Chapter 5: Exploring Forces

A Comprehensive Briefing

Introduction

This briefing provides a detailed overview of forces, encompassing their definition, effects, types, and key concepts such as weight, mass, and buoyancy. The information is drawn from chapter 5 of the class 8 NCERT Curiosity science book which explores fundamental principles of physics relevant to everyday experiences.

1. What is a Force?

A force is fundamentally defined as a **push or pull applied on an object, resulting from the object's interaction with another object.** This interaction is crucial, as "at least two objects must interact for a force to come into play." The standard International System of Units (SI) unit for force is the **newton (N)**.

2. What Can a Force Do? (Effects of Force)

Forces have a wide range of observable effects on objects:

- **Initiate Motion:** A force can "make an object move from rest."
- **Change Speed:** It can "change the speed of an object if it is moving." For instance, a friend holding a moving bicycle from behind will cause it to stop or decrease speed.
- **Change Direction:** A force can "change the direction of motion of an object," such as "hitting a moving ball with a bat."
- **Change Shape:** Forces can also "bring about a change in the shape of an object," as seen when "pressing an inflated balloon."
- **Combined Effects:** A single force or multiple forces can cause "some or all of these effects."

It's important to note that "none of these take place without the action of force."

3. Types of Forces

Forces are categorized into two main types based on whether physical contact is required between the interacting objects.

3.1 Contact Forces

Contact forces require "physical contact... between our body and the object" or indirectly through tools like a stick or rope.

3.1.1 Muscular Force

This is the force generated by the action of muscles in living beings. Examples include "walking, running, lifting, pushing, jumping, or stretching." Muscular force is vital for movement and survival in animals, and historically, humans have leveraged animal muscular

force for tasks. Internally, muscular force is crucial for processes like "chew food and push it through the alimentary canal" and the "expansion and contraction of our heart muscles."

3.1.2 Friction

Friction is a force that **"comes into play when an object moves or tries to move over another surface."** It "always acts in a direction opposite to the direction in which the object is moving or trying to move," and is responsible for objects slowing down and stopping, such as a rolling ball or a bicycle when pedaling stops.

Key characteristics of friction:

- **Opposes Motion:** It always opposes the motion or attempted motion.
- **Contact Force:** It arises because "two surfaces are in contact."
- **Surface Irregularities:** Friction is caused by "irregularities in the two surfaces in contact." Even seemingly smooth surfaces have minute irregularities that "lock into each other and oppose any effort to move one surface over the other."
- **Dependence on Surface Nature:** The "force of friction depends upon the nature of the surfaces in contact," being "greater on rough surfaces."
- **Acts in Fluids:** Friction also acts on "objects moving through liquids and gases," which is why "aeroplanes, ships, boats, or high-speed trains are designed with specific shapes to reduce the force of friction due to the air or water around them."

3.2 Non-Contact Forces

Non-contact forces exert their effect "even if the objects are not in contact."

3.2.1 Magnetic Force

This force exists between magnets and magnetic materials. "Like poles (North–North, South–South) repel each other while unlike poles (North–South) attract each other." A key aspect is that "a magnet could exert force on another magnet or a magnetic material without being in contact with it," making it a non-contact force.

3.2.2 Electrostatic Force

This force arises from **electrical charges** that build up on surfaces when certain materials are rubbed together. These are called "static charges as they do not move by themselves."

- **Attraction/Repulsion:** A charged object can "attracts, that is, exerts a force on uncharged objects made of certain materials," like paper pieces attracted to a rubbed plastic scale.
- **Like charges repel, unlike charges attract:** "Two similarly charged balloons repel each other," while "a charged balloon and the woollen cloth (with which the balloon was rubbed) attract each other," indicating "opposite kind of charges attract each other."
- **Non-Contact:** This force "comes into play even when the bodies are not in contact."

3.2.3 Gravitational Force

This is the force by which the Earth (or any celestial body) "attracts objects towards itself." It is also known as the **force of gravity or simply gravity.**

- **Always Attractive:** Unlike magnetic or electrostatic forces, gravitational force "is always an attractive force."
- **Non-Contact:** Since it acts "without contact with the object it attracts, it is a non-contact force."

- **Causes Vertical Motion:** Objects thrown upwards slow down, stop, and fall back down due to this force, undergoing "vertical motion."

4. Weight and Its Measurement

Weight is defined as **"the force with which the Earth pulls an object towards itself."** As a force, its SI unit is also the **newton (N).**

- **Measurement:** Weight can be measured using a **spring balance**, which works by measuring the stretch in a spring caused by the gravitational force on an object. The stretch is proportional to the weight.
- **Variation:** The Earth "pulls different objects with different forces, that is, the weight of different objects is different." Moreover, "gravitational force can vary very slightly from place to place on the Earth (and can be very different on different planets), weight can change." For example, an object with a mass of 1 kg weighs 10 N on Earth but only 1.6 N on the Moon.

Distinction Between Weight and Mass

- **Mass:** "Mass is the amount of matter in an object and is measured in grams (g) or kilograms (kg). Its value remains the same at every place."
- **Weight:** "Weight, on the other hand, is the gravitational force with which the Earth (or another planet) pulls an object."
- **Everyday Language:** In everyday life, the term "weight" is often used colloquially to refer to mass (e.g., "weight of the wheat bag is 10 kg"), but scientifically, "it is important to use the correct terms with their correct units."

5. Floating and Sinking (Buoyant Force)

When an object is placed in a liquid, it experiences an **upward force** known as **upthrust or buoyant force.** This force is applied by the liquid.

- **Interaction of Forces:** "When an object is placed in a liquid, the gravitational force due to the Earth acts on it downwards. But a buoyant force is applied on it by the liquid in the upward direction."
- **Floating vs. Sinking:**If "the gravitational force is more than the buoyant force, the object sinks."
- If "the two forces are equal, the object floats."
- **Archimedes' Principle:** This principle states that "when an object is fully or partially immersed in a liquid, it experiences an upward force which is equal to the weight of the liquid it displaces."
- Sinking occurs if "the weight of a liquid displaced by an object is smaller than the weight of the object."
- Floating occurs if "the weight of the liquid displaced is equal to the weight of the object."
- **Factors Affecting Buoyancy:** "One of the factors on which the buoyant force depends upon, is the density of the liquid."

Conclusion

Forces are fundamental to understanding the physical world around us, influencing everything from pedaling a bicycle uphill to the celestial dance of planets. They are an interaction between objects, capable of causing motion, changing speed and direction, and altering shapes. Understanding the various types of forces—contact forces like muscular force and friction, and non-contact forces like magnetic, electrostatic, and gravitational forces—provides a comprehensive framework for explaining everyday phenomena. The concepts of weight, distinct from mass, and the buoyant force acting in liquids further elaborate on how these interactions manifest.