Water Rokit

Newton's Law of Inertia

This session consists of:

- An introduction to this session.
- How moving objects behave.
- Newton's First Law of Motion.
- What is inertia?
- Examples of inertia.
- A quiz.
- Experiments.
- Videos.

At Water Rokit, we inspire learning though inspirational characters and stories.

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A Table of Contents

Introduction

We're going to split this law into two, so you can grab a basic understanding of each area.

In part 1 of this session, we're going to look at moving objects and how they behave both on Earth and in Space. In part 2, we'll discover what inertia is.

Part 1: A Moving Object

Place your Water Rokit or another object on the table in front of you.

See if you can make it move without touching it, and no cheating by throwing something at it! No, we're not asking you to perform a Jedi mind trick from Star Wars.

Question 1: Can you tell me why the Water Rokit or object didn't move?

Unless you push, pull, or pick it up, or in scientific terms, **apply a force to it,** it won't move.

Now visualise a slippery ice rink with an ice hockey player. The player holds their stick and hits a puck straight down the middle of the rink. Using your imagination, watch whilst the puck gracefully slides along the smooth, almost frictionless surface. It seems like it's never going to stop unless another player hits it, or else it runs into the net.

Newton's First Law of Motion

Question 2: Can anyone tell me what Newton's First Law is?

"An object at rest will remain at rest, and an object in motion will remain in motion, unless it's acted upon by some external force."

If this ice puck were travelling in the vacuum of Space where there is no atmosphere and hardly any particles, no friction and no resistance, whatever velocity it has (which is just speed with direction) it would keep and retain. The puck would continue on its journey indefinitely. In other words, it would keep on going and going in the same direction it was first hit by the stick forever and ever (unless it bumped into something else).

After talking about the puck in Space, there are a couple of words we've mentioned that we should understand more about before we continue.

The first word is **vaccuum** – and I don't mean a vacuum cleaner or hoover!

Question 3: Who can explain what a vacuum is?

"A vacuum is a space where there is no pressure gas or matter, and no air."

You may think when you've finished your glass of juice that the glass is empty – but it's still full of air molecules.

A complete vacuum doesn't really exist in Space. There are usually a few tiny particles hanging around being lonely and probably feeling a bit bored, but in a vacuum, not a lot else is kicking about – nothing significant anyway. (There may be some dark matter, but I will leave you to research that one.)

This video shows the effects of a vaccuum on the body.

The second important word to understand is **friction.**

Question 4: Who can explain what friction is?

"Friction is the force which opposes the motion of an object, it always acts in the direction opposite to the direction of motion."

Have you ever noticed how easy it is to ride your bike on a smooth road compared to a rough surface? The smoother the surface, the easier it is to peddle. When you're on a rough surface like gravel, it takes much more effort because there is more resistance when riding on gravel.

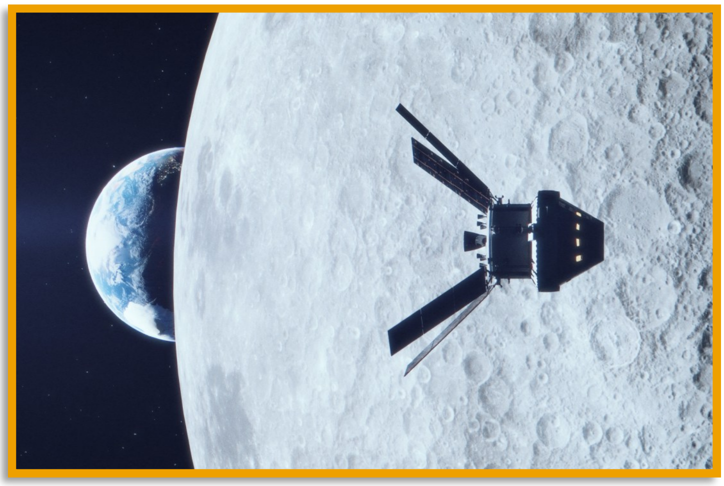
Check out this quick video on friction!

So, let's get back to this idea that things either stay put, or they just keep on moving unless something intervenes.

This is the big one to wrap your head around. This never-ending motion in Space is a **UNIVERSAL CONSTANT.** A constant means that it always happens. As we have already said, an object will continue at its same velocity (which is speed with direction) unless a force acts upon it. This is far easier to observe in Space because it's big, empty and vast!

On Earth, objects are subjected to many different forces like gravity, air resistance, and friction that cause them to start, accelerate, change direction, and stop – and an object often experiences several different forces at once. So, if you hear the term **NET FORCE,** it's all the forces added up together. We can talk about net force in another session.

Because of the forces we have on Earth, cars need a constant running engine to move because there is resistance from the atmosphere and friction from the road, which will eventually slow the car down. But up in Space, a rocket can accelerate to set velocity and then cruise at that constant velocity without end. Just like the Orion Space Capsule that travelled to and around the Moon and back. Apart from the occasional directional burn to keep it on course from its vacuum-designed engines, it used very little fuel because it was in Space.



So now we've got our heads around the first part of this law, let's get stuck into the next bit!

Part 2: Inertia

Question 5: Can anyone explain what inertia is?

Inertia is an object's resistance to a change in motion. The more mass an object has, the more inertia it has – let's look at this more closely.

Oh, and in case you didn't know – mass is the amount of stuff an object is made up from. An apple has a small amount of mass, compared to a car that has a lot more (we will discuss this again shortly).

So back to our Water Rokit, or our chosen object, sitting on our table. I hate to break it to you, but unless we do something to it, it will just sit there gathering dust, and that's no fun at all!

(I often think of The Law of Inertia as the **lazy law.** I know that if I don't **FORCE** my son to move, he will sit on his games console all day long! I hope none of you can relate to this example.)

I would like two volunteers to come up here.

I'm going to ask you both to carefully lift this empty chair up into the air.

Next, I need another willing and able volunteer.

(For this, I would choose one of the older and taller children in the class.)

I would like you to sit in the same chair.

Now, I would like our first two volunteers to try and gently lift the chair again.

Question 6: Who can tell me what happened, and why?

The chair with the person sitting in it, is more difficult to move and lift than the empty chair. It requires a bigger force to move it. This is because of the increase in its mass, and we now know that more mass, means greater inertia.

Inertia recap

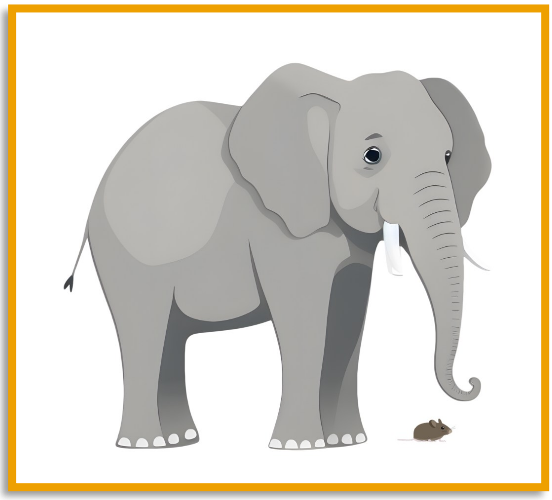
Inertia is the capacity of an object to resist a change in motion.

Inertia is proportional to the mass of an object. An object that has more **mass** has more inertia.

The chair that is empty has less **mass,** so less inertia, and therefore less resistance to motion. (It's easier to lift!)

Once a person sits in the chair there is more **mass,** therefore more inertia, so there is a greater resistance to motion, and the chair takes a lot more effort to lift.

Question 7: Can you remember from earlier what mass is?



Mass is the amount of matter or stuff an object contains. The more mass something has the more it will weigh.

For example, an elephant has a lot more mass than a mouse.

Question 8: Why, in Physics, do we tend to refer to MASS and not WEIGHT?

We do this because your weight can change in different environments and places. Weight is directly linked to how much gravity or force is exerted on an object. The more mass an object has (like a planet), the more gravity it has. For example, here on Earth, you weigh more than if you were on the Moon, as the Moon is 1/6th smaller in size than the Earth, so it has 1/6th of the gravity.

On the Moon, you would in fact weigh 1/6th of what you weigh on Earth because there is less force (gravity) acting upon you. That is why, in Physics, we talk about **mass**, as it's a constant amount, wherever you are.
(A constant means it doesn't change.)

Remember what we discovered earlier? In the absence of a force, an object will either remain still (at rest) or if it's moving, it will keep moving at the same velocity.

A force must be applied to an object to get it moving, and again to get it to stop. How easy it is to get that object moving, or to change its direction, or to stop it, is directly related to how much mass (and therefore inertia) it has.

Albert Einstein once said, "nothing happens until something moves".

Let’s look at some more real-life examples in practice

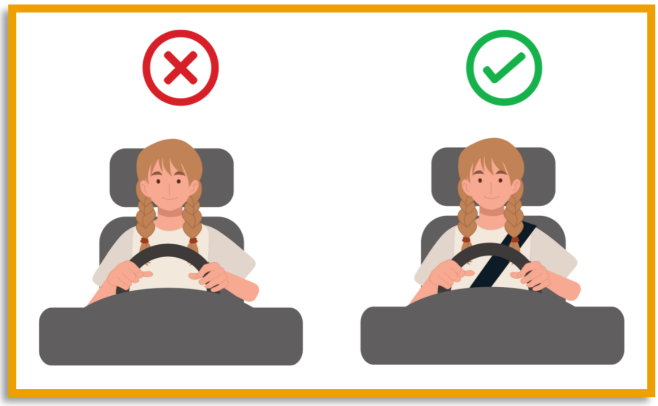
A toy sailing boat will move across the water with just the slightest gust of wind, and if it hits a rock, it will stop immediately on impact.

But with a gigantic cruise or cargo ship, because of its great inertial mass, it needs a huge force in the form of its powerful engines to get it moving. Plus, a lot of force needs to be applied to stop it in an emergency. Did you know that ocean liners and big ships shut off their engines miles and miles out at sea before they reach port, just to slow themselves down? They have a huge mass, so they take a long time to slow down and come to a stop.

Let’s consider your inertial mass.

Question 9 - Who can tell me why you need to wear a seat belt in a car?

If a car slows down suddenly and stops abruptly, your body will try to continue in the same direction. It takes another force to stop you from moving in the same direction, hence the seat belt.



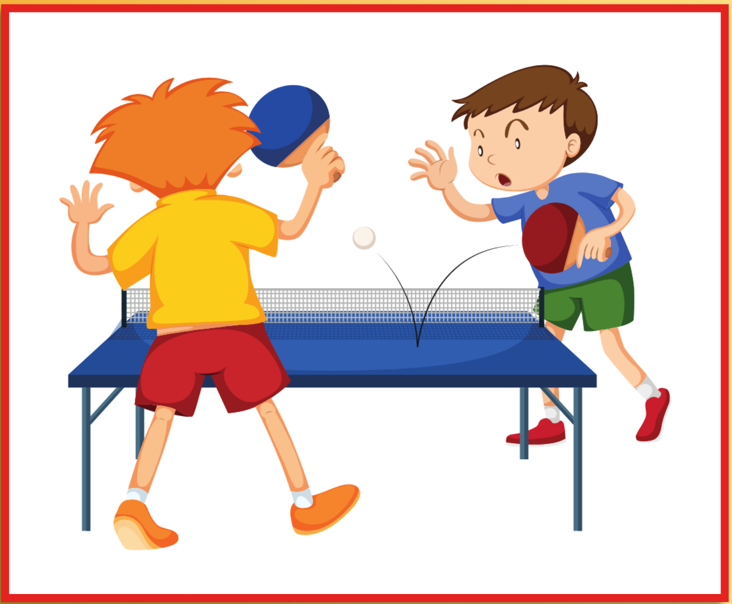
This is why people in the back seats of a car need seat belts too. If the car has to stop quickly, these people will be flung forwards.

Let's Wrap Things Up

Here is a **great comparison** that you can think about when you're having fun with your friends or family.

Next time you play table tennis, remember this session and think about how easy it is for you to flick a ping pong ball. Then, compare it to when you next go bowling.

You'll be able to explain to your friends and family what inertia is!



Quiz Time!

1. Force is applied to initiate motion for an object in…

A) Earth's atmosphere
B) Outer space
C) The ocean
D) All of the above

Answer: D) All of the above.

2. The inertia that an object possesses depends on its…

A) Velocity
B) Mass
C) Volume
D) None of the above

Answer: B) Mass.

3. What has more inertia?

A) A ping pong ball
B) A tennis ball
C) A bowling ball
D) A boulder

Answer: D) A boulder.

4. What happens to an object in motion if no force is applied to it?

A) It goes to the right and eventually stops
B) It continues in the same direction indefinitely
C) It lands on the ground
D) It floats in the air

Answer: B) It continues in the same direction indefinitely.

Experiments

The coin drop

Have a go at this experiment. Why do you think it works? Discuss with your group.

Water Rokit experiment

Let's head outside with our Water Rokit.

How do you increase the **mass**, and therefore the **inertia** of your Water Rokit?

What happens when you do this?

Answer: By increasing the amount of water in the bottle, you increase the Water Rokit's inertia. Find out the optimum amount of water that makes the Water Rokit fly as high as possible.

Videos

Inertia | Forces and Motion | Physics

Newton's First Law of Motion: Mass and Inertia