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## Classroom Resource

# Investigating Gravity and Falling Objects

Science Foundation Ireland For what's next

Ireland esero

# Investigation

# Investigating Gravity and Falling Objects

**Class Level** – All

## Curriculum Links

| | |
|---|---|
| **Strand:** | Energy and Forces |
| **Strand Unit:** | Forces |
| **Curriculum Objectives:** | Investigate falling objects: Come to appreciate that gravity is a force; Become aware that objects have weight because of the pull of gravity; Explore how some moving objects may be slowed down |
| **Skills Development:** | Questioning, Observing, Predicting, Investigating and Experimenting, Estimating and Measuring, Analysing, Recording and Communicating |
| **New words/vocabulary:** | Force, Gravity, Air resistance, Mass, Weight |
| **Focail nua:** | Forsa (force), Domhantarraingt (gravity), Ag titim (falling), An Domhan (Earth), An Gealach (The Moon), Friotaíocht aeir (air resistance), Paraisiút (parachute) |
| **Cross curricular links:** | Geography, Maths |
| **Equipment/materials** | • Sheets of paper, bottles, sand, mat/rug, selection of objects of different shape and mass.<br>• For parachutes: tissue paper, waste plastic, waste cloth, string, sticky tape, staples, paper clips, Lego® figures or small toys, plasticine |

# Engage

## Prompt questions / Wondering

- Why do things fall to towards the Earth?
- If you throw a ball in the air, why does it come back down?
- What would happen if you threw a ball into the air while standing in Australia? (The force of gravity is not up or down - it is towards the centre of the Earth)
- Why could you jump higher on the Moon than on Earth?
- What is the mass of 10Kg of potatoes on the Moon?
- If you hit a golf ball on the Moon with the same force as on the Earth, will it go further or just the same distance as it would on Earth?
- Can you feel the effects of gravity on your own body?

## Background information:

Much of this topic will involve lively debate and it is hoped the background information below will help you, the teacher, to guide this. Any search on Google on topics of gravity, gravitation, mass, and weight will give many very good resources. The Institute of Physics (IOP) website has some excellent material.

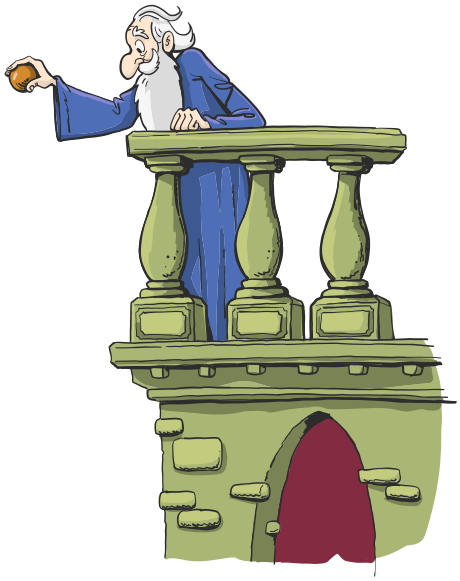
To move an object, force is needed. To slow down or stop a moving object, force is needed. This is obvious with moving cars, etc. If an object is held above the ground and released, it moves towards the ground. There must be a force causing the movement. This is the force of gravity which pulls everything towards the ground (to the centre of the Earth).

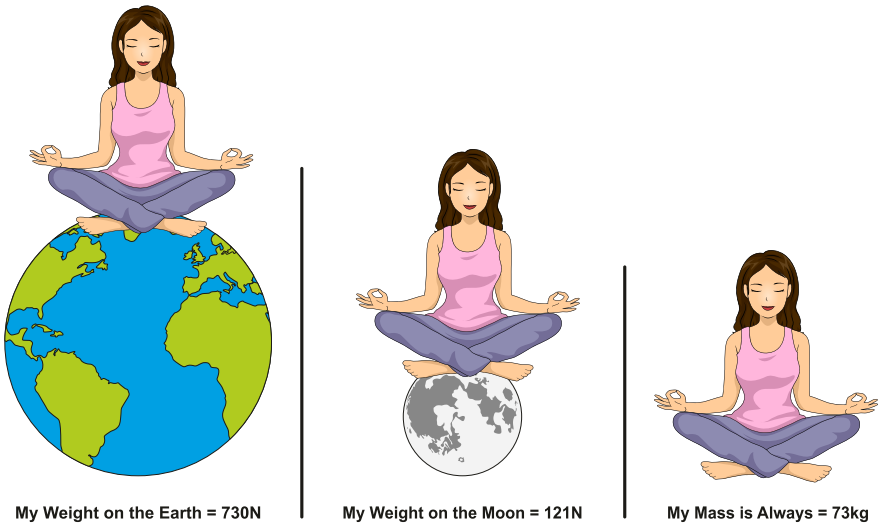
The Earth and all planets exert a gravitational force on all objects. The size of this force depends on the mass of the object. The greater the mass of an object, the greater the gravitational force on it.

The **mass** of an object is a measure of the amount of material in it. It is measured in kilograms. The greater the mass of an object, the harder it is to move or push it. It is twice as hard to move a 20kg object as it is to move a 10kg object along the same surface. Twice as much effort or force would have to be used.

The force of gravity acting on an object is called its **weight** and is measured in units called **Newtons**. Weight is what makes it difficult to lift an object. Gravity is a force pulling an object down towards the centre of the Earth. To lift the object, we must exert an upward force greater than the downward force of gravity. If the object has a big mass, there is a big gravitational force on it. We will have to use a big force to lift the object and so the weight of the object is big. Less force will have to be used to lift an object with smaller mass and therefore its weight is smaller. **The weight of an object is a measure of how hard it is to lift it.**

**It can be shown than that 1kg = approx. 10 Newtons on Earth.**





My Weight on the Earth = 730N | My Weight on the Moon = 121N | My Mass is Always = 73kg

What about gravity on the Moon? There is gravity on the Moon. The Moon is smaller and much lighter (has less mass) than the Earth. This means that the gravitational pull exerted by the Moon will be much less than that exerted by the Earth on the same object. It would be easier to lift the object on the Moon because the downward force is less. Therefore, the weight of the object on the Moon is less than that on the Earth. Mathematically, it can be shown that objects on the Moon are approximately 1/6$^{th}$ their weight on Earth. An object that weighs 560 N on Earth will weigh approx. 90 N on the Moon. Its mass on Earth and the Moon is 560/10=56kg. The mass of an object is the same wherever you are in the Universe.

If we had two objects of the same material on the Moon and on the Earth, it would take the very same effort or force to move them on the same surface. The mass of the object remains the same wherever it is. There is the very same amount of matter in the object wherever it is in the Universe. You do not get very skinny if you are in the Moon, but it would be much easier to lift you off the ground.

On Jupiter, you would weigh nearly three time more than on Earth. This is because the mass of Jupiter is far greater than that of the Earth and so the gravitational forces are far greater. Your mass on Jupiter is the same as on the Earth.

**Falling objects:** when two stones of different mass are dropped together from the same height, they both move towards the ground. As they move, they both accelerate at the same rate and they both hit the ground at the same time.

This is reputed to have been first observed by Galileo when he dropped two cannon balls of different masses from the Leaning Tower of Pisa. Since they have different masses, they have different gravitational forces acting on them and this keeps the acceleration the same for both. On the flat, a bigger force is needed to keep a lorry accelerating at the same rate as a car. On the Earth's surface, falling objects accelerate at a rate of approx. 10m/s$^2$.

This is all very good until a flat sheet of paper or feather is dropped from a height at the same time as a stone. The stone reaches the ground long before the sheet of paper.

The sheet of paper is being slowed down. This means there must be a force on it in an upward direction opposing the motion. What causes this force? **Air Resistance**. As the paper falls down it is colliding with molecules in the air. It has a large surface area and there are lots of collisions. As it accelerates, the rate of collisions increases, and the upward force increases and slows the paper down. The stone has a much bigger mass than the paper. Therefore, it experiences a much greater gravitational force. The upward force due to air resistance is relatively much smaller and the stone does not appear to be slowed down.

If the stone and sheet of paper were dropped in a vacuum where there is no air, they would hit the ground at the same time. There would not be any upward air resistance. Learners can view the video of astronaut David Scott dropping a feather and hammer on the Moon: https://youtu.be/oYEgdZ3iEKA

Air resistance is the principle for the working of a parachute.

## Real World Application:

Learners in 5th/6th class should become aware of the difference between mass and weight. The teacher should try to speak about the mass of objects rather than the using the term weight. Items in supermarkets are sold by mass, not weight e.g., 3 kilograms is the mass of a bag of potatoes, not the weight. Kilograms and grams are units of mass.

When we want to launch a rocket into space, there needs to be enough of a force to overcome the pull of gravity towards the Earth and launch the rocket. A parachute is designed to make use of the force of air resistance to counteract the force of gravity, and so it will slow down the falling object or person.

## Explore

The learners can explore the effect of gravity on various objects in the classroom by dropping them one by one. They can see the effect of gravity on objects.

Learners can also feel the effects of gravity on their own bodies. When you are standing, some of the blood in your body is pulled down towards your legs by gravity. If you lie on the floor with your legs in the air, you can feel the blood rushing to your head.

# Investigate

## Conducting the Investigation

- Drop a collection of solid objects observe how and where they fall. Question and discuss (Infants class).
- One bottle full of sand and a similar bottle half full. Drop both and observe fall. Question and discuss (1st/2nd class).
- Bottle of sand and sheet of paper crunched into a ball. Drop both and observe. Question and discuss (3rd/4th class).
- Bottle of sand and flat sheet of paper. Drop both and observe air resistance. Question and discuss (3rd/4th class).
- Discussion on weight, gravity on other planets and the Moon should be left for 5th/6th class.

Designing and making parachutes: This will follow on from investigation on air resistance.

Materials required: Range of materials for the parachute canopy – paper, cloth, waste soft plastic. String, Sellotape, scissors, plasticine/toy parachutists.

Design, make and test parachute. Best material, best shape, best size, length of strings, etc. What defines 'best.'

Fair testing - test alongside a toy/ plasticine of the same mass and shape with no parachute at the same height for a fair comparison.

# Take the Next Step

## Adapt for home:

Making different types of aeroplanes and rockets.

## Adapt for junior/senior level:

Juniors get concept of gravity from ideas about force.

Seniors look at concepts of weight, air resistance, etc.

Try the Paper Helicopters activity on www.curiousminds.ie

## Follow-up challenge/project/citizen science link:

Make a 'foam' rocket and test factors which influence its flight - applied force, angle of launch, fins, etc.

There is a separate document on how to make a foam rocket.