EASY EXPERIMENTS TO UNDERSTAND A COMPLICATED EARTH

THE CLIMATE HANGING BY A THREAD

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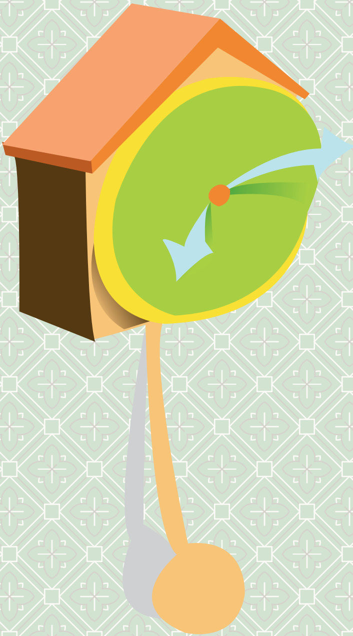

EASY EXPERIMENTS TO UNDERSTAND A COMPLICATED EARTH

4. The climate hanging by a thread

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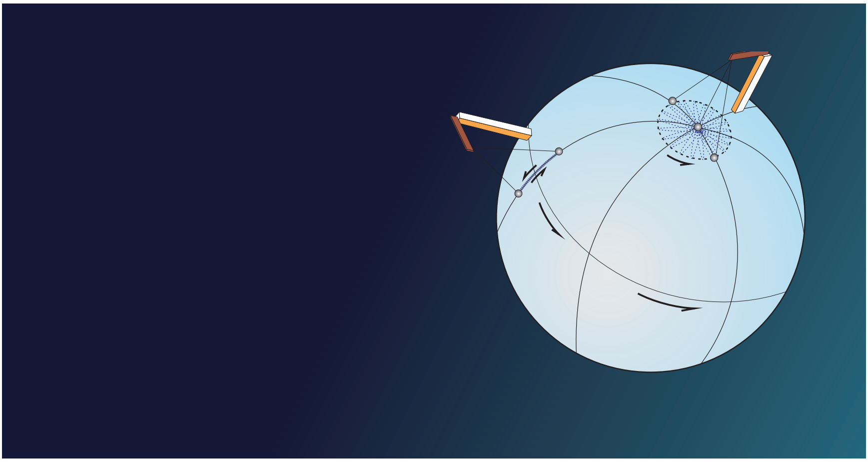
Introduction

This is the fourth booklet in the series "Simple experiments to understand a complicated Earth". Here you will find more experiments that you can do at home with simple and easy-to-buy materials. This time we chose those that are related to the climate. We invite you to perform them carefully and observe how Mother Nature carries them out as well.

In the news, they mention that the weather is determined by several factors: temperature, humidity, wind speed and atmospheric pressure. With this information they can tell us if the day will be sunny, rainy or stormy. The weather changes from day to day, and the study of local factors is used to make forecasts. The climate, on the other hand, is the atmospheric conditions that characterize a region. That is, they prevail throughout the year. The types of climates are tropical, subtropical, temperate, desert and polar. Climate is controlled primarily by the sun and by the Earth's gravity, rotation, and translation. Although the climate is a very complex phenomenon, with these simple experiments you will be able to understand some of the basic principles that regulate it.

Jean Bernard León Foucault is the main character in this booklet because he found a very ingenious way to demonstrate the rotation of the Earth without having to look at the stars, and, as we will see, this rotation plays a fundamental role in the climate of a region.



Jean Bernard León Foucault (1819-1868) was born in Paris, France. He took advantage of the popularity that science had taken in France during the 19th century to show his experimental genius. He introduced photography to astronomy in 1845, and in 1850, he measured the speed of light using a rotating mirror system and demonstrated experimentally that light travels more slowly in water than in air. He conceived the modern telescope in 1851, and in 1852, he invented the gyroscope (a circular disk that rotates on an axis, somewhat like a spinning top or a bicycle wheel) to demonstrate the rotation of the Earth.

He leaped to international fame at the Paris World's Fair in 1851 when he showed the world the pendulum that today bears his name. A pendulum is a body that hangs from a thread and always sways in the same direction. Focault's pendulum was just over 65 m long, and the hanging body was a cannonball. He mounted it at the famous Pantheon in the French capital, and with it he demonstrated the rotation of the Earth by showing that the pendulum made one complete swing in a certain amount of time. As the direction of the movement of the pendulum does not change, he indicated that when registering a complete swing what was rotating was the floor! Thus, he conceived the idea that a pendulum can demonstrate the rotation of the Earth without having to observe the stars. The trace left by the pendulum at one of the poles of the Earth would make a complete revolution in one day, while at the equator it would always stay in the same position.

‘To measure time, a thread and a screw are enough for me.’

Experiment 1

Measuring time with a pendulum

Materials

Screws or any other heavy object that you can tie with a thread.
Strings of different sizes: 10 cm, 30 cm, 100 cm, 150 cm.
A watch or clock, or a chronometer

Procedure

1. Make several pendulums by tying an object (screw) with a certain weight at one end of each string.
2. Hang them from a horizontal bar (such as a railing).
3. Activate one pendulum at a time and count the time it takes for it to swing back and forth.
4. Write the result in a notebook.
5. Do it again, this time pulling the screw more so that it has a wider range of motion.
6. Then do the same with pendulums hanging from strings of different lengths.

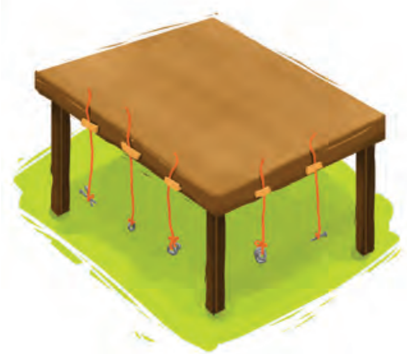
Observe

The travel time for each pendulum between one swing and another is the same regardless of whether the distance traveled by the screw is longer or shorter. For a length of 50 cm, the pendulum makes each swing in approximately one and a half seconds. You will also notice that as time goes by the pendulum stops. This is due to the air resistance that gradually slows down the movement of the pendulum.

The experiment will work better the longer and lighter the string, the heavier the screw, and the smaller the amplitude of the oscillations.

Variants

You can also tie objects with different weights, and you will notice that if the length of the pendulum is the same, the travel time will not change. When the length of the string is longer, you will notice that the trajectory of the pendulum is not exactly a straight line, but it is rather an ellipse, similar to a crushed circle.



Uses in daily life

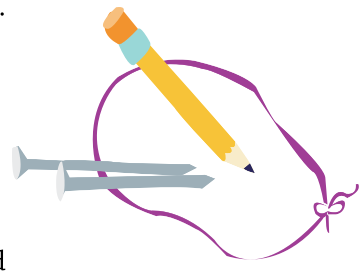
A pendulum is very useful for measuring time, and without a doubt its main use is for making clocks. Note that the bob (weight) of old clocks is flat to decrease air resistance. The funniest pendulum is the playground swing. A still pendulum (without movement) is a plumb line used to indicate the verticality of a wall or a plane.

Experiment 2

Let's make an ellipse

Materials

2 nails (can be branches, sticks, pencils).
String.
Soil or sand.
A pencil.



Procedure

1. Push the nails into the ground, separated one from the other.
2. Tie the two ends of the string together.
3. Place the pencil inside the string and form a triangle between the pencil and the nails.
4. Make sure the string is taut.
5. Move the pencil inside the string and draw the ellipse.

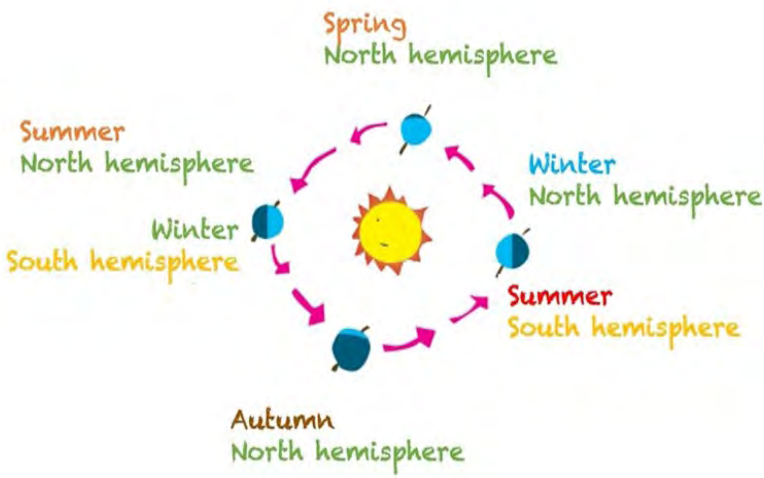
Observe

If the distance between the nails (technically known as foci) is very large, the ellipse will be very elongated, becoming a straight line in the extreme case. On the other hand, if the distance between the nails is very short, the line will almost be a circle. One way to characterize the ellipse is by

the ratio of its length to its width. If these two distances are similar, the ellipse will be more like a circle. If they are very different, it will be more like a straight line.

Find it in Nature

The trajectory that the Earth follows around the sun is an ellipse. However, the trajectory is almost like a circle, so this is NOT the cause of the seasonal variation of the climate. Note that when the Earth is farthest from the sun it is summer and winter, and, when it is closest, it is spring and autumn (you can also notice that when it is summer in the northern hemisphere, it is winter in the southern hemisphere).



Experiment 3

...and yet it moves

Materials

Adhesive tape (masking tape).
A window.
A starry night.

Procedure

1. On a starry night, go to your bedroom window and mark with a piece of masking tape the position of at least three stars.
2. Every half an hour or so (for example between television programs), stand at exactly the same place and mark the position of the same stars again.
3. Do this at least four times to complete two hours.

Observe

The stars seem to move, and what you are doing is marking their trajectory. Note that some stars travel a greater distance than others.

If on the following night, at the same time and in the same place, you check the marks you left, you will see that they cover the same stars as the night before. This is because it takes the Earth 23 hours and 56 minutes to make one complete revolution on its axis of rotation.

Explain it

It is you that moves, or rather the Earth under your feet, due to the rotation of the Earth. The more distant stars move more slowly than the planets and the moon, which are closer to us. In this experiment, the different distances marked on the window do not depend on the distance to the stars, but on their position with respect to North. If you mark the polar star in the window, it will not move.

Observe it in your everyday life

When you are travelling by car or by bus, nearby trees pass by quickly and those further away pass by less quickly.

The trajectory of stars around the polar star in the sky seen from the northern hemisphere.

« I prefer heaven for the climate, hell for the company. »
Mark Twain

Experiment 4

Sun exposure time

Materials

A sunny day.
Shirts of various colors including a black one and a white one.

Procedure

1. Put on a black shirt and go out in the sun for five minutes.
2. Then put on the white shirt and go out in the sun for another five minutes.
3. Try shirts of various colors and materials.

Observe

You will feel warmer in the black shirt than in the white one.

Explain it

Heat is transmitted by radiation, conduction, and convection. In conduction, heat is transmitted by contact (for example by touching a hot pot). In convection, heat is transmitted through a moving fluid (the steam that comes out of the pot with boiling water), and in radiation, it is transmitted through wave motion without the intervention of a moving fluid (when you approach any fire, you immediately feel the heat). All three mechanisms are involved in this experiment. The sun's rays emit light and heat, and the heat travels by radiation through the air layer of the atmosphere. When the rays touch the surface they heat it up, and the air that touches the hot surface heats up by conduction. When the air is heated, it expands and rises by convection. The sun's rays come in contact with the black shirt, and the black color absorbs almost all the rays and heats up while the white shirt reflects almost all the rays.

Apply it to your life

Black cars get hotter than light-colored ones. The longer the car stays in the sun, the warmer the air inside will get.

In extremely hot weather, you can improve the temperature in your car by leaving the window slightly open. Keep your bedroom cool by not letting the sun in so that the air does not heat up. You can do this by keeping the curtains closed.

Find it in Nature

The weather of a region depends, among other things, on the time of exposure to sunlight during the day. In summer, days are longer than in winter. The longer the day lasts, the longer the sun will shine and the more the air will heat up.

As we saw with materials of different colors, there are colors that trap more radiation than others, with dark ones trapping more than light ones. The percentage of radiation reflected by the materials, that is, the amount that is not absorbed, is called albedo (see Table). If we consider that the air heats up when it is in contact with the ground and see that the clouds reflect a large part of the sun's rays, then we understand why it is cooler on cloudy days than on clear days. The snow-covered poles are hardly heated because almost all the rays are reflected and because there the rays arrive very steeply.

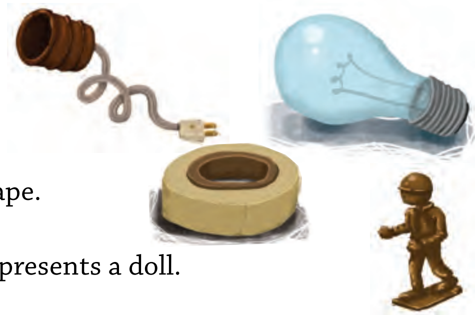
In recent years, an important part of the north polar cap has melted, and scientists are concerned as this indicates that the global temperature of the Earth is rising. The Earth can absorb more heat when snow is converted to water, since the albedo of water is less than that of snow.

	Albedo
Recent snow	86 %
Very shiny clouds	78 %
Clouds (average)	50 %
Deserts	21 %
Soil without vegetation	13 %
Forests (average)	8 %
Volcanic ash	7 %
Oceans	5-10%

Chasing your own shadow

Experiment 5

Inclination of the sun's rays



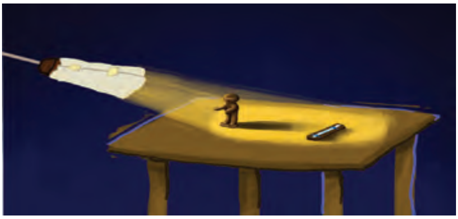
Materials

A 60- or 100-watt light bulb.
Socket with extension plug.
A sheet of paper and masking tape.
A room thermometer.
A doll or a piece of chalk that represents a doll.

Note: Be careful with the electric current and the hot light bulb

Procedure

1. Roll up the sheet of paper and tape it to make a screen.
2. Place it over the light bulb to focus the light. First place the screen perpendicular to the table in such a way that the beam (of light rays) forms a circle. Make sure that it illuminates both the thermometer and the doll.
3. After 3 minutes, measure the temperature indicated by the thermometer. You will notice that the little doll has almost no shadow.
4. Then tilt the screen so that the light hits the table diagonally, making sure that it is at the same distance as before and that it illuminates the thermometer and the doll. You will see that now the illuminated area forms an ellipse.
5. Measure the temperature after 3 minutes. You will notice that the doll now has a shadow.



Observe

When the beam of light is circular, the temperature of the table is higher than when the beam is an ellipse.

The shadow of the doll will be larger the more horizontal the light is.

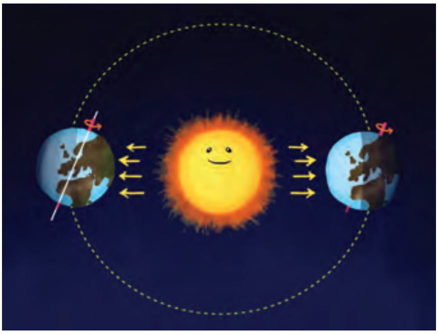
Explain it

The radiation that comes out of the light bulb, like that of the sun, comes in the form of light and heat. The screen concentrates the light, and when it takes up less space it concentrates the heat, heating the illuminated area more. When the same amount of light is scattered, the illuminated area will become less hot.

Find it in Nature

The Earth rotates around an axis that is inclined 23.5 ° with respect to the plane in which it rotates around the sun. When the sun's rays shine directly on our head, the shadow is almost nil. The more inclined the rays are, the more shadow there will be. During the day our shadow changes, and it also changes with the seasons. At noon, sun rays strike most directly upon us.

During winter you will be able to notice how much the Earth leans on its axis by observing that your shadow will get longer. The further you are from the equator, the steeper the sun's rays will reach in the winter. The more inclined the rays arrive, the less they will heat and the larger the shadows will be. The tilt of the Earth's axis of rotation causes the seasons.



Experiment 6

Specific heat: How much energy is required to change your temperature?



Materials

Three plastic cups.
Water, soil, air.
Thermometer.

Procedure

1. Fill a cup with water.
2. Put some soil in another cup and leave the third one empty (that is, with air).
3. Put the three cups in the refrigerator, take them out after ten minutes, and touch them with your forehead.
4. Compare them to find out which one is the coldest.
5. Then put the cups with water and soil in the sun for 5 minutes, and with a thermometer measure the temperature of the water and the soil.

Observe

When you take the cups out of the refrigerator you will be able to perceive that the cups that contain air and soil are colder than the one that has water. When you measure the temperature of the soil and the water after leaving them under intense sun for 5 minutes, you will see that the soil is warmer than the water.




Explain it

Water, air, and soil have different specific heat values, this being a measure of how much energy is needed to change the temperature of a material. Water needs four times more energy than air or soil, so a glass with water gets cooler more slowly. The same happens when you put them in the sun. The energy that comes from the sun, which is the same for every item, heats the soil faster than the water.

Apply it to your life

It is known that all objects tend to have the same temperature. This means that if a considerable time passes without exposing the objects to a heat source, they will all tend to be at the ambient temperature. The time it takes to acquire this temperature depends on their specific heat values and the amount of material.

Human beings, like mammals and birds, regulate their own temperature. Warm-blooded animals use most of the energy they consume to keep themselves at a constant temperature (approximately 36.5 ° C), while the ambient temperature is almost always much lower. Cold-blooded reptiles depend on environmental heat to increase their temperature. So, when the day is sunny, they move quickly, and at night when the ambient temperature is lower they remain immobile.

The human body, like the Earth, has a high percentage of water and can easily regulate its temperature thanks to its high specific heat value.

How does it affect the climate?

Although the ocean absorbs almost all the heat from the sun (it has a low albedo), its temperature barely changes due to its high specific heat value. If 5% of the planet were not covered with water, the nights would be very cold. The places near a lake or an ocean have a much more pleasant climate than deserts, where the changes in temperature are very extreme between day and night.

Experiment 7

Density as an engine for water

Materials

Vegetable food coloring.
Hot water.
Ice.
A small jar.
A nut or a screw.
A large transparent container.

Procedure

1. Make blue ice cubes by adding blue food coloring to the water before putting it in the freezer.
2. Also, heat some water and add a few drops of red food coloring.
3. Place the hot water and a nut or screw in the jar, and submerge it uncovered in the large transparent container with cold water.
4. Put the blue ice in the same container as well.

Observe

The red hot water inside the jar rises while the blue cold water from the melted ice sinks.

Explain it

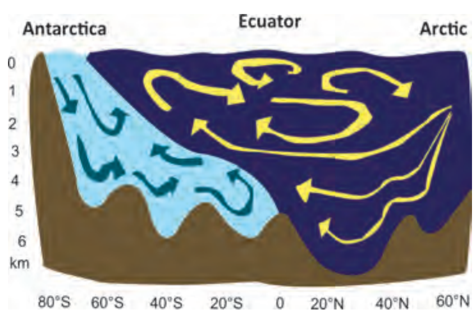
When water is heated, it expands (gas state), thus occupying more space with the same amount of water (that is, it becomes lighter), and rises. Curiously, ice floats in water for the same reason, since it expands as it freezes and becomes less dense than the water itself. When the ice melts, the water is still cold and is denser than the surrounding water, which is why it sinks.

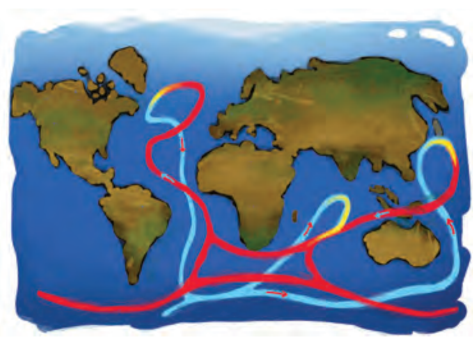
Water has its highest density at 4ºC. When its temperature increases or decreases, water expands and is less dense.

Find it in Nature

Whenever two fluids (whether gas or liquid) come together with different temperatures, and therefore with different densities, there will be movement. The role that convection (when heat is transmitted by the movement of a fluid) plays in climate is very important. Winds and ocean currents are generated by convection. The movement of oceanic waters at a global level occurs, in part, due to the rise of warm waters and the descent of cold waters, thus transferring large amounts of heat.

The Great Oceanic Transporter Belt is the main ocean current; you may observe in the illustration that the warm waters (in red) coming from the equator and the tropics travel to the North Atlantic. This allows a warm ocean current to contact western Europe. This explains why countries that are at the same latitude have different climates, such that England is less cold than eastern Canada, and Russia is colder than Scotland.





Great oceanic transporter belt

Experiment 8

Density as an engine for the wind

Materials

A lamp.
Talcum powder, flour, or any fine material.

Procedure

1. Turn on the lamp at night.
2. Sprinkle talcum powder (or any other fine material that floats in the air) on top of the light bulb.

Observe

The talcum powder rises together with the air leaving the lamp.

Explain it

Air expands with increasing temperature, decreasing its density. The less dense air floats on the cooler air and rises. In the experiment, the rising air carries the talcum particles with it. Gases increase in volume with increasing temperature and decreasing pressure.

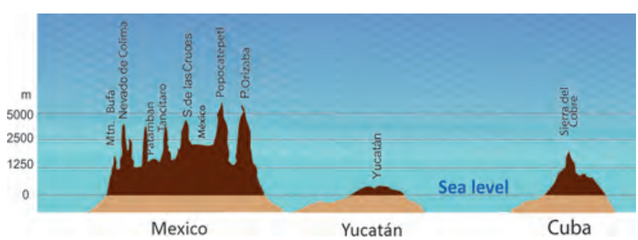
Variations

You can see this experiment repeatedly throughout the day when someone is smoking a cigarette, or when observing a fire, or when you boil water in the kitchen.

How does density affect climate?

The heating effect of the sun begins when its rays hit the Earth's surface, heating some places more than others (due to the effect of the albedo mentioned above and the inclination of the sun's rays). The air is warmer at sea level and this is why it rises. As the atmospheric pressure rises, the air density becomes lower and the molecules separate. When this happens, the air gets cooler.

In the Earth's atmosphere, the temperature decreases by approximately 6.5 °C for every thousand meters. This is why the highest volcanoes and mountain ranges have snow on their tops even if they are in a hot zone like the equator (for example the Cotopaxi volcano) or in a tropical zone (for example the Pico de Orizaba and the Nevado de Colima). This also explains why Mexico City has a pleasant temperature, around 22°C, while Popocatépetl volcano, which is adjacent to the city, has a snowy top.



Skyline of North America, from West to East, at latitude 20° N.

Experiment 9

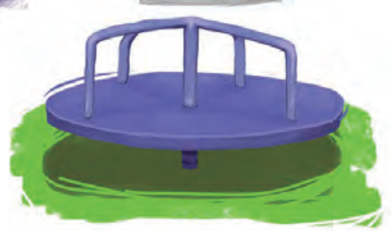
The Coriolis Effect

You may have heard that when you empty the water from a sink in the northern hemisphere, the water rotates clockwise, while in the southern hemisphere the opposite occurs. This is said to be due to the Coriolis effect. First of all, it must be made clear that this is false because the Earth´s rotation cannot affect such small masses of water, but this myth has allowed the popularization of the Coriolis effect.

The Coriolis effect explains the deviation of the trajectory of a body moving on a rotating surface. As the Earth has air and water on its surface, the trajectory of the movement of these fluids is altered by the rotation of the Earth, and this effect has been used to explain the directions of the wind and the ocean currents. To understand how the Coriolis effect works, experience it first:

Materials

A spinning disk, this can be a carousel or a sheet of paper that you can turn by hand.
A ball or a pencil.



Procedure

1. Roll the ball over the carousel while it is spinning. First roll it out fromthe center of the carousel and then from the outside in towards the center.
2. Spin the carousel counterclockwise. Another way to do this experiment is to take a sheet of paper and ask someone to draw a straight line while you turn the sheet.

3. Try drawing the line first from the outside in towards the center and then from the center to the outside.

Observe

If we throw the ball (or draw the line) from the outside to the center, or from the center to the outside, the trajectories will be curved clockwise.

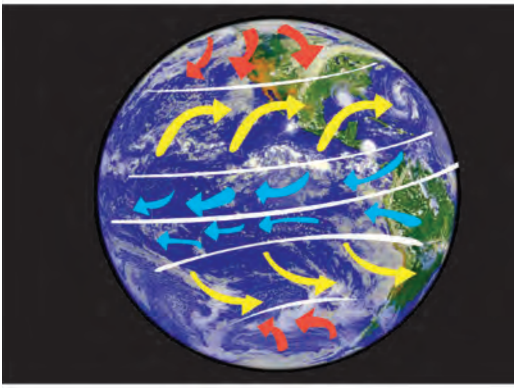
Variations

If we rotate the disk in a clockwise direction, the trajectories will be curved in the opposite direction.

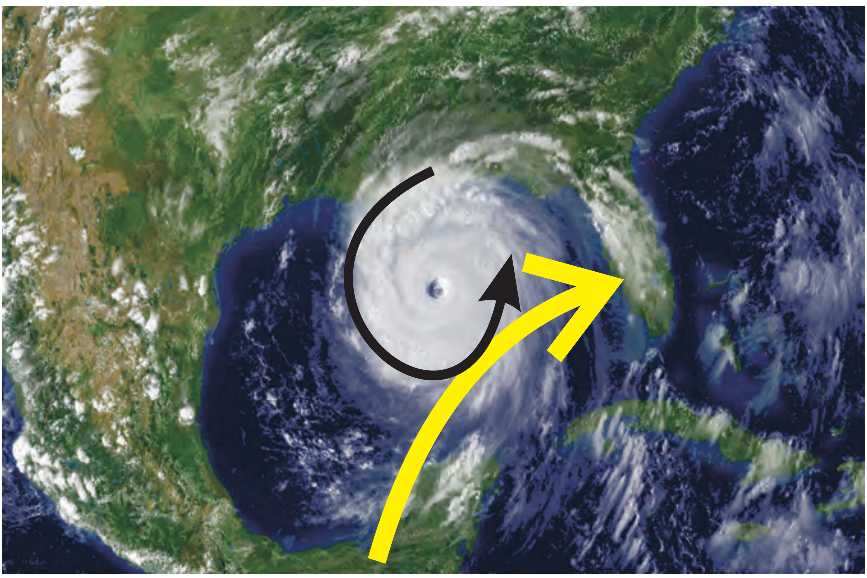
How does the Coriolis effect work on Earth?

We rotate together with the Earth when we are standing still, but the fluids (air and water) move with different speeds than the solid Earth.

At the equator the winds and ocean currents move towards the west. In the northern hemisphere, the prevailing winds traveling north detour to the northeast, while those traveling south deviate to the southwest. Thus, due to the Earth's rotation, currents and winds move clockwise in the northern hemisphere and counterclockwise in the southern hemisphere.



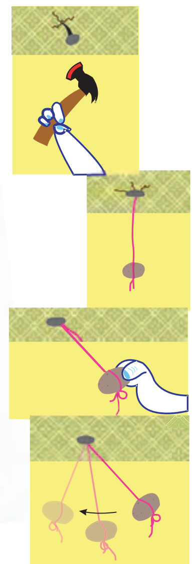
If you look at a satellite image of the Earth you will see that cyclones in the northern hemisphere rotate counterclockwise. One way to explain this is that since the cyclone is a low pressure zone, it tends to attract the surrounding air, which due to the Coriolis effect would be moving clockwise in the northern hemisphere. This causes the center zone, that is the cyclone zone, to rotate in the opposite direction, as seen in the Figure. The same thing happens when you hit a spinning disk with a clockwise motion of your hand and the disk moves in the opposite direction.



Conversation on Foucault's Pendulum

Miguel de Icaza Herrera

The following conversation between the children Julia, Joseph and John takes place in the facilities of the Manuel Gómez Morín Educational and Cultural Center in the State of Querétaro. The most beautiful Foucault Pendulum in Mexico is installed there. The children refer to the workshops of the Sophie project of the Center for Applied Physics and Advanced Technology of UNAM where science is introduced to children. All children are welcome, especially in summer.



John. I did not understand. Yes, the ball is very nice. I think I could watch it for a long time without getting bored, but I didn't understand the explanation Ulysses gave us. .

Joseph. First he explained to us how to make a plumb line. He told us that we just needed to tie a string to a pebble and hang the string from a nail..

John. Who doesn't understand that? But then Ulysses said that we had to wait until it no longer moved. I don't understand how it's going to move on its own. It's a stone! It's not alive !

Joseph. Yes, he explained that as soon as the plumb line is hung from the nail, it keeps moving, but it moves less and less. If we wait until it stops moving, the thread shows the direction to the center of the Earth.

John. And what does that have to do with masons?

Joseph. Well, what were you doing? He explained to us that it is used so that houses are straight and not crooked.

Julia. What he said about the rotation of the Earth seemed much more interesting to me. And I really began to see the pendulum of Querétaro so big and, seeing it rotate slowly, I even had the impression of feeling the rotation of the Earth.

John. I really didn't even know what he was talking about.

Joseph. It's your fault. I saw that you began to take out chocolates and, because you were covering yourself so that he wouldn't see

you, you didn't even pay attention. Hey Julia, and did you understand? It even seemed like he was talking about the planets !

Julia. Which planets? You must have gone to see Star Wars !

Joseph. Yes, remember he was talking about the orbit of the bob

John. What is that bob thing?

Joseph. This is what the pebble or whatever hangs from the thread to form the pendulum is called.

Julia. Ulysses gives the name of 'orbit' to the path followed by the bob, which is held by the thread at all times.

John. Starting with that. Which way? I only saw the darn bob going from one side to the other.

Joseph. I really don't see how to explain it to you. A standing donkey must have clearer ideas.

Julia. Look, you have seen some airplanes that paint the sky with smoke. These marks are left as they are passing and show the path where the airplane has been.

John. Well, I haven't seen the smoke that the bob leaves behind.

Joseph. (About to lose control) With or without smoke, the path is simply where the bob goes.

Julia. Remember that Ulysses showed us how the bob could move in ellipses.

John. In whaaaat?

Julia. Yeah, those are like squashed circles. Remember that last week we were playing geometry.

Joseph. You're talking about those that we built with a string and two nails? (see Figure 1).

Julia. Exactly! Remember that we spent the whole afternoon drawing flattened circles!

Joseph. That was really fun! All we had to do was drive in two little nails and tie the thread to them, and then draw with a pencil, taking care that the thread is stretched.

Julia. That part was very important. It was always the same thread but the nails were placed at different distances from each other. And when the nails were very close together, we got something that looked like a circle. Whereas when the nails were very far apart, one obtained a lengthened figure that they called an 'ellipse', and this figure could be made narrower and narrower, placing the two little nails more and more apart, so that in the end the figure almost looked like a line.

Joseph. I hadn't noticed that. Are you sure?

Julia. Ulysses told us that the normal orbit of the bob was an ellipse, and that this orbit could, with care, be converted into a rectilinear motion.

John. recti . . recti what?

Joseph. You say 'rectilinear' when you mean 'in a straight line'.

John. Ah... all this, how beautiful the huge ball is!

Julia. What is more attractive is its sensitivity to the faint, very faint rotational movement of the Earth. So faint that we don't feel it.

Joseph. I remember that he drew the Earth for us, that he pointed out the equator and the axis of the Earth for us. And then he chose a point on the perimeter of that circle and told us that that point represented Querétaro. However, I don't remember what the rule was (see figure 2).

Julia. Think well. Think back. Remember that we drew a triangle.

Joseph. You're right! Yes, we joined with a line the center of the Earth and the point that represents Querétaro! And then? I already forgot it! What's next?

Julia. Just so that you don't forget, I remind you that that short line is called 'radius'.

John. I do remember this, because it was when Ulysses slipped. He took the ruler and drew a vertical line through

Figure 1. How to draw an ellipse using two nails, a thread and a pencil.

the point that represents Querétaro up to the point where it cut the equator and he put the letter h on it.

Julia. Well, you're right, but what he did was draw a line parallel to the Earth's axis of rotation, and he extended it to the point where it intersects the equator.

John. And all these triangles, for what?

Julia. C'mon John! How come all these triangles? There is only one!

John. Well, okay, and this triangle, what for?

Joseph. Yeah, I didn't understand that either.

Julia. The secret is in that triangle. All we have to do is measure the . . . , the lines, as John calls them, the one that connects Querétaro with the center of the Earth, that is the radius of the circle that we can represent by the letter r, and that of the parallel through Querétaro that we have indicated with the h, which is nothing but the height of Querétaro above the equator.

John. I can already imagine how much the measuring tape costs to make those measurements! My dad had to buy a special 25- meter-long tape to measure the house and it was quite expensive!

Julia. Nope! No need for a 6,300-km-long tape! A drawing made to scale can be used! Since what interests us is the ratio of the radius r to the height h, that is, r/h. I remember that the result of the division which we all did was,...

John. Yes, it was 2.8. But, what about it?

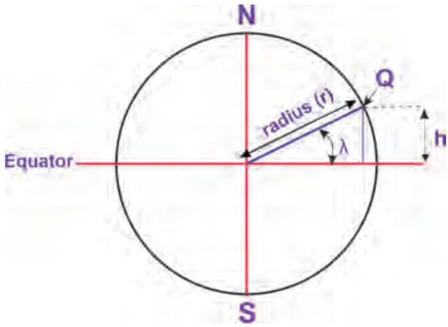


Figure 2. Position of Querétaro in the circle of the Earth. The angle λ is what is known as 'latitude'. The figure is drawn to scale: the reader can use it to measure the radius r and the height h on it and check the result for himself.

Julia. Well, the above is the rule to calculate the time it takes for the pendulum to make a complete turn. Can you remember when it's correct?

Joseph. Yes, I do remember that he said it, but not what he said.

Julia. It's very simple. The rule is applicable to the case where the bob moves along a very, very narrow ellipse, so thin that it appears to be or resembles a straight line.

Joseph. Ah..., that's what you meant a while ago, when you mentioned the rectilinear motion, right?

Julia. Well, it turns out that the line along which the bob moves, that is the orbit, is not fixed, but it rather rotates, very slowly, in a clockwise direction.

Joseph. In other words, the bob does not keep going back and forth along the same path, but rather that path turns around?

Julia. Exactly! And, the time it takes for that path to make a full turn is two point eight.

John. Two point eight what?

Julia. Two point eight days, that is, almost three days. Since there are 24 hours in a day, remember that we multiplied 24 hrs × 2.8 and got 67.2 hrs.

Joseph. Does that mean that the bob makes that turn, in response to the Earth's rotation, in just over 67 hours?

Julia. Precisely! Honestly, I don't understand why you don't ask Ulysses and you ask me. Remember that we only learn when we ask!

Joseph. I already remember. Then Ulysses told us that the same result is presented in another way in the books. He explained to us that adults prefer to talk about the speed of rotation of the Earth and the speed of rotation of the orbit.

John. Now it does seem that we are listening, not to Ulysses, but to Professor Nutty.

Julia. Why do you think so?

John. Because Joseph uses strange words. Didn't he say Earth's rotation speed?

Julia. Well, yes, but what do you want me to call it? The rule that Ulysses mentioned to us connects two speeds, one is the speed of the Earth's rotation, and the other, the speed of rotation of the bob's orbit.

John. In any case, I don't know what that speed of rotation of the Earth is, and if I don't know that one, I don't know the other one either.

Joseph. False! You do know it and everyone knows it.

John. How come everyone knows it?

Joseph. Well, everyone knows it, but it is essential to stop to think for a moment. And possibly therein lies your difficulty.

John. What are you implying? You're wrong! I don't know the speed of the Earth!

Joseph. I better tell you, and you tell me if you know or not. The speed of the Earth is one turn per day. That's it! That's all!

John. Well, yes, frankly I must admit that I did know.

Julia. In other words, the speed of rotation is number one, and since we must multiply it by the length h of the parallel line and divide it by the radius r, then the speed of rotation of the bob's orbit is simply the quotient h/r

Joseph. Ulysses explained to us that the angle between the equator and the line that joins the center of the Earth with Querétaro bears the name of Querétaro's latitude (figure 2). He told us that he was going to teach us how to find the Polar star and to measure the latitude of Querétaro.

John. Yes, and he also told us that next week we were going to play trigonometry and that after that we were going to understand why the speed of rotation of the bob's orbit is said to be equal to the sine of the latitude where the pendulum is located.

Julia. Look, my parents are here to pick me up. See you!

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The collection of booklets entitled 'Easy experiments to understand a complicated Earth' is based on the list of the most beautiful experiments published by Physics World magazine in September 2002. These experiments were chosen for their simplicity, elegance and the transformation they caused in the scientific thought of their time.
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