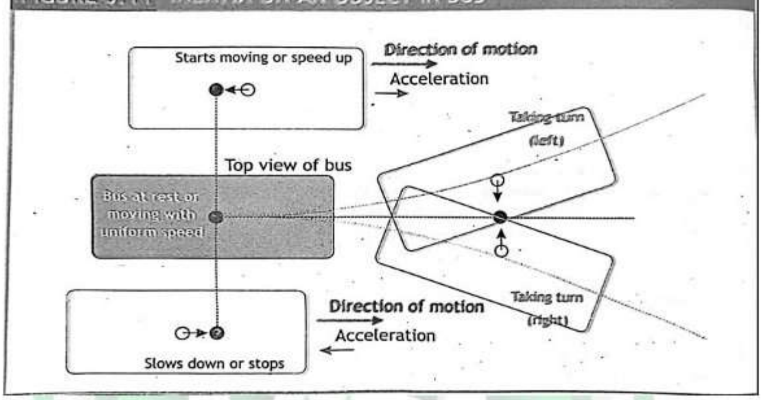


FIGURE 3.11 INERTIA ON AN OBJECT IN BUS



As the bus start moving with uniform speed if we hold on to the pole, it supplies the forces needed to give us the same motion as the bus, we no longer feel pushed. But when the bus goes around a curve, again we feel a tendency to move to the side of the bus. The bus has changed its straight-line motion, but we tend to move straight ahead. The same principle is again at work when the bus start to slow down or stops, we feel to move forward as shown in the figure 3.11. Thus, the forces we feel when the bus starts moving, speeds up, slows down or turn around a corner are a result of our tendency to remain at rest or follow a straight path.

Inertia:

The property of a body to maintain its state of rest or of uniform motion in a straight line is called inertia.

Q.2 State and Explain Newton's Second law of motion.

Ans:

NEWTON'S SECOND LAW OF MOTION

Introduction:

"What causes acceleration (change in velocity)? We can get this answer from Newton's first law of motion as 'external, unbalanced net force is required to produce a change in velocity'. Newton went further and related acceleration to inertia (or mass), that it tends to reduce this acceleration."

Statement:

"The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object."

Mathematical Form:

If the force 'F' is acting on the body of mass 'm' then we can write this in the mathematical form as,The acceleration produced by a net force acting on an object (or mass) is directly proportional to the magnitude of the force ($\vec{a} \propto \vec{F}_{net}$) and in the direction of the force (the$\propto$ symbol is a proportionality sign). In other words, the greater the unbalanced net force, the greater the acceleration.

$$\vec{a} \propto \vec{F}_{net} \text{ .... (1)}$$

The acceleration of an object being acted on by a net force is inversely proportional to the mass of the object ($a \propto 1/m$). That is, for a given unbalanced net force, the greater the mass of an object, the smaller the acceleration. Combining these effects of net force and mass on acceleration gives.

and $\vec{a} \propto \frac{1}{m}$ ………….... (2)

From relation (1) and (2), we have

$$\vec{a} \propto \frac{\vec{F}_{net}}{m}$$

$$\vec{F}_{net} \propto m\vec{a}$$

Changing the sign of proportionality into the sign of equality

$$\vec{F}_{net} = (\text{constant})\ m\vec{a}$$

Putting k as proportionality constant, we get

$$\vec{F}_{net} = k\,m\vec{a}$$

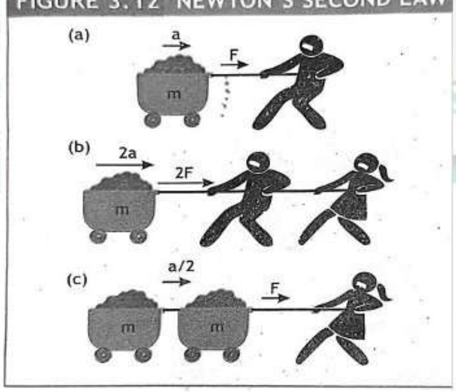
In above equation, according to international system of units if m = 1Kg,
$a = 1m/s^2$, F_{net} = 1N then the value of the constant k will be '1'. So, the equation can be written as,

$$\vec{F}net = (1)m\vec{a}$$

$$\vec{F}net = m\vec{a}$$

An example, consider the figure 3.12 (a), mass m is the mass of the system, when net force acts it produces an acceleration 'a'. In figure 3.12 (b) the force is doubled by keeping the mass same, the acceleration also doubles where as in figure 3.12 (c) the mass is doubled while force is kept the same the acceleration is halved.

FIGURE 3.12 NEWTON'S SECOND LAW



This is the mathematical form of Newton's Second law of motion.

Unit of Force:

In the System International, the unit of force is newton, which is represented by the symbol **'N'**.

Definition of newton:

"One newton **(1N)** is the force that produces an acceleration of $\mathbf{1m/s^2}$ in a body of mass **1kg.**"Thus, a force of one newton can be expressed as

$$1\ N = 1\ kg \times 1\ m/s^2$$

$$\text{or}\ 1\ N = 1\ Kgm/s^2$$

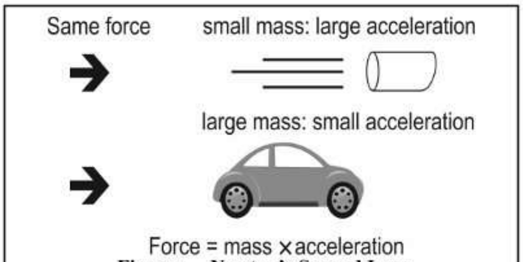


Figure: **Newton's Second Law**

Effect of Force on Velocity:
Newton's second law also tells that a force can change the velocity of a body by producing acceleration or deceleration in it. As velocity is a vector quantity, so the change may be in its magnitude, direction or in both of them.

State and Explain Newton's Third law of motion.

Ans: **NEWTON'S THIRD LAW OF MOTION**

Introduction:
"When we press a stone with our finger, the finger is also pressed upon by the stone. The reason is given by Newton's third law of motion, which can be stated as"

Statement:
Newton's Third Law of Motion states that:
"Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object."

OR

"To every action there is always an equal but opposite reaction**".**

- **Action Force:** The applied force on a body is called action.
- **Reaction Force:** The responsive force to action is called reaction force.

Newton's third law of motion deals with the reaction of a body when a force act on it. Let a body A exerts a force on another body B, the body B reacts against this force and exerts a force on body A. The force exerted by body A on B is the **action force** whereas the force exerted by B on A is called the **reaction force.**

Dependence:
Its direction depends upon surface of contact of two bodies.

Examples:
Newton's third law of motion are present everywhere, because when we talk of force we also consider its reaction.
For example, when we jump, our legs apply a force to the ground, and the ground applies an equal and opposite reaction force that pushes us into the air.

When we punch an object or kick something as an action, we also get a force onto our hands and legs as a reaction force.
That is why we feel pain when punching a wall, or falling on the ground. The exhaust from the rocket creates a downward force which creates an equal and opposite thrust in the upward direction as.
Applying Newton's third law of motion allow us to explore two important forces normal force and tension force.

3.2.4 LIMITATIONS OF NEWTON'S LAWS OF MOTION

Although Newton's laws of motion are a fundamental set of principles and are applied in variety of situations. While they are very useful for describing the behavior of everyday objects, there are some limitations to their applicability.

- "Newton's laws are not readily applied on the very small scale: As one goes to extremely low energies on the atomic scale, position and acceleration are not well defined, where the concepts of quantum mechanics take over."
- "Newton's laws are not applied for objects moving at high speed (speeds close to the speed of light) relativistic effects complicate the dynamics at high speeds and high energies. In such situations we would require to use relativistic mechanics."

However, Newton's laws are not exact but provide a good approximation on the large (macroscopic) scale and over the vast range of practical energies and forces.
Newton's laws are still work spectacularly well in physics and engineering.

3.6 MASS AND WEIGHT

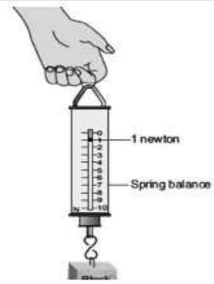
LONG QUESTIONS

Q.3 Differentiate between Mass and Weight.

Ans: **DIFFERENTIATION**

Mass and weight can be differentiated as:

MASS	WEIGHT
Definition	
• Thecharacteristicofabodywhichdetermin esthemagnitudeofacceleration produced when a certain force acts upon it is known as mass of the body	The weight of an object is equal to the force with which the Earth attracts the body towards its centre.
Quantity	
• It is a base and scalar quantity.	• It is a derived and vector quantity.
Measurement	
• It is measured by comparison with standard masses.	• It is measured by spring balance.
Variations	
• It remains same everywhere and does not change with change of place.	• It does not remain same at all places and varies with the value
Unit	
• Unit of mass is kilogram (Kg).	• Unit of weight is newton (N).
Formula	

• It can be calculated by using the formula F = ma	• It can be calculated by using the formula w = mg
Zero Value	
• Mass of a body can never be zero	• Weight of body can be zero
Measuring Instruments	
 **Figure: A Physical Balance**	

SHORT QUESTIONS

Q.1 State Law of Inertia. OR What is the Law of Inertia?

Ans: **LAW OF INERTIA**

Since Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as law of inertia.

Statement:

According to Law of Inertia:

"If the net external force acting on an object is zero, the object will maintain its state of rest or uniform motion (constant velocity).**"**

Example:

A book lying on a table remains at rest as long as no net force acts on it. Similarly, a moving object does not stop moving by itself.

Q.2 Why Newton's First law of motion is also called law of inertia?

Ans: **LAW OF INERTIA**

According to Newton's first law of motion "A body continues its state of rest or of uniform motion in a straight line provided no net force acts on it".

The property of a body due to which it resists any change in its state of rest or motion is known as inertia.

On comparing the above two statements we find that statement of Newton's first law of motion is in accordance with statement of inertia. It means Newton's first law of motion deals with inertial property of matter that's why Newton's first law of motion is also known as law of inertia.

Q.3 State Newton's Second law of motion.

Ans: **NEWTON'S SECOND LAW OF MOTION**

Statement:

Newton's Second Law of Motion states that:

"The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object."

Mathematical Form:

$$\vec{F}net = m\vec{a}$$

Q.4 What is the unit of force? Define it.

Ans: **UNIT OF FORCE**

In the System International, the unit of force is newton, which is represented by the symbol **'N'**.

Definition of newton:

"One newton **(1N)** is the force that produces an acceleration of **$1m/s^2$** in a body of mass **1kg"**.

Thus, a force of one newton can be expressed as

$$1\ N = 1\ kg \times 1\ m/s^2$$
$$\text{or} \quad 1\ N = 1\ Kgm/s^2$$

Q.5 State Newton's Third law of motion.

Ans: **NEWTON'S THIRD LAW OF MOTION**

Statement:

Newton's Third Law of Motion states that:

"Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object."

OR

"To every action there is always an equal but opposite reaction**".**

Example:

- Consider a book lying on a table as shown in figure.

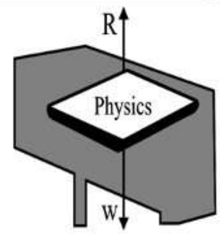


Figure: Action and Reaction on a Book Placed at Table

The weight of the book is acting on the table in the downward direction. This is the action. The reaction of the table acts on the book in the upward direction.

Q.6 If a moving body has no acceleration; does it mean that no force is acting on it?

Ans: **ACCELERATION AND NET FORCE**

According to Newton's second law of motion, we have

$$F = ma$$

When acceleration = a = 0, we get

$$F = m \times 0$$

$$\text{So,} \quad F = 0$$

Result:

When acceleration is zero then the net force acting on the body is zero but it does not mean that no force is acting on the body. When body is in motion, some forces be acting on the body but in case of zero acceleration, net (resultant) force should be zero.

Q.7 Action and reaction are always equal and opposite then why they don't cancel each other?

OR Action and reaction are always equal and opposite then how does a body move?

Ans: **ACTION AND REACTION DONOT CANCELL EACH OTHER**

According to this law, action is always accompanied by a reaction force and the two forces must always be equal and opposite. Note that action and reaction forces act on different bodies due to this reason they do not cancel each other due to which the body will move.

Q.8 How much force you need to prevent the book from falling?

Ans: **PREVENTING BOOK FROM FALLING**

Force equal to the weight of the book is needed to prevent the book from falling.

Q.9 Which is action?

Ans: **ACTION**

Weight of the book is action in this case.

Q.10 Is there any reaction? If yes, then what is its direction?

Ans: **REACTION**

Yes there is a reaction offered by hand. The direction of reaction is opposite to the weight.

Q.11 Difference between mass and weight.

Ans: **DIFFERENTIATION**

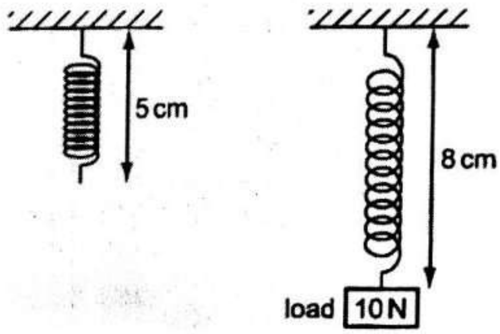
• Mass is the amount of matter an object contains (and a measure of inertia).	• Weight is the gravitational force acting on a mass or object.
Quantity	
• It is a base and scalar quantity.	• It is a derived and vector quantity.
Measurement	
• It is measured by comparison with standard masses using a physical balance (beam balance or electronic balance etc.	• It is measured by spring balance.
Variations	
• It remains same everywhere and does not change with change of place.	• It does not remain same at all places and varies with the value of 'g', acceleration due to gravity.
Unit	
• Unit of mass is kilogram (Kg).	• Unit of weight is newton (N).
Formula	
• It can be calculated by using the formula F = ma	• It can be calculated by using the formula w = mg
Zero Value	
• Mass of a body can never be zero	• Weight of body can be zero

MULTIPLE CHOICE QUESTIONS

1. **Laws of motion were presented by:**
   (A) Einstein (B) Newton
   (C) Galileo (D) Archimedes
2. **Isaac Newton described the laws of motion in his famous book:**
   (A) Qanoon-ul-Masoodi (B) Principia Mathematica
   (C) Kitab-ul-Astralab (D) Al-Manazir
3. **The laws of motion established the relationship between motion and:**
   (A) Force (B) Torque
   (C) Acceleration (D) Momentum
4. **Mass of body is 2000g its weight on the surface of earth.**
   (A) 20000N (B) 2N
   (C) 20N (D) 0.2N
5. **If m is the mass of an object then its weight on the surface of earth will be**
   (A) mg (B) 2mg
   (C) $\frac{1}{2}$ mg (D) None of these
6. **The mass of the body is a measure of its**
   (A) Inertia (B) Weight
   (C) Rest (D) Acceleration
7. **First law of motion is also known as law of:**
   (A) Torque (B) Acceleration
   (C) Inertia (D) None of these
8. **Law of inertia is actually the which law of motion?**
   (A) First (B) Second
   (C) Third (D) Fourth
9. **When a net force is applied on the body, what is produced in the body?**
   (A) Weight (B) Acceleration
   (C) Energy (D) None of the above
10. **The acceleration produced in a moving body is always in the direction of applied:**
    (A) Velocity (B) Force

(C) Speed (D) Momentum

11. The diagram shows how the length of a spring changes when a load of 10N is hung on it.



The 10 N load is replaced by a 20N load. What is the new length of the spring?

(A) 6 cm (B) 11 cm
(C) 14 cm (D) 16 cm

12. If mass of the body is doubled while keeping the force constant, then acceleration will be:

(A) One half (B) Doubled
(C) One fourth (D) Four times

13. A car of mass 1500 kg travels along a horizontal road.
It accelerates steadily form 10 m/s to 25 m/s in 5.0 s.
What is the force needed to produce this acceleration?

(A) 300 N (B) 500 N
(C) 4500 N (D) 7500 N

14. If force applied on the body is doubled while keeping the mass constant, then acceleration will be:

(A) One half (B) Doubled
(C) One fourth (D) Four times

15. SI unit of force is:

(A) Kilogram (B) Dynes
(C) Newton (D) Pound

16. When a force of 8 newton is applied on a body of mass 2 kg, then the acceleration produced will be:

(A) 16 ms^{-2} (B) 4 ms^{-2}
(C) 0.4 ms^{-2} (D) 160 ms^{-2}

17. 1 N = ?

(A) $kgms^{-2}$ (B) $kgms^{-1}$
(C) kgm^2s^{-1} (D) kg^2ms^{-2}

18. Action and reaction are equal in magnitude but opposite in direction is known as:

(A) First law of motion (B) Second law of motion
(C) Third law of motion (D) Fourth law of motion

19. Walking on road is an example of which law of motion?

(A) First (B) Second
(C) Third (D) Fourth

20. When a block is lying on a smooth surface, its weight is balanced by:

(A) Mass (B) Momentum
(C) Inertia (D) Normal Reaction

21. The weight of a body of mass 10 kg on earth will:

(A) 10 N (B) 1 N
(C) 100 N (D) 1000 N

22. Always acting towards the center of the earth:

(A) Mass of the body (B) Force of the body

(C) Velocity of the body (D) Weight of the body

23. A force is applied to a body. Which property of the body cannot be changed by the force?
(A) its mass (B) its shape
(C) its size (D) its velocity

24. Quantity of matter in a body:
(A) Mass (B) Force
(C) Velocity (D) Weight

25. The Force with which earth attracts a body towards its centre is known as:
(A) Mass (B) Force
(C) Weight (D) Inertia

26. The characteristic of a body which determines the magnitude of acceleration produced when a certain force acts upon it:
(A) Mass (B) Force
(C) Inertia (D) Weight

27. Mass of the body is measured by:
(A) Free Fall Apparatus (B) Physical balance
(C) Spring balance (D) All of above

28. Weight of the body is measured by:
(A) Free Fall Apparatus (B) Physical balance
(C) Spring balance (D) All of above

29. Unit of weight is:
(A) kg (B) ms^{-1}
(C) Nm (D) N

30. Remains same everywhere:
(A) Weight (B) Acceleration
(C) Velocity (D) Mass

31. Does not remain same everywhere:
(A) Weight (B) Inertia
(C) Mass (D) All of above

32. The value of weight of a body of constant mass depends on:
(A) Inertia (B) Momentum
(C) Force (D) 'g'

33. Mass is a quantity:
(A) Scalar (B) Vector
(C) Derived (D) Negative

34. Weight is a quantity:
(A) Scalar (B) Vector
(C) Unit less (D) Negative

3.7 MECHANICAL AND ELECTRONIC BALANCES

LONG QUESTIONS

Q.1 Write a note on Mechanical Balances.

Ans: Structure:

A mechanical balance consists of a rigid horizontal beam that oscillates on a central knife edge as a fulcrum. It has two end knife edges equidistant from the centre. Two pans are hung from bearings on the end knife edges.

Working:

The material to be weighed is put in one pan. Standard weights are put on the other pan. The deflection of the balance may be indicated by a pointer attaches to the beam. The weights on the pan are adjusted to bring the beam in equilibrium.

Type:

There is another type of mechanical balances which are used to weigh heavy items like flour bags, cement bags, steel bars, etc. These are called mechanical platform balances. Standard weights are not required to use this balance. Its reason is that the fulcrum of the beam of such a balance is kept very near to its one end. Therefore, much smaller weights have to be put at the other end of beam to bring it to equilibrium. These smaller weights have already been calibrated to the standard weights.

Q.2 Write a note on Force Meter.

Ans: Definition:

A force meter is a scientific instrument that measures force. It is also called as a Newton meter or a spring balance.

Construction:

An ordinary force meter has a spring inside it. Upper end of the spring is attached to a handle. A hook is attached to the lower end the spring that holds the object. A pointer is also attached to the spring at it supper end. A scale in Newton is provided along the spring such that the pointer coincides with zero of the scale when nothing is hung with the hook.

Working:

The object to be weighed is hung with the hook. The mass of the object causes the spring to compress. The pointer indicates the weight of the object. However, some force meters are also based on the stretching of the spring when a load is hung. In this case, the pointer is attached at the lower end of the spring.

Q.3 What is electronic Balance?

Ans: No standard weights are required to use in an electronic balance (Fig.3.18).Only it has to be connected to a power supply. There are some models which can operate by using dry cell batteries. An electronic balance is more precise than mechanical balance. When an object is placed on it, its mass is displayed on its screen.

3.8 FRICTION

Q.1 What is Friction? Explain its types.

Ans: Friction:

Friction is a dissipative force due to which the energy is wasted in doing work to over come against friction. The lost energy appears in the form of heat.

Examples:

A very common example of energy dissipation is the rubbing of hands. When we rub our hands, heat is produced due to friction and our hands become warm. Similarly, the temperature of machines rises due to friction between its moving parts that can cause many problems. The tyres of vehicles also wear out after

Becoming too hot due to friction between tyres and road. Shooting of stars seen in the sky at night also happen due to friction of air. These are actually asteroids that enter the Earth's atmosphere. As they are moving, air resistance causes generation of heat. Their temperature becomes so high that they start burning and ultimately disintegrate.

Sliding Friction:

The friction between two solid surfaces is called sliding friction which can be divided into two categories.

1. Static friction
2. Kinetic friction

Static friction:

Let us consider the motion of a block on a horizontal surface. The arrangement is shown in Fig. 3.22. When a weight is put in the pan, a force **F=T** equal to the sum of this weight and weight of the pan acts on the block. This force tends to pull the block. At the same time an opposing force appears that does not let the block move. This opposing force is the static friction $\mathbf{F_S}$.

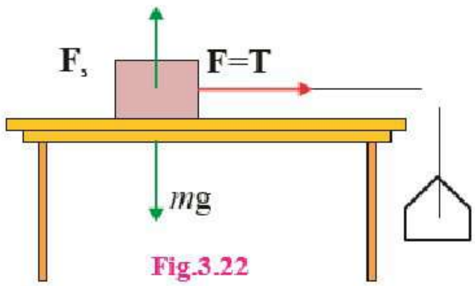


Fig.3.22

Kinetic friction:

If we go on adding more weights in the pan one by one in small steps, a stage will come when the block starts sliding on the horizontal surface. This is the limit of static friction that is equal to the total weights including pan. When the block is sliding, friction still exists. It is known as kinetic friction.

Rolling Friction:
When an object rolls over a surface, the friction produced is called rolling friction.
Examples:
The idea of rolling friction is associated with the concept of wheel. In our everyday life, we observe that a body with wheels faces less friction as compared to a body of the same size without wheels.
Ball bearings also play the same role as is played by the wheels. Many machines in industry are designed with ball bearings so that the moving parts roll on the ball bearing and friction is greatly reduced. The rolling friction is about one hundred times smaller than the sliding friction.
Rolling Friction is less than Sliding Friction:
The reason for the rolling friction to be less than the sliding friction is that there is no relative motion between the wheel and the surface over which it rolls. The wheel touches the surface only at a point. It does not slide.

Q.2 What is Terminal Velocity? Explain.
Ans: Terminal Velocity:
When upward air resistance balances the downward force of gravity on a falling object, it falls down with constant (safe) velocity, it is called terminal velocity.
Example:
This principle applies to paratroopers. Air resistance acting against the large surface area of a parachute allows for descent at a safer velocity.
Explanation:
When an object falls freely, it is accelerated by an amount g=10ms^{-2}. But practically the acceleration may be different. Air resistance plays an important role in determining how fast an object accelerates when it falls.
If we drop a cricket ball and a piece of Styrofoam of the same weight from a certain height, they will hit the ground at the same time only if there were no air resistance. Both would fall with the same acceleration g=10ms^{-2}. Practically, the ball in air, would drop faster.
The Styrofoam having larger surface would face greater opposing force of the air and thus moves slowly.

Q.3 Write Methods to Reduce Friction.
Ans:
METHODS TO REDUCE FRICTION
The following methods are used to reduce friction:
(i) The parts which slide against each other are highly polished.
(ii) Since, the friction of liquids is less than that of solid surfaces, therefore, oil or grease is applied between the moving parts of the machinery.
(iii) As rolling friction is much less than the sliding friction, so sliding friction is converted into

rolling friction by the use of ball bearings in the machines and wheels under the heavy objects.

(iv) Frictional force does not act only among solids, high speed vehicles, aero planes and ships also face friction while moving through air or water. If the front of a vehicle is flat, it faces more resistance by air or water. Therefore, the bodies moving through air or water are streamlined to minimize air or water friction. In this case, the air passes smoothly over the slanting surface of vehicle. This type of flow of air is known as streamline flow. A streamline flow over the car is. The vehicles designed pointed from the front are said to be streamlined.

3.9 MOMENTUM AND IMPULSE
3.10 PRINCIPLE OF CONSERVATION OF MOMENTUM

SHORT QUESTIONS

Q.1 Define momentum:

MOMENTUM

Definition:

"The product of the object's mass 'm' and velocity '$\vec{v}$' is called momentum."

Formula:

$$\vec{P}=m\vec{v}$$

Unit:

SI Unit of momentum is kilogram-meter per second (kgm/s), or newton-second (Ns).
Newton's second law is used to relate force and momentum.

Quantity:

Momentum is a vector quantity that points in the same direction as the velocity.

FORCE AND CHANGE IN MOMENTUM

LONG QUESTIONS

Q.2 What is the relation between force and momentum

FORCE AND MOMENTUM

Statement:

"The time rate of change of linear momentum of a body is equal to the net force acting on the body. This means that for sudden change in momentum force is large and vice versa."

A force 'F' produces acceleration 'a' in a body of mass 'm'. By Newton's second law of motion it is written as

'$\vec{F}$'$=\overrightarrow{ma}$ $---1$

The acceleration produced changes the velocity of the body from initial velocity '$\vec{V}_f$,' to final velocity '$\vec{V}_f$,' during time interval ''Δt'.'. Then by definition of acceleration.

$$\vec{a}=\frac{\overrightarrow{v_f}-\overrightarrow{v_f}}{\Delta t}----2$$

Putting equation 2 in equation 1

$$\vec{F}_{net}=m\frac{\overrightarrow{v_f}-\overrightarrow{v_f}}{\Delta t}$$

Or

$$\vec{F}_{net}=\frac{m\overrightarrow{v_f}-m\overrightarrow{v_f}}{\Delta t}$$

FIGURE 3.18 CATCHING

Hence $\vec{F}_{net} = \frac{p_f - p_r}{\Delta t} = \frac{\Delta \vec{P}}{\Delta t}$ ----3.5

Example:

Catching a ball with your bare hands will hurt depending on the force of the ball. However, if you allow your hands to move with the ball as you catch it, duration of time ' Δt will increase, and force will be smaller, and your hands will hurt less.

IMPULSE AND CHANGE IN MOMENTUM

LONG QUESTIONS

Q.3 What is the relation between impulse and change in momentum?

IMPULSE AND CHANGE IN MOMENTUM

Definition:

"Impulse is the product of the force exerted on an object and the time interval over which the force acts"

Newton's second law enable us to write force and change in momentum relation as:

Mathematical form:

$$\vec{F}_{net} = \frac{\vec{p_f} - \vec{p_f}}{\Delta t} = \frac{\Delta \vec{p}}{\Delta t}$$

$$\vec{F}_{net} x \Delta t = \Delta \vec{p} \text{----3.6}$$

Unit:

The SI unit of Impulse is kgm/s and Ns.

Quantity:

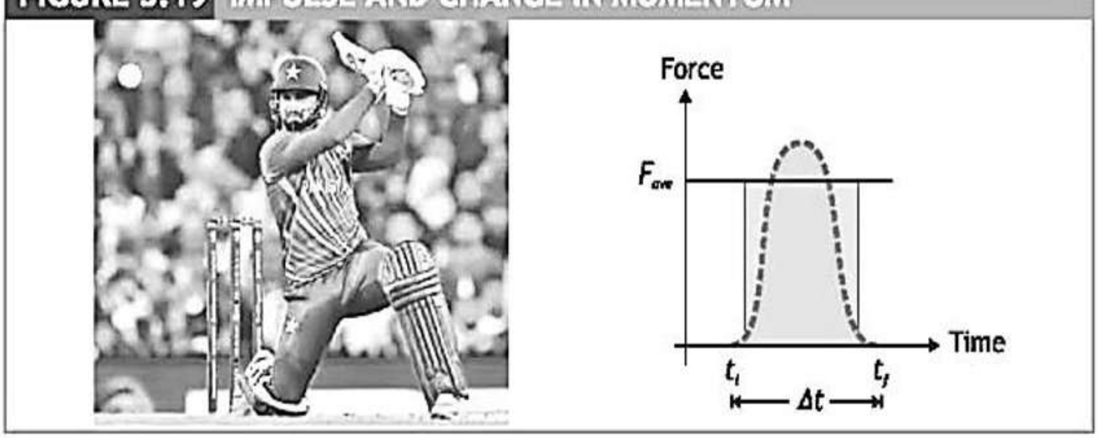
Impulse is a vector quantity, and the direction of the impulse is the same as the direction of the force that causes it, and have the same SI units as momentum.

In many situations, the net force on the object is not constant and the force applied to an object changes non-linearly during its time of application. The equation 3.8 still applies, provided the net force 'F_{net}' is equal to the average force acting on the object over the time interval At.

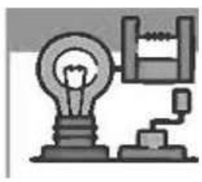
Example:

When a batter hits a cricket ball, initially the force is very small. Within milliseconds, the force is large enough to deform the ball. The ball then begins to move by return to its original shape and the force soon drops back to zero. Graph in figure 3.19 shows how the force changes with time. We can find the impulse by calculating the area under the curve in force versus time graph.

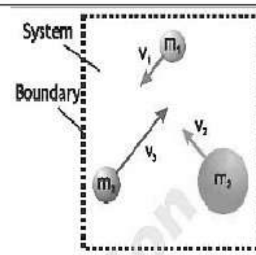
FIGURE 3.19 IMPULSE AND CHANGE IN MOMENTUM



In many collisions, it is difficult to make the precise measurements of force and time that you need in order to calculate the impulse. The relationship between impulse and momentum provides an alternative approach to analyzing such collisions, as well as other interactions. By analyzing the momentum before and after an interaction between two objects, we can determine the impulse.



Group of bodies or particles, under study separated by a boundary is called as a system. If the net external force on the system is zero, it is termed as isolated system.
An isolated system is a collection of bodies that can Interact with each other but whose interactions with the environment have a no effect on their properties is termed as an isolated system.



PRINCIPLE OF CONSERVATION OF MOMENTUM

LONG QUESTIONS

Q.4 What is Principle of conservation of momentum?

NEWTON'S LAWS AND CONSERVATION OF MOMENTUM

Statement:

"The momentum of an isolated system remains constant."

Explanation:

Consider a system of two balls of masses m_1 and m_2. Suppose that the balls are moving with velocities $\mathbf{v}_1$ and $\mathbf{v}_2$ along a straight line in the same direction. If $\mathbf{v}_1 > \mathbf{v}_2$, the balls will collide. If their velocities become $\mathbf{v}_1$, and $\mathbf{v}_2$ respectively after collision, then In the absence of external force (isolated system) the final momentum 'P$_f$' of the system must be equal to initial momentum 'P$_f$'. If no net external force acts on a system of particles, the total momentum of the system cannot change. This enable us to write the law of conservation of momentum which states:

Total momentum of the system before collision $= m_1\mathbf{v}_1 + m_2\mathbf{v}_2$

Total momentum of the system after collision $= m_1\mathbf{v}_1 + m_2\mathbf{v}_2$

Consider an isolated system of bullet of mass m, and gun of mass me. Such that before firing the total initial momentum ($p_i = 0$) of the system is zero as shown in figure 3.20.

After firing the bullet moves with velocity 'v_B,' in one direction and the rifle recoils with velocity 'v_G' in the other direction such that the total final momentum ($P_f = 0$) is again zero

By conservation of momentum $\vec{p}_f = \vec{p}_i = 0$ or $m_B\vec{v}_B + m_G\vec{v}_G = 0$

Or $m_G\vec{v}_G = -m_B\vec{v}_B$

Hence $\vec{v}_G = -\dfrac{m_B\vec{v}_B}{m_G}$ -----3.9

Negative sign indicates that velocity of the gun is opposite to the velocity of the bullet, i.e., the gun recoils. Since mass of the gun is much larger than the bullet, therefore, the recoil is much smaller than the velocity of the bullet.

SHORT QUESTIONS

Q.1 Define an isolated system?

Ans:

ISOLATED SYSTEM

Definition:

An isolated system can be defined as:

"An isolated system is a group of interacting bodies on which no external force is acting. If no unbalanced or net force acts on a system then its momentum remains constant thus, momentum of an isolated system remains constant."

Q.2 Define collisions?

Ans:

COLLISIONS

When particles in an isolated system come close to each other and interact by means of forces, it is called collision.

Q.3 Momentum of a body depends on which factors?

Ans:

DEPENDENCE OF MOMENTUM

We know

$$P = mv$$

This formula is showing that:

Momentum of a body depends on two factors:

- Mass of the body
- Velocity of the body

Q.4 Why is the law of conservation of momentum important?

Ans:

IMPORTANCE OF LAW OF CONSERVATION OF MOMENTUM

Law of conservation of momentum is very important in our daily life. It has vast applications and is applicable universally on bigger bodies as well as on atoms and molecules. It helps us to understand:

- Working of a system of gun and bullet,
- Working of rockets and jet engines etc.

Q.5 When a gun is fired, it recoils. Why?

Ans:

GUN RECOILS

Total momentum of the gun and the bullet is zero before the firing. When gun is fired, bullet moves in forward direction and attains momentum as a result the gun recoils to conserve momentum according to Law of Conservation of Momentum.

Q.6 Write relation between Force and Momentum.

Ans:

FORCE AND MOMENTUM

Relation:

"Rate of change of Momentum is equal to applied Force"

Mathematically:

$$\frac{P_f - P_i}{t} = F$$

Q.7 State Newton's Second Law of Motion in terms of Momentum.

Ans:

NEWTON'S SECOND LAW OF MOTION IN TERMS OF MOMENTUM

We can state Newton's Second law of motion in terms of momentum as

Statement:

"When a net force acts on a body, it produces acceleration in the body and the net force will be equal to the rate of change of momentum of the body."

Mathematically:

$$\frac{P_f - P_i}{t} = F$$

Q.8 Prove that $kgms^{-1} = Ns$

Ans:

PROOF

As we know that

"Rate of change of Momentum is equal to applied Force"

$$\frac{P_f - P_i}{t} = F$$

$$P_f - P_i = F \times t$$

$$m\Delta v = F \times t$$

Putting units, $kgms^{-1} = Ns$

Hence Proved

Q.9 How rockets accelerate in space as there is no air in space to push against such that as a reaction the rocket is pushed forward?

Ans: In rockets, hot gases produced by burning of fuel rush out with large momentum. The rockets gain an equal and opposite momentum, thereby causing them to accelerate.

(a) From the relation between force and momentum for truck $F_T = m_T\left(\frac{v_f - v_i}{\Delta t}\right)$

Putting values $F_T = \frac{(10,000kg \times 0m/s) - (10,000kg \times 8m/s)}{5s}$

Therefore $F_T = -16,000N$ ________ Answer

From the result it is clear that a much larger magnitude of force is required to stop a truck because it carries much larger momentum. The negative sing shows that force is applied opposite to the direction of motion., velocity.

MULTIPLE CHOICE QUESTIONS

1. Rate of change of momentum is equal to:
(A) Force (B) Velocity
(C) Acceleration (D) Impulse

2. Direction of the rate of change of momentum is in the direction of:
(A) Acceleration (B) Momentum
(C) Velocity (D) Force

3. Which of the following is the unit of momentum?
(A) Nm (B) $kgms^{-1}$
(C) Ns (D) Both b and c

4. Momentum of a moving body depends upon its:
(A) Mass (B) Velocity
(C) Weight (D) Both (A) & (B)

5. Motion of the rocket is an example of:
(A) First law of motion (B) Law of conservation of Momentum
(C) Law of conservation of Energy (D) Weigh

6. The product of force and time is called
(A) impulse (B) momentum
(C) acceleration (D) torque

7. A force of 10N act on a body of mass 10kg for 5 sec. The change in momentum of the body is
(A) 10Ns (B) 100Ns
(C) 50Ns (D) 150Ns

8. Force acting on a body is equal to
(A) rate of change of momentum (B) change of momentum
(C) momentum (D) both a & b

9. The unit of impulse is
(A) Nm (B) Ns
(C) Ns^{-1} (D) N

10. Direction of impulse is same that of
(A) change in momentum (B) velocity
(C) acceleration (D) no direction

11. SI unit of impulse is same that of
(A) momentum (B) velocity
(C) force (D) acceleration

12. Which bullet of same momentum is more effective in knocking a bear down
(A) rubber bullet (B) lead bullet
(C) both are equally effective (D) none of these

13. If the force of 250N acts on an object for 2 seconds then change in momentum will be
(A) 50Ns (B) 450Ns

(C) 500Ns (D) 125Ns

14. In the absence of an unbalanced force, the momentum of an isolated system always

(A) increase (B) decreases

(C) conserved (D) none of these

15. Does a moving object has impulse?

(A) may or may not be (B) yes always

(C) never (D) none of these

16. The force which might be enough to fracture the naked skull is

(A) 50N (B) 10N

(C) 15N (D) 5N

17. The relation $I = \overline{F} \times \Delta t$ shows

(A) momentum (B) power

(C) impulse (D) work

18. The rate of change in momentum is called

(A) force (B) torque

(C) distance (D) time

STUDENTS LEARNING OBJECTIVE

MULTIPLE CHOICE QUESTIONS

1. Which is not a function of force:

(A) It moves (B) It stops

(C) It can change mass (D) It can change shape of the body

2. In order to apply inertia the state of the object should be:

(A) Moving object (B) Object at rest

(C) Both A and B (D) None

3. If the resultant of action and reaction forces is evaluated, The outcome will be:

(A) Greater than zero (B) Smaller than zero

(C) Zero (D) Equal to the reaction

4. A feather and a heavy steel ball are dropped from a certain height in a vacuum chamber, so that there is no air resistance. The object having greater acceleration is:

(A) Feather (B) Steel Ball

(C) Both will have same (D) None

5. A mobile phone has a mass of 100g. If g is $10Nkg^{-1}$ then its weight will be:

(A) 1N (B) 10N

(C) 1000N (D) 90N

6. Newton's first law of motion is valid only in the absence of:

(A) force (B) net force

(C) friction (D) momentum

7. Inertia depends upon:

(A) force (B) net force

(C) mass (D) velocity

8. A boy jumps out of a moving bus. There is a danger for him to fall:

(A) towards the moving bus (B) away from the bus

(C) in the direction of motion (D) opposite to the direction of motion

9. A string is stretched by two equal and opposite forces of 10 N each. The tension in the string is:

(A) Zero (B) 5 N

(C) 10 N (D) 20 N

10. The mass of a body:

(A) decreases when accelerated (B) increases when accelerated

(C)decreases when moving with high velocity (D) none of the above

11. A body of mass m is hanging vertically from ceiling with the help of a massless spring. The

body is at rest and its weight is acting downwards. For that body:**

(A) T=W
(B) T=0
(C) T<W
(D) T>W

12. A rocket is moving vertically upward and 5 kg gas is ejecting out of it in downward direction with the velocity of 6500 ms^{-1}. If the mass of rocket is 1500 kg, the forward velocity of the rocket will be:

(A) 21.67ms^{-1}
(B) –21.67ms^{-1}
(C) – 25.95ms^{-1}
(D) 25.95ms^{-1}

13. Let's suppose that you are driving a car and suddenly the friction disappears then:

(A) The car will speed up
(B) The car will stop suddenly
(C) The car will not stop will keep on sliding
(D) None of these

14. If we tie a bucket with a string and whirl the bucket in a circular direction, then the bucket gets enough centripetal force from:

(A) The string and bucket
(B) Air Molecules
(C) String
(D) The bucket itself

15. Which of the following is the unit of momentum?

(a) Nm
(b) $kgms^{-2}$
(c) Ns
(d) Ns^{-1}

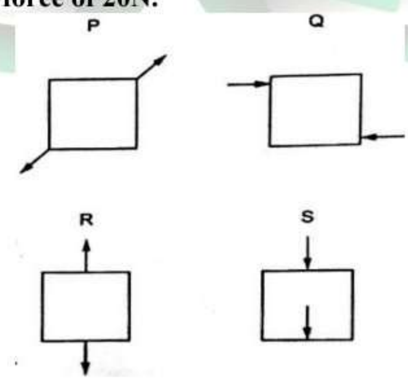
16. When horse pulls a cart, the action is on the:

(a) cart
(b) earth
(c) horse
(d) earth and cart

17. In a model of an atom, electrons move in circular orbits around a nucleus. Which statement about the electrons is correct?

(A) The electrostatic fore on the electrons is away for the nucleus.
(B) The acceleration of the electrons is towards the central nucleus.
(C) The speed of the electrons varies continuously.
(D) The velocity of the electrons remains constant.

**18. The diagrams show the forces acting on four identical solid blocks.
Each arrow represents a force of 20N.**



Which blocks are in equilibrium?

(A) P and R only
(B) Q and S only
(C) P, Q and R only
(D) P, Q, R and S

**19. A student list three changes that affect the stopping distance of a car.
Increasing the braking force.
2. Increasing the friction between the tyres and the road
3. Increasing the speed of the car.
Which change or changes increases the stopping distance?**

(A) 1 and 2 (B) 1 and 3
(C) 1 only (D) 3 only

20. Which equation is correct, when the object is stationary?

(A) F + W = 0 (B) F – T = 0
(C) F – W – T = 0 (D) F – W + T = 0

21. A metal wire is stretched by a force F up to the limit of proportionality. Which statement describes what happens when F is increased slightly?

(A) The wire breaks
(B) The wire continues to extend but not in direct proportion to F.
(C) The wire continues to extend in direct proportion to F.
(D) The wire does not extend any further.

STUDENTS LEARNING OBJECTIVE

SHORT QUESTIONS

3.1 Why is it dangerous to travel on the roof of a bus?

Ans: **<u>TRAVELLING ON THE ROOF</u>**

It is dangerous to travel on the roof of a bus because when brakes are applied suddenly, the lower part of body of passenger sitting on its roof comes to rest immediately but due to inertia upper part of his body continues its motion in a straight line and he may fall forward and gets injured if there is no support.

3.2 Why does a passenger move outward when a bus takes a turn?

Ans: **<u>OUT WARD MOTION</u>**

When a moving bus takes a sharp turn, passengers fall in the outward direction. It is due to inertia that they want to continue their motion in a straight line and thus fall outwards.

3.3 When a tree is shaken, its fruits and leaves fall down why?

Ans: **<u>FALL OF FRUIT</u>**

When a tree is shaken it moves, but its fruits and leaves remains at rest due to inertia and therefore detach from the branch of the tree and fall down under the action of gravity.

3.4 Why does dust fly off, when a hanging carpet is beaten with a stick?

Ans: **<u>FLY OFF OF DUST</u>**

When a hanging carpet is beaten with a stick it moves forward along with the dust particles but when the carpet moves back, the dust continues its motion in forward direction due to inertia and therefore flies off from the carpet.

3.5 What will be the tension in a rope that is pulled from its ends by two opposite forces 100 N each?

Ans: **<u>TENSION IN THE ROPE</u>**

The tension in a rope that is pulled from its ends by two opposite forces 100 N each will be 100 N.

3.6 Action and reaction are always equal and opposite then how does a body move?

Ans: **<u>ACTION AND REACTION</u>**

Action and reaction are equal in magnitude but opposite in direction. Action and reaction do not act on the same body. Action is applied on one body due to which an equal and opposite reaction is acting on another body. Both of these do not neutralize each other due to which the body will move.

3.7 A horse pushes the cart. If the action and reaction are equal and opposite then how does the cart move?

Ans: **<u>MOTION OF THE CART</u>**

Yes, Action and reaction are equal in magnitude but are opposite in direction but they do not cancel each other because they act on two different bodies.
The horse apply action on the road by his feet, the reaction is given by the road on the horse, due to which horse moves. The cart which is tied with the horse will also move.

3.8 Why is the law of conservation of momentum important?

Ans: **<u>LAW OF CONSERVATION OF MOMENTUM</u>**

<u>Importance</u>:

Law of conservation of momentum has vast applications and is applicable universally on bigger bodies as well as on atoms and molecules. A system of gun and bullet, rocket and jet engines etc. work on the Principle of law of conservation of momentum. This law helps us to understand variations in quantity of motion of different bodies.

3.9 Why does water not fall out of a bucket when it is whirled in a vertical circle?

Ans: **FALL OF WATER**

When the bucket of water is whirled in vertical circle, a centripetal force is provided to water due to which the velocity of water becomes tangent to circular path and does not fall.

3.10 When a gun is fired, it recoils. Why?

Ans: Total momentum of the gun and the bullet is zero before the firing. When gun is fired, bullet moves in forward direction hence gains some momentum in order to conserve momentum according to law of conservation of momentum the gun recoils.

Mathematically:

By conservation of momentum

$\vec{P}_f = \vec{P}_i = 0$ or $m_B \vec{v}_B + m_G \vec{v}_G = 0$

Or $m_G \vec{v}_G = -m_B \vec{v}_B$

Hence $\vec{v}_G = -\dfrac{m_B \vec{v}_B}{m_G}$

Here negative sign indicates that velocity gun is opposite to the velocity of bullet i.e. the gun recoils.

3.11 Why it more difficult to push large man on swing compared to a small child?

Ans:

There is a difference in the resistance to a change in motion between the man and the child. Also, when you try to stop their motions, you would again notice a difference in the resistance to a change in motion. Because large man has more intertia due to more mass.

3.12 What would happen if all friction suddenly disappears?

Ans: **FRICTION SUDDENLY DISAPPEARS**

If all friction suddenly disappears the movement will become uncontrollable. The balance of natural forces will be disturbed and the whole system will collapse.

3.13 The weight of a body is 147 N. What is its mass?

Solution:

Given Data:

Weight of the body = w = 147 N

Gravitational acceleration = g = 10 ms^{-2}

To Find:

Mass of the body = m = ?

Calculations:

As we know that

$$w = mg$$

So $$m = \frac{w}{g}$$

By putting the values, we have

$$m = \frac{147}{10}$$

$$m = 14.7 \text{ kg}$$

Result:

Hence, the mass of the body will be 14.7 kg.

3.14 How much force is needed to prevent a body of mass 10 kg from falling?

Solution:

Given Data:

Mass of the body = 10 kg

Gravitation acceleration = g = 10 ms^{-2}

To Find:

Force required to prevent the body from falling = R = ?

Calculations:

As we know that in stable position,

$$R = w = mg$$

By putting the values, we have

$$R = w = 10 \times 10$$

$$R = 100\ N$$

Result:

Hence, the force required to prevent the body from falling will be 100 N.

3.15 A body has weight 20 N. How much force is required to move it vertically upwards with an acceleration of 2 ms^{-2}.

Solution:

Given Data:

Weight of the body = 20 N

Acceleration of the body = a = 2 ms^{-2}

Gravitational acceleration = g = 10 ms^{-2}

Normal reaction = R = w = 20 N

To Find:

Force acting on the body moving vertical upward = F =?

Calculations:

As we know that

$$w = mg$$

So $$m = \frac{w}{g}$$

By putting the values, we have

$$m = \frac{20}{10} \Rightarrow m = 2\ kg$$

From Newton's second law of motion

$$F = ma$$

By putting the values, we have

$$F = 2 \times 2 \Rightarrow F = 4\ N$$

Now net force required to move the body upward

= normal reaction + force producing acceleration

= 20 N + 4 N ⇒ 24 N

Result:

Hence, the force acting on the body moving vertical upward will be 24 N.

3.16 How much time is required to change 22 Ns momentum by a force of 20 N?

Solution:

Given Data

Change in momentum = ΔP = 22 Ns

Force applied = F = 20 N

To Find:

Time required = t = ?

Calculations:

As we know that, $F = \frac{\Delta p}{t} \Rightarrow t = \frac{\Delta p}{F}$

By putting the values, we have

$$t = \frac{22}{20} \Rightarrow t = 1.1s$$

Result:

Hence, the time required to change the momentum of the body will be 1.1 s.

SUMMARY

• **Dynamics**	• Dynamics is the branch of mechanics in which we discuss the motion of bodies along with causes of motion of bodies
• **Force**	• Force is a physical quantity which moves or tends to move a body, stops or tends to stop a moving body or which tends to change the speed and direction of a moving body
• **Newton's First Law of Motion**	• Newton's First Law of Motion states that everybody continues in its state of rest or uniform motion in a straight line unless an external net force act upon it.
• **Newton's Second Law of Motion**	• Newton's Second Law of Motion states that whenever a net force acts on a body, it produces acceleration in the direction of the net force. The acceleration is directly proportional to the net force and inversely proportional to the mass of the body
• **Newton's Third Law of Motion**	• Newton's Third Law of Motion states that to every action there is an equal and opposite reaction.
• **Mass**	• Mass is the quantity of matter in a body.
• **Weight**	• Weight is the downward force with which the earth pulls a body towards its center.
• **Gravitational Field Strength**	• Gravitational Field Strength is defined as the force per unit mass that earth exerts on a body.
• **Momentum**	• Momentum is the product of mass and velocity. It is a vector quantity.
• **Law of Conservation of Momentum**	• Law of Conservation of Momentum states that if there is no external force applied to a system, the momentum of that system remain constant.

TEXT BOOK EXERCISE
MULTIPLE CHOICE QUESTIONS

Q. 1 Choose the best possible option.

3.1 When we kick a stone, we get hurt. This is due to:

(a) inertia (b) velocity
(c) momentum (d) reaction

3.2 An object will continue its motion with constant acceleration until:

(a) The resultant force on it begins to decrease.
(b) The resultant force on it is zero.
(c) The resultant force on it begins to increase.
(d) The resultant force is at right angle to its tangential velocity.

3.3 Which of the following is a non-contact force?

(a) Friction (b) Air resistance
(c) Electrostatic force (d) Tension in the string

3.4 A ball with initial momentum p hits a solid wall and bounces back with the same velocity. Its momentum p' after collision will be:

(a) $p' = p$ (b) $p' = -p$ (c) $p' = 2p$ (d) $p = -2p$

3.5 A particle of mass m moving with a velocity v collides with another particle of the same mass at rest. The velocity of the first particle after collision is:

(a) v (b) –v (c) 0 (d) –1/2

3.6 Conservation of linear momentum is equivalent to:

(a) Newton's first law of motion (b) Newton's second law of motion
(c) Newton's third law of motion (d) None of these

3.7 An object with a mass of 5 kg moves at constant velocity of 10 m s^{-1}. A constant force then acts for 5 seconds on the object and gives it a velocity of 2ms^{-1} in the opposite direction. The force acting on the object is:

(a) 5N (b) –10N (c) –12N (d) –15N

3.8 A large force acts on an object for a very short interval of time. In this case, it is easy to determine:

(a) magnitude of force (b) time interval
(c) product of force and time (d) none of these

3.9 A lubricant is usually introduced between two surfaces to decrease friction. The lubricant:

(a) decreases temperature (b) acts as ball bearings
(c) prevents direct contact of the surfaces (d) provides rolling friction

SHORT ANSWER QUESTIONS

3.1 What kind of changes in motion may be produced by a force?

Ans: Due to force a body at rest begins to move and a body in motion comes to rest and a the direction of a moving body can also be change.

3.2 Give 5 examples of contact forces.

Ans: Example of contact forces are:
a) Friction
b) Tension
c) Normal Force
d) Applied Force
e) Spring Force

3.3 An object moves with constant velocity in free space. How long will the object continue to move with this velocity?

Ans: In free space, an object moving with constant velocity will continue to move at that velocity indefinitely, as long as no external forces act on it. This is due to Newton's First Law of Motion, also known as the Law of Inertia, which states that an object will remain at rest or continue to move in a straight line at constant speed unless acted upon by an external force.
Therefore, in the absence of external forces (like gravity, friction, or other forces), the object will maintain its constant velocity forever.

3.4 Define impulse of force.

Ans: The product $\mathbf{F}\times\Delta t$ is called as **Impulse** of the force.
$\mathbf{F}\times\Delta t=m(\Delta \mathbf{v})=m(\mathbf{v}_f\Delta \mathbf{v}_i)$

3.5 Why has not Newton's first law been proved on the Earth?

Ans: Newton's First Law of Motion, also known as the Law of Inertia, has not been "proven" on Earth in the strictest sense because it is a fundamental principle that is based on empirical observations and is a starting point for understanding motion.

3.6 When sitting in a car which suddenly accelerates from rest, you are pushed back into the seat, why?

Ans: You are pushed back into the seat because your body resists the sudden acceleration, and the seat applies the force needed to change your body's motion. This effect is a direct result of inertia, where your body wants to remain in its state of rest while the car accelerates forward.

3.7 The force expressed in Newton's second law is a net force. Why is it so?

Ans: Newton's Second Law uses the net force because it accounts for all the forces acting on an object and their combined effect on the object's motion.

3.8 How can you show that rolling friction is lesser than the sliding friction?

Ans: The reason for the rolling friction to be less than the sliding friction is that there is no relative motion between the wheel and the surface over which it rolls. The wheel touches the surface only at a point. It does not slide.

3.9 Define terminal velocity of an object.

Ans: **Terminal Velocity:**
The constant velocity achieved by an object is called its terminal velocity.
Example:
This principle applies to paratroopers. Air resistance acting against the large surface area of a parachute allows for descent at a safer velocity.

3.10 An astronaut walking in space wants to return to his space ship by firing a hand rocket. In what direction does he fire the rocket?

Ans: The astronaut fires the rocket in the opposite direction of the spaceship to propel themselves back towards it, leveraging Newton's Third Law of motion.

CONSTRUCTED RESPONSE QUESTIONS

3.1 Two ice skaters weighing 60 kg and 80 kg push off against each other on a frictionless ice track. The 60 kg skater gains a velocity of 4ms^{-1}. Considering all the relevant calculations involved, explain how Newton's third law applies to this situation.

Ans: **Newton's Third Law**: The action and reaction forces between the two skaters are equal in magnitude but opposite in direction.

- The 60 kg skater gains a velocity of 4 m/s in one direction, and the 80 kg skater gains a velocity of 3m/s in the opposite direction.
- The total momentum of the system is conserved because the skaters push off each other with equal and opposite forces, as predicted by Newton's Third Law.

3.2 Inflatable air bags are installed in the vehicles as safety equipment. In terms of momentum, what is the advantage of air bags over seatbelts?

Ans: In terms of momentum, **airbags** are more effective than seatbelts because they increase the time over which the occupant's momentum is reduced, which reduces the force on the body, making them a crucial additional safety feature in reducing injury during a crash.

3.3 A horse refuses to pull a cart. The horse argues, "according to Newton's third law, whatever force I exert on the cart, the cart will exert an equal and opposite force on me. Since the net force will be zero, therefore, I have no chance of accelerating (pulling) the cart." What is wrong with this reasoning?

Ans: The horse's mistake is in thinking that the action and reaction forces (between the horse and the cart) should cancel out, which would lead to no motion. However, the key is that these forces act on different objects. The horse's force on the cart causes the cart to move (if it overcomes friction), and the reaction force on the horse is balanced by the force it applies to the ground.

3.4 When a cricket ball hits high, a fielder tries to catch it. While holding the ball he/she draws hands backward. Why?

Ans: The fielder draws their hands backward to **increase the time** over which the ball's momentum is brought to zero. This reduces the force acting on the fielder's hands and makes the catch more manageable and less painful, effectively using the principles of **impulse** and **momentum**.

3.5 When someone jumps from a small boat on to the river bank, why does the jumper often fall into the water? Explain.

Ans: The jumper often falls into the water because the jump causes the boat to move in the opposite direction (away from the riverbank), reducing the person's forward motion. The person may then fall into the water due to the boat's reaction and loss of balance.

3.6 Imagine that if friction vanishes suddenly from everything, then what could be the scenario of daily life activities?

Ans: Without friction, nearly every activity in daily life would be affected in a major way. Movement would become challenging and dangerous, basic tasks like walking or driving would become almost impossible, and machines and tools would stop functioning. Friction is essential for interaction with surfaces, so its sudden disappearance would fundamentally alter how we live and function. The world as we know it would be unrecognizable, and our daily routines would be impossible to carry out.

COMPREHENSIVE QUESTIONS

3.1 Explain the concept of force by practical examples.

Ans: **<u>Examples</u>:**

- We can open the door either by pushing or pulling the door.
- A man pushes the cart. The push may move the cart or change the direction of its motion or may stop the moving cart.
- A batsman changes the direction of a moving ball by pushing it with his bat.

3.2 Describe Newton's laws of motion.

Ans: **1^{ST} LAW OF MOTION:**

Newton's First Law of Motion states that:

"If the net external force acting on an object is zero, the object will maintain its state of rest or uniform motion (constant velocity).**"**

2^{ND} LAW OF MOTION:

"The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object."

3^{RD} LAW OF MOTION:

Newton's Third Law of Motion states that:

"Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object."

OR

"To every action there is always an equal but opposite reaction**".**

3.3 Define momentum and express Newton's 2^{nd} law of motion in terms of change in momentum.

Ans: **MOMENTUM**

Definition:

"The product of the object's mass 'm' and velocity '$\vec{v}$' is called momentum."

Formula:

$$\vec{P}=m\vec{v}$$

Unit:

SI Unit of momentum is kilogram-meter per second (kgm/s), or newton-second (Ns).
Newton's second law is used to relate force and momentum.

Quantity:

Momentum is a vector quantity that points in the same direction as the velocity.

Statement:

"The time rate of change of linear momentum of a body is equal to the net force acting on the body. This means that for sudden change in momentum force is large and vice versa."
A force 'F' produces acceleration 'a' in a body of mass 'm'. By Newton's second law of motion it is written as

$$'\vec{F}'=\overrightarrow{ma}---1$$

The acceleration produced changes the velocity of the body from initial velocity '$\vec{v}_f$,' to final velocity '$\vec{v}_f$,' during time interval ''Δt'.'. Then by definition of acceleration.

$$\vec{a}=\frac{\overrightarrow{v_f}-\overrightarrow{v_f}}{\Delta t}----2$$

Putting equation 2 in equation 1

$$\vec{F}_{net}=m\frac{\overrightarrow{v_f}-\overrightarrow{v_f}}{\Delta t}$$

Or

$$\vec{F}_{net}=\frac{m\overrightarrow{v_f}-m\overrightarrow{v_f}}{\Delta t}$$

Hence $\vec{F}_{net}=\frac{p_f-p_r}{\Delta t}=\frac{\Delta\vec{P}}{\Delta t}$ ----3.5

3.4 State and explain the principle of conservation of momentum.

Ans: **NEWTON'S LAWS AND CONSERVATION OF MOMENTUM**

Statement:

"The momentum of an isolated system remains constant."

Explanation:

Consider a system of two balls of masses m_1 and m_2. Suppose that the balls are moving with velocities $\mathbf{v}_1$ and $\mathbf{v}_2$ along a straight line in the same direction. If $\mathbf{v}_1>\mathbf{v}_2$, the balls will collide. If their velocities become $\mathbf{v}_1$, and $\mathbf{v}_2$ respectively after collision, then In the absence of external force (isolated system) the final $\vec{\text{momentum}}$ 'P_f' of the system must be equal to initial $\vec{\text{momentum}}$ 'P_f'. If no net external force acts on a system of particles, the total momentum of the system cannot change. This enable us to write the law of conservation of momentum which states:

Total momentum of the system before collision = $m_1\mathbf{v}_1+m_2\mathbf{v}_2$

Total momentum of the system after collision $=m_1\mathbf{v}_1+m_2\mathbf{v}_2$

Consider an isolated system of bullet of mass m, and gun of mass me. Such that before firing the total initial momentum ($p_i = 0$) of the system is zero as shown in figure 3.20.
After firing the bullet moves with velocity 'v_B,' in one direction and the rifle recoils with velocity 'v_G' in the other direction such that the total final momentum ($P_f = 0$) is again zero

By conservation of momentum $\vec{p}_f=\vec{p}_t=0$ or $m_B\vec{v}_B+m_G\vec{v}_G=0$

Or $m_G\vec{v}_G = -m_B\vec{v}_B$

Hence $\vec{v}_G = -\frac{m_B\vec{v}_B}{m_G}$ -----3.9

Negative sign indicates that velocity of the gun is opposite to the velocity of the bullet, i.e., the gun recoils. Since mass of the gun is much larger than the bullet, therefore, the recoil is much smaller than the velocity of the bullet.

3.5 Describe the motion of a block on a table taking in to account the friction between the two surfaces. What is the static friction and kinetic friction?

Ans: **Static friction:**

Let us consider the motion of a block on a horizontal surface. The arrangement is shown in Fig. 3.22. When a weight is put in the pan, a force **F=T** equal to the sum of this weight and weight of the pan acts on the block. This force tends to pull the block. At the same time an opposing force appears that does not let the block move. This opposing force is the static friction $\mathbf{F_S}$.

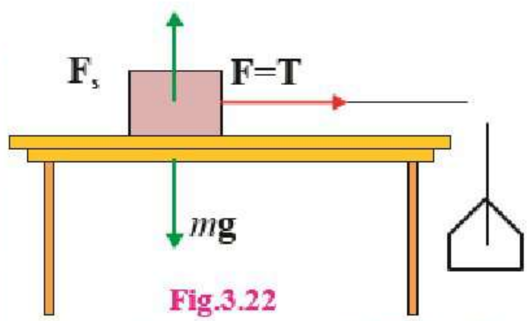


Fig.3.22

Kinetic friction:

If we go on adding more weights in the pan one by one in small steps, a stage will come when the block starts sliding on the horizontal surface. This is the limit of static friction that is equal to the total weights including pan. When the block is sliding, friction still exists. It is known as kinetic friction.

3.6 Explain the effect of friction on the motion of vehicles in context of tyre surface and braking force.

Ans: Friction is absolutely essential in the motion and control of vehicles. The tyres rely on friction to provide traction for movement, steering, and braking. Effective braking depends on friction between the tyres and the road, and too little or too much friction can lead to dangerous driving conditions. This is why proper tyre maintenance and road conditions are critical for safe vehicle operation.

NUMERICAL PROBLEMS

3.1 A 10 kg block is placed on a smooth horizontal surface. A horizontal force of 5 N is applied to the block. Find:

(a) the acceleration produced in the block.

(b) the velocity of block after 5 seconds.

(0.5 m s^2, 2.5 ms^1)

Given Data:

Mass of black = m = 10kg

Force = F = 5N

Initial velocity = vi = $0ms^{-1}$

Time = t = 5 sec

To Find:

Acceleration = a = ?
Final velocity = vf= ?

Solution:

Formula:

$$a = \frac{F}{m} \quad \therefore F = ma$$

$$vf = vi + at$$

By applying values

$$a = \frac{5}{10} \Rightarrow \boxed{0.5ms^{-2}}$$

$$vf = 0 + (0.5)(5) \Rightarrow \boxed{2.5ms^{-1}}$$

Result:

Acceleration produced in the block will be 0.5 ms-2 and its final velocity will 2.5 ms^{-1}.

3.2 The mass of a person is 80 kg. What will be his weight on the Earth? What will be his weight on the Moon? The value of acceleration due to gravity of Moon is 1.6 ms^2.

(800 N, 128 N)

Given Data:

Mass of the pessen = m = 80kg
Gravitational Acceleration on earth = ge = $10ms^{-2}$
Gravitational acceleration on moon = gm = $1.6ms^{-2}$

To Find:

Weight of the person on earth = W_m= ?
Weight of the person on Moon = W_m =?

Solution:

Formula:

$$w = mg$$

On earths $w = (80)(10) \Rightarrow \sqrt{800N}$

Moon $w = (80)(1.6) \Rightarrow \boxed{128N}$

Result:

Weight of the person on earth and on moon will be 800N and 128N respectively.

3.3 What force is required to increase the velocity of 800 kg car from 10 m s^1 to 30 m s^1 in 10 seconds?

(1600 N)

Given Data:

Mass of car = m = 800kg
Initial velocity = vi = $10ms^{-1}$
Final velocity = vf = 30 ms^{-1}
Time = t = 10 sec

To Find:

Force = F = ?

Solution:

Formula:

$$a = \frac{vf - vi}{t}$$

$$F = ma$$

By applying values

$$a = \frac{30-10}{10} \Rightarrow \frac{20}{10} \Rightarrow \boxed{2ms^{-2}}$$

$$F = (800)(2) \Rightarrow \boxed{1600N}$$

Result:

Required force will be 1600N.

3.4 A 5g bullet is fired by a gun. The bullet moves with a velocity of 300 m s¹. If the mass of the gun is 10 kg, find the recoil speed of the gun.

(-0.15 ms¹)

Given Data:

Mass of bullet $= m = 5g \Rightarrow \frac{5}{1000} kg \Rightarrow 0.005kg$

Velocity of bullet = v = 300 ms^{-1}

Mass of gun=M=10kg

To Find:

Velocity of Gun = V = ?

Solution

Formula:

According to law of conservation of momentum.

$$mv + MV = 0$$

$$MV = -mv$$

$$V = -\frac{mv}{M}$$

By putting the values

$$V = \frac{-(0.005)(300)}{10} \Rightarrow -\frac{1.5}{10} \Rightarrow \boxed{-0.15ms^{-1}}$$

Result:

Velocity of the Gen will be – 0.15ms^{-1}.

3.5 An astronaut weighs 70 kg. He throws a wrench of mass 300 g at a speed of 3.5 m s¹.
Determine:
(a) the speed of astronaut as he recoils away from the wrench.
(b) the distance covered by the astronaut in 30 minutes.

(-1.5 x 10²ms, 27 m)

Given Data:

Mass of fastronout = M = 70 kg

Velocity of wrenth = v = 3.5 ms^{-1}

Mass of wrench = m = 300g $\Rightarrow \frac{300}{1000} kg \Rightarrow 0.3kg$

Time = t = 30 minutes $\Rightarrow$ 30 × 60 sec $\Rightarrow$ 1800 sec

To Find:

Velocity of Astronant = V = ?

Distance covered by astronant = S = ?

Solution:

Formula:

$$V = \frac{-mv}{M}$$

$$S = V \times t$$

By applying values

$$V = \frac{-(0.3)(3.5)}{70} \Rightarrow \frac{-1.05}{70} \Rightarrow \boxed{-0.015 ms^{-1}}$$

$$S = (0.015)(1800) = \boxed{27m}$$

Result:

Velocity of astronant will be – 0.015 ms^{-1} and it will cover the distance of 27 m.

3.6 A 6.5 ×10 kg bogie of a goods train is moving with a velocity of 0.8 m s^{-1}. Another bogie of mass 9.2×10^3 kg coming from behind with a velocity of 1.2 m s¹ collides with the first one and couples to it. Find the common velocity of the two bogies after they become coupled.

(1.03 ms¹)

Given Data:

Mass of bagie 1 = m = 6.5×10^3kg
Velocity of begie 1 before conisen = v_1 = 0.8 ms^{-1}.
Mass of bogie 2 = m_2 = 9.2×10^3kg
Velocity of begie 2 before collision = V_2 = 1.2ms^{-1}

To Find:

Common velocity of bogies after coupling = vf= ?

Solution

Formula:

$$m_1v_1 + m_2v_2 = m_1vf + m_2vf$$

$$m_1v_1 + m_2v_2 = (m_1 + m_2)vf$$

$$\frac{m_1v_1 + m_2v_2}{m_1 + m_2} = vf$$

By applying values

$$vf = \frac{(6.5\times10^3)(0.8) + (9.2\times10^3)(1.2)}{(6.5\times10^3) + (9.2\times10^3)}$$

$$vf = \frac{5200 + 11040}{15.7\times10^3}$$

$$vf = 1.03 ms^{-1}$$

Result:

Common velocity of the begies after coupling will be1.03ms^{-1}.

3.7 A cyclist weighing 55 kg rides a bicycle of mass 5 kg. He starts from rest and applies a force of 90 N for 8 seconds. Then he continues at a constant speed for another 8 seconds. Calculate the total distance travelled by the cyclist.

(144 m)

Given Data:

Mass of cyclist = m_1 = 55kg
Mass of cycle = m_2 = 5kg
Total mass = m = m_1+m_2 = 55kg + 5kg = 60kg
Force = F = 90 N
Time = t = 8 sec

Initial velocity = v_i = 0ms^{-1}.

To Find:

Total distance travelled = S = ?

Solution:

Formula:

$$a = \frac{F}{m}$$

$$vf = vi + at$$

$$S_1 = vit + \frac{1}{2}at^2$$

$$S_2 = vf \times t$$

$$S = S_1 + S_2$$

By applying values

$$a = \frac{90}{60} \Rightarrow \boxed{1.5ms^{-2}}$$

$$vf = 0 + (1.5)(6) \Rightarrow \boxed{12ms^{-1}}$$

$$S_1 = (0)(8) + \frac{1}{2}(1.5)(8)^2$$

$$S_1 = 0 + \frac{1}{2}(1.5)(64)$$

$$\boxed{S_1 = 48m}$$

$$S_2 = 12 \times 8 = \boxed{96m}$$

$$S = 48m + 96m \Rightarrow \boxed{144m}$$

Result:

Total distance travelled by the cyclist will be144 m.

3.8 A ball of mass 0.4 kg is dropped on the floor from a height of 1.8 m. The ball rebounds straight upward to a height of 0.8 m. What is the magnitude and direction of the impulse applied to the ball by the floor?

(4 Ns)

Given Data:

Mass of ball = m = 0.4kg

Height of ball from floor = h_1 = 1.8m

Height of ball after relovrd = h_2 = 0.6m

To Find:

Impulse = F.Δt = ?

Solution

Formula:

$vf^2 = vi^2 + 2g^3$ beforeliting the floor

$vf^2 = vf^2 + 2g^3$ after rebounding of ball

$$F.\Delta t = m(vf - vi)$$

By applying values

$$vf^2 = (0)^2 + 2(10)(1.8) \Rightarrow 36$$
$$\sqrt{vf^2} = \sqrt{36}$$
$$\boxed{vf = 6ms^{-1}}$$
$$0 = vf^2 + 2gh$$
$$0 = vi2 + 2(-10)(0.5)$$
$$0 = vfi^2 - 16$$
$$\boxed{16 = \sqrt{vi^2}} \Rightarrow \boxed{v_i = 4ms^{-1}}$$
$$F.\Delta t = 0.4(6+4) \Rightarrow 0.4(10) \Rightarrow \boxed{4Ns}$$

$\therefore$ Velocity will cosideswegatic due to divide

Result:

Impulse of the ball will be 4Ns.

3.9 Two balls of masses 0.2 kg and 0.4 kg are moving towards each other with velocities 20 m s¹ and 5 m s¹ respectively. After collision, the velocity of 0.2 kg ball becomes 6 m s¹. What will be the velocity of 0.4 kg ball?

(2 m s¹)

Given Data:

Mass of ball 1 = m_1 = 0.2 kg
Mass of ball 2 = m_2 = 0.4 kg
Velocity of m_1 before collision = v_1 = 20ms^{-1}
Velocity of m_2 before collision = v_2 = 5ms^{-1}
Velocity of m_1 after collision = v_1 = 6ms^{-1}

To Find:

Velocity of m2 after collision = v_2= ?

Solution

Formula:

$$m_1v_1 + m_2v_2 = m_1v_1 + m_2v_2$$

By applying values

$$(0.2)(20) + (0.4)(-5) = (0.2)(6) + (0.4)v_2$$
$$4 - 2 = 1.2 + (0.4)v_2$$
$$2 - 1.2 = (0.4)v_2$$
$$\frac{0.8}{0.4} = v_2$$
$$\boxed{v_2 = 2ms^{-1}}$$

$\therefore$ V_2 is taken as negative (-5ms^{-1}) because the second ball is moving towards the first ball.

Result:

Velocity of second ball after collision will be 2ms^{-1}.

ANSWER KEY

MCQ'S ANSWER KEY (TOPIC WISE)
3.1 FORCE
3.1.1 TYPES OF FORCES
3.1.2 FUNDAMENTAL FORCES IN NATURE
3.1.3 FORCE DIAGRAMS
3.1.4 CONCEPT OF NET FORCE

1	2	3	4	5	6	7	8
C	B	C	C	C	C	A	A

3.2 NEWTON'S LAWS OF MOTION
3.2.1 NEWTON'S FIRST LAWS OF MOTION
3.2.2 NEWTON'S SECOND LAWS OF MOTION
3.2.3 NEWTON'S THIRD LAWS OF MOTION
3.2.4 LIMITATIONS OF NEWTON'S LAWS OF MOTION
3.3 MASS AND WEIGHT
3.3.1 MEASURING FORCE AND MASS

1	2	3	4	5	6	7	8	9	10	11	12
B	B	A	C	A	A	C	A	B	B	B	A
13	14	15	16	17	18	19	20	21	22	23	24
C	B	C	B	A	C	C	D	C	D	A	A
25	26	27	28	29	30	31	32	33	34		
C	A	B	C	D	D	A	D	A	B		

3.4 GRAVITATIONAL FIELD

1	2	3	4	5
B	B	D	A	A

3.5 MOMENTUM
3.5.1 FORCE AND CHANGE IN MOMENTUM
3.5.2 IMPULSE AND CHANGE IN MOMENTUM
3.5.3 NEWTON'S LAWS AND CONSERVATION OF MOMENTUM

1	2	3	4	5	6	7	8	9	10
A	D	D	D	B	A	C	A	B	A
11	12	13	14	15	16	17	18		
A	A	C	C	A	D	C	A		

STUDENT LEARNING OBJECT

1	2	3	4	5	6	7	8	9
C	C	C	C	A	B	C	C	C
10	11	12	13	14	15	16	17	18
D	A	B	C	C	C	D	B	A
19	20	21						
A	D	D						

TEXT BOOK EXERCISE

1	2	3	4	5	6	7	8	9

D	A	C	B	C	C	C	C	C

LAST HOPE STUDY