PhysicsKIT 4STEM

GRAVITY

Lesson Plans

[Scholé]

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1. Lesson Plan: Weightless water

1.1 General information

This lesson plan is about gravity. Gravity is a force that is all around us and it is responsible for attracting two objects towards each other.
This force has been around since the beginning of the universe, and it works the same way everywhere. It is the gravitational force that keeps us from falling off the Earth and what keeps Earth and all other Solar System planets orbiting around the sun. It was thanks to the gravitational force that the sun was formed, four and a half billion years ago.

1.2 Short description

In this lesson plan, and using everyday objects, students will be able to understand what gravity is and how you can see its effect on objects.
They will also be able to correctly use the vocabulary and terms regarding the gravity topic, such as gravity, mass, weight, force, attraction, for example.

1.3 Learning objectives

The main learning objectives for this lesson plan are:

- Acknowledge the existence of a force that pulls everything to the planet - gravity
- Understand what gravity is
- Reflect on the importance of gravity
- Experiment how the gravitational force works

1.4 Links to curriculum

The domains / topics to which this lesson plan can be linked are:

- Mathematics: the calculation procedure (equations)
- Physics: Gravity (gravitational force, effects of gravity)

1.5 Materials required

To perform this experiment, it will be required:

- Cups (plastic, paper or Styrofoam)
- Scissors or another sharpened object (to make holes in the cups)
- Water
- Tray or big container

1.6 Duration

It is expected that this lesson plan can take up to 90 minutes:

- Introduction and explanation of the activity: 15-30 minutes
- Experiment: 30 minutes
- Discussion and conclusion: 20-30 minutes.

2 Lesson Plan

2.1 Introduction

What are forces?

A force is defined as a push or pull move which can make things move, change direction, or change shape. A force has both magnitude and direction. It is measured in newtons and represented by the symbol F.

Forces can be identified everywhere in our world. For example, there is an object in our house, let us say a box. When the box stands still there are two forces applied to it, a force which pulls the object to the ground ensuring the box does not float in the air and an equal and opposite force pushing the box from the ground. When we try to change the box's position, we apply another force to it, which causes the box to move and change position. At the same instance, another force resists us pushing the box. There are also other forces applied to the box or us which are equally important to learn.

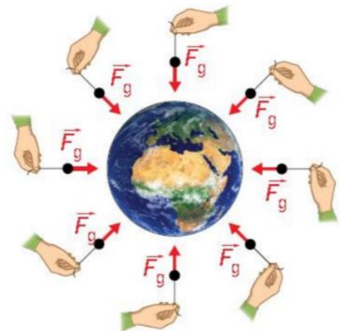
What is the gravitational force?

Any object that is dropped will fall on Earth and is falls due to a force.

This force, that acts on the body at distance, attracting it to Earth, is called gravitational force.

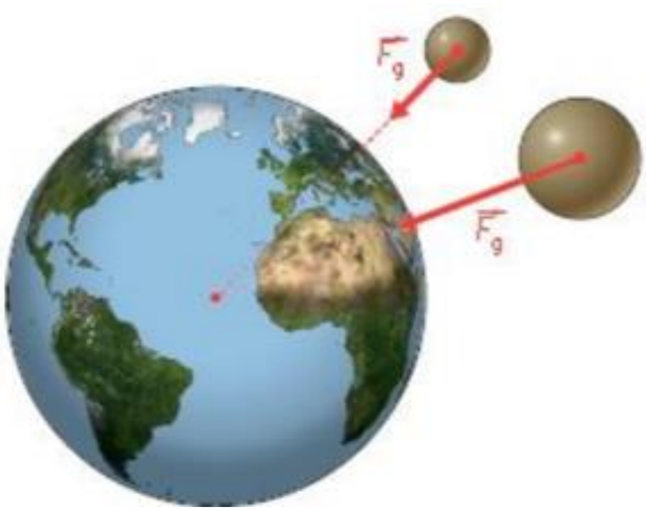
The gravitational force exerted by Earth on an object, wherever that object is, has:

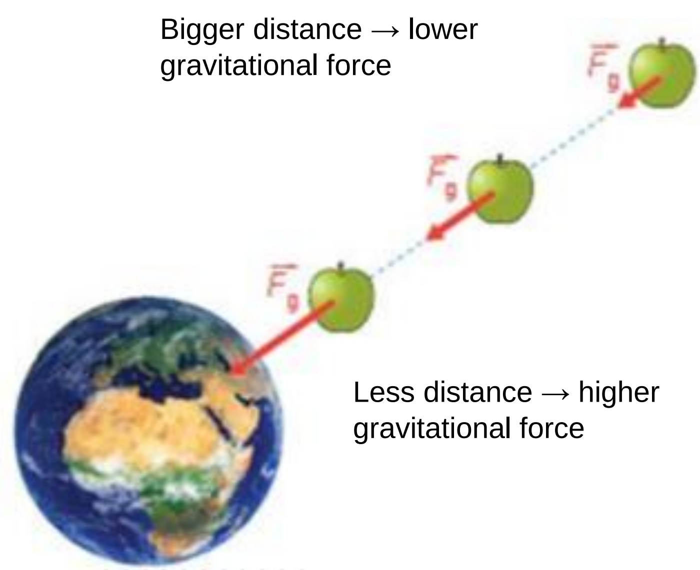
- The direction of the line that goes through the center of the object and the center of the planet Earth;
- The sense of the body to the Earth.



The intensity of this force depends on:

- The mass of the object;
- The distance between the object and the center of Earth;



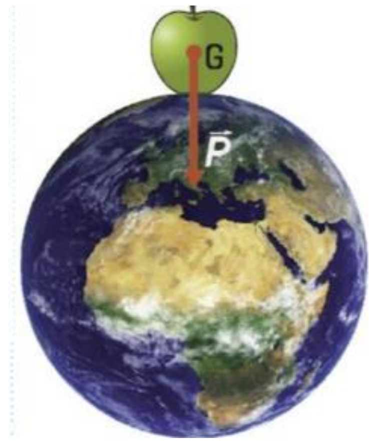


What is the difference between mass and weight?

Physicists name **weight** of an object to the force that attracts this object to the Earth.

The weight of an object can be represented by a vectorial:

- **Application point** – the center of gravity of the G object.
- **Direction** – vertical, the same direction of the line that goes through the center of the object and the center of Earth;
- **Sense** – downwards, from the object to Earth;
- **Strength** – the value of the weight.



The SI unit of **weight** is the same as that of force: **N**, the **newton**.

Mass is a property of matter that is fully understandable by its value. It is a scalar physical greatness.

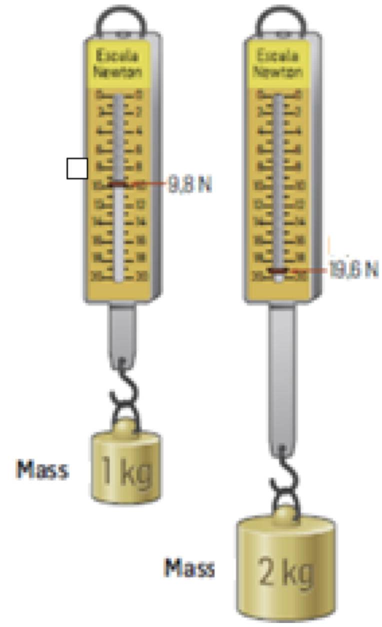
The SI unit of mass is the kilogram, kg.

We measure an object’s mass using scales:

Precision scale

Plate scale

Analitical scale



In the same place of the planet, the weight of an object is proportional to its mass. This means that as the mass increases, the weight will also increase.

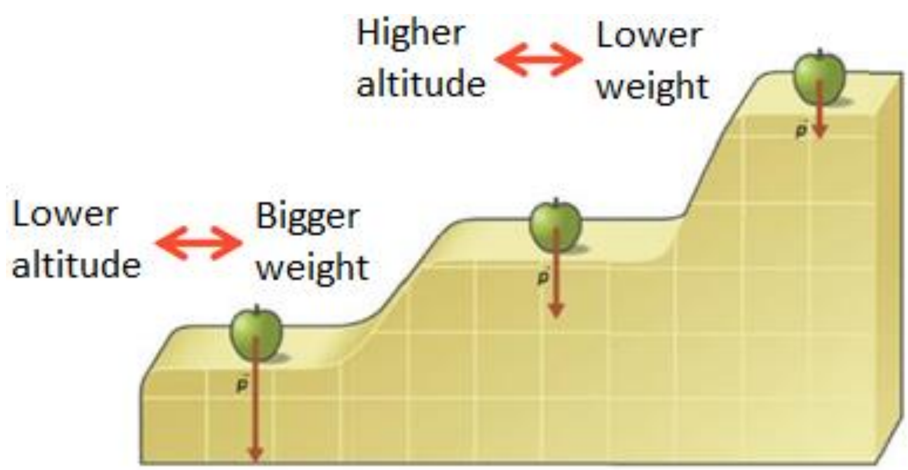
If we divide the weight of these objects, that is in N, by each of their mass, that is in kg, we get the same result:

$$\frac{9{,}8\ N}{1\ kg} = \frac{19{,}6\ N}{2\ kg} = 9{,}8\ N/kg$$

$$\frac{weight}{mass} = constant$$

On Earth, the gravitational force is approximately $9,8\ N/s^2$.

Since weight is the force the attracts an object to Earth, its value depends on the distance between the Earth center and the center of the body.

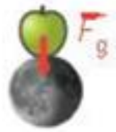


Gravity force in our Solar System

The intensity of the gravitational force also depends on the mass of the planet that is attracting the object.

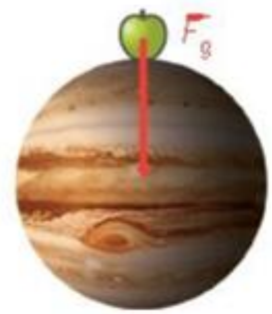
The biggest the mass of the planet, the strongest is the intensity of the force that pulls an object towards the planet.

On the Moon, $\vec{F}_g$ is lower than on Earth…

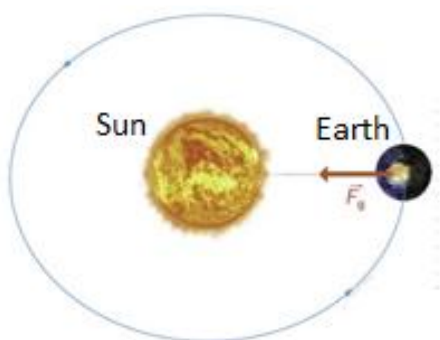


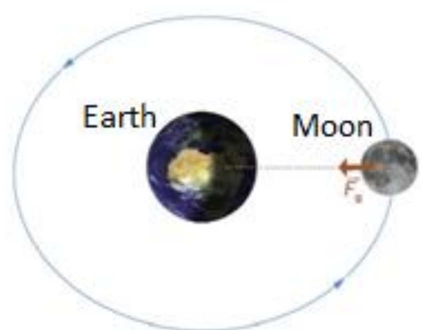
On Earth…

On Jupiter, $\vec{F}_g$ is higher than on Earth…



The intensity of the gravitational force depends on the mass of the two celestial objects and the distance between them. This force is more intense the bigger the mass of the objects and the closest they are from each other.





The intensity of the gravitational force that the Sun exercises on Earth and on the Moon	>	The intensity of the gravitational force that Earth exercises on the Moon
The mass of the Sun and Earth	>	The mass of Earth and the Moon

(even though the distance is smaller between the Earth and the Moon)

How to calculate the weight or mass of an object

We call weight to the measure of the force of gravity pulling on an object. To determine the weight we use Newton's second law:

$$W = m \times g \,,$$

in which ***m*** is the mass of the object, in *kg* and ***g*** is the measure of the force of gravity that, on Earth, is around ***9,8 m/s²***.

Since weight is the measure of a force, we can write:

$$\vec{F} = m \times g$$

With this formula, we can determine both the weight or the mass of as object, since we know the value of the gravity.

2.2 Preparation

This experiment must be done in a place that can get messy because there will be a lot of water spilling.

Divide the class into small groups and start by asking them what they know about gravity.

According to the answers, the teacher can choose to ask the students to share what they know or, if there aren't many students that seem comfortable enough in the subject to explain it, the teacher can share with the students some information about gravity so they can understand and explore the next experiment with a grater understanding of the concept they are working with.

Give the students the cup, the scissors and the water and ask they what they think will happen if they fill the cup with water.

Explore with the students what happens to the water if they drop the glass full of water from some height, like from the top of a chair.

Use that example to explain the effect of gravity and for them to realize that while dropping, the water won't come out of the cup.

Then, ask the students to make two holes on the cup, near the bottom of the cup, in such way that they can cover them with their fingers.

Ask one of the students in the group to put the cup inside the tray and then to cover the holes of the cup. Then, pour water up to the line before the top rim of the cup.

Repeat in every group and then ask the students what will happen if they take their fingers from the hole.

Ask them to remove the fingers for a moment, to verify their hypothesis. Tell the students to cover the holes again and refill the cup to the same place it was before.

Ask the students what they think will happen if they drop the water cup, allowing it to fall into the tray.

Ask one student of each group to get on a chair (with the fingers covering the holes in the cup) and drop the water cup to the tray, on the floor.

No water falls from the wholes of the cup during the fall. Discuss with the students why does this happen.

2.3 Investigation

Ask students some questions to get them to reflect on the experiment they have done and the changes that were made during the activity.

Questions like “why do you think the water fell from the holes when the cup was sitting on the table, but didn’t come out when the cup was free falling?” or “what do you think happened to prevent water from coming out the holes when you drop the cup from a certain high?” will help to keep the discussion after the experiment and will allow the students to gain the sense of gravity and to understand how it applies in “real life”.

2.4 Conclusion

The gravitational force pulls the water through the hole in the container if the container remains motionless. When the container is dropped and allowed to free fall toward the empty tray, the water remains inside the container because there is an equal amount of gravity being exerted on the container and the water inside the container. This way, both the water and the cup will fall at the same speed.

2.5 Follow-up exercise (optional)

Once the students realize and understand the meaning of gravity, teachers can explore the effect of this force in objects with different characteristics, like dropping objects with different sizes or weights.

Teachers can use the Experiment 1 in the Lesson Plan of the *Conservation of Energy and Momentum* module to help students realize the effect of gravity in objects and calculate the speed or the mass of the different objects thrown.

References or Resources

https://www.metrofamilymagazine.com/simple-science-experiments-gravity-water-drop/

https://teaching.betterlesson.com/lesson/645431/gravity

Lesson Plan from the module Conservation of Energy and Momentum