

**Gyan Bharati School
Block D, Saket, New Delhi
Affiliated to C.B.S.E
Presents
A Morning with Newton**



**Subject: Physics
Class: IX
Chapter: Force and Laws of Motion
Topic: Laws of Motion**

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DISCLAIMER

Unless otherwise indicated, all the names, characters, businesses, places, events and incidents in this book are either the product of the author's imagination or used in a fictitious manner. Any resemblance to actual persons, living or dead, or actual events is purely coincidental.



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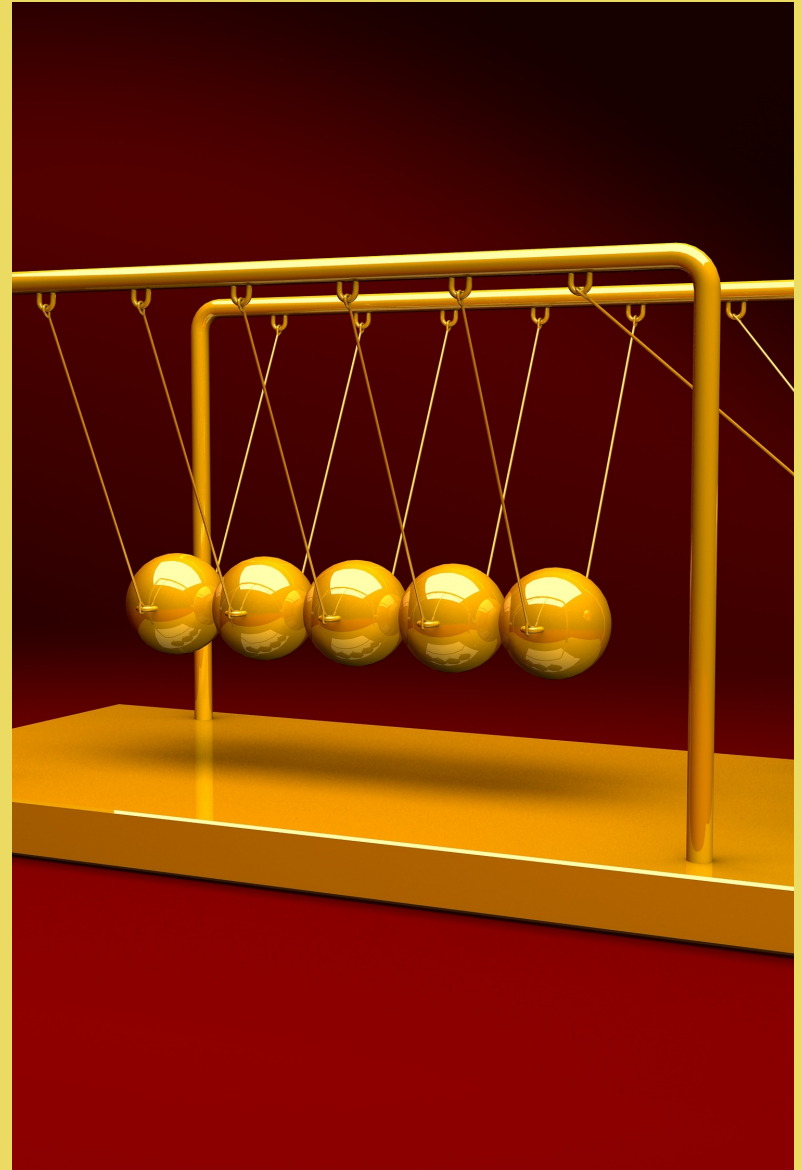
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The objective of the novel is to nurture the curious eye of the learners, create an ecosystem for them to experience, engage and penetrate further into the realms of reason and to become the masters of their own learning. Our aim is to inculcate the spark to learn and to sustain the fire that motivates us to forge ahead.

***Mr. Sanjay Bhardwaj
Ms. Simran Bhatia***

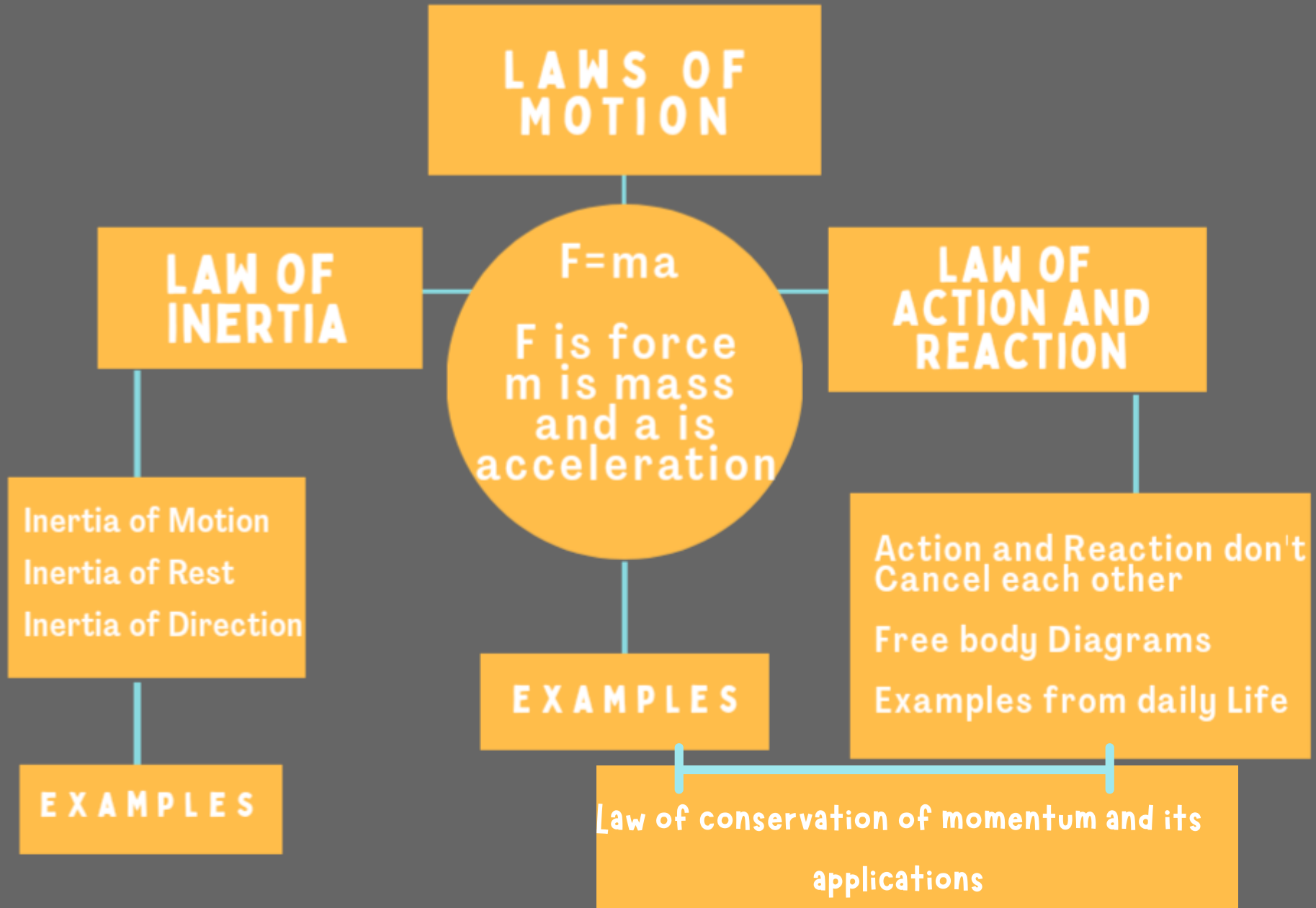
LEARNING OUTCOMES:

The children will be able to

- * Identify examples and situations that illustrate the use of Newton's first Law of motion and Inertia.**
- * Examine forces acting on a body in order to determine change in body's motion as a consequence of resultant force**
- * Apply Newton's Second Law of Motion and calculate rate of change of momentum in objects.**
- * Identify situations that demonstrate the application of Newton's third Law of Motion.**

STORY OUTLINE

What starts as an exchange about the general tendency of mankind to comfortably stay in their beds turns into a learning moment as the father introduces the concept of inertia to his daughter.



GLOSSARY

****Acceleration: rate of change of velocity is called acceleration. A motion is accelerated if the speed of the body changes or its direction of motion changes.***

****Inertia: the tendency of body to resist a change. In motion, inertia depends on mass. Heavier bodies have more inertia.***

****Force: A push or pull is called force. A force is necessary to accelerate a body.***

****Balanced and unbalanced force: If net addition of all the forces on an object is zero then the forces action on it are called Balanced Forces but if net addition of all the forces is not zero then the forces are termed as unbalanced forces. A body accelerates only when an unbalanced force is applied on object***

****newton (N): it is the unit of force in S.I system of units. 1newton= 1 kg m/s²***

****Newton's laws of motion: A set of three physical laws which describe the relationship between the forces acting on a body and its motion due to those forces. Together they form the basis for classical or Newtonian mechanics.***

****Momentum: the product of mass and velocity of the body is called momentum.***

****Conservation of momentum: the momentum of a system of particles remains constant if no external force acts on the system.***

Character Introduction!

Sanjay - A father whose passion for Physics knows no bounds.

Samriddhi - An
Inquisitive
Daughter!



Sanjay was trying to wake up his daughter as her Physics homework was pending.

11



Samriddhi, you need to wake up! Who will finish your homework?

Papa! Just 10 more minutes!



Don't convert my morning walk into the evening stroll. You need to get up or I'm leaving without you.

Why do you insist to go on an early morning walk? Why can't we go little later?



Do I witness resistance in my daughter, a property that can be seen in all bodies?



What property?



This property of resisting change is called Inertia.

Yes, we studied it in Science. But what does it have to do with getting up early?



Open your eyes Samriddhi and you will witness the wonders of Science all around you.



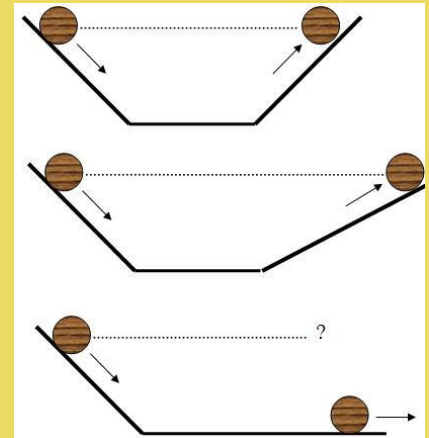
Alright, then the wonders can wait while I keep my eyes shut.

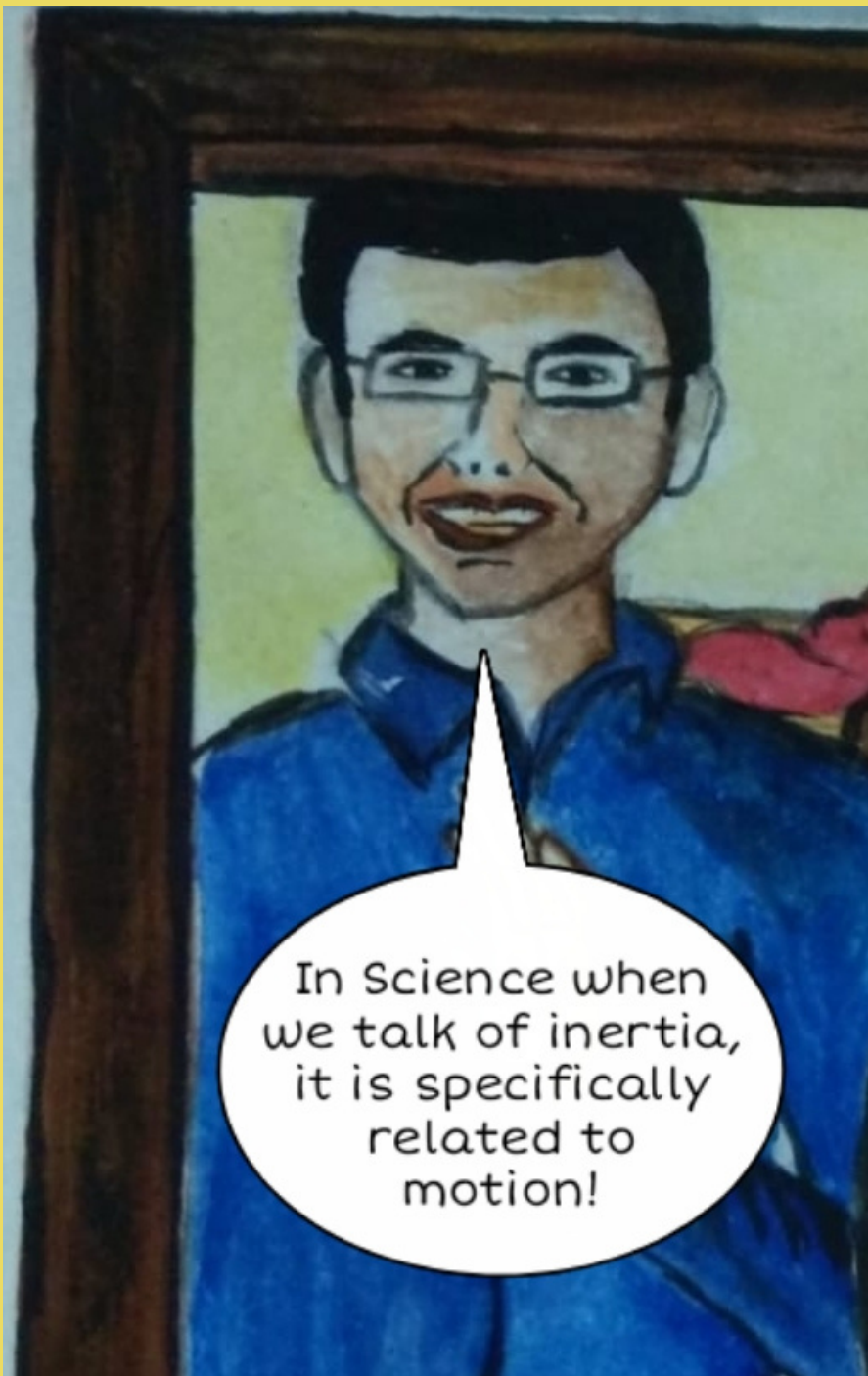
Sanjay and Samriddhi decided to go for a walk.



Galileo Galilei

Galileo Galilei was born on 15 February 1564 in Pisa Italy. He performed an experiment in which he considered rolling balls on inclined planes in the absence of friction or other resistant forces. The speed acquired by a body moving down a plane from a certain height was sufficient to enable it to reach the same height when climbing up another plane at a different inclination. As the angle decreases, the body should travel a greater distance. Galileo proposed that the body could travel indefinitely if the plane is flat. Therefore, Galileo can be credited with introducing the concept of inertia, later exploited by Newton.







There is inertia of rest,
inertia of motion and
inertia of direction and
it is.....

No...let me try! A body at
rest has a tendency to
remain at rest and a body
moving with certain speed
has a tendency to
maintain that speed and
also to maintain the
direction of motion!



Good! Why do we jerk off the wet clothes before drying them?

Simple, the water droplets on the wet clothes are at rest and therefore have a tendency to remain at rest. When we jerk off the clothes, water molecules are separated from the surface of the cloth.

Sanjay and Samriddhi go for a bicycle ride on the next day.



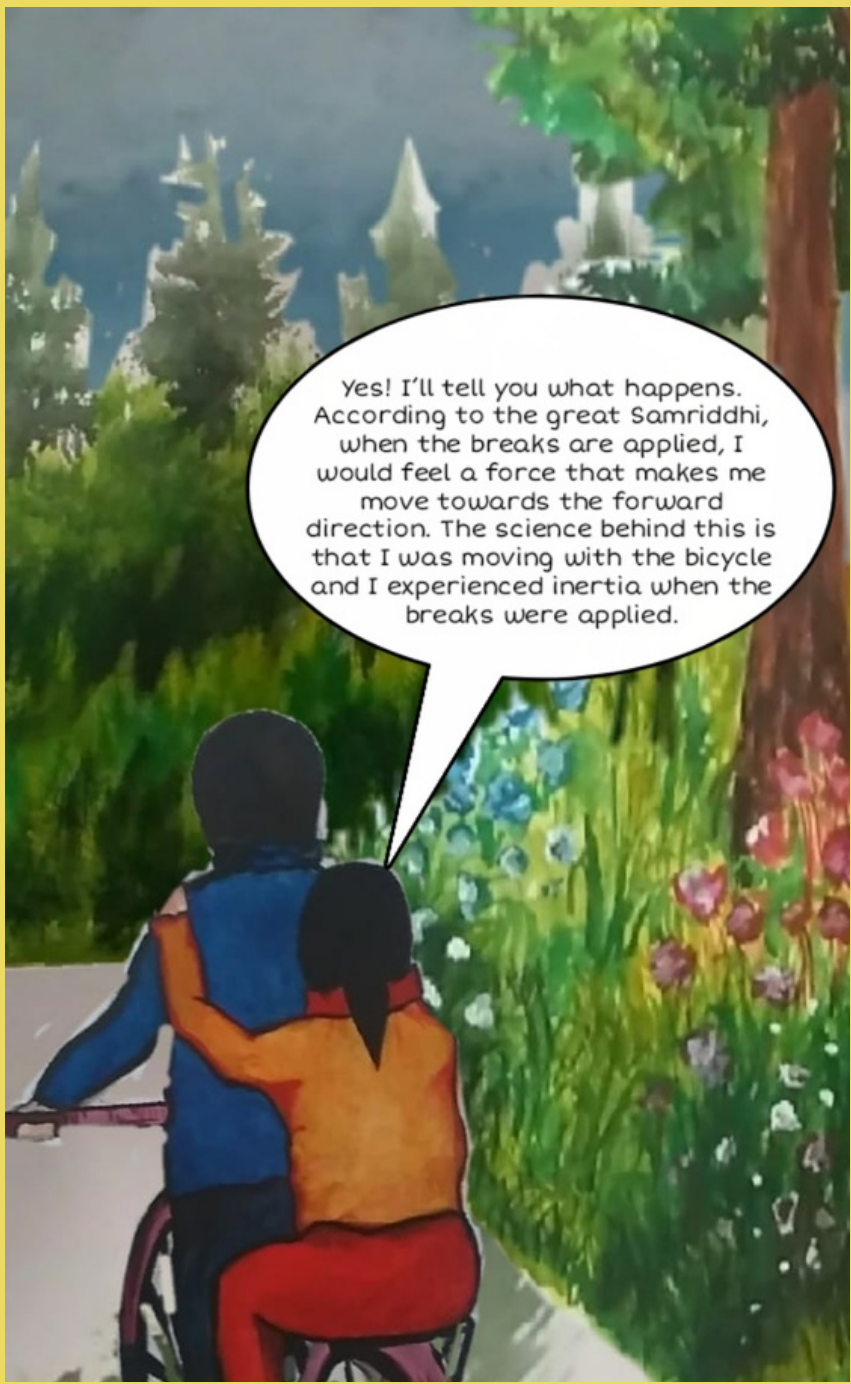


How exactly do you intend to fall? Care to explain?

Yes professor! When the cycle starts moving my lower body part starts moving with it but the upper part wants to remain at rest. That is why I feel a backward push that could potentially misbalance me, result in my fall and ergo break my teeth!

A man with short black hair and glasses, wearing a blue button-down shirt, is riding a bicycle. A young child with dark hair is sitting behind him, holding onto his shoulders. They are on a path surrounded by lush green trees and flowers. In the background, a castle with white spires is visible through the foliage.

Okay Einstein! Now, I am going to apply the breaks Samriddhi. Let's observe what happens.

The same man and child from the previous panel are shown from behind, riding the bicycle away on the path. The man is wearing a blue shirt and the child is wearing an orange shirt and red pants. The background remains the same with greenery and a castle in the distance.

Yes! I'll tell you what happens. According to the great Samriddhi, when the breaks are applied, I would feel a force that makes me move towards the forward direction. The science behind this is that I was moving with the bicycle and I experienced inertia when the breaks were applied.



Samriddhi and her father have reached home now.

Yes, because it's the cycle that is taking a turn and upper body still wants to move in the direction it was moving. And now brace yourself, I have to apply the brakes as we have reached home.

Okay... Papa, so the law of inertia states that a body at rest remains at rest and a body in motion has a tendency to continue in that state if left undisturbed. Just as you have a tendency to irritate me every time we go out.



LAW OF INERTIA OR NEWTON'S FIRST LAW OF MOTION:

An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

**When pedaling a bicycle, if you stop pedaling, then the bike continues going until friction or gravity slows it down.*

**If you are rolling a cart with something on top and you hit something that makes the cart stop, what is on top may fall off.*

What do we know? What have we learnt?

- *If an index card is placed on top of a glass with a penny on top of it, the index card can be quickly removed while the penny falls straight into the glass! Why?*
- *If we jump from a moving bus, we tend to fall in forward direction! Why?*







But Papa, is there a way to overcome the inertia?

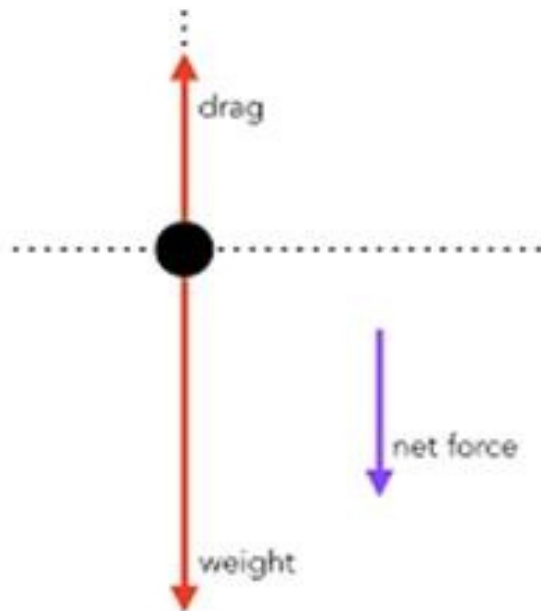
Push or pull can set a stationary object in motion, it can change the speed or even the direction of a moving body.



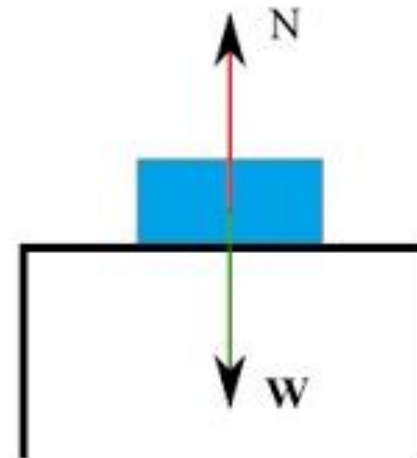
It is this push
or pull that is
called force.

Voila! Finally you are
speaking in a language
that I can understand.
Congratulations for
successfully explaining
the concept of 'force' to
me and not enabling the
force in me to run away
from you.





On a freely falling ball two forces are acting, Weight in downward direction and air drag in upward direction. But weight is more than the drag so the ball accelerates downward. The forces are said to be unbalanced.



On an object placed on a table two forces are acting, weight in downward direction and the reaction by the table in upward direction. Both are equal and opposite so the force on the object is zero and the object does not accelerate. The forces are said to be balanced.



And is there a way that all of these quantities could be tied together?

Of course! We can thank Newton for that who gave us the second law of motion i.e. $\text{Force} = \text{mass} \times \text{acceleration}$!

NEWTON'S SECOND LAW OF MOTION:

The product of mass and velocity of a body is called momentum of the body. Newton's second laws of motion states that the force acting on a body is equal to the rate of change of momentum of the body.

If a body of mass m is moving with velocity u and a force f onto it changes its velocity to v in time t , then

Change in momentum $P_2 - P_1 = mv - mu$

$F = (mv - mu)/t = ma$, where a is acceleration of the body

$$F = ma$$

So for bodies of constant masses the law can also be written as $F = ma$

If mass is in kg acceleration in m/s^2 then the unit of force is kgm/s^2 which is also called newton.

$$1 \text{ newton} = 1 \text{ kgm/s}^2$$

Time to Ponder!

** A cake is cut by Sara on her birthday, during cutting of the cake the force on the cake is applied*

- a. downward*
- b. upward*
- c. side ways*
- d. zero*

** If we take the mass of a body in kg, its acceleration in metre per second square and the unit of force as newton. Can you now define one newton force?*





our teacher told us that the speed of an object can be altered without touching it. Could it be possible?

Yes, for an example - Earth is moving around the sun in an elliptical path changing its direction continuously because the sun is pulling it towards itself.



CONTACT AND NON-CONTACT FORCES:

A contact force is one that one body applies on other when they come in contact while a non-contact force is a force applied to an object by another body that is not in direct contact with it.

Examples of contact forces:

- * When a moving ball hits us we feel a force due to contact.*
- * The force of friction that acts between two bodies in contact*
- * Buoyant force*

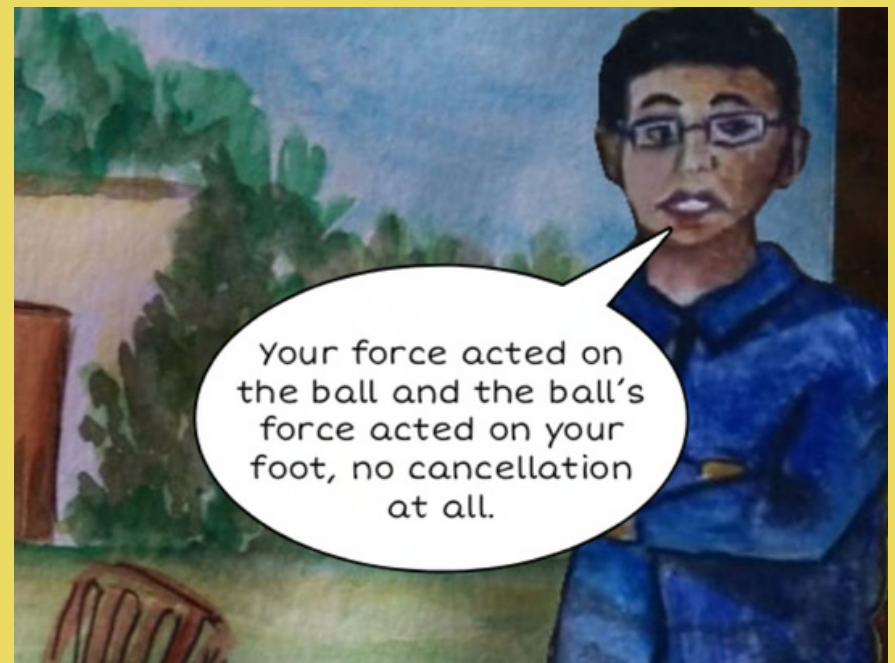
Examples of non- contact forces:

- * Force of gravity such as the force between the sun and the earth*
- * The electrostatic force between two charges*
- * The magnetic force between two magnets*









NEWTON'S THIRD LAW OF MOTION:

If an object A exerts a force on object B, then object B also exerts a force of equal magnitude and opposite direction back on object A.

This law actually tells that forces always occur in pairs, and one body cannot exert a force on another without experiencing a force itself. We also call it the law of action-reaction, where the force exerted is the action and the force experienced as a consequence is the reaction.

Examples of third law:

** Rockets move forward by expelling gas backward at high velocity. This means the rocket exerts a large backward force on the gas and the gas therefore exerts a large reaction force forward on the rocket.*

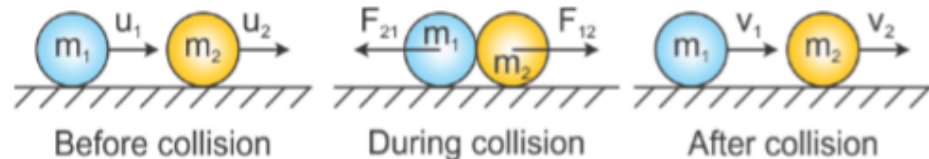
** We move forward by pushing the ground backward. The action is the force on ground by us and reaction of this force is in forward direction on us which helps us to move.*

MOMENTUM CONSERVATION PRINCIPLE

Law of conservation of momentum states that for two or more bodies in an isolated system total momentum remains constant unless an external force is applied. Therefore, momentum can neither be created nor destroyed. This principle is a direct consequence of Newton's third law of motion.

Newton's third law states that for a force applied by an object 1 on object 2, object 2 exerts back an equal force in magnitude, but opposite in direction. This idea may be used to derive the law of conservation of momentum.

Consider two colliding particles 1 and 2 whose masses are m_1 and m_2 with initial and final velocities as u_1 and v_1 of 1 and u_2 and v_2 of 2. The time of contact between two particles is given as t .



change in momentum of particle A = $m_1(V_1 - U_1)$

change in momentum of particle B = $m_2(V_2 - U_2)$

from third law of motion the force on second body due to first is equal and opposite to the force on first body due to the second, $F_{21} = -F_{12}$

multiplying both sides by time t .

$$F_{21} \times t = -F_{12} \times t$$

$$m_2(V_2 - U_2) = -m_1(V_1 - U_1)$$

$$m_2V_2 + m_1V_1 = m_2U_2 + m_1U_1$$

This is the equation of law of conservation of momentum. where $m_2U_2 + m_1U_1$ is the total momentum of particles A and B before the collision and $m_2V_2 + m_1V_1$ is the total momentum of particles A and B after the collision.

The thrust that you feel at the time of firing is one of the real-life examples of the conservation of momentum.



Now lets
play a
quiz!

Yes! I feel that
now I know all
these laws.

Now that Samriddhi and Sanjay are inside, Sanjay decide to quiz her.







What do we know ? What have we learnt?

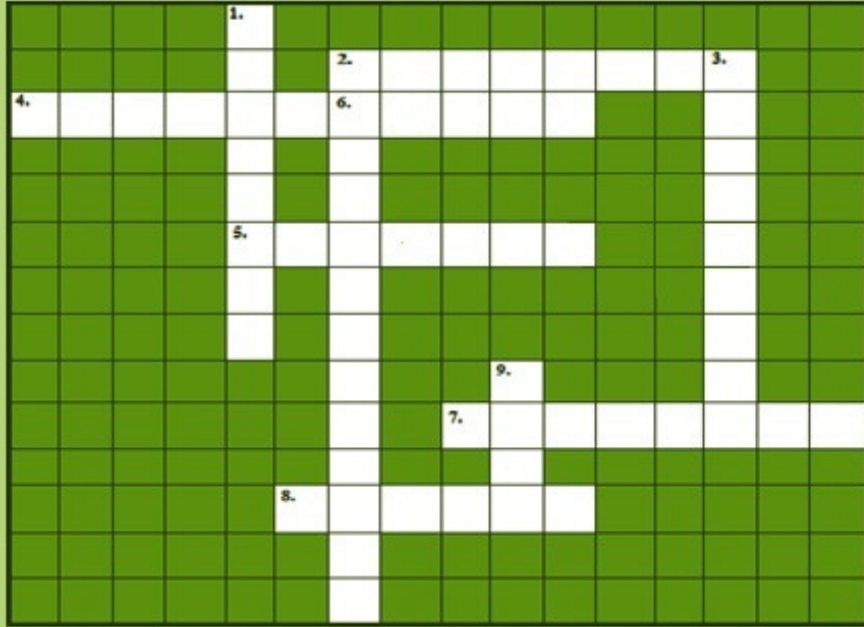


Find the reason:

- 1. Why is it dangerous to jump out of a moving bus?***
- 2. How do safety belts of cars help in preventing accidents?***
- 3. Why does one get hurt on jumping from a great height to the floor?***
- 4. If first law of motion holds true, why does a ball rolling on ground stop on its own?***
- 5. What would happen if gravitational force of the Sun suddenly vanishes?***
- 6. What did Galileo observe by placing two inclined planes facing each other and rolling down a marble ball from top end of one of them?***
- 7. In a cricket match, why does a player lower his hands slightly while catching the ball?***
- 8. When a force acting on a body has equal and opposite reaction, then why should the body move at all?***

CROSSWORD PUZZLE

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ACROSS

2. ____ forces don't produce acceleration.

4. for a freely falling body, force of ____ is more than the upthrust.

5. The resistance offered by an object to change its state of motion ____.

7. Force can change the ____.

8. Equal forces produce ____ acceleration in lighter bodies.

DOWN

1. A rolling ball stops due to ____.

3. Action and reaction do not cancel each other because they act on ____ bodies.

6. Without force there can't be any ____.

9. Heavier bodies have ____ inertia.



FROM THE PRINCIPAL'S DESK

We at the Gyan Bharati School sincerely hope that this graphic novel, A MORNING WITH NEWTON based on the theme, Laws of Motion from the Class IX science Text Book, will prove greatly beneficial to educators and students alike. This graphic novel has been illustrated by a class IX student, Samriddhi Bhardwaj and the tech support has been provided by Parv Marvah (class XI) and Aniketh Patwal (class IX), with support from their teachers. The immense learning and skill development that the students have experienced in the process has been note worthy.

The popularity of the Graphic Novel is on the rise and it is steadily being recognised as a visual literacy tool for educating. I feel that a child's engagement with this genre whether as a writer, illustrator or a reader can bring about enhancement in learning, skill building and engagement with books, in a joyful manner. Surely, this format will help encourage the love for reading, develop comprehension and vocabulary and an understanding of grammar rules along with the much needed reading confidence in the reluctant reader. Above all, students can comprehend apparently abstract concepts in a simpler way, as evident in this Graphic Novel.

It is felt that children struggling with learning disabilities will find this book easy to read without getting overwhelmed as they do with lessons mostly comprising text.

I appreciate the school Vice Principal Mr. Sanjay Bhardwaj, for the passion he has for his subject, Physics and for the lucid script. Much valued is the contribution of Ms. Simran Bhatia, who teaches Mathematics for having extended technical support.

I take this opportunity to express our thankfulness while acknowledging the constant support and guidance of Mr. Sandeep Sethi (Director Education, MGIS Museum Trust) as he mentored our teachers on this journey of new learnings. Sincerely,

Nishi Misra Manglik

Principal,

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