

Unit 1 Broken Chopstick

A car is driving along the road. What happens if it drives onto someone's lawn?

The speed of the car changes. The road and the lawn are made of different things.

The car turns, too.

What about light? It's the same for light.

Light passes through many materials. They change its speed.

Water is denser than air. Because of this, light slows down when it enters water. It refracts the light. The light changes direction.

When we look at an object inside water, it looks different. Light refraction changes how it looks.

Step 1. Prepare a solid cup and a chopstick.

Step 2. Put the chopstick into the empty cup. You can see the straight chopstick.

Step 3. Now, fill the cup with water and put in the chopstick. What does it look like now?

Did the chopstick look straight when it was inside the water?

No, it didn't. It looked bent. It looked like the chopstick was broken. The chopstick in the water also looked slightly wider.

Why is this? Light changed direction when it entered the water. When the light reflected from the chopstick hit our eyes, it looked like the chopstick was in a different position. Refracted light is focused. It makes things look bigger. So the chopstick looked wider, too.

Unit 2 Tall Boy, Short Legs

Rick was the tallest boy in the entire school. He had really long arms and legs.

One hot summer, Rick, Ted, and Amy went to the swimming pool. Rick dove into the water. He was so surprised when he saw his legs!

“Look! My legs look so short and wide! What happened to my legs?” he laughed.

“Ha ha, you look so funny!” said Ted.

Amy said, “It’s because of light refraction. Light goes into the water and slows down. It changes direction.”

“Why does that make my legs look strange?”

“The light from the sun bounces off your legs in the water. Our brain only sees light as a straight line. It doesn’t know the light has been refracted. So your legs look curved and strange. They look shorter than they really are...”

Amy wanted to keep talking, but Rick pulled her into the pool.

“I can’t be the only one with short legs. Come in, everyone!”

Unit 3 Pressure Changes, Volume Changes

Pressure is the amount of force air makes on a certain area.

Can pressure change the volume of things? If we apply pressure to water, will its volume change? What about the volume of a gas?

Yes, pressure changes the volume of a gas.

When you apply gentle pressure to a gas, the volume gets a little smaller. And when you apply high pressure to it, it gets a lot smaller.

Let's watch it happen.

Step 1. Put 40 ml of water in a syringe without a needle. Cover the end with your finger.

Step 2. Press the plunger lightly and observe the changes. Then press the plunger hard.

Step 3. Now, put 40 ml of air in the syringe. Cover the end with your finger.

Step 4. Repeat step 2 with air instead of water. Observe the changes based on the pressure you put on the plunger.

What happened? The volume of water in the syringe didn't change. No matter the pressure you put on it, it stayed at 40 ml.

What about when you put air in the syringe? Did the volume stay the same?

It didn't. When you pressed the plunger lightly, the volume got a little smaller. It was lower than 40 ml.

When you pressed the plunger hard, the volume of the air got a lot smaller. The harder you pressed the plunger, the smaller the volume of the air got.

Now you know that pressure can easily change the volume of a gas.

Unit 4 A Bag of Chips

Irene went hiking with her family. She packed a bag of her favorite chips in case she got hungry.

Irene was so proud when she reached the top of the mountain! She sat down for a rest and took out her bag of chips.

She was very surprised! The bag was swollen. It looked like it was about to burst.

Irene showed it to her mom.

“Mom, look, the bag of chips is inflated. It looks like it’s gone bad!”

Mom answered, “It’s the air pressure here that makes the bag inflate. The air pressure gets lower as you go up the mountain. Do you notice how it’s harder to breathe up here? That’s because of the low air pressure. When air pressure outside the bag lowers, air volume inside it increases. This is why it inflates.”

Irene looked at her mom. She had a suspicious look on her face.

“So, these chips are safe to eat?”

“Of course they are! Can I have some chips?” said Mom.

Unit 5 Two Different Lenses

We use a lens to bend and focus light. Lenses can be convex or concave. Convex lenses are thick in the middle and thin at the edges. Concave lenses, on the other hand, are thick at the edges and thin in the middle.

Let's take a closer look at convex lenses.

Convex lenses are mostly round. They are made of glass or transparent plastic.

Let's watch how light goes through a convex lens.

Step 1. Prepare a convex lens and a laser pointer.

Step 2. Point the laser at the edge of the lens. You'll see the laser beam curve toward the middle.

Step 3. Now, point the laser at the middle of the lens. The laser beam doesn't curve, but goes straight through.

The laser beam bent toward the middle as it went through the edge of the lens. It was refracted.

The laser beam went straight through the middle of the lens. It didn't bend.

When a light beam passes through a convex lens, it is refracted just like the laser beam.

All light beams that hit the edge of a convex lens are refracted to the middle. Light is focused at one point. This focused light makes things look bigger.

Sunlight, a type of light, can also be refracted through a convex lens.

What happens when it is focused in one place?

Unit 6 Telescopes, Microscopes, and More!

Fran went on a field trip to the observatory. She learned about stars and planets. She saw rocks from space. She saw many cool telescopes there, too.

Fran was very excited. "Wow, it's my first time seeing a real telescope! It's so big!"

"These are Keplerian telescopes," explained the teacher.

"How do they work?" asked Fran.

"Well, they use two lenses. A convex lens gathers and focuses light from far away. It makes faraway things look bigger or closer. We can see stars and planets in more detail. Then a concave lens takes this light, and it spreads into your eye."

"Teacher," said Fran, "cameras use convex and concave lenses, too, right?"

"That's right," the teacher answered. "Cameras use convex and concave lenses. Binoculars use them, too. Convex lenses help us see far away and make small things look bigger and closer. This is why microscopes use convex lenses. Concave lenses spread the light and give us a clearer image."

Unit 7 The Flow of Electricity

How does electricity flow? First, it needs an electrical circuit. The electricity flowing through the circuit is called an electric current.

Can we make a circuit to turn on a light bulb? Prepare a battery, wires, and a light bulb. Let's make two different circuits.

Circuit 1

Step 1. Get two wires. Connect one end of each wire to each pole of the battery (+/-).

Step 2. Connect the other ends of the wires to the light bulb. What happens?

Circuit 2

Step 3. Get two wires. Connect one end of two wires to one pole of the battery.

Step 4. Connect the other ends of the wires to the bulb. What happens?

When did the bulb light up? It only turned on in Circuit 1.

Why do you think that was?

An electrical circuit needs certain things.

1. The battery, wires, and bulb should all be connected.
2. The electrical conductors should be connected to both poles of the battery.
3. The light bulb should be connected to both conductors.

In Circuit 2, only one pole of the battery was connected.

The bulb didn't turn on because the electrical circuit wasn't complete. The electricity couldn't flow.

Take the battery, wires, and light bulb again. What other circuits could you make with them?

Unit 8 All of the Lights

Liam and his dad were getting ready for New Year's Day. They were going to have a party. Liam was putting up a string of lights.

"Dad, these lights are too short. Can I cut the wire in half? Then I can add some thread to make the lights longer."

"No," said Dad. "You need to connect the bulbs to conductors. Otherwise they won't light up. They're joined with copper wires which conduct electricity. Thread isn't a conductor, so the lights won't light up."

"Okay, Dad. Is there anything else I need to know?"

"You should check whether the wires are connected to both poles of the battery. They should be connected to the positive and negative poles. Otherwise the circuit won't be complete."

"The wires go into a battery pack. I'm sure they're already connected to both poles. I'm going to turn them on!"

"Wow, Liam! These lights look great. Let's show Mom!"

Unit 9 More Batteries

We made an electrical circuit with just one battery. We can use two or more batteries, too.

You can connect the opposite poles of each battery. That's called a "series connection."

You can connect the same poles of each battery. That's called a "parallel connection."

Let's make both types of electrical circuits.

Circuit 1

Step 1. Connect the positive (+) pole of one battery to the negative (-) pole of the other battery. Connect wires to the remaining positive and negative poles. Connect both wires to a light bulb.

Circuit 2

Step 2. Connect the positive and negative poles of two batteries together. Connect wires to each pole of one of the batteries. Connect to the light bulb.

Step 3. Compare the brightness of the bulb in each connection.

Which circuit was series? Which was parallel?

Circuit 1 was a series connection.

Circuit 2 was a parallel connection.

Which was brighter? The bulb with the series connection was brighter than the one with the parallel connection.

Why is that? Series connections increase battery voltage. They make the batteries stronger. Parallel connections aren't as strong. But they make the batteries last longer.

Which do you think is better?

Do you know any other ways to make a series or parallel circuit?

Unit 10 Electricity Everywhere

Sophia was at home watching TV. She had the lights on. The electric heater was also running. The TV was boring, so she turned on the radio as well.

Her phone battery was low. She plugged her phone and the TV into the same outlet.

Then she looked outside. It was snowing!

She called her brother James. They went outside to play in the snow. They threw snowballs and made a snowman.

Sophia started getting cold. She went back inside to make some hot chocolate. The snow on her gloves melted and made her hands wet. She was about to plug in the kettle when...

“Stop!” Her mom was just back from the grocery store.

“Sophia, don’t touch electrical things with wet hands. It’s very dangerous.”

“Oh! Sorry, Mom.”

“And look! You didn’t turn off any of the electrical things. You plugged the TV and your phone, which are electronics, into the same outlet.”

“Is that wrong?”

“Yes, it is. The plug could overheat. It could start a fire.”

Unit 11 Sea Breeze and Land Breeze

Have you ever felt the breeze at the sea coast? It's not always the same.

In the daytime, a cool breeze blows from the sea. We call it a sea breeze.

In the evening, a cool breeze blows as well. But now it blows from the land to the sea.

This is a land breeze.

Why does this happen? Let's see.

Step 1. Prepare two lamps, a bowl filled with water, a bowl filled with sand, a transparent box, and an incense stick. Turn on the lamps and heat the sand and water for about 5 minutes.

Step 2. Put the box over the heated sand and water. Put the lit incense stick into the box.

Step 3. Observe the movement of smoke for 30 seconds.

The smoke moved from the cool water to the warm sand.

Why did this happen? The sand was warm, but the water was still cool.

Sand heats up more quickly than water. The warm sand created a low air pressure area. The cool water created a high pressure area.

Air always moves from high to low pressure. This movement is what we call wind.

In the daytime, the land heats up faster than the sea. The temperature of the land is higher. A sea breeze blows from the sea to the land.

At night, the land cools down faster than the sea. Now the temperature of the land is lower. A land breeze blows from the land to the sea.

Unit 12 Flying a Kite

One sunny weekend, Daniel took a trip to the beach with his family.

He flew a kite with his dad.

“Dad, why is the kite flying toward us? I thought it would fly above the sea.”

“Well, Daniel, the wind blows from the sea to the land in the daytime.”

“Will the kite fly toward the land at night, too?”

“Why don’t we check it out after eating dinner?”

They went out to the beach again after dinner. Daniel flew his kite again. Now it flew in the opposite direction.

“Dad, it’s flying toward the sea! Does the wind blow in the opposite direction at night?”

“Yes, because it’s cooler at night. Sand cools down much faster than water. So the sand’s temperature is lower than the water’s temperature at night.”

“Wind always blows from a cooler place to a warmer place, right?”

“Yep. Cool air creates higher air pressure, and warm air creates lower pressure. Wind is the flow of air as it moves from higher to lower pressure,” said Dad.

Unit 13 The Height of the Sun

Have you ever noticed something about the sun?

In summer, it's very high in the sky. On the other hand, in winter, the sun is much lower.

The height of the sun differs from season to season.

The height of the sun in the sky affects the length of the day. It affects the temperature, too.

Let's do an experiment.

Step 1. Set a lamp at a steep angle to a bowl of sand.

Step 2. Heat the sand using the lamp for 5 minutes. Then, measure the temperature.

Step 3. Now, set the lamp at a shallow angle to the sand.

Step 4. Once again, heat the sand for 5 minutes and measure the temperature.

When was the temperature of the sand higher?

It was higher when the lamp and the sand formed a steep angle. The lamp was at its highest.

This is what the sun is like in summer. The sun is high up in the sky.

When the sun is at its highest, it shines on a narrower area.

The heat energy in that area increases. The ground is heated up. The temperature rises.

That's why it is hot in summer when the sun is high. That's why it is cold in winter when the sun is low.

Unit 14 The Length of the Day

It's too cold to play outside. Emily reads books at home instead.

She reads by the sunlight through the window. She notices her shadow is long.

It starts getting dark. Emily can't see her book well. She looks outside. The sun has almost set!

She looks at the clock. It's only 5 p.m. How strange! In summer, it was so bright at 5 p.m.!

Emily turns on the light. She looks for another book. She finds a science book. She learns about solar altitude and the sun. Solar altitude changes during the day. It changes with the seasons as well.

She learns that Earth is at an angle. As it revolves around the sun, we get closer and farther away from the sun.

During the summer, solar altitude is at its maximum. The days are longer. During the winter, solar altitude is at its minimum. The days are shorter.

Emily closes her book. She learns something today. And she can't wait for summer to come again!

Unit 15 Electricity from the Sun

We can't imagine a world without electricity. We use it every day.

But most of our electricity comes from burning coal or gases. This creates pollution. It causes climate change. It's bad for our planet.

Solar power comes from the sun. Solar engineers turn light from the sun into electricity. This is much better for the planet.

Solar power has many uses. It can power houses and cars. It can heat water.

Solar engineers work to make solar power more effective. They plan, design, and implement solar energy projects.

There are problems with solar power. It only makes power when the sun is shining. It is expensive, too. As a result, only 2% of the world's electricity comes from solar power.

But solar power is essential to the future of the planet. The work of solar engineers is very important. Their hard work can make solar power stronger and cheaper. They can help make the world a cleaner place.

Unit 16 Web Developer

You want to buy tickets for your favorite singer.

You go on the website to buy them. You click on the “Buy” button for the tickets.

Nothing happens. You click again. The website crashes.

What is happening? Too many people are using the website. Finally it works. You manage to put the tickets in your basket.

You want to pay, but you can’t find the button for it. You scroll down the page. You find it at the bottom of the page.

Finally, you click “Pay.” But the tickets have sold out. You were too slow!

Doesn’t this sound annoying?

Web developers have an important job. They design websites. They design what websites look like. Text should be easy to read. Buttons should be easy to find.

They also design the technical side of the website. Websites should load fast. They shouldn’t crash when many people use them.

Websites are fun to use. But they’re difficult to design!