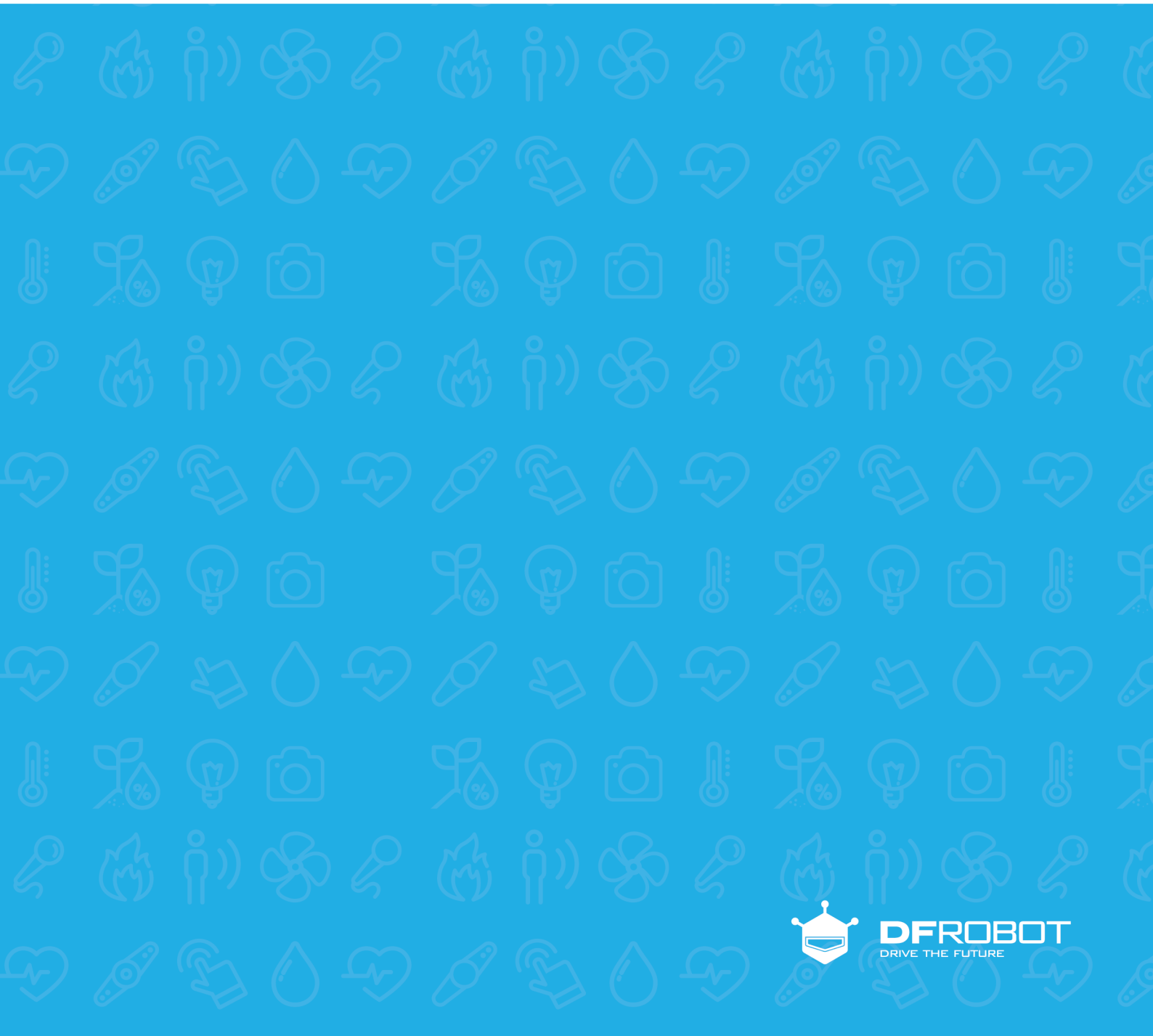
DFROBOT
DRIVE THE FUTURE

BOSON

Science Design Kit

Tutorial


DFROBOT
DRIVE THE FUTURE

Contents

LESSON 1： Why Are Electrical Wires Covered in Plastic?

Introduction

Standards

NGSS

5-PS1-3 Matter and Its Interactions : Make observations and measurements to identify materials based on their properties.

Science - Grade 3-5

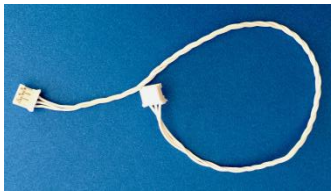
Overview

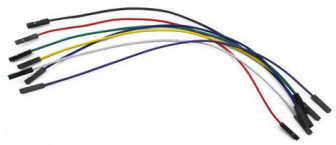
Observe a phenomenon in daily life, explore the question---"Why are electrical wire covered in plastic?" to lead out the concept of conductivity, and help students get to know conductor and insulator by experimenting so as to understand the principle of electrical wire and learn the electrical safety basics.

Materials

BOSON Module	Image	Function

Battery Holder (3x AAA batteries installed)		4.5V Power Supply
MainBoard-1IO (m2)		Supply power for other modules
Conductivity Switch (i12)	 	Use with alligator clips to detect the conductivity of objects

Display Module(o11)		Provide visual effect for users to check experiment results
BOSON cable *2		Use with 3Pin Foolproof connector to connect other modules

Additional Materials	Image	Function
Electric wires		Experimental Subjects
Wire stripper		Used to peel off the electrical wire. If you don’ t have such a tool, find scissors or other suitable tools.

		Please be careful during the operation.

Engage

If we observe the electrical equipment in our home, we can find that the electrical wires for household appliances are all wrapped in plastic, but their power plugs are bare metal. Why is that? What is inside an electrical cord? Why does it have plastic coverings? Take a guess!

Explore

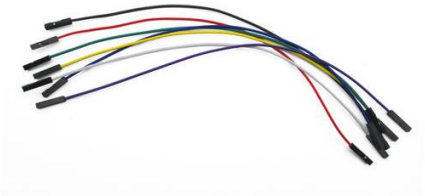
After making a supposition about an unknown question, we have to prove it by performing experiments.

This experiment consists of two parts: 1. Find the component of an electrical wire; 2. Explore the properties of all component parts and then explain why electrical wires are covered in plastic.

Part 1 What are the components of an electrical wire?

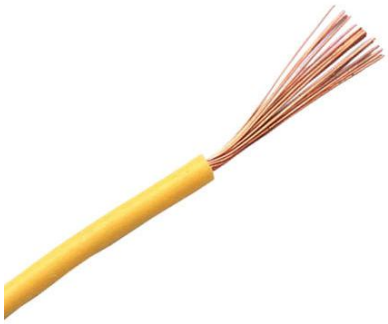
Preparation

To explore the composition of electrical wire, we have to prepare electrical cables, and wire stripper (or scissors).

	
Wire Stripper	Electrical Wire (Dupont wires are used here)

Step

Cut the end of the Dupont wire and peel off its electric skin.



Conclusion

From the above, we can see that the electrical wire mainly has two parts: wire core, and plastic coverings.

Make a Conjecture

Take a guess, what are the functions of each part of the electrical wire?

Question 1: What is the function of the electrical wire core?	Supposition 1:
Question 2: What is the function of electrical wire plastic coverings?	Supposition 2:

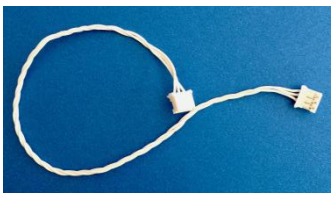
Part 2 What is the function of electrical wire plastic coverings?

We know that an electrical cable is used to transfer power. But which part of the electrical wire does the work, wire core or plastic coverings? Can the human body transfer power too? Let' s look for the answers one by one through experiments, and record the results in the form below.

Object	Can it transfer power?
Wire Core	
Plastic Coverings	
Human Body	

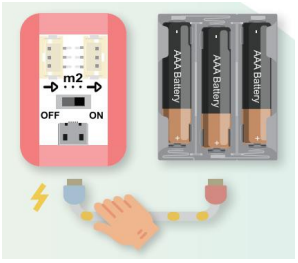
Preparation

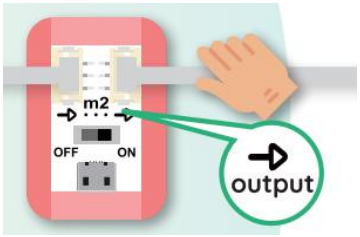
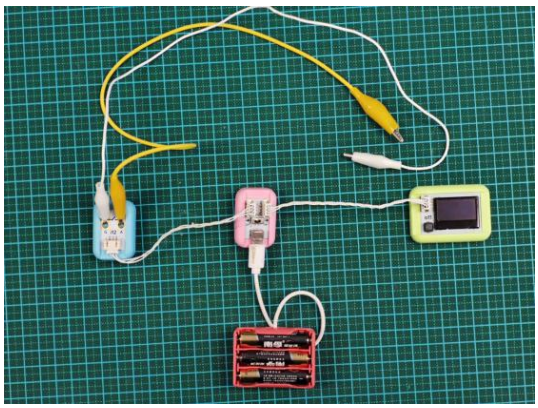
Take out the following module blocks from BOSON Science Design Kit.

 Display Module(o11)	 MainBoard-1IO (m2)	 Battery Holder（3x AAA batteries installed）
  Conductivity Switch （i12）		 BOSON cable *2

Step

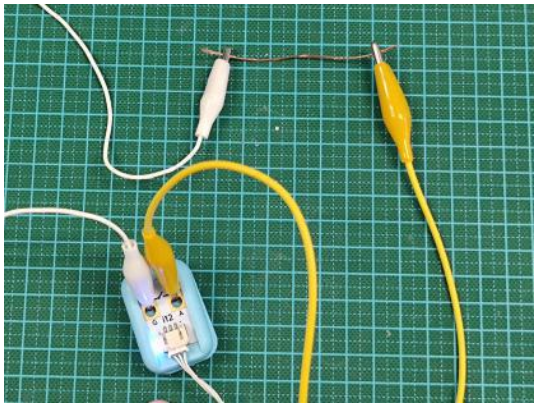
1. Build an experimental circuit to detect if the wire core, wire plastic coverings and human body can transfer power?

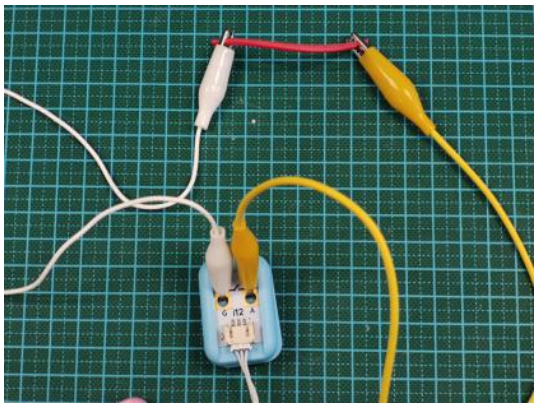
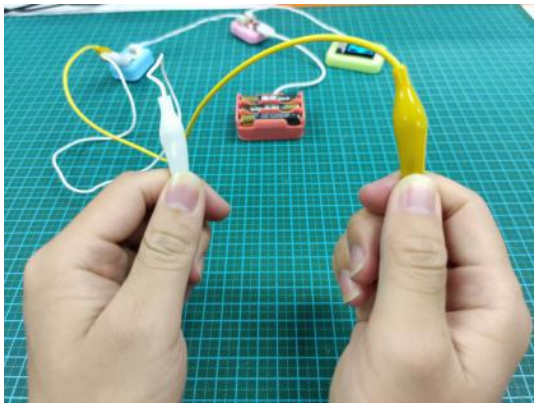
1-1 Connect the Battery Holder and two Module Cables to the Main Board.	  The cable's pin header should be plugged in completely so that it is not easy to pull it out.

1-2 Connect the Display Module to the output side of the Main Board with a Module Cable.	
1-3 Clip two alligator clips onto the two sides of the conductivity switch respectively.	
1-4 Connect the Conductivity Switch to the input side of the Main Board with a Module Cable.	
1-5 Switch the Main board "On"	
1-6 Press the black button on the module several times until the "i12 Conductivity" is displayed.	

1-7 When the two alligator clips are connected, if the OLED module displays a lightning bolt symbol, the circuit is connected.	

2. When the circuit building is finished, make the two alligator clips contact each other, then there is a lightning bolt symbol appearing on the screen, which indicates that the electrical power can be transferred; Separate the two alligator clips, the lightning bolt sign disappears, which means the power transmission fails. Therefore, we can clip the two alligator clips onto electrical wire core, plastic coverings, and human body to test whether they can transfer power.

2-1 Clip the two alligator clips onto the two ends of the electrical wire core, record the result in the form. (Lightning Bolt Sign Appear/Not)	

2-2 Clip the two alligator clips onto the two ends of the electrical wire coverings, record the result in the form. (Lightning Bolt Sign Appear/Not)	
2-3 Hold the two alligator clips with your bare hands, record the result in the form. (Lightning Bolt Sign Appear/Not)	

Conclusion

The experiment results are shown below:

Object	Can it transfer power?
Electrical Wire Core	Yes
Electrical Wire Coverings	No
Human Body	Yes

It can be seen from the experiment that only the electrical wire core and human body can transfer electrical power. Did you guess correctly about the previous two questions? Let’ s check the right answers.

Question 1: What is the function of electrical wire core?	Answer: The electrical wire core is used to transfer electrical power.
Question 2: What is the function of electrical wire plastic coverings?	Answer: The electrical wire plastic coverings cannot transfer power, but electrical power can pass through our bodies. So, the plastic coverings can insulate the metal wire core from human body so as to protect our safety. (When the electricity reaches a certain range, it will cause damage to human body. We only use a very small amount of electricity in the experiments, so no worries.)

Now you must have known why the electrical wires are always covered in plastic.

Science Background

By the experiment we get known that electrical power can pass through some objects like metal wire core, human body. Actually, objects with such properties are called conductors. Conversely, objects that cannot

conduct electricity, like plastic, are insulators. Let’ s get to know more details about the conductor and insulator!

Conductors & Insulators

Conductors——Some materials let electricity pass through them easily. These materials are known as electrical conductors.

Insulators——Some materials do not allow electricity to pass through them. These materials are known as electrical insulators.

What makes a material a conductor or an insulator? Simply put, electrical conductors are materials that conduct electricity and insulators are materials that do not. Whether a substance conducts electricity is determined by how easily electrons move through it.

Electrical conductivity is dependent on electron movement because protons and neutrons don't move—they are bound to other protons and neutrons in atomic nuclei.

*https://www.thoughtco.com/examples-of-electrical-conductors-and-insulators-608315

How the Body Conducts Electricity

So why is electricity so dangerous? Electricity flows from one point to another along anything that will conduct it. One of the better conductive substances for electricity is water, which happens to represent about 70 percent of the human body. But even with all of that water inside of us, electricity doesn't flow through the human body unobstructed. It encounters resistance along the way, which causes some of the energy from the electric current to turn into heat. That heat from resistance causes one of the dangers of electricity: burns.

According to the industry regulations, the safe voltage should not be higher than 36V, and the safe current is 10mA.

Conclusion

In this project, we explored the question about a common phenomenon—- “Why are electrical wire covered in plastic?” , and learned what the conductors and insulators are. In fact, there are tons of scientific principles behind our various daily life phenomenon. Go and observe things in your everyday life carefully, you will learn more!

That’ s all for this lesson. Put all Boson modules in the original box.

Extend

The electrical wires we used at home are always wrapped in plastic coverings, but why are the high-voltage transmission lines not wrapped and insulated?

LESSON 2： Why Does the Moon Shine at Night?

Introduction

Standards

NGSS

4-PS4-2 Build a physical model to explain that when the light reflected by an object enters our eyes, the object can be seen.

5-ESS1-2 Present data in charts to illustrate how the length and direction of shadow changes throughout the day, the alternation of day and night, and seasonal changes of stars.

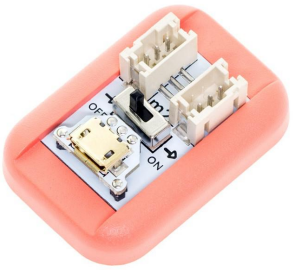
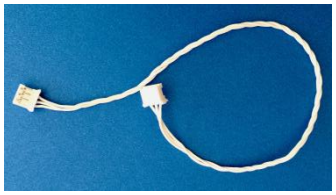
Science - Grade 3-5

Overview

Introduce the light of reflection principle to students starting from the question “Why does the Moon shine at night?” , then lead them to observe the phenomenon of light reflection by experimenting to recognize the nature of light.

Materials

BOSON Module	Image	Function

Battery Holder (3x AAA batteries installed)		4.5V Power Supply
MainBoard-1IO (m2)		Supply power for other modules
Light Sensor (i4)		Detect the intensity of ambient light
Display Module(o11) *1		Provide visual effect for users to check experiment results
BOSON cable *2		Use with 3Pin Foolproof connector to connect other

		modules

Additional Materials	Image	Function
Flashlight		Light source
White foam ball		Simulate the moon. Recommended diameter: 8-12cm
Paperboard Box		Provide a dark environment for the experiment

Mirror		Provide Mirror and plastic reflective surfaces for experiments

Engage

We often see the moon shining in the dark sky. The moon itself does not produce any light of its own, but why does it seem bright at night? And if we observe it carefully enough, we can find that the moon is not uniformly bright and there are dark shades all over it. Why is that?

Take a guess!

Explore

After making suppositions about the unknown question, let’ s test them by experimenting.

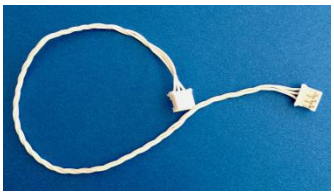
The first part of the experiment will mainly explore the question "why does the moon shine at night?". Then we will move on to the second part to discuss "why the moon is not uniformly bright?".

Part 1 Why does the moon shine at night?

Preparation

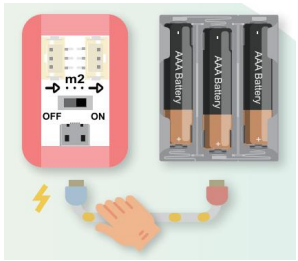
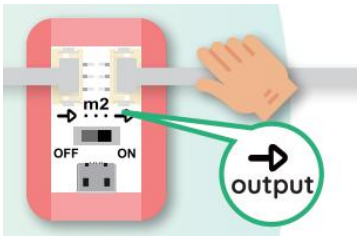
Use a flashlight (can emit light) to simulate the sun, take a white foam ball (cannot emit light) as the moon, and the BOSON light sensor as the human eyes to detect the intensity of light. Observe and think about why the moon shines at night in the experiment.

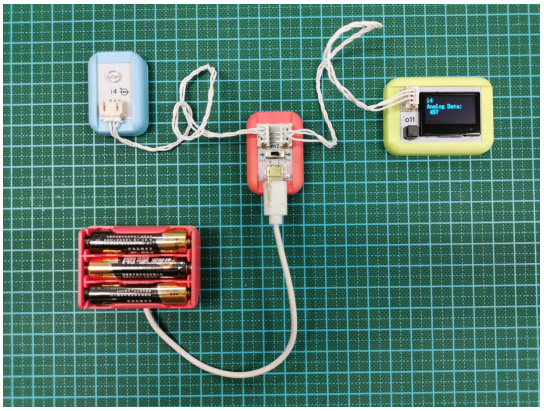
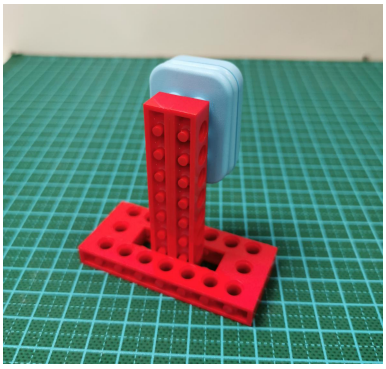
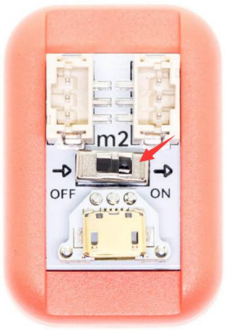
 Light Sensor (i4)	 Display Module(o11)	 MainBoard-1IO (m2)
 Paperboard Box	 Flashlight	 White foam ball

 Battery Holder（3x AAA batteries installed）	 BOSON cable *2

Step

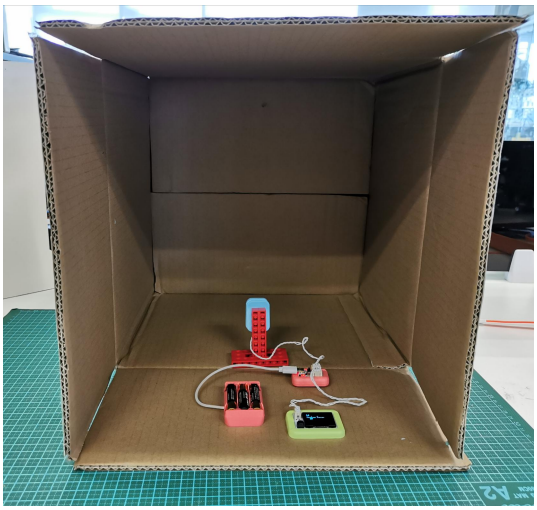
1. Build an experimental circuit to detect the intensity of light using the light sensor.

1-1 Connect the Battery Holder and two Module Cables to the Main Board.	  The cable's pin header should be plugged in completely so that it is not easy to pull it out.
1-2 Connect the Display Module to the output side of the Main Board with a Module Cable.	

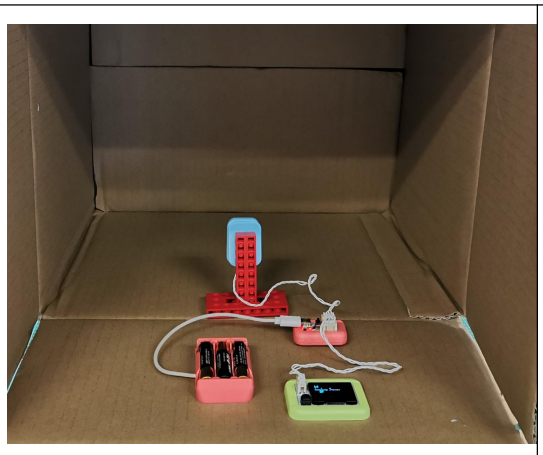
1-3 Connect the Light Sensor to the input side of the Main Board with a Module Cable.	
1-4 Build a socket with Lego to fix the light sensor.	
1-5 Switch the Mainboard to ON"	
1-6 Press the black button on the module several times until the "i4 Analog Data" is displayed.	

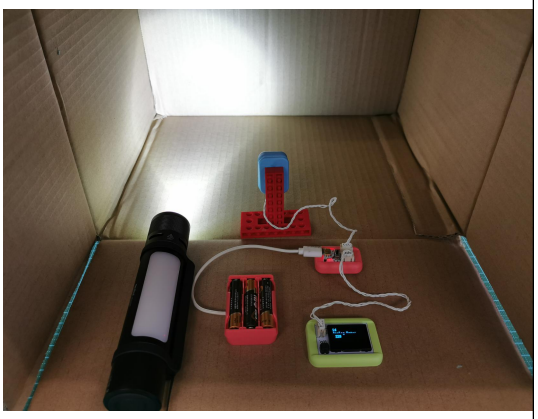
2. After the circuit is built, put it in a big paperboard box (if you can complete it in a dark environment, then the box is not necessary), point the round detector of the light sensor at the inner side of

the box, as shown below. It is suggested to fix the light sensor onto the box with adhesive tape to ensure the accuracy of the experimental results.



Carry out the three experiments below, and record the results in the form.

2-1 Record the light value displayed on the OLED module.		Light value: (Test result: 23)

2-2 Put the flashlight behind the light sensor (do not let the flashlight shine directly on the light sensor). Turn on the flashlight and record the light value.		Light value: (Test result: 228)
2-3 Put the white ball in front of the flashlight, and record the light value.		Light value: (Test result: 593)

Activity Conclusion

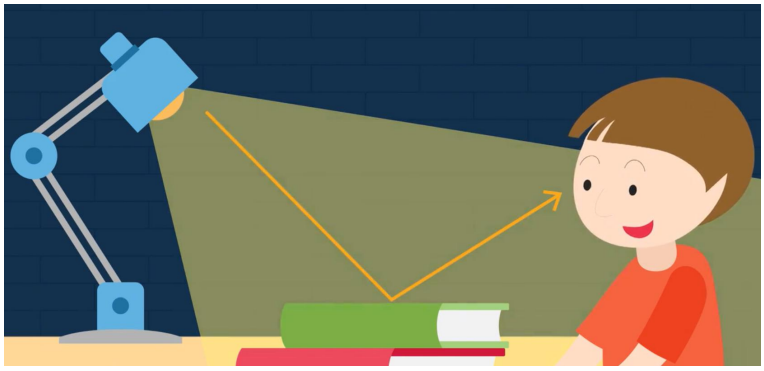
Imagine, if we do this experiment in a very dark environment, then we can’ t see anything before the flashlight is turned on.

When turning on the flashlight, the light emitted from the flashlight enters our eyes so we can see it. The foam ball does not produce light,

but it reflects the light of the flashlight into our eyes so it can be seen by us too.

We can see objects that do not produce light because they can reflect light.

For instance, at night, we turn on the lamp for reading. The light from the lamp enters our eyes so we can see it. The book cannot shine, but the lamp’ s light shines on the book and is reflected into our eyes by the book, as a result, the book can be seen by us.



Likewise, the moon itself does not emit light, but its surface reflects light from the sun, so we are able to see it.

Now, you must have known why the Moon shines at night!

Make a Conjecture

In the experiment above, the detected light data becomes larger gradually from the first to the third group.

When the flashlight is turned on, the paperboard box can be seen, indicating that the box can reflect light. After putting the white foam ball inside the box, the detected light value gets larger and the ball looks brighter than the box, from which we can infer that the white foam ball can reflect more lights than the paperboard box.

Do different objects has the same ability to reflect light? In the environment with a same light source, does the object with stronger reflection look brighter?

Then let' s go back to the previous question, why doesn' t the moon seem uniformly bright? Would it have something to do with the surface of the moon? Fill your supposition in the table below:

Question 1: Do different objects has the same ability to reflect light?	Supposition 1:
Question 2: Why doesn' t the moon seem uniformly bright?	Supposition 2:

Part 2 Why doesn’ t the moon seem uniformly bright?

We can suspect based on the analysis above that the light and dark patches on the moon are related to the different abilities of the moon’ s surface to reflect light.

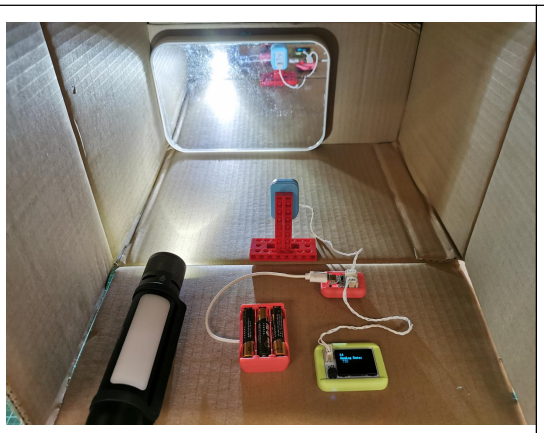
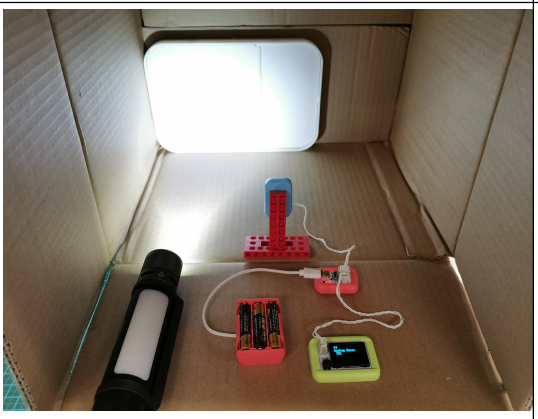
To test different objects’ ability to reflect light, we can use a mirror to carry out contrast experiments. The two sides of a mirror would be the experimental objects here since they are in the same size, which can avoid the effect of size difference on the light reflection. Complete the experiments below and record the result in the table.

Preparation

The circuit built in the previous experiment will be still used here. The two sides of a mirror will be the experimental objects.

 Mirror front side（Metal-coated glass）	 Mirror backside（plastic）

Step

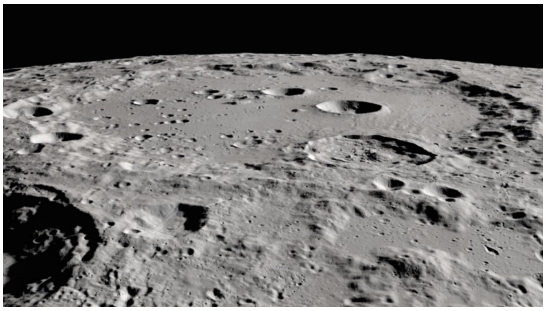
2-1 Let the mirror face the flashlight, record the light value.		Light value: (Test result: 708)
2-2 Let the mirror backside face the flashlight, record the light value.		Light value: (Test result: 291)

Conclusion

The experiments show that the mirror front side performs a stronger ability to reflect light compared with its back side, which states that the light reflection ability of different objects appears to be distinct, and the metal-coated surface can reflect more lights than a plastic surface.

The moon is like a big stone that doesn't shine. The moon’ s surface had what looked like valleys, plains and highlands much like the distinctly unheavenly surface of the Earth. Moreover, the material composition of these places is also various. The moon highlands are mainly composed of

light-colored rocks, and have a strong ability to reflect sunlight. So, when the sun shines on the highlands, they seem brighter. While the valleys areas are often covered by black volcanic rocks that have a much weaker ability to reflect light. Then, of course, they look much dimmer by contrast.



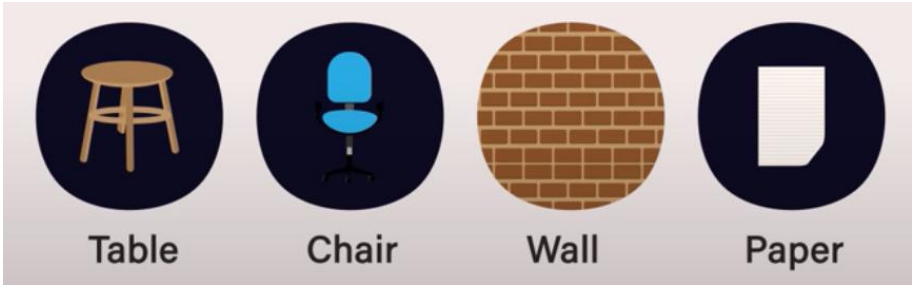
So now you may understand why the moon is not uniformly bright!

Science Background

In our daily life, there are a lot of objects that can make light, and we call them light sources. On the contrary, the objects that cannot produce light themselves are non-light sources. Through the experiments, we learn that human beings can see objects that do not shine by the reflection of light. Now let’ s get to know the light sources and non-light sources!

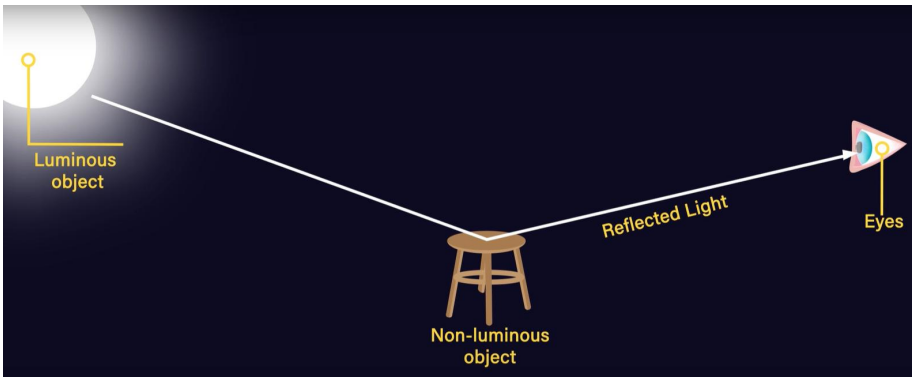
Light Source & Non-light Source

In physics, objects that can make light are called light sources, like the sun, fluorescent bulbs, burning candles, etc. The objects cannot emit light are non-light sources, such as table, chair, wall, paper, etc.



Reflection of Light

Reflection of light is the change in direction of a light ray at an interface between two different media so that the light returns into the medium from which it originated. It is because of the reflection of light that we can see objects that do not emit light.

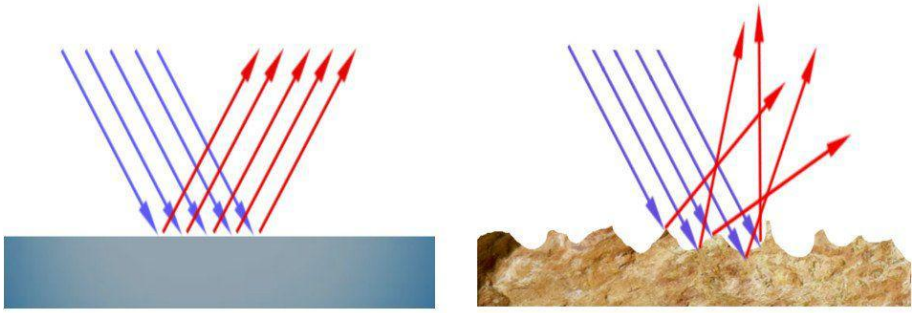


Specular reflection and diffuse reflection

The reflection of light can be roughly categorized into two types: specular reflection and diffuse reflection.

Specular reflection is defined as light reflected from a smooth and shiny surface at a definite angle, for instance, when a light beam falls on a surface like glass, water or polished metal, it reflects at the same time as it hit the surface.

Diffuse reflection is the scattering of light that occurs when it reflects off rough surfaces such as clothes, rocks, etc. Unlike specular reflection, which is calculated based on the surface angle, diffuse reflection is calculated based on the structure of the surface itself. For instance, a rough surface will reflect light at many angles, depending on its bumps, divots, and grain. Even a very smooth surface, like a wall, produces a diffuse reflection at many angles, due to the molecular structure of the material. Diffuse reflection contributes mostly to identifying the object when compared to specular reflection.



Specular Reflection **Diffuse Reflection**

Specular reflection and diffuse reflection often occur simultaneously. For example, sometimes, we may find the specular reflection on the blackboard since it comes with a very smooth surface, which makes it hard for us to see the contents on it clearly. But, the lights from the diffuse reflection of other objects like, ground and wall, can help us identify the words on the blackboard.

Think about it, when we look in the mirror, what kind of reflection happened? Can you find some specular and diffuse reflection phenomena in our daily life? What are the effects of specular reflection on our everyday life?

Conclusion

In this project, we mainly talk about the question "why does the moon

shine at night?", and get known to the reflection of light by experimenting, as well as have a rough understanding of the basics of specular reflection and diffuse reflection.

Then that's all for this lesson. Put all BOSON modules and tools back to the original place.

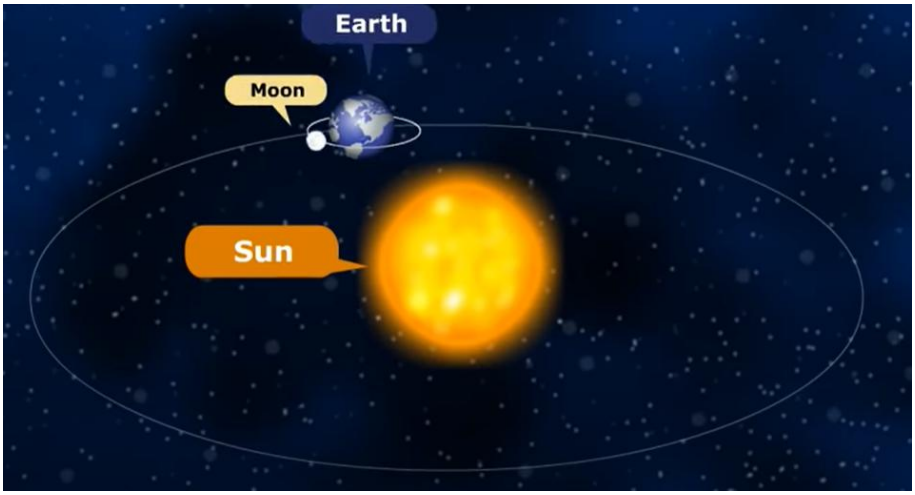
Extend

1. The moon's shape appears to be various at different times of a month, why does the moon change shape?

2. It seems that the moon always shows the same side to us, can we see other sides of the moon?

Appendix – Why the moon change shape?

In the universe, the sun is a star, the earth is a planet, and the moon is the permanent natural satellite of the earth. The moon rotates on its axis and revolves around the earth as the earth revolves around the sun. The moon's period of rotation and revolution are identical. So, one side of the moon always faces the earth.



Although we can only see one side of the moon, the moon may have different "shapes" in a month. It could look like a full circle, a half circle, a crescent, or sometimes it is even invisible. Why is that? Let' s find out the answer through a simple experiment.

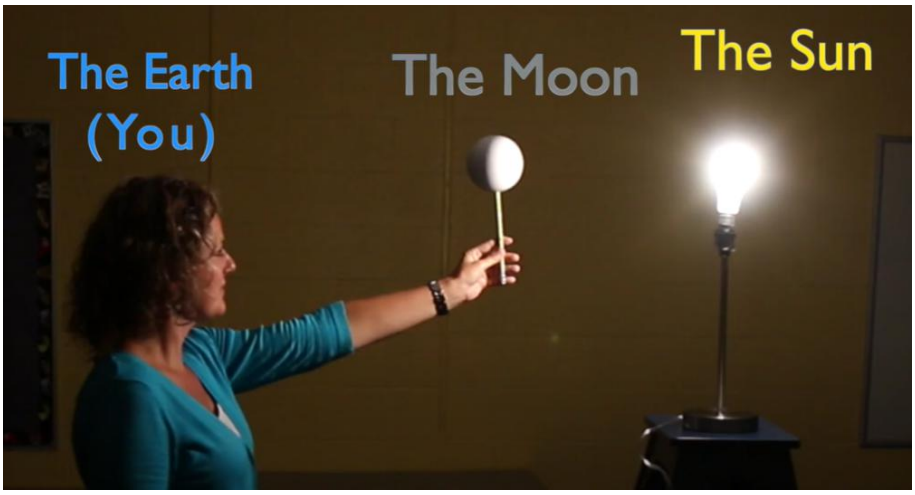
First, find a dark room (the darker, the better) to simulate the cosmic environment, prepare a table lamp to simulate the sun, think of our own head as the earth, and a white foam ball as the moon. Then the "Sun-Earth-Moon" models are corresponding to the "lamp-head-foam ball".

		
Lamp	White foam ball	Pencil

Step

1. Carefully piece the ball with the pencil, and hold it with your one hand.

2. Stand with the white ball at arm' s length in front of the sun(lamp), and keep turning to the left slightly to simulate that the moon(ball) rotates around the earth (your body).



3. The lamp is the model of the sun. Keep turning your body to the left while observing how the lighted portion of the ball looks at different positions.

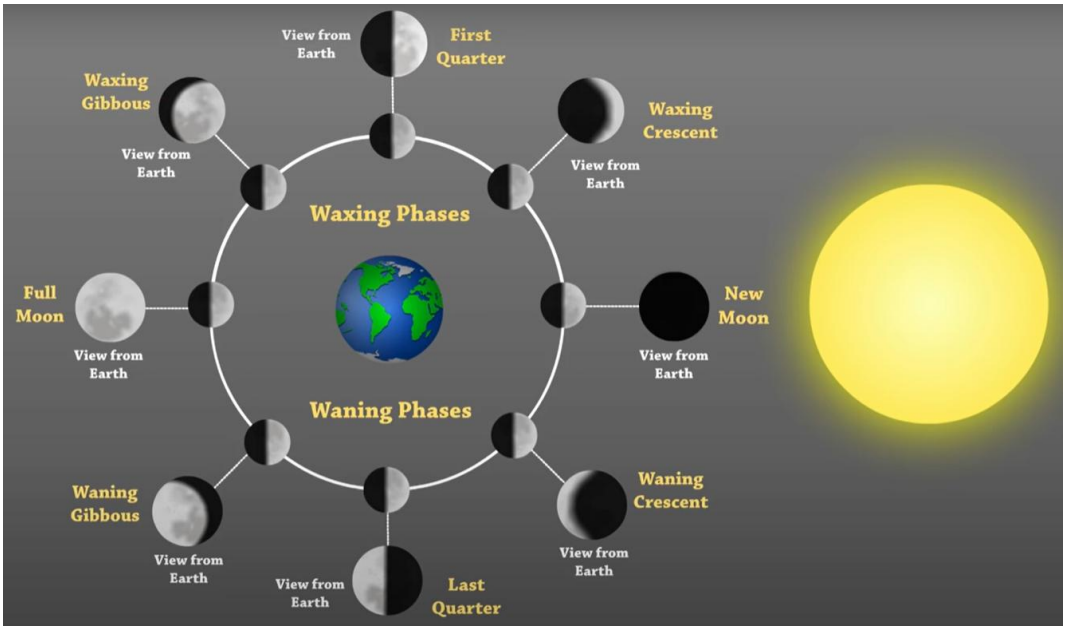
	Your positions	

* Video for reference:

https://www.youtube.com/watch?v=wz01pTvuMa0

Conclusion

We have known that the moon shines because its surface reflects light from the sun. In this experiment, as the moon orbits the Earth, we see the different parts of the lighted area. The revolution of the Moon around the Earth makes the Moon look as if it is changing shape in the sky. These are called phases of the Moon. Refer to the figure below to see if the results of your observation are consistent with the moon phase chart!



LESSON 3: How to Make Your Living Room Comfortable?

Introduction

Standards

NGSS

5-PS1-3 Make observations and measurements to identify materials based on their properties.

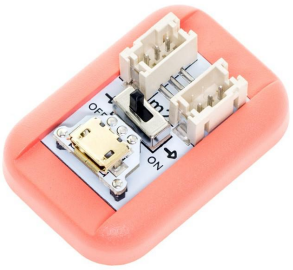
4-PS3-2 Make observations to provide evidence that energy can be transferred from one place to another via sound, light, heat, and current.

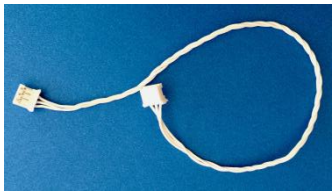
Science - Grade 3-5

Overview

There are many types of materials used in construction and their thermal insulation capacities are various. What materials are best for building a comfortable house? In this lesson,we will mainly explore the thermal insulation performance of wood, plastic, and metal so as to introduce the concept of heat, leading students to find out which kind of material has better thermal insulating performance as well as get to know the basics about heat transfer.

Materials

BOSON Module	Image	Function
Battery Holder (3x AAA batteries installed)		4.5V Power Supply
MainBoard-1IO (m2)		Supply power for other modules
Temperature Sensor (i11)		Detect environmental temperature
Display Module(o11)		Provide visual effect for users to check experiment results

BOSON cable *2		Use with 3Pin Foolproof connector to connect other modules

Additional Materials	Image	Function
Wooden Cup		Used for exploring the thermal insulation performance of wood
Plastic Cup		Used for exploring the thermal insulation performance of plastic
Metal Cup		Used for exploring the thermal insulation performance of metal
Blu-Tack		Fix the temperature sensor

Cup Cap x3		Cover the cups
Ice blocks		Temperature Experiments

Engage

Whether it's in the hot equatorial region or the cold Arctic, people all want a very comfortable indoor temperature. Imagine that we have just arrived at a deserted tropical island, where the scenery is beautiful, but it's pretty hot... There are three kinds of materials on the island that can be used to build a house: wood, plastic and metal sheet. If we want to live in a cool and comfortable house, which one should we choose? Take a guess!

Explore

The thermal insulation performance is closely related to the transfer speed of heat. The better the thermal insulation effect, the slower the heat transfer speed. Will the three materials wood, plastic and metal transfer heat at the same speed?

This lesson mainly contains two parts: 1. Feel the temperature of the three materials by touching. 2. Use the BOSON temperature sensor to explore the thermal insulation capacity of the three materials so as to find out the most suitable one for building a house.

Part 1 Observation: Which material feels colder?

It is known that in winter, metal feels colder than plastic and wood, while in summer, it feels hotter than the latter two materials. Why is that?

If we put a piece of ice in a wooden cup, a plastic cup and a metal cup, which will feel colder after keeping still for a while?

Material

			
Plastic Cup	Wooden Cup	Metal Cup	Ice blocks

Step

1. Put three ice blocks of the same size into the plastic cup, wooden cup and metal cup respectively.	
2. Put the three cups at the same indoor temperature, and keep still for 5 minutes(Do not touch them within this time) Note: If the experiment is carrying out in summer with high temperature, then shorten the experiment time in case the ices melt completely.	
3. After 5 minutes, touch the outer wall of the plastic cup and the wooden cup with both hands to see which cup feels colder.	
4. After the temperature of your both hands back to normal, touch the outer wall of the wooden cup and metal cup to see which cup	

feels colder.	

Conclusion

The experiment shows that the metal cup feels colder than the other two cups, which indicates that metal has the fastest heat transfer speed among them. Wooden cups and plastic cups feel almost the same, so they transfer heat at about the same rate.

Make a Conjecture

When building a house, which kind of material should we choose to achieve better thermal insulation performance? Take a guess!

Part 2 Measurement: The thermal Insulation Performance of different material

In this experiment, we need a wooden cup, a plastic cup and a metal cup with similar volume and thickness, put ice blocks of the same size into each cup, and then use the BOSON temperature sensor to measure the temperature change of the three cups. Present the thermal insulation capacity of the three materials by the experimental data and record values in the table below.

Time / Material	0min	10min	20min	30min
Plastic Cup				

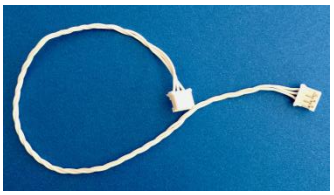
Wooden Cup				
Metal Cup				

Note:

If the experiment is carrying out in summer with high temperature, then shorten the experiment time in case the ices melt completely.

Material

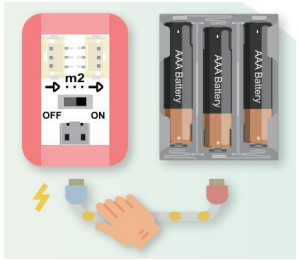
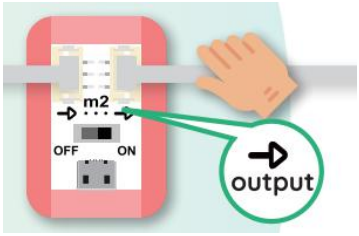
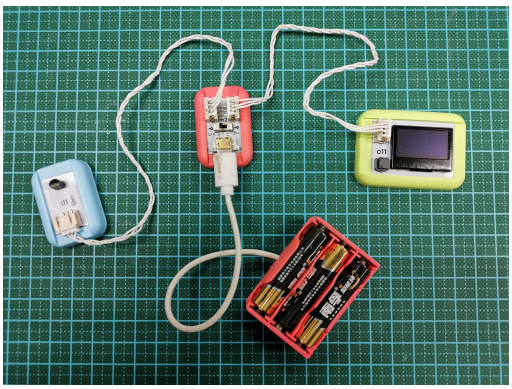
Prepare the following BOSON modules and other materials.

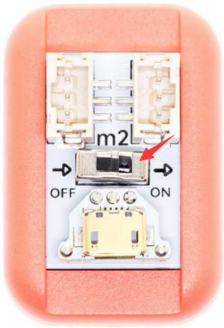
 Display Module(o11)	 MainBoard-1IO (m2)	 Temperature Sensor（i11）
 Battery Holder（3x AAA batteries installed）		 BOSON cable *2
 Wooden Cup	 Plastic Cup	 Metal Cup

		
Blu-Tack	Cup Cap x3	Ice Blocks

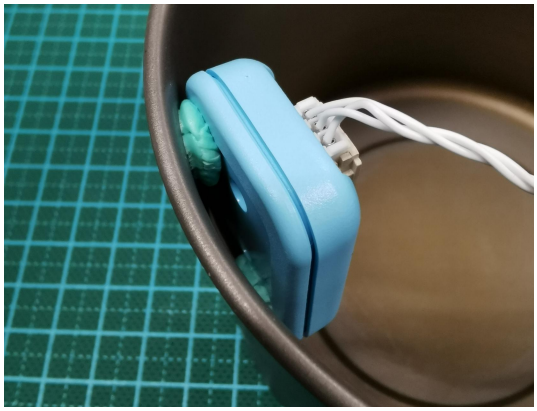
Step

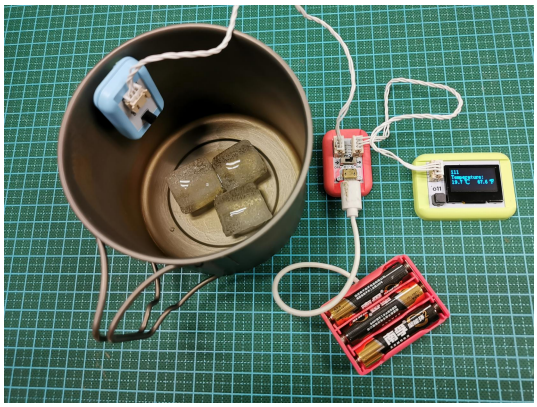
1. Build an experimental circuit to detect the environmental temperature.

1-1 Connect the Battery Holder and two Module Cables to the Main Board.	  The cable's pin header should be plugged in completely so that it is not easy to pull it out.
1-2 Connect the Display Module to the output side of the Main Board with a Module Cable.	
1-3 Connect the Temperature Sensor to the input side of the Main Board with a Module Cable.	

1-4 Switch the Mainboard to “ON” .	
1-5 Press the black button on the module several times until the “i11 temperature” is displayed.	

2. When the circuit is built, complete the following steps.

2-1 Fix the BOSON temperature sensor on the inner wall of the metal cup with Blu-Tack. Note: Fix the sensor at a suitable height. The cup cap should be able to be covered properly and make sure the sensor will not be immersed and damaged by water when the ices melt.	

2-2 Put three ice blocks into the metal cup, put the lid on it. Record the temperature at 0min, 5min, 10min and 15min, as shown in the table below. Note: To ensure the accuracy of the result, the cup should be covered by the lid all the time during the experiment period.	
2-3 Change the metal cup into the plastic cup and wooden cup, repeat the above two steps, and record the experimental data.	

Tip: In the actual experiment, for saving time, teachers can arrange three groups of students to choose different materials and do the experiment at the same time, and then summarize the data in one table.

Conclusion

The reference experiment data are shown below(at indoor temperature 20℃):

Time	0min	10min	20min	30min

Material				
Plastic Cup				
Wooden Cup				
Metal Cup				

The experimental data shows that, for the heat transfer performance: metal>wood>plastic, which also means, for material thermal insulation capacity: metal<wood<plastic.

Now, do you know what material we should choose to build a house?

Science Background

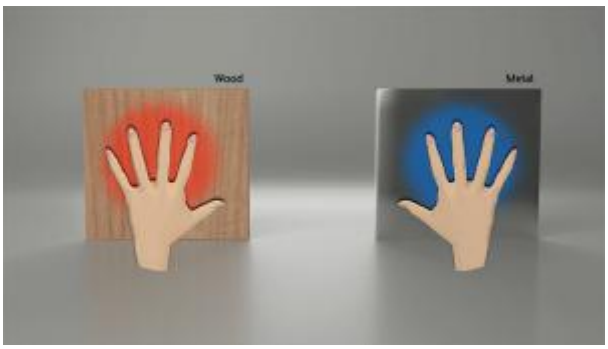
From the experiment, we get known to the thermal insulation of material, also heat transfer performance. Next, we will get into more details about how heat is transferred.

How is heat energy transferred?

Take wood and metal as examples. In a cold winter, the temperatures of wood and metal outdoors are almost the same as the ambient temperature.

When we touch metal, since our hand is warmer than the metal, the heat will be transferred from the hand to the metal. Metal material transfers heat so quickly that when the heat is just transferred to the part where our hand touches the metal, it will be transferred out by other parts of the metal, which will make us feel cold when touching it.

When touching a wood, similarly, that heat will be transferred from the hand to the wood because its temperature is higher than the latter. The difference is that, since the wood transfers heat slowly, the heat absorbed by the wood will accumulate at the part where our hand touches the wood, as a result, it does not feel so cold compared with the metal.



Good Conductor and Poor Conductor of Heat

Metals are called good conductors of heat since they can speedily transfer heat, whereas materials that transfer heat slowly like wood, plastic, paper, air, and cloth are poor conductors of heat.

Metals among solids are good conductors of heat, such as silver, copper and aluminum. Other solids are mostly poor conductors of heat, such as stone, ceramics, glass, wood, etc. And materials like, wool, feathers, fur, cotton, asbestos have very poor heat transfer performance, which can save the heat emitted by the human body and keep the body warm. So people often wear cotton-padded clothes, sweaters or down jackets in winter.

Conclusion

In this project, we explored the scientific principle behind the common phenomenon “Why do metals feel colder than plastic”, finished the research experiment using the BOSON temperature sensor, and learned the basics about good conductors and poor conductors of heat. So the question at the beginning of this lesson can be answered now.

That’s all for this lesson. Please put all BOSON modules into the original box.

Extend

Many mugs are made of stainless steel, why do they still have such a good thermal insulation effect?

Lesson 4: Does the Car Sun Shield Really Work?

Introduction

Standards

NGSS

4-PS3-2 Make observations to provide evidence that energy can be transferred from one place to another via sound, light, heat, and current.

4-PS3-4 Design, test, and optimize a device that can convert energy form from one to another based on scientific conception.

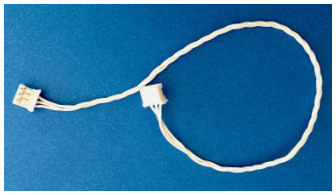
Science - Grade 3-5

Overview

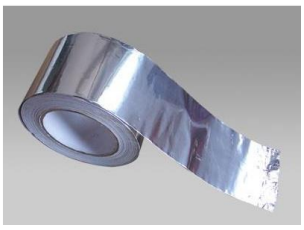
In summer, our cars always get hot easily. How can we solve this problem? In this lesson, starting with this common phenomenon, we are going to test whether a sun shield is effective in shading and insulating the heat from the sun, and review the knowledge about heat transformation. Then, we are going to study which of the three materials, aluminum foil, corrugated paper and black EVA sponge paper, is more suitable for making sun shields for cars, so that we can learn the energy transformation process and the knowledge of thermal radiation.

Materials

BOSON Module	Icon	Function
Battery Holder (3x AAA batteries installed)		4.5V Power Supply
MainBoard-1IO (m2)		Provide power for other modules
Temperature Sensor (i11)		Measure the environment temperature
Display Module(o11)		Provide visual effect for users to check experiment results

BOSON cable *2		Cooperate with 3Pin Foolproof interface to connect each module

Additional Materials	Icon	Function
Warm-light Lamp		Generate heat and light as the sun (be sure not to use cold-light lamps, because they only generate light but no heat)
Plastic Box		It is used to simulate the vehicle. A glass one is also okay. (smaller one is recommended for a

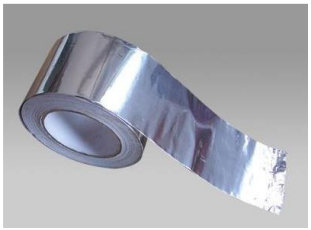
		better effect)
Aluminum Tape		It is used to make the sun shield. You can also choose household aluminum foil
Corrugated Paper		It is used to make the sun shield. Its thickness is 2mm or so
Black EVA Sponge Paper		It is used to make the sun shield. Its thickness is 2mm or so
Paper Knife		Cut the paper
Blu Tack		Fix the sensors and the materials

Engage

Sunlight is everywhere, and we can’ t live without it. But sometimes, it may also be annoying. For example, in open parking in summer, after continuous exposure to the sun, the car will be super-hot, like an oven. Every time you enter the car, you will feel like entering a sauna!

Many people have come up with many methods, such as turning on the AC to cool down in advance, or opening the door to have ventilation, while some people put a sun shield made of tin foil in front of the windshield to block out the sunshine and cool the car down.

Do you think sun shields really work? Why are sun shields usually made of tin foil? If there is aluminum-foil paper, corrugated paper, black EVA sponge paper to be chosen, which one do you think is the best? Make a guess!



Explore

We have already made a guess about the above two questions, now let's check it out!

The experiment will be divided into two parts. In the first part, the BOSON temperature sensor will be used to test whether the sun shield has a cooling effect through comparative experiments. In the second part, we will explore the cooling effect of aluminum aluminum-foil paper, corrugated paper and black EVA sponge paper respectively, and select materials more suitable for making sun shield.

Part1 Does Sun Shield Really Work?

In order to explore whether the sun shield really works, we can study it in real life. For example, find two vehicles, one with sun shield, while the other without. Carry out experiments under the same sunlight to compare the temperature changes inside the two vehicles.

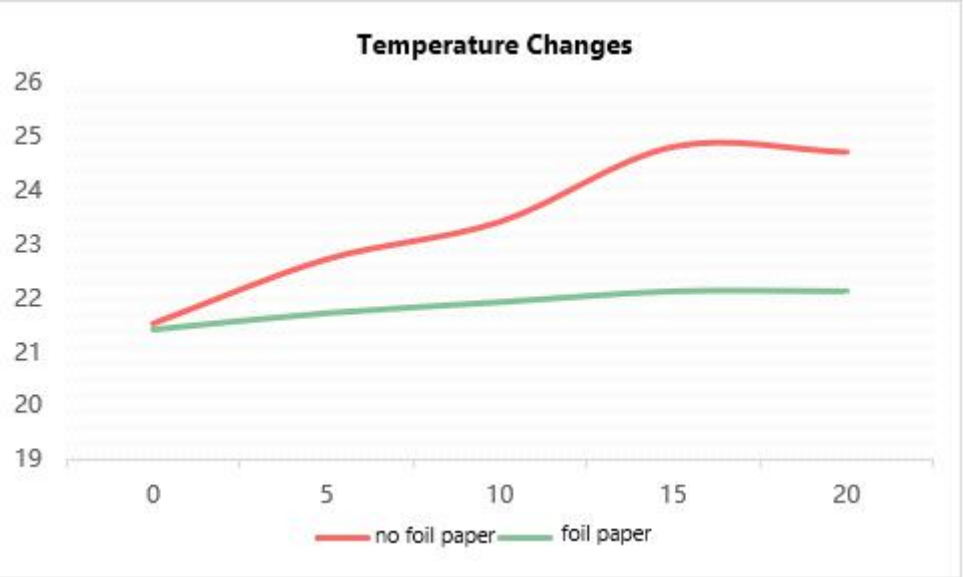
With some simple materials, we can simulate this scenario. For example, take a lamp as a light resource, turn a plastic box upside down to simulate vehicle (plastic box can be used to simulate the enclosed interior of a vehicle), foil tape as a simple sun shield. We can carry out two groups of the controlled experiments, and draw conclusions through the comparison of temperature changes.

Record the value of temperature in the table below!

Exposure Time	0min	5min	10min	15min	20min
No Aluminum-foil paper					
With Aluminum-foil paper					

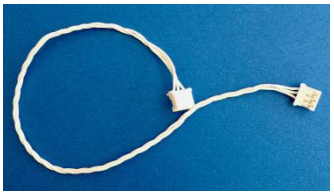
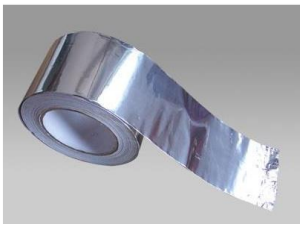
It is suggested to guide the students to draw data into a line graph manually.

In the line graph, the horizontal line refers to time, while the vertical line refers to temperature. When drawing, mark the measured temperature values with points, and finally connect the points together in turn with a smooth curve. Distinguish the temperatures of different conditions with different colored lines, as shown in the figure below.



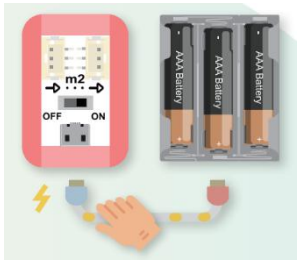
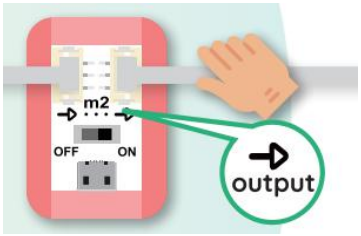
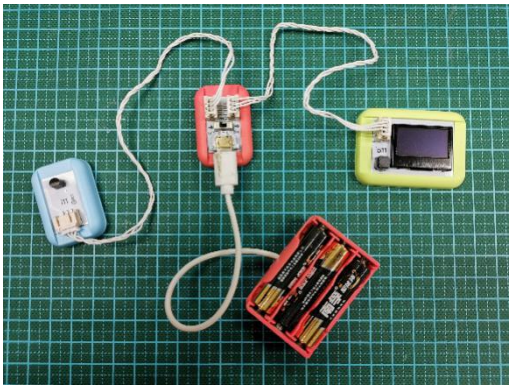
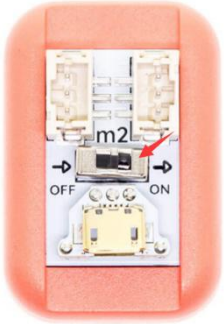
Materials

Prepare the BOSON module and other materials below.

		
Display Module(o11)	MainBoard-1IO (m2)	Temperature Sensor（i11）
		
Battery Holder（3x AAA batteries installed）		BOSON cable *2
		
Warm-Light Lamp	Plastic Box	Aluminum-Foil Tape
		
Blu Tack	Paper Knife	

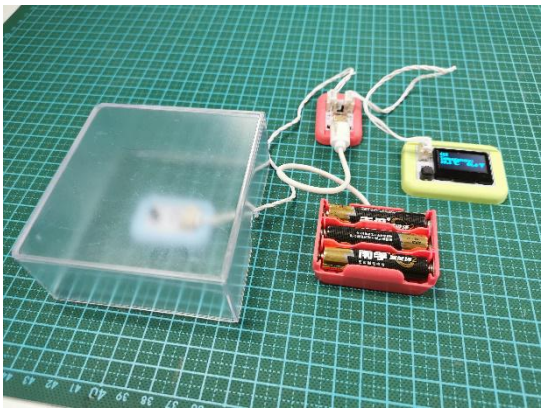
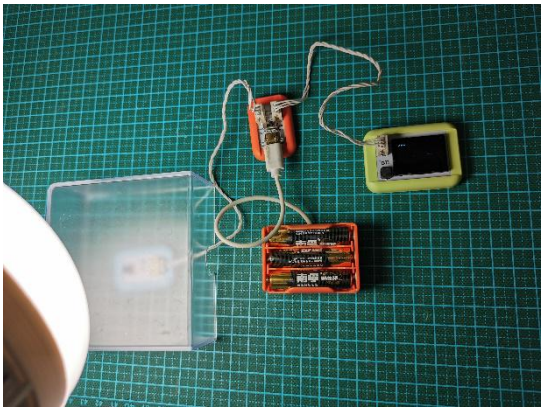
Step

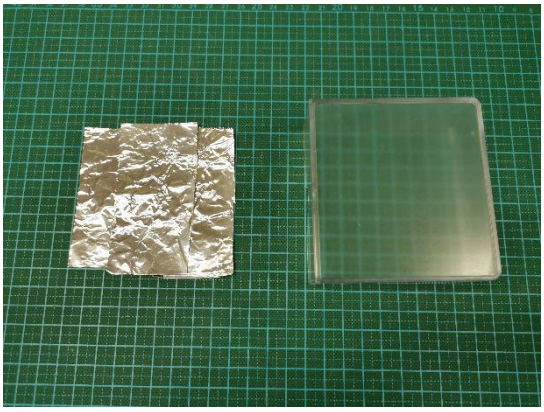
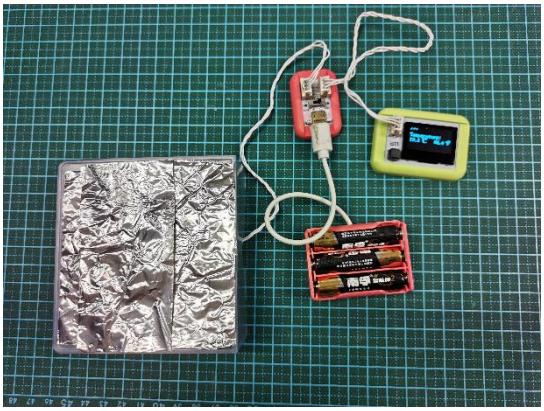
1. Build an experimental circuit to measure the environmental temperature

1-1 Connect the battery holder and two module cables to the main board.	  The cable's pin header should be plugged in completely so that it is not easy to pull it out.
1-2 Connect the display module to the output side of the main board with a module cable.	
1-3 Connect the temperature sensor to the input side of the main board with a module cable.	
1-4 Switch the Mainboard to "ON" .	

1-5 Press the black button on the display module several times until “i11 Temperature” is displayed.	

2. Continue the following steps after finishing connecting the circuit. Set two groups of experiments, one with aluminum-foil paper and the other without. Illuminate them with strong light, and then record the temperature changes of the two groups.

2-1 Fix the BOSON temperature sensor with blue tack and place the plastic box upside down to cover the temperature sensor.	
2-2 Point the lamp as close as possible to the top of the plastic box and turn on the lamp. According to the time in the previous table, record the temperature values of 0min, 5min, 10min, 15min and, 20min successively.	

(Do not move the position of the light source or the sensor during the experiment to avoid inaccurate experimental data)	
2-3 Turn off the lamp, wait for 5-10 minutes to let the temperature sensor value return to room temperature. Use a paper knife to cut the foil tape into the size of the top of the plastic box.	
2-4 Cover the foil on the top of the box, turn on the lamp and record the temperature values of 0min, 5min, 10min, 15min, 20min. (Do not move the position of the light source or the sensor during the experiment to avoid inaccurate experimental data)	

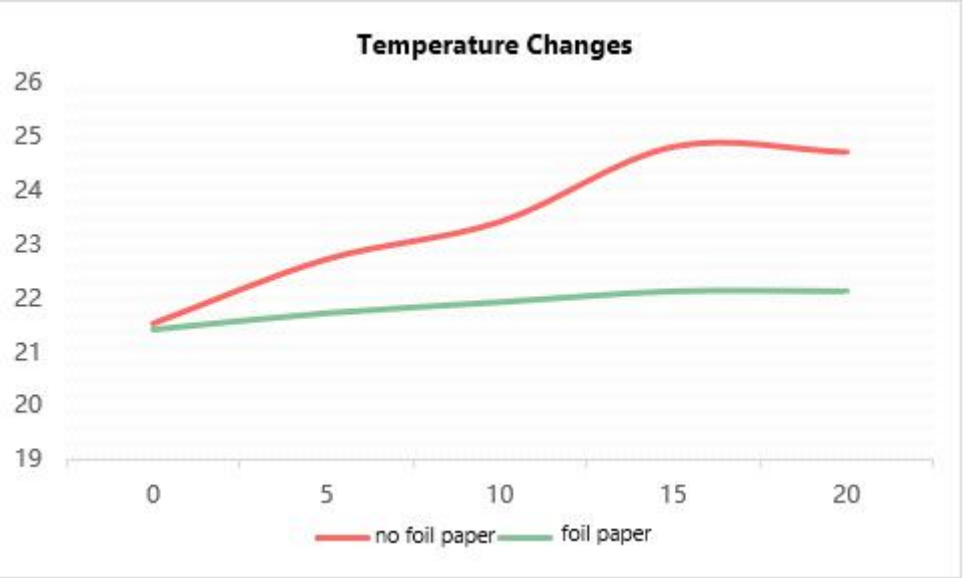
In the actual experiment, we can use two sets of equipment to carry out two groups of experiments at the same time, saving experimental time.

Conclusion

The referable experimental data are as follows (in the actual experiment, the room temperature is around 21℃):

Exposure Time	0min	5min	10min	15min	20min
No Aluminum-foil paper	21.5℃	22.7℃	23.4℃	24.8℃	24.7℃
With Aluminum-foil paper	21.4℃	21.7℃	21.9℃	22.1℃	22.1℃

The referable line chart is as follows :



It can be clearly informed from the line graph that when there is no aluminum-foil paper, the temperature rises all the time. After adding aluminum-foil paper, the temperature rises very slowly. Therefore, we can conclude that aluminum-foil paper does play a cooling effect, which means the sun shield really works.

Actually, a sun shield is just like a person with a sun umbrella. By blocking

part of the light, the heat from the sun cannot be directly transferred to the covered object, so it plays a role in heat insulation. However, when the sun is very strong or the object is illuminated for a long time, do you think the sun shield is still useful?

Part 2 What Materials Should the Sun Shield Be Made of?

In the above experiment, we learned that sun shields do have a cooling effect, so what would be a better material to use to make them? Here we will explore the cooling effect of aluminum-foil paper, corrugated paper and black EVA sponge paper, and select the most suitable material.

On the basis of Part 1 experiment, only two groups of the controlled experiments with corrugated paper and black EVA sponge paper are needed. Record the data in the table below.

Exposure Time	0min	5min	10min	15min	20min
No Aluminum-foil paper					
Aluminum-foil paper					
Corrugated Paper					
EVA Paper					

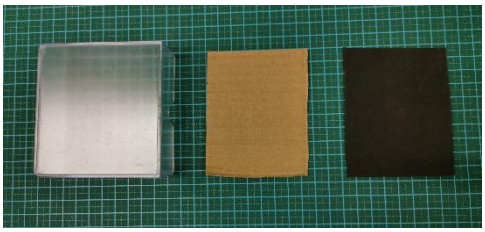
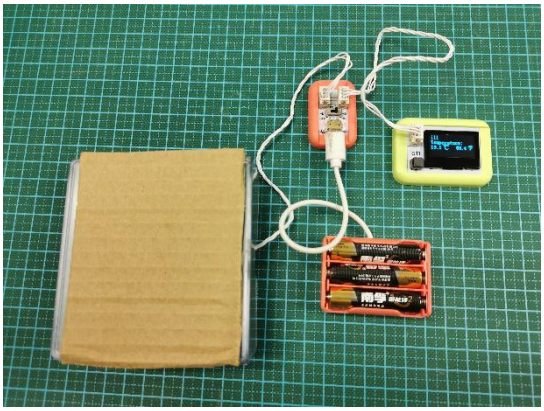
Draw the data into a line chart for easy comparison.

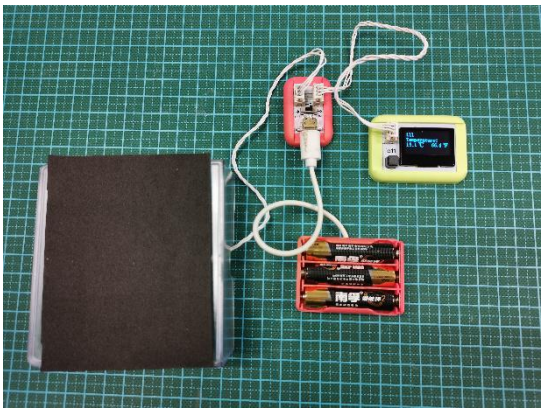
Materials

On the basis of Part 1 experiment, add the following materials.

 Corrugated Paper	 Black EVA Sponge Paper

Step

1 Use a paper knife to cut corrugated paper and black EVA sponge paper into the top size of the box.	
2 Cover the corrugated paper on the top of the box, turn on the desk lamp and record the temperature values of 0min, 5min, 10min, 15min, 20min. (Do not move the position of the light source or the sensor during the experiment to avoid inaccurate experimental data)	

3 Turn off the lamp, wait for 5-10 minutes to let the temperature sensor value return to room temperature.	
4 Cover the black EVA sponge paper on the top of the box, turn on the desk lamp and record the temperature values of 0min, 5min, 10min, 15min, 20min. (Do not move the position of the light source or the sensor during the experiment to avoid inaccurate experimental data)	

In the actual experiment, we can use two sets of equipment to carry out two groups of experiments at the same time, saving experimental time

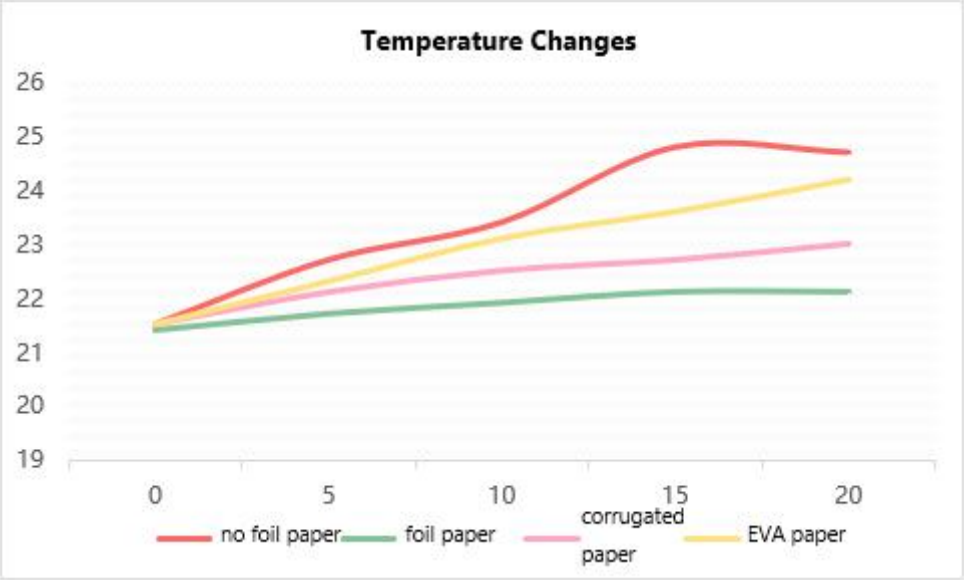
Conclusion

The referable experimental data are as follows (in the actual experiment, the room temperature is around 21℃):

Exposure Time	0min	5min	10min	15min	20min
No Aluminum-foil paper	21.5℃	22.7℃	23.4℃	24.8℃	24.7℃

Aluminum-foil paper	21.4℃	21.7℃	21.9℃	22.1℃	22.1℃
Corrugated Paper	21.5℃	22.1℃	22.5℃	22.7℃	23.0℃
EVA Paper	21.5℃	22.3℃	23.1℃	23.6℃	24.2℃

The referable line chart is as follows :



Analyze the line chart, which material do you think is the best for making sun shields?

Think about why different materials are with different effects? Try to explain it from the perspective of light reflection.

Science Background

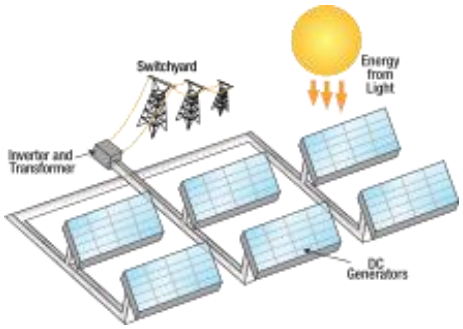
The sun brings warmth and light to the earth. It provides the earth with endless energy. That's why life on earth keeps growing. Do you know what energy is? Let's learn it together!

What Is Energy?

Energy is a basic physical concept, and it is also a very abstract concept. In the world, all things are in constant motion with various forms of motion. For every specific form of motion, there is corresponding form of energy, such as chemical energy of objects, heat energy of objects, radiation energy of sunlight, nuclear energy and so on.

Almost all the energy on the earth comes from the sun. The sun is like a big fireball with an extremely high temperature. Nuclear fusion is going on inside the sun, creating huge amounts of energy that radiates outward through the sun's rays and reaches the earth.

Energy is convertible, such as power plants that burn coal to convert chemical energy into electricity, or solar water-heaters that convert radiant energy from sunlight into heat energy from water.

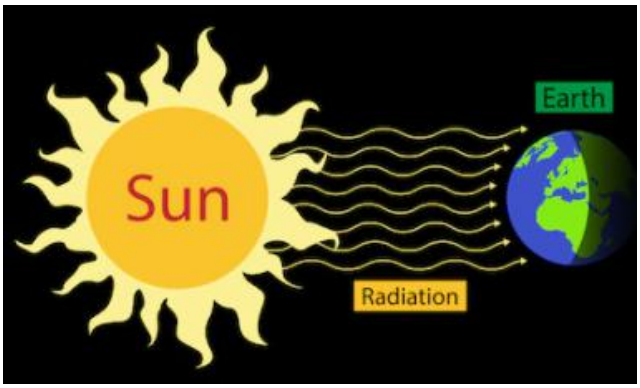


What Is Radiation?

Radiation is short for thermal radiation. It refers to the phenomenon that an object emits light and heat due to its temperature. Anything above absolute zero produces thermal radiation. The higher the temperature,

the stronger the radiation.

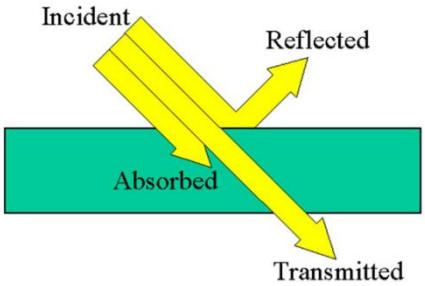
Some light emitted by thermal radiation is visible to the naked eye, while the other invisible. Human body temperature is lower, radiates invisible infrared light, with very low energy. The sun is very hot, radiates a lot of light, and it's with high energy.



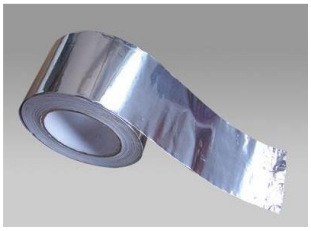
Why use aluminum-foil paper to make sun shield of a car?

When light hits on an object, three things happen: part of the light can be absorbed by the object, part of the light can be reflected by the object, and part of the light can continue to spread through the object.

The light absorbed by the object is converted into heat energy, which heats up the object.

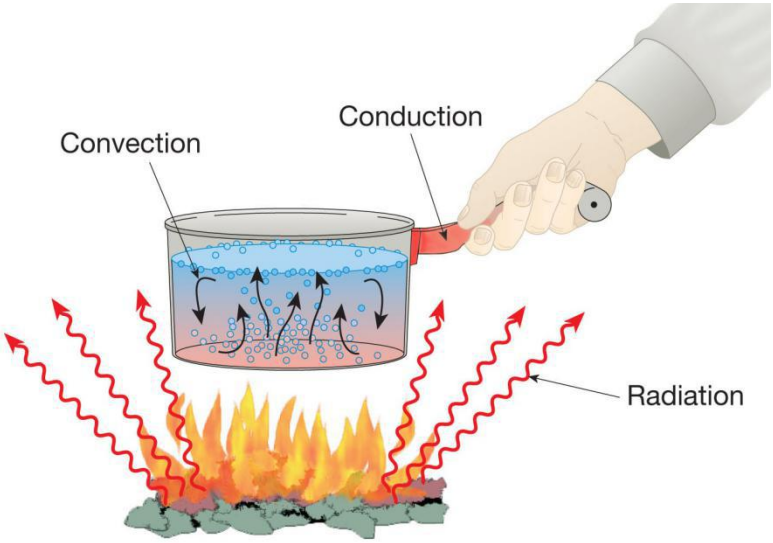


Aluminum-foil paper, corrugated paper, and black EVA sponge paper reflect light differently. Aluminum-foil paper, which reflects light very well, with less light absorption and slow heating, is suitable for sun shield.



Three ways of transferring heat

Heat radiation is one of the three ways in which heat is transferred, as well as by thermal conduction (conduction for short) and thermal convection (convention for short). As long as there is a temperature difference within or between objects, heat energy is bound to transfer from high temperature to low temperature in one or several of three ways. Here is an example.



Thermal conduction refers to the transfer of heat from a hotter object to a cooler one, such as touching the handle of a pot.

Thermal convection refers to the transfer of heat by the flow of the liquid or gas, such as the circulation of water in boil.

Thermal radiation refers to the electromagnetic waves radiated by objects because of their temperature. For example, when you are near a fire, you feel warm.

Both thermal convection and conduction require contact. Since there is a vacuum between the earth and the sun, the sun transmits heat to the earth through thermal radiation.

Conclusion

In this project, we started our exploration from a common phenomenon in life：Do car sun shields really work? We used the BOSON temperature sensor for scientific experiments, and drew the conclusion. We also further explored the cooling effect of three kinds of material: aluminum-foil paper, corrugated paper, and black EVA sponge paper, to help us choose the most suitable one for making car sun shields. Besides, we studied relevant knowledge of the thermal radiation as well.

The project is going to an end, please remove cables, and put all the BOSON modules back into the original position of the kit.

Extent

1. Do you think the sun shield should be put inside or outside the car?

2. Why can we warm ourselves with a heater in winter? Can you tell the scientific principles behind it?

LESSON 5：Why Is It Summer After Spring ,not Winter?

Introduction

Standards

NGSS

4-PS3-2 Make observations to provide evidence that energy can be transferred from one place to another via sound, light, heat, and current.

3-ESS2-1 Present data in charts to describe the expected typical weather conditions in a specific season.

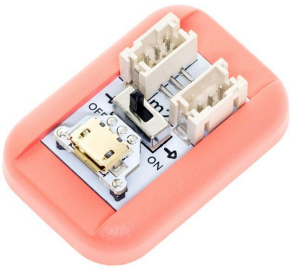
5-ESS1-2 Present data in charts to illustrate how the length and direction of shadow change throughout the day, the alternation of day and night, and seasonal changes of certain stars.

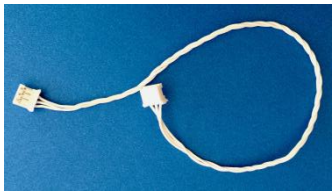
Science - Grade 3-5

Overview

This lesson will mainly focus on seasonal alternation, discussing the question "why is spring followed by summer, not winter?". It will lead students to construct a simple "earth-sun" model to explore the distribution of sunlight on the earth, study the direct and oblique light knowledge, and learn the revolution of the earth and the formation of the four seasons.

Materials

BOSON Module	Image	Function
Battery Holder (3x AAA batteries installed)		Provide power of 4.5V
MainBoard-1IO (m2)		Provide power for other modules
Light Sensor（i4)		Measure the intensity of ambient light
Display Module(o11) *1		Provide visible effect for other modules, make it easy to check the result

BOSON cable *2		Cooperate with 3-Pin fool-proofing interface to connect modules

Additional Materials	Image	Function
Flashlight		Light source
Globe		Model of the earth
LEGO Blocks		Set up a base for the flashlight
Blu Tack		Fix the sensors and the materials

Engage

In most places on the earth, people experience spring, summer, autumn and winter every year. Do you feel the differences between different seasons?

We feel different temperature during different seasons. The climate is pleasant in spring and autumn, hot in summer and cold in winter. Think about it, why are there four seasons in a year? Why is it summer after spring, not winter?

Explore

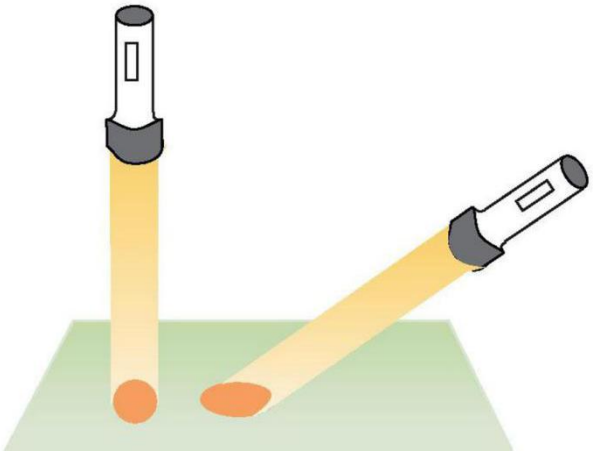
Last lesson, we talked about how the sun brings light and heat to the earth, and makes the earth full of vigor. Think about it, does the

distribution of sunlight on the earth vary during the year? Let's perform an experiment to find it out!

This experiment will be divided into two parts. The first part is to learn the direct and oblique light, and the second part is to explore the distribution of the direct and oblique light of the sun on the earth.

Part 1 Observation: Direct and Oblique Light

The effect is different when the light hits at different angles. A beam of light that shots vertically is called direct light, and one that shots at an oblique angle is called oblique light.



What is the difference between direct and oblique light? Try filling in your guess in the table below.

	Light (Concentrated/Scattered)	Temperature (High/Low)
Direct		
Oblique		

Materials

Flashlight

Step

Let us observe the direct and oblique light with a flashlight. The operation is as follows.

1-1 Illuminate the flashlight vertically on a flat surface and observe the size of the aperture of the direct light. We can also draw the aperture on the paper, so that we can compare and observe easily.	
1-2 Tilt the flashlight gradually and observe the change in the aperture of the oblique light.	

Activity Conclusion

The referable results are as follows.

	Light (Concentrated/Scattered)	Temperature (High/Low)
Direct	Concentrated	High
Oblique	Scattered	Low

As we can see from the above experiment, the direct light is concentrated, while the oblique light is scattered. The greater the angle of oblique light is, the more scattered the light is. With what we've learned about thermal radiation, we know that the energy is higher when the light is concentrated, and the temperature is higher.

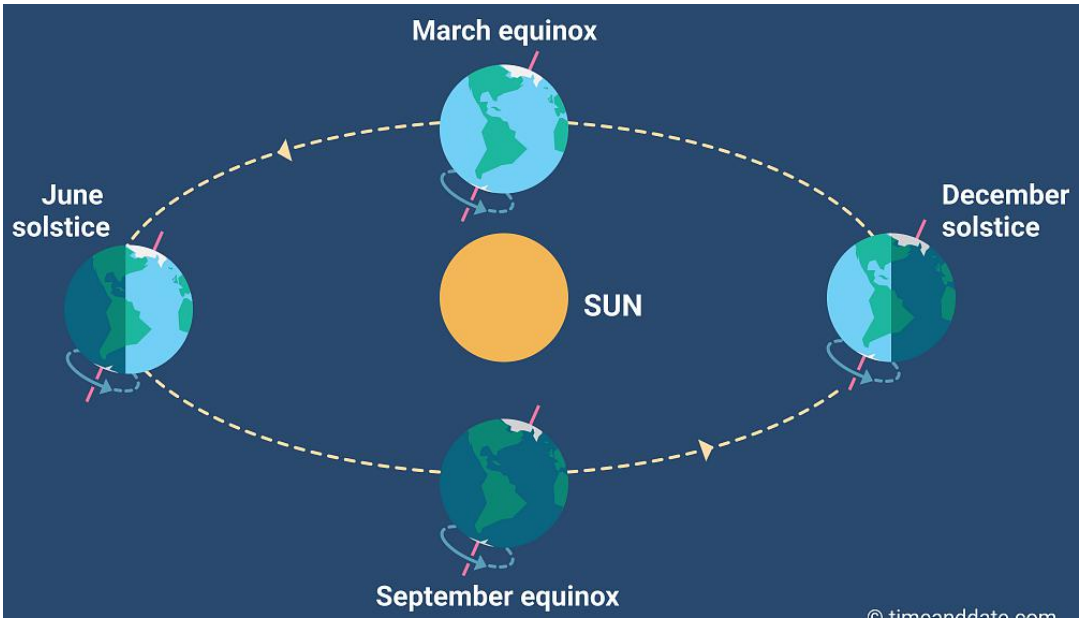
Conjecture

Think about it, is the sunlight direct or oblique? Will the distribution of the sun's direct and oblique light on the earth change? Come up with your conjecture!

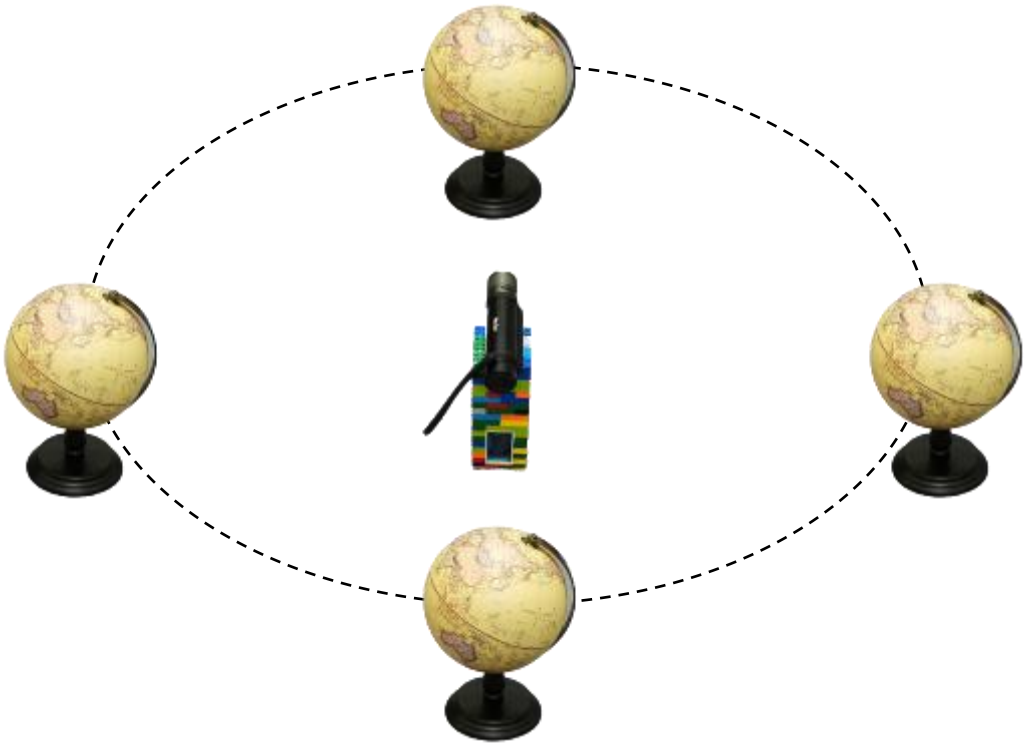
Part 2 Experiment: The Distribution of The Sun's Direct and Oblique Light on the Earth

In many places on the earth, people will experience spring, summer, autumn, and winter every year. The seasons alternate and repeat. Do you know why the cycle of the four seasons is one year? Will the distribution of the sun's direct and oblique light on the earth change during the year? Let's learn it together!

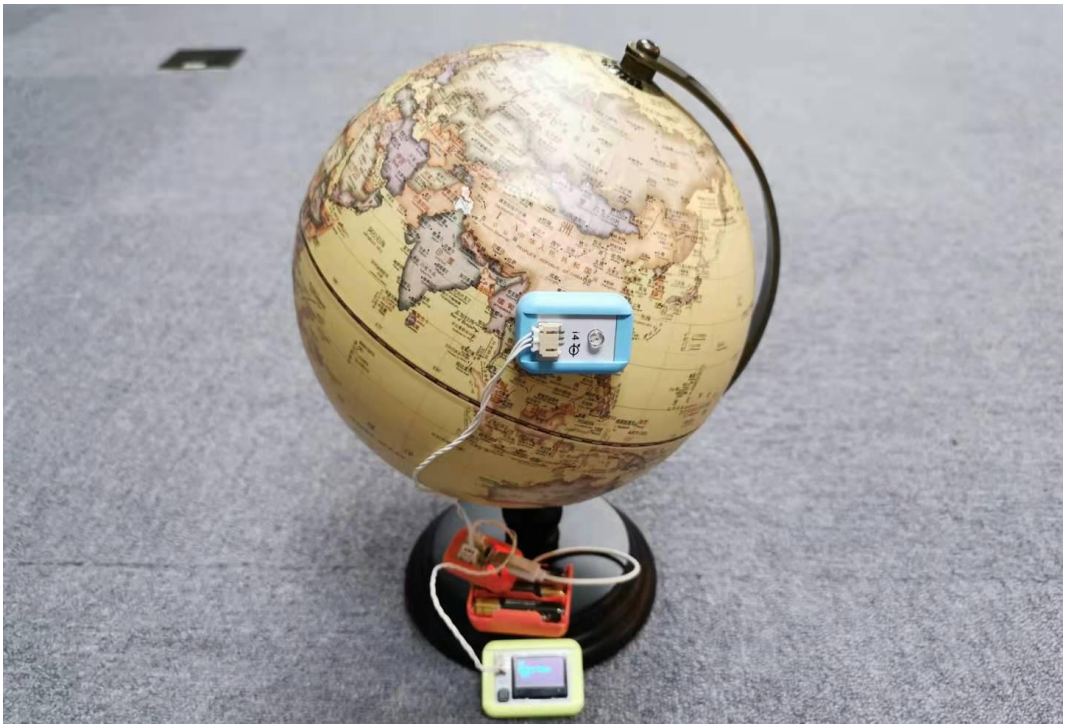
Let’ s learn about the revolution of the earth first. The earth revolves around the sun, which is the revolution of the earth, and the time for one revolution is one year. During the year, the earth will revolve to different positions. The following figure shows the relative position of the earth and the sun in March, June, September, and December. During the revolution, the earth is slightly tilted.



As the figure below, we can use a globe to represent the earth and a flashlight to represent the sun. Let the globe rotate around the flashlight to simulate the revolution of the earth. For example, in March, when the earth is in front of the sun, we turn on the flashlight and shine it on the globe, just like the sun shines on the earth.



Now, let’ s find a place with four seasons and observe the changes of light here as the earth revolves. For example, we select Guangzhou, China as the location. Find the location of Guangzhou on the globe (it is located near the Tropic of Cancer in China), and use the BOSON light sensor to detect the light intensity.

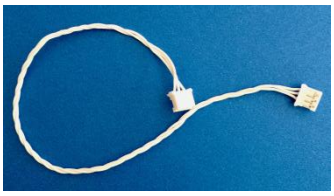


Finally, we choose March, June, September, and December as the observation points, when the earth revolves to the front, left, back, and right positions of the sun, observe whether the light in Guangzhou is direct or oblique, and whether the oblique angle is large or small. Record the results in the table below.

	March	June	September	December
Light intensity				
Direct/Oblique				
Angle of Oblique				

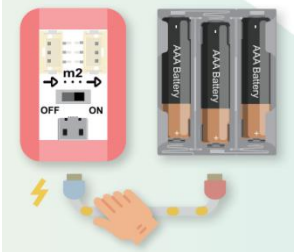
Materials

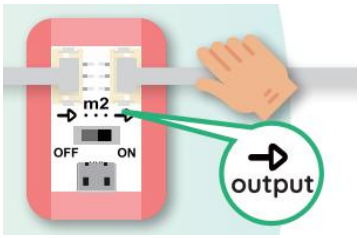
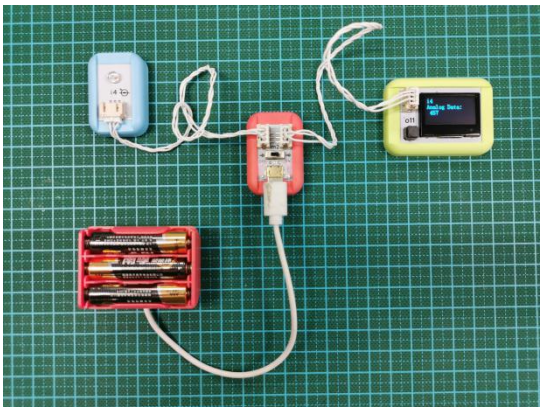
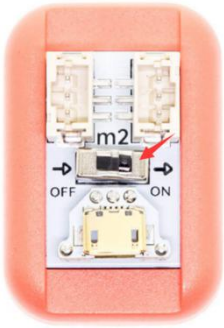
Prepare the following BOSON modules and other materials.

		
Display Module(o11)	MainBoard-1IO (m2)	Temperature Sensor（i11）
		
Battery Holder（3x AAA batteries installed）		BOSON cable *2
		
Flashlight	Globe	LEGO Block

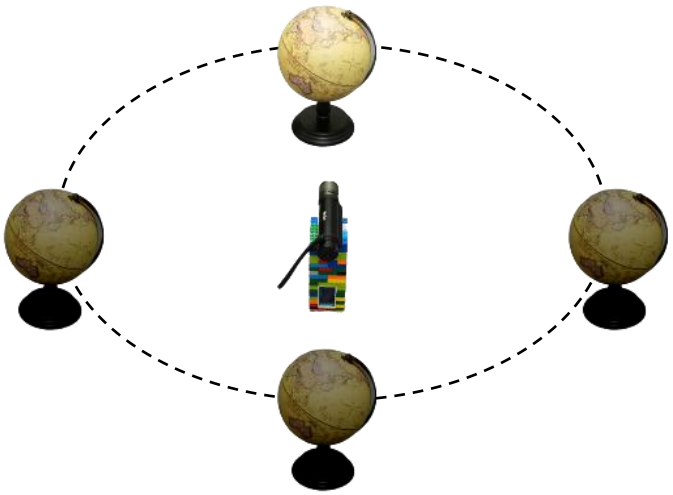
Step

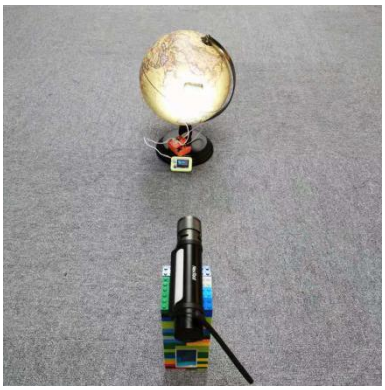
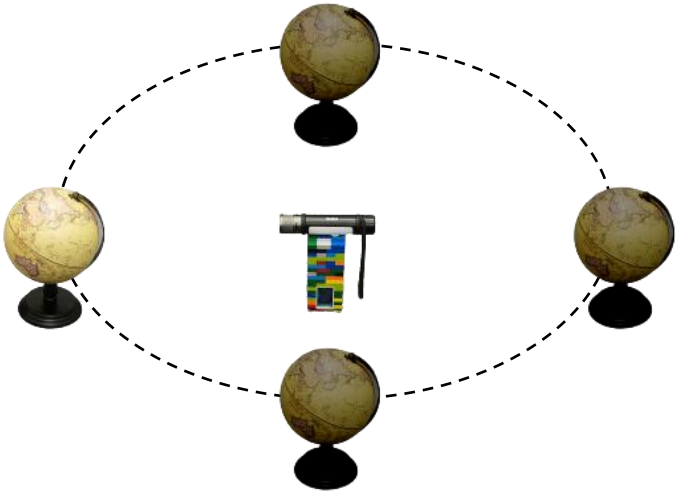
1. First, build an experimental circuit, and detect the light intensity through the light sensor.

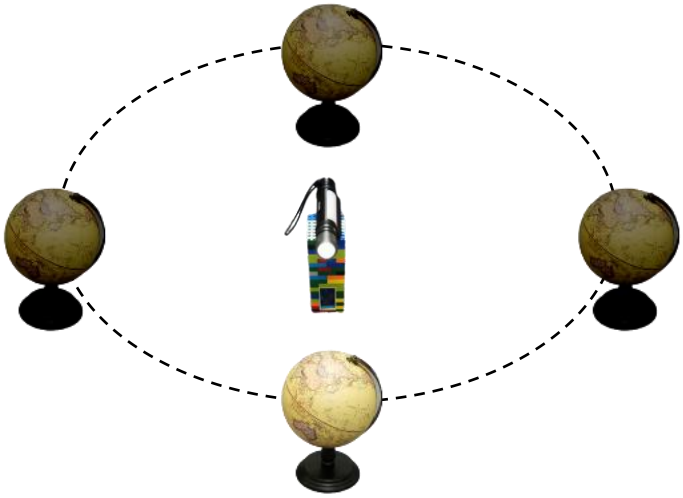
1-1 Connect the Battery Holder and two Module Cables to the Main Board.	

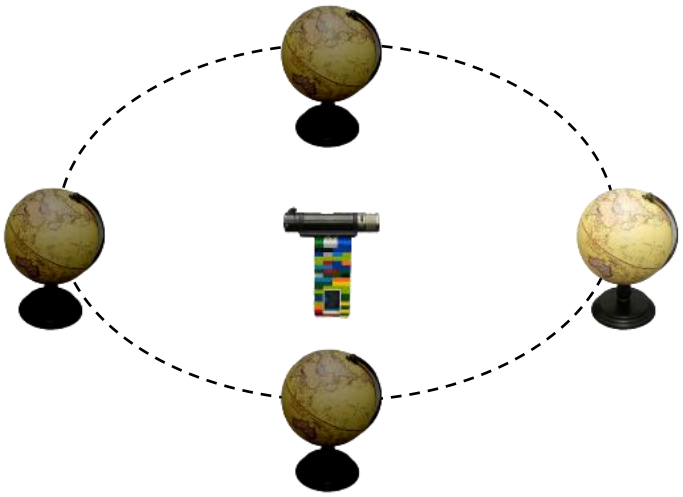
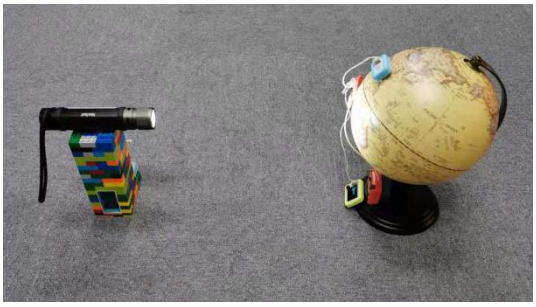
	
1-2 Connect the Display Module to the output side of the Main Board with a Module Cable.	
1-3 Connect the Light Sensor to the input side of the Main Board with a Module Cable.	
1-4 Dial the power module to "ON".	
1-5 Press the black button at the lower left corner of the display module several times until "i4 Analog Data" is displayed on the screen.	

2. After finishing the circuit connection, use the "Globe-Flashlight" to build the "Earth-Sun" revolution model.

2-1 Build a base with LEGO blocks and put the flashlight on it. Make the height of the flashlight the same as the center of the globe and fix the flashlight with blue tack.	
2-2 Fix the light sensor at the position of Guangzhou with blue tack.	
2-3 In March, place the globe in front of the flashlight, and make the flashlight face the globe with a distance of 30cm. Note: the globe is tilted in the same direction as the image on the right.	

2-4 Make Guangzhou face the flashlight. Turn on the flashlight, check the light intensity on the screen, and record the results in the column of March.	
2-5 In June, place the globe on the left side of the flashlight, and make the flashlight face the globe with a distance of 30cm. Note: the globe is tilted in the same direction as the image on the right.	
2-6 Make Guangzhou face the flashlight, and it will be blocked by the globe stand. So, we can fix the light sensor on the stand of the globe.	

Turn on the flashlight, check the light intensity on the screen, and record the results in the column of June.	
2-7 In September, place the globe behind the flashlight, and make the flashlight face the globe with a distance of 30cm. Note: the globe is tilted in the same direction as the image on the right.	
2-8 Make Guangzhou face the flashlight. Turn on the flashlight, check the light intensity on the screen, and record the results in the column of September.	

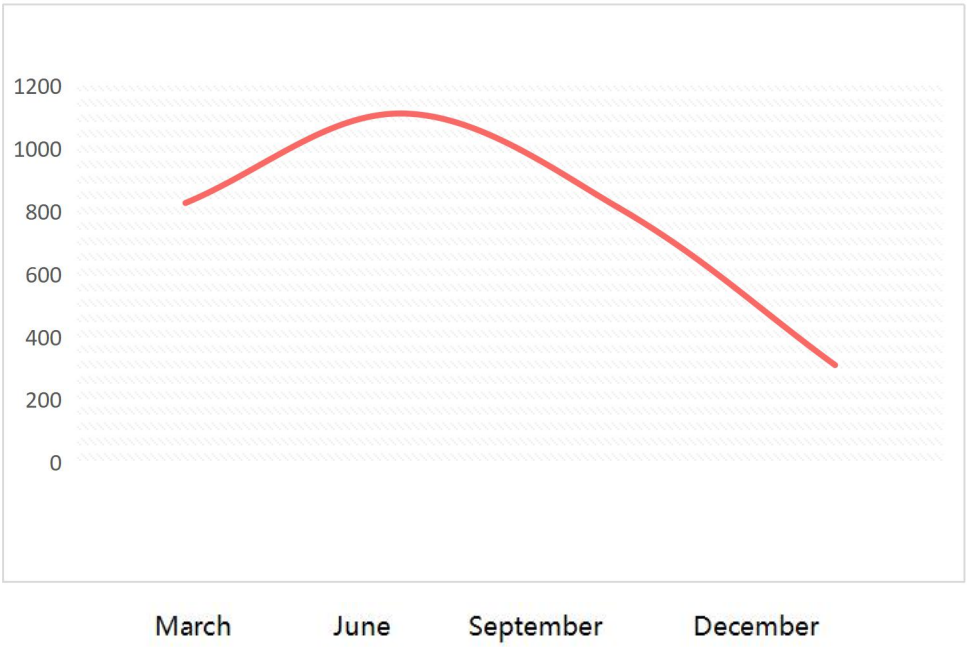
2-9 In December, place the globe behind the flashlight, and make the flashlight face the globe with a distance of 30cm. Note: the globe is tilted in the same direction as the image on the right.	
2-10 Make Guangzhou face the flashlight. Turn on the flashlight, check the light intensity on the screen, and record the results in the column of December.	

Activity Conclusion

The referable experimental data are as follows:

	March	June	September	December
Light intensity	827	1112	812	311
Direct/Oblique	Oblique	Direct	Oblique	Oblique
Angle of Oblique	Small	/	Small	Large

The referable line chart is as follows:



From the data, we can see that in Guangzhou, it is direct light in June, when the light is the strongest; In March and September, it is oblique light with a small oblique angle, and moderate light intensity; In December, it is also oblique light, with a larger oblique angle. The light is the weakest during this period. According to the information, Guangzhou will enter the hot summer in June, spring and autumn in March and September, and cold winter in December.

It can be concluded that the change in the angle of light irradiation corresponds exactly to the seasonal temperature change. When it is direct sunlight, the light is strong and the temperature is high; when it is oblique sunlight, the light is weak and the temperature is low. As the earth revolves, the angle of illumination in Guangzhou changes, causing

temperature change, forming the four seasons of spring, summer, autumn and winter.

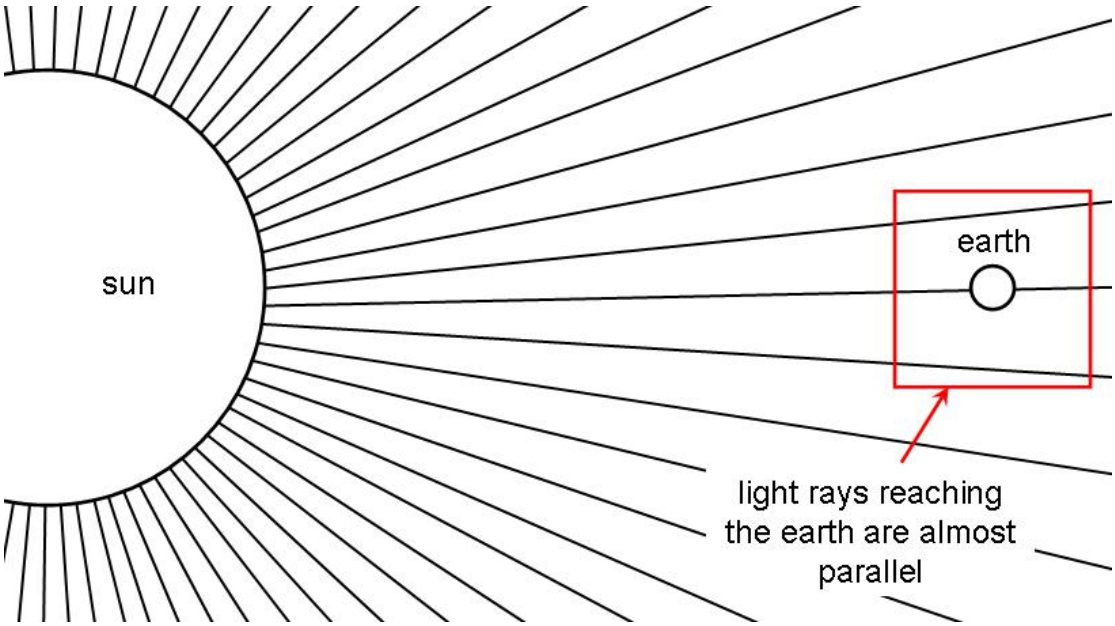
Now you know why spring is followed by summer, not winter!

Science Background

In the experiment, we assume that the sunlight is a parallel beam like the flashlight. Is the sunlight really a parallel one? Let's have a look!

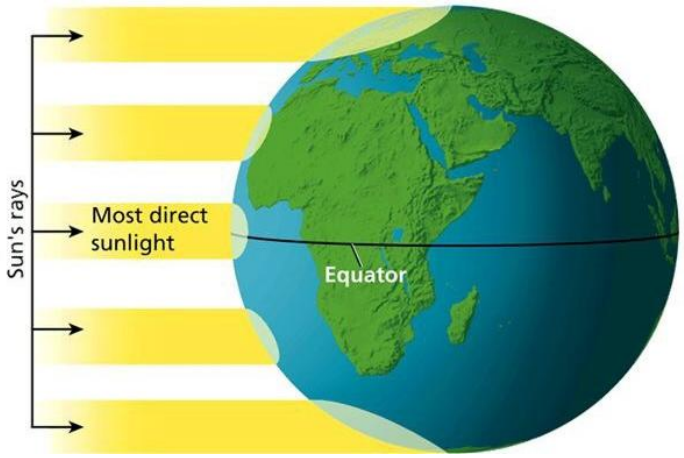
Is Sunlight a Parallel One?

The sun is like a shining fireball, radiating light equably around. The sunlight is not parallel theoretically. But because the distance between the earth and the sun is very far, about 150 million kilometers, the sunlight on the earth can be approximately regarded as parallel light.



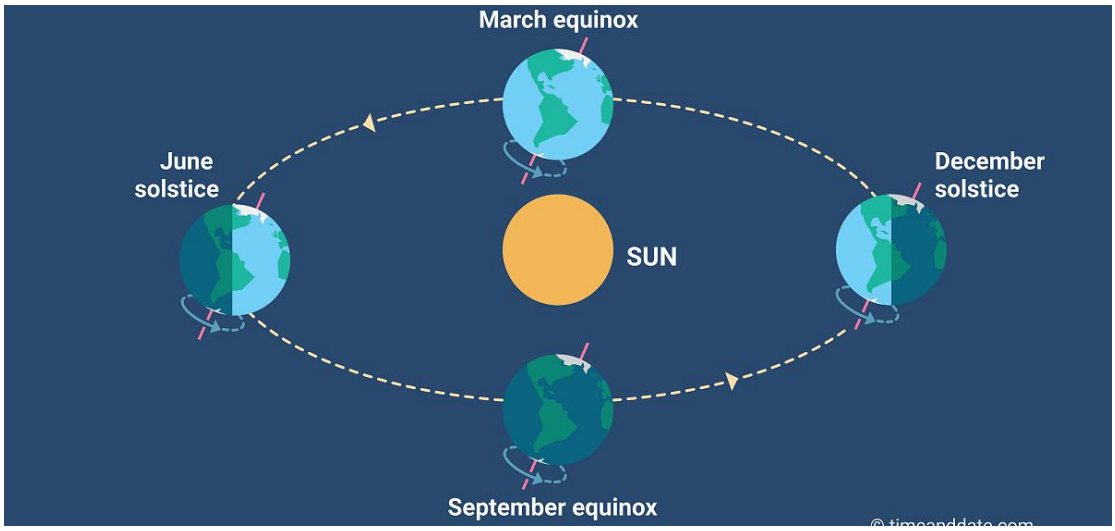
The Direct and Oblique Light on the Earth

If you regard sunlight as parallel light, since the earth is a sphere, there are some places where sunlight is direct light, while there are some places where sunlight is oblique light, it depends on the angle between the light and the surface of the earth. For example, in the picture below, in the equatorial region, the light is perpendicular to the surface of the earth, so it is direct light, and when going to the south or north pole form the equator, the light gradually obliques, so it is oblique light.



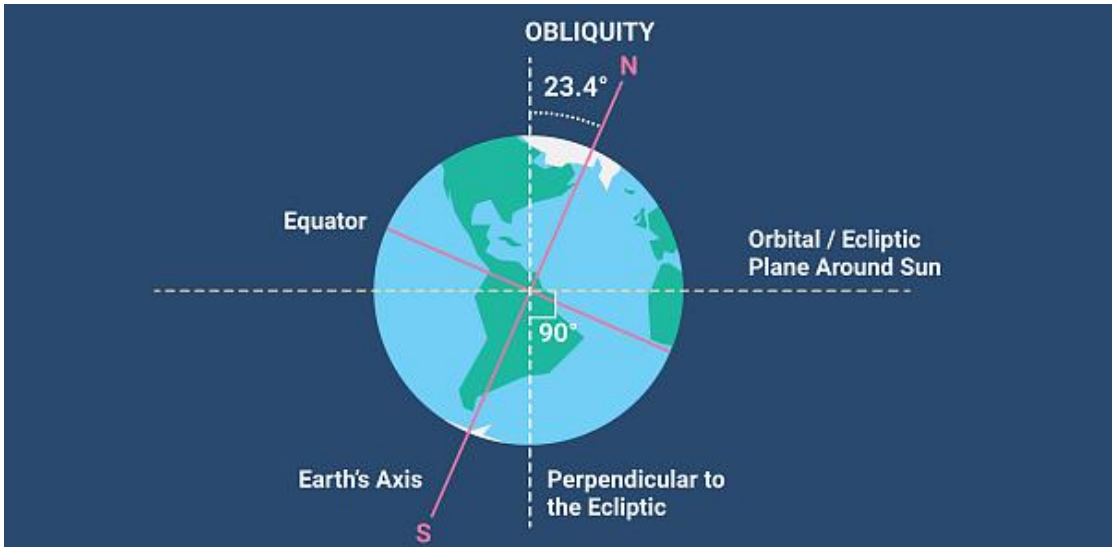
The Rotation and Revolution of the Earth

As everyone knows that the earth is not stationary. There are two forms of motion, one is revolving around the sun, the other is rotation around its axis of rotation.



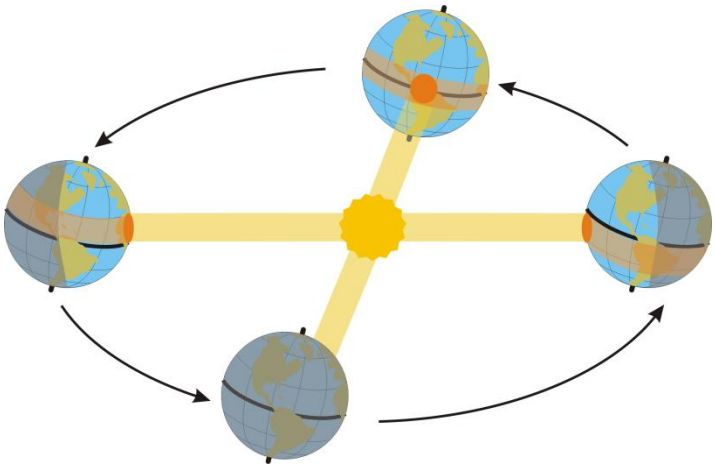
Most celestial bodies in the universe rotate, and the earth rotates for about 24 hours a turn, which is one day. The plane formed on the equator when the earth rotates is called the equatorial plane.

Because of the gravity of the sun on the earth, the earth will also revolve around the sun. One revolution of the earth takes about 365 days, that is, a year. The plane on which the earth revolves around the sun is called the ecliptic. There is a fixed angle between the equatorial plane and the ecliptic plane, called the obliquity of the ecliptic, which is about 23.4°.



The Formation of Four Seasons

Since the earth always revolves around the sun in a tilting condition, the direct light from the sun is centered on the equator and constantly sweeps north and south with the Tropic of Cancer as the boundary once a year, thus forming the four seasons, and the sequence of alternation.



Conclusion

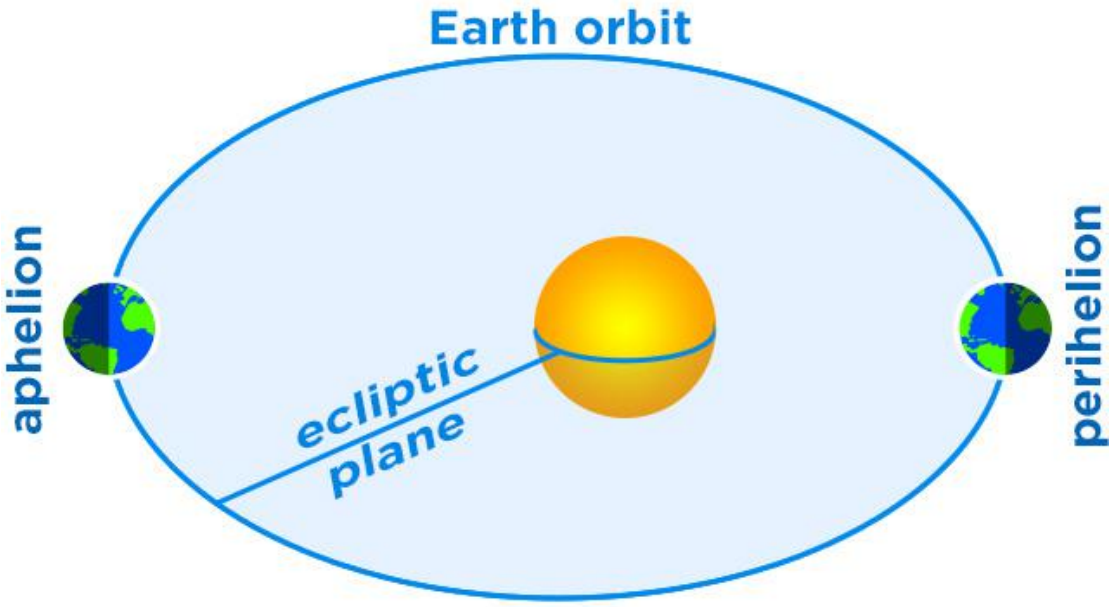
In this project, we first observed the direct and oblique light phenomenon, and then constructed a simple "earth-sun" model, simulated the process of the earth's revolution in the experiment, and learned the formation of the seasonal alternation.

The project is going to an end, please remove cables, and put all the BOSON modules back into the kit according to the corresponding position.

Extend

1. Why are the seasons opposite in the northern and southern hemispheres? Is there seasonal alternation near the equator?

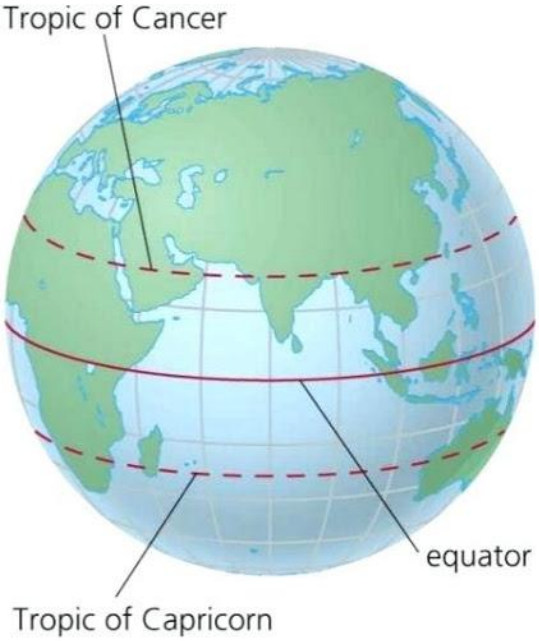
2. The orbit of the earth’ s revolution is actually an ellipse, and there are perihelion and aphelion on it. Will they influence the seasonal alternation?



Appendix – Explore “Why are the seasons opposite in the northern and southern hemispheres?”

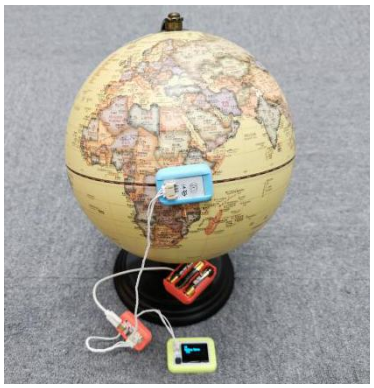
There are three crucial lines on the globe, namely the Tropic of Cancer, the Equator, and the Tropic of Capricorn. North of the equator is the northern hemisphere, and south of the equator is the southern

hemisphere. During one year, the seasons are opposite in the northern and southern hemispheres. Why is this? Let's explore it together!

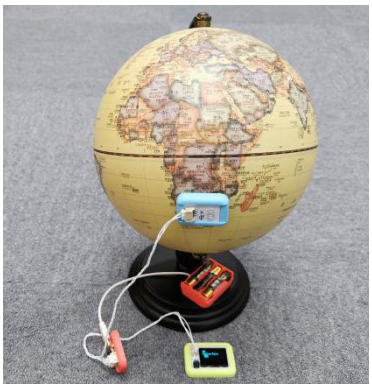


Use the "Globe-Flashlight" model to simulate the earth's revolution. During the revolution, we use the BOSON light sensor to detect the light intensity values at the Tropic of Cancer, Equator, and Tropic of Capricorn in March, June, September, and December. Check the distribution of light in different places on the earth at the same time.

Tropic of Cancer



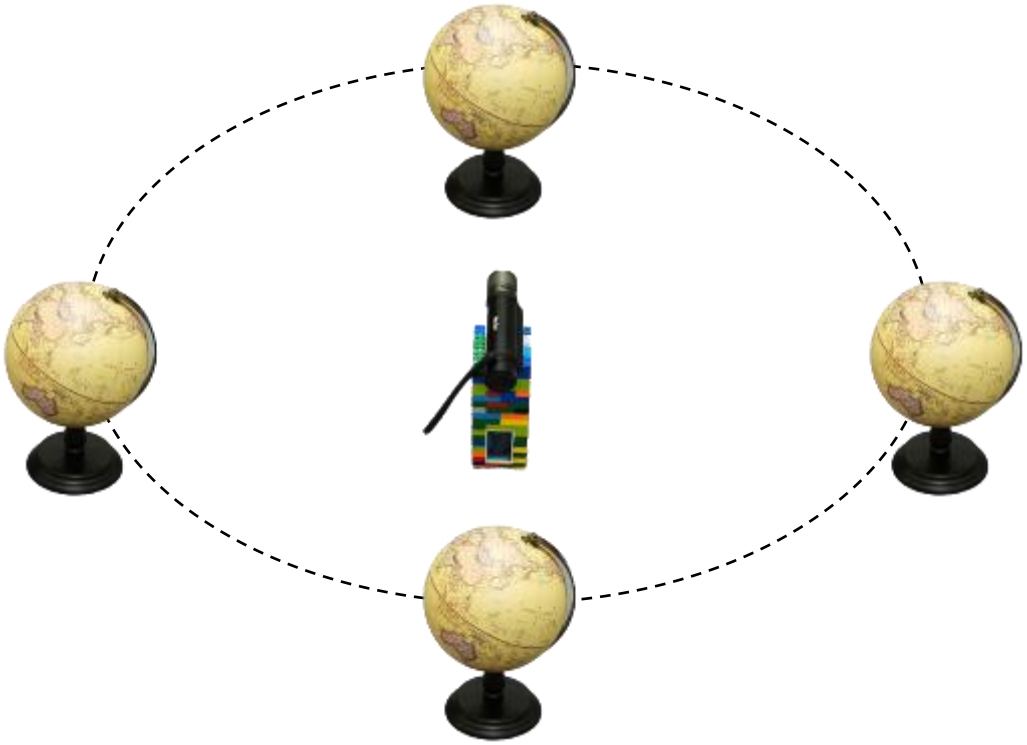
Equator



Tropic of Capricorn

Step

1. Continue to use the previous experimental circuit and model.



2. Record the light intensity at the Tropic of Cancer, Equator, and Tropic of Capricorn in March, June, September, and December. Fill them in the table.

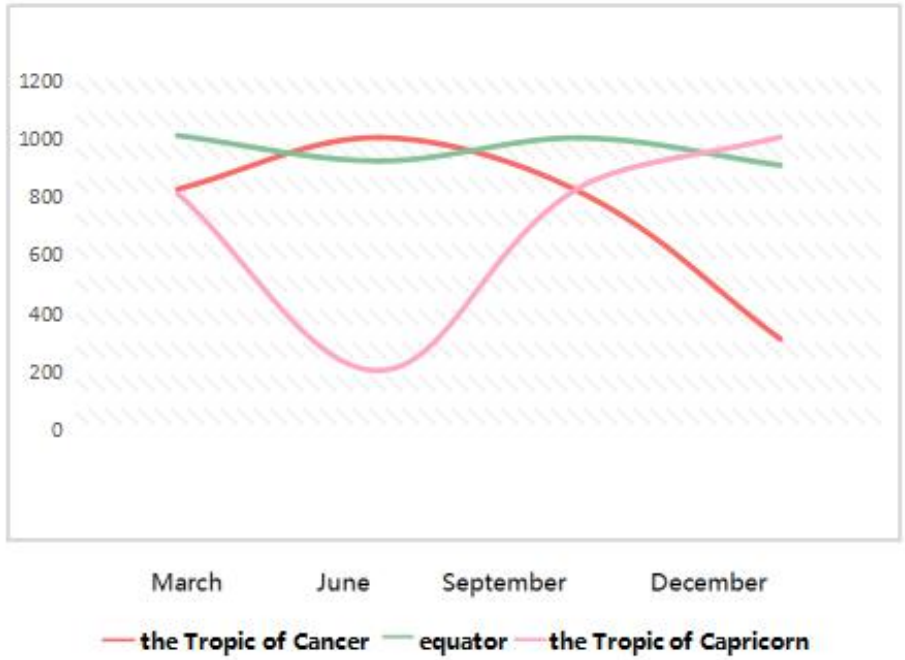
	March	June	September	December
Tropic of Cancer				
Equator				
Tropic of Capricorn				

Activity Conclusion

The referable experimental data are as follows:

	March	June	September	December
Tropic of Cancer	826	1003	817	311
Equator	1010	923	1002	908
Tropic of Capricorn	811	203	831	1005

The referable line chart is as follows:



Through experiments, we can know that in March the sun shines directly on the equator. By this time, it is spring in the northern hemisphere and autumn in the southern hemisphere; then the point of direct light gradually moves northward, and the sun shot directly on the Tropic of Cancer in June, and it is summer in the northern hemisphere and winter in the southern hemisphere. ; Then the direct shot point gradually moved south, and in September the sun shot directly on the equator, and by this time, it is autumn in the northern hemisphere and spring in the southern

hemisphere; Then the point of direct light continued to move southward and the sun shot on the Tropic of Capricorn in December, and by this time, it is winter in the northern hemisphere and summer in the southern hemisphere.

When the earth revolves, the direct light always sweeps back and forth between the Tropic of Cancer and the Tropic of Capricorn, so the seasons are opposite in the northern and southern hemispheres. In the equatorial region, the light intensity in a year does not change much, so there will be no obvious seasonal alternations.

LESSON 6: Why Do Very Few Plants Grow in Deserts?

Introduction

Standards

NGSS

5-LS1-1 To expound and prove that plants mainly get nutrients from air and water.

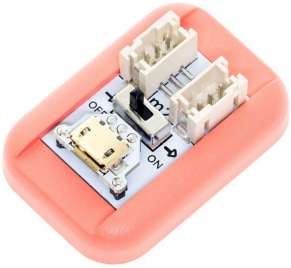
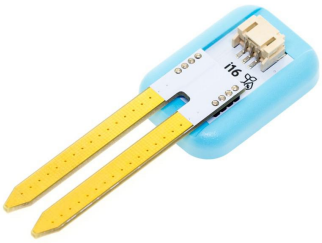
Science - Grade 3-5

Overview

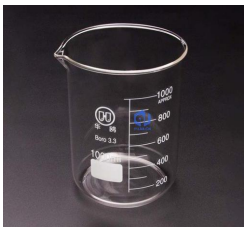
This lesson focuses on talking about the question “why do very few plants grow in deserts”, and leading students to find out the difference between sand and soil. It aims to help students explore the difference in water storage capacity between sand and soil through experiments, and understand that water in the soil is stored in soil pores through capillarity.

Materials

BOSON Module	Image	Function

Battery Holder (3x AAA batteries installed)		4.5V Power Supply
MainBoard-1IO (m2)		Provide power for other modules
Soil Moisture (i16)		Measure the moisture of the soil
Display Module(o11)		Provide visible effect for users to check experiment results
BOSON cable *2		Use with 3-Pin fool-proof connector to connect other modules

Additional Materials	Image	Function
Sand		It is used for experimental exploration. It can be obtained from the beach or toy sand.
Soil		It is used for experimental exploration. It can be obtained from the potting or garden.
Paper x2		It is used to hold sand and soil.
Disposable Cup x2		It is used to hold sand and soil.

Beaker x4		It is used to measure the amount of sand, soil, and water.
Water		For experimental exploration.
Screwdriver		It is used to dig holes in the disposable cup
Magnifying Glass		It is used to observe the sand and soil.

Engage

Our general impression of deserts is that they are vast seas of sand, piled up into dunes, always very barren, with scarce plants. But in most plain areas on land, there are large areas of grassland, arable land, and forests, which breed a variety of plants. Have you ever wondered why there are so few plants in the desert?

We know that plants cannot grow without water, while deserts are often dry all year round. So, could it be that there are so few plants in the

desert because of the lack of water? Let's make a bold assumption that if there is enough precipitation in the desert, can sand breed life? Can sand hold water like soil? Have a guess!

Explore

The experiment is divided into two parts. The first part is to observe sand particles and soil particles. In the second part, we will compare the difference in water storage capacity between sand and soil.

Part 1 Observation: What’ s the Difference between Sand and Soil

We use a magnifying glass to observe sand particles and soil particles, compare the particle size and uniformity, and record the results in the table below.

	Sand	Soil
Particle Size		
Particle Uniformity		

Materials

 Sand	 Soil
 Paper x2	 Magnifying Glass

Step

1-1 Prepare two sheets of paper, place some dry sand on one paper, and put some soil on the other.	
1-2 Observe the sand and soil particles with a magnifying glass, and record the results in the table.	

Activity Conclusion

The referable results are as follows:

	Sand	Soil
Particle Size	Large	Large, Small
Particle Uniformity	Uniform	Nonuniform

Through the above observation, it can be found that the sand particles are large and uniform in size, while the soil particles are with both large and small size, and nonuniform in size.

Conjecture

If the same amount of water is given to sand and soil, which one is more likely to hold water? Take a guess!

Part 2 Experimental Exploration: Which Holds Water better, Sand or Soil?

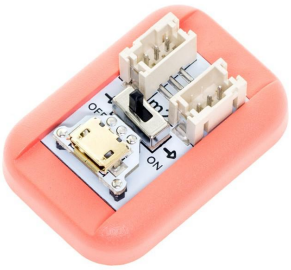
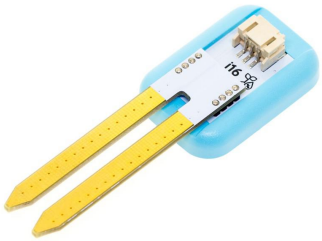
In order to investigate the water storage capacity of sand and soil, we can add equal amounts of water to sand and soil. Then use BOSON soil moisture sensor to observe changes in moisture of sand and soil. And we

use the data to verify whose water storage capacity is better. The referable experimental table is as below.

	Initial Value	0min	10min	20min	30min
Sand					
Soil					

Materials

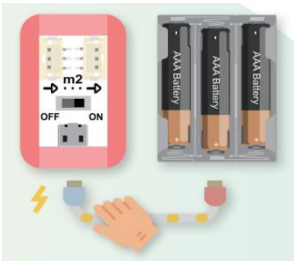
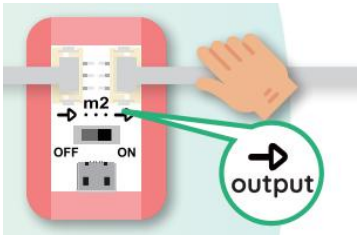
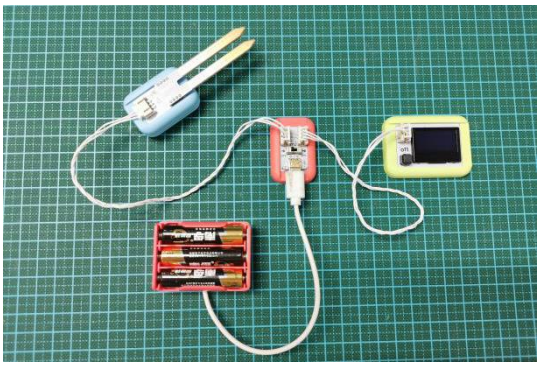
Prepare the following BOSON modules and other materials.

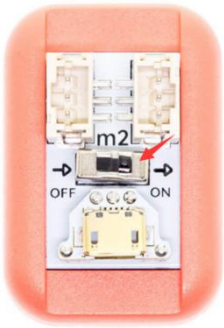
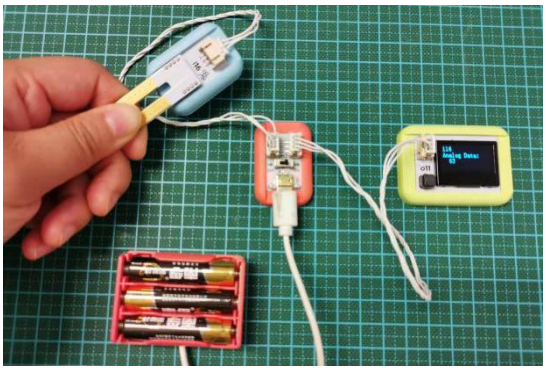
<table>
<tr><td> 
Display Module(o11)</td><td> 
MainBoard-1IO (m2)</td><td> 
Soil Moisture（i16）</td></tr>
<tr><td colspan="2"> 
Battery Holder（3x AAA batteries installed）</td><td> 
BOSON cable *2</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
</table>

Disposable Cup x2	Beaker x4	Water
 Screwdriver		

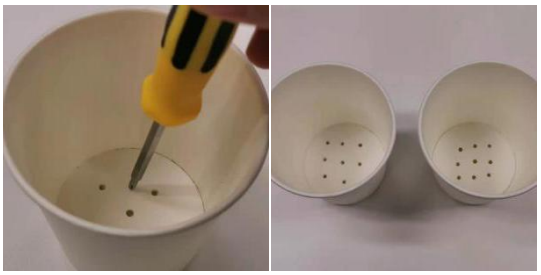
Activity Step

1. Let's build an experimental circuit together to detect the soil moisture value.

1-1 Connect the Battery Holder and two Module Cables to the Main Board.	  The cable's pin header should be plugged in completely so that it is not easy to pull it out.
1-2 Connect the Display Module to the output side of the Main Board with a Module Cable.	
1-3 Connect the Soil Moisture to the input side of the Main Board with a Module Cable.	

1-4 Switch the Main-board to "ON".	
1-5 Press the black button at the lower-left corner of the display module several times until "i16 Analog Data" is displayed.	
1-6 Hold the probes of the soil moisture sensor with your hands, it will display the moisture of your hand. When releasing, the value will be 0.	

2. After completing the circuit connection, set up the two experimental groups of sand and soil. The experimental process is as follows.

2-1 Take two paper cups and use a screwdriver to dig the same number of holes at the bottom of each cup. Try to make the positions of the two paper cups the same. Note: You can also spread a layer of gauze on the bottom to prevent	

sand or soil from losing through the holes.	
2-2 Take two beakers, measure the same amount of soil and sand, and pour them into two paper cups.	 
2-3 Insert the BOSON soil moisture sensor into the soil, measure the initial soil moisture value, and record it in the table. Clean the soil moisture sensor, then insert it into the sand, try to keep it at the same depth, measure the initial moisture value of the sand and record it in the table.