PHYSICS

MATRICULATION

STANDARD

X

Untouchability is a sin
Untouchability is a crime
Untouchability is inhuman

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PREFACE

As a teacher of Physics, I have always found myself inspired by the words of Professor D.S. Kothari, a renowned Physicist who often said to his students, "You must regard yourself fortunate that you have got a chance to study Physics, for Physics a fundamental and exciting science, is the basis of all sciences". This book has been meticulously designed to provide a seamless transition to the Higher Secondary course. The enriched contents will accelerate the desire to probe into the concepts. The challenging presentation of physical ideas aim at developing the spirit of enquiry, to enhance creativity and aesthetic sense. Each concept has been explained clearly, in simple and lucid language in order to amplify the students' scientific temper for problem solving and critical thinking. The systematic and progressive explanations and illustrations, evolve a logical approach and rational analysis, enabling the students to master the essence of science in general and physics in particular.

The salient features of this book are

* The thorough explanation of concepts lead the students gradually and methodically from the known to the unknown.
* The concepts explained are based on daily life situation.
* 'Let us muse upon' - provided at the end of each chapter serve as a ready reckoner for quick revision.
* Every chapter has a number of thought provoking questions.

The information given under 'Know it yourself' is only to enhance the knowledge of the students and not for evaluation.

Dr. N. Vijayan
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CONTENTS

1. MECHANICS

'Joy in looking and comprehending is nature's most beautiful gift', said Albert Einstein.

In the world around us, we see a falling apple, an orbiting satellite, a speeding race car, an acrobat balancing on a bar. This is what 'Mechanics' is all about.

Mechanics is that branch of physics which deals with the conditions of rest or motion of bodies around us. Statics is that branch of mechanics which deals with the science of forces balancing one another. Dynamics is that branch of mechanics which deals with the motion of bodies under the action of forces.

The falling apple reminds us of Sir Isaac Newton. He was Einstein's predecessor in understanding gravity. His theories of gravity help us to explain the fall of an apple or the path of a satellite. Albert Einstien represents the human spirit and creative drive in all of us. Now it is your turn to experience the excitement and challenge of Physics.

In this chapter, we shall study about the fundamental concepts of centre of gravity, projectile motion and circular motion.

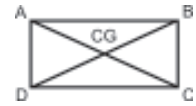
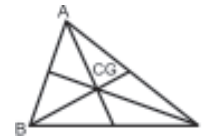
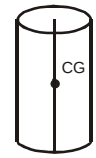
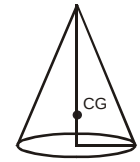
1.1 Centre of gravity

All objects are made up of tiny particles. Each particle has a mass of negligible volume. These particles behave as if their mass is concentrated at some point. The point at which their mass appears to act or is concentrated is called its 'centre of mass'. When the shape of the object is regular, then the centre of mass is its geometric centre.

When an object falls towards the earth, every particle of the object is pulled by the force of gravity and the object behaves as if all that force is concentrated at one point in the object. This point is called the 'centre of gravity'

The centre of gravity of an object is a fixed point through which the entire weight of the object acts, irrespective of the position of the object.

TABLE 1.1 Centre of gravity of regular objects

No.	Name of the object	Figure denoting the position of the centre of gravity	Position of the centre of gravity of the object
1.	Uniform rod.		At the midpoint of the rod.
2.	Rectangle.		At the point of intersection of the diagonals.
3.	Circular ring, disc, solid sphere, hollow sphere.		At its geometric centre.
4.	Triangle.		At the point of intersection of the medians. This point is called the centroid.
5.	Right cylinder.		At the midpoint of its axis, h/2 from the base where 'h' is the height of the cylinder.
6.	Solid cone.		At a point on the axis, h/4 from the base where 'h' is the height of the cone.

1.2 Illustrations for the stability of bodies

(a) A man carrying a bucket of water in his right hand, leans towards his left. He does it to keep the vertical line through the centre of gravity fall between his legs.

(b) The bottom of a ship is made heavy, to keep the centre of gravity as low as possible. The cargo is kept at the base of the ship and this makes the ship stable.

(c) In the 'Leaning Tower' of Pisa in Italy, the vertical line through the centre of gravity falls within the base of the tower. Thus the tower does not fall and remains stable. (Fig. 1.1).

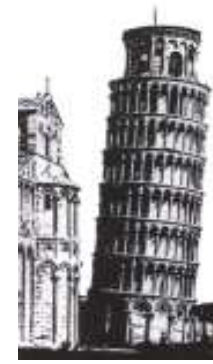


Fig. 1.1 The leaning tower of Pisa

(d) A student carrying a school bag and climbing up a flight of stairs always leans forward to maintain his stability.

(e) 'Tanjore - dolls' and 'Hit-me' dolls have a broad and heavy base to enable them to come back to a vertical position when they are knocked down. (Fig. 1.2).

Fig. 1.2 Tanjore doll.

Conditions for the stability of bodies

From the above illustrations it is understood that the following conditions are necessary for an object to be stable.

(i) The base of the body should be broad.

(ii) The centre of gravity should be as low as possible.

(iii) The vertical line through the centre of gravity should fall within the base.

1.3 Free fall

Galileo stated "In the absence of air resistance, all bodies fall at the same acceleration, which is approximately 9.8 m s^{-2}".

The value of acceleration due to gravity at different locations are given below.

TABLE 1.2

Location	Acceleration due to gravity (m s^{-2})
1. At the equator	9.780
2. At the poles	9.832
3. At Chennai	9.782
4. At the surface of the earth (average)	9.8
5. At the centre of the earth	zero

An object is said to have a free fall when it falls vertically under the influence of gravity alone, free from air resistance.

Examples

(i) Fruits like ripe mangoes falling from a tree.
(ii) A skydiver with an unopened parachute.
(iii) Bungee jumper.

Galileo Galilei

Imagine a body falling from a certain height. In each succeeding second of its fall, it is seen that the velocity of the body increases by 9.8 m s^{-1}. Initially the velocity of the body is zero . As it descends down, the velocity increases and reaches a maximum value on reaching the ground.

1.3.1 Newton's feather and coin experiment

A dry leaf, a feather or a sheet of paper may flutter to the ground, while, a stone or a coin falls rapidly. The fact that air resistance is responsible for these different accelerations is explained with the 'Feather and coin' experiment performed by Sir Isaac Newton.

Newton took a long glass tube as shown in Fig. 1.3 and dropped a feather and a coin simultaneously into it. He noticed that the coin travelled much faster than the feather because of the air inside the tube.

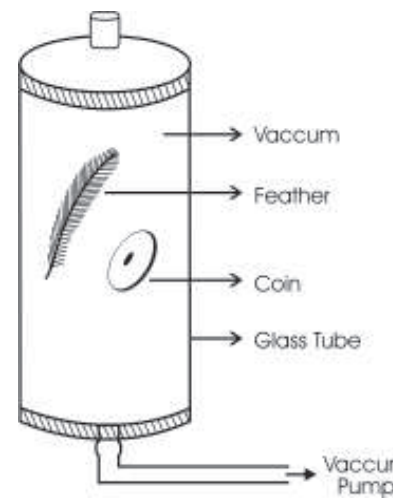


Fig. 1.3 Feather and coin experiment

Then the air from the glass tube was removed with the help of a vacuum pump. When the experiment was repeated, the coin and the feather reached the other end of the tube at the same time.

From this experiment he proved that in the absence of air, all objects fall with the same acceleration. Thus Galileo's statement was proved by Newton.

The velocity of a freely falling object (under the influence of the force of gravity) increases at a constant rate. Hence, it is said to be accelerated. This acceleration is known as 'acceleration due to gravity' and it is denoted as 'g'. The average value of 'g' has been found to be 9.8 m s^{-2}.

Sir Isaac Newton

1.3.2 Equations of motion for a freely falling object

When an object is dropped from a certain height

initial velocity $u = 0$

acceleration due to gravity $a = +g$

displacement $s = h$

$v = u + at$ becomes $v = gt$

$s = ut + \frac{1}{2} at^2$ becomes $h = \frac{1}{2} gt^2$

$v^2 = u^2 + 2as$ becomes $v^2 = 2gh$

When an object is thrown vertically up,

initial velocity $u = u$

acceleration due to gravity $a = -g$

displacement $s = h$

final velocity $v = 0$ at the maximum height

$u = gt$

$h = ut - \frac{1}{2} gt^2$

$u^2 = 2ghh$