Lesson: “How long did it take to travel across the country before cars and planes?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi, it's Doug! Imagine if you lived your whole life without ever leaving your town. If you live in the mountains, you’ll never see the ocean. If you live by the ocean, you'll never see the mountains. Imagine the country where you live is the only country you'll ever visit. That would mean, unless you're within walking distance, you'll never get to see things like the Hollywood sign or Disney World or a sunset at the Grand Canyon. You'll never get to visit the Eiffel Tower in France or the Great Wall of China. You'll never see the great barrier reef of Australia. It's kind of sad to think of never having a chance to see any of these things, right? But if you lived in pretty much any other time in history, that's what would've been like. Long-distance travel just wasn't possible. People were pretty much stuck wherever they were born. If they did travel, the journeys were slow, uncomfortable, and sometimes even dangerous. Luckily, travel today is easier and cheaper than ever. It's so easy we often take it for granted. Let's stop and think about it. What's one distant place that you'd like to visit in your lifetime? How would you travel there?

EXPLORATION VIDEO 2

A long time ago, if you wanted to go somewhere, you had to get there by foot. Imagine you wanted to travel across an entire continent, like from one side of North America to the other. On

foot, that would take you about six to eight months. A journey like that took such a long time and was so dangerous and difficult that it wasn't really a trip that most people took. Before long, though, people realized there was a better idea. Why not hitch a ride on an animal instead? That's a big improvement. Riding a horse, for example, doesn't require nearly as much of your energy as walking does. Plus, you could hook up a cart or a wagon to carry things with you or move several people at a time. Now, on a horse, people could go from one side of the continent to the other in only about three to five months. That's definitely a lot better than six to eight months, but it's still such a long time. There were also new challenges that came along with having animals to carry you or pull a wagon for you. Now you had to care for them, bringing them to fresh water and letting them rest. Plus, you had to get food to feed them, like oats or hay, plants that had to be grown. It took a lot of work planting those crops and then harvesting them. And that's not even food people got to eat. That was just the food for the horses. Surely there must be some better way to get around, people thought. In fact, you know that there's a better way. Things we use for travel today like airplanes and cars and trains. But these weren't invented until the 1800s and the 1900s. Each one is incredibly complex, made of many different parts working together. These machines weren't just thought up overnight. It took many years to develop them into what we know today. But it still seems like a big jump. How did we go from having to travel everywhere on foot to riding animals to then having amazing machines like cars and trains and airplanes? It turns out the first clue was actually discovered more than 2,000 years ago. An ancient Greek inventor named Hero came up with a toy, a little device like this. You could take off the top and fill it with water. Then you can heat it over a flame. What do you think will happen? Watch. Let's see that again. When the water begins to boil inside, it becomes steam, which builds up inside the container. Then the steam shoots out of the openings on the sides of the container. Since the openings are angled a little bit, the container starts to turn and

spin. No one, not even Hero himself, thought about using this device to make it easier for people to get around. For Hero, it was just something fun to play with and show off to friends at parties. But does it have potential to help people get around? How could this be useful to people? What do you think?

ACTIVITY INTRODUCTION VIDEO 1

In today's activity, you're going to make a machine that uses heat to make a spinner spin. In the first part of the activity, you'll make a spinner and a spinning support tower. In the second part of the activity, we challenge you to use heat to make your spinners spin steadily. To do that, you're going to have to think like an inventor. Inventors experiment and pay attention to what happens. And just as important, they pay attention to times when nothing happens. Sometimes, the only way to figure out why something works is to see where it doesn't work. I'll show you how to get started experimenting, step by step.

ACTIVITY PART 1 STEP 1

Find a partner. If you're working alone, that's okay too. When you're done with this step, click the arrow on the right.

ACTIVITY PART 1 STEP 2

If you're working with a partner, decide who will be the Twister and who will be the Spin Master.

ACTIVITY PART 1 STEP 3

Get these supplies.

ACTIVITY PART 1 STEP 4

You'll start by making the spinner. Each person cut out one spinner. Set aside the extra one; you may need it later.

ACTIVITY PART 1 STEP 5

Flip the square over, so that you're looking at the white side. You're going to fold on both diagonals, like this. To do this, line up the ruler on the corners and fold the paper on the ruler, like this. Then, take away the ruler and crease the fold with your fingernail. Unfold it and fold along the other diagonal too.

ACTIVITY PART 1 STEP 6

Unfold the square and flip it over so that the printed side is up. Now you're going to fold it in half both ways, side to side and up and down. Do it like this. Use your ruler to fold it. Then, crease the fold with your fingernail. Unfold and fold the other way. When you're done, it should look like this.

ACTIVITY PART 1 STEP 7

Flip the square over so that you're looking at the blank side. Find where all of the fold lines intersect and draw a dot on that spot.

ACTIVITY PART 1 STEP 8

Now that you've folded your square, you should be able to gently push the sides together so that it looks like this. Once you do that, cut out the four gray shapes. When you're done, your spinner shouldn't be flat. It should stick up a little in the center like a mountain.

ACTIVITY PART 1 STEP 9

Now it's time to make a support tower for your spinner. Spin Master: use a pen or pencil to poke a hole in the bottom of your paper cup, like this. Then widen the hole with your fingers as big as you can.

ACTIVITY PART 1 STEP 10

Spin Master: hold the cup with the bottom side up. Twister: put two rubber bands around the cup like this, one around the bottom and one around the top. If you're working alone, get help if you need it.

ACTIVITY PART 1 STEP 11

Twister: fold the pipe cleaner in half around the push pin. Then hold the pipe cleaner like this and twist the pencil like this. Twist until the pipe cleaner holds the push pin tight. Then take the pin off the pencil.

ACTIVITY PART 1 STEP 12

Spin Master: pull the rubber bands away from the cup, like this. And Twister: slide the pipe cleaner in between the rubber bands and the cup, like this. The rubber bands will hold the pipe cleaner in place.

ACTIVITY PART 1 STEP 13

Twister: bend the pipe cleaner so that the push pin points straight up over the middle of the cup. It might take you a few tries to get it straight. It will look like this when you're done.

ACTIVITY PART 1 STEP 14

Spin Master: set one of the spinners on the point of the pushpin. Give it a gentle push. Does it spin easily? If not, you can use the engineering checklist to fix it.

ACTIVITY PART 1 STEP 15

Before we do some experiments with heat, you're going to get to know your spinner. Working with your partner, try the experiments under number one and number two on your worksheet. Be sure to write down what you notice.

ACTIVITY PART 1 STEP 16

Discuss, then watch the next video.

ACTIVITY INTRODUCTION VIDEO 2

In case it's helpful, here are some things we noticed. You can make the spinner move by blowing on it, by fanning it, or even by talking at it. You might find out that some words even make it spin more than others. The spinner moves because talking, blowing, and fanning all make air move. That moving air is what pushes on the spinner and makes it spin. When I pick up the cup, I do have to move it slowly to keep the spinner balanced on the pin, but once I get the hang of it, I can make the spinner move by lifting it up or by lowering it. By moving the spinner through the air, I made the air push on the spinner, and that made the spinner move. Did you notice that the spinner turned in one direction when I lifted it up but then turned in the other direction when I lowered it? The direction of spin depends on which way the air is moving. Now, you're going to try using heat to make your spinner move. As you experiment with heat, be sure to move slowly and cover or shield your nose while you're breathing or talking. A sudden movement or breath of air can change your results.

ACTIVITY PART 2 STEP 1

If you're in a class, form a group of four. Your teacher has set up an experiment station. Groups will take turns experimenting at the station and discussing and inventing at your desks.

ACTIVITY PART 2 STEP 2

Later, when you're at the experiment station, your goal will be to use heat to get the spinner to spin 30 times. Now, to make it easy to count the spins, we've marked one blade of the spinner with a star. To count the spins, just count how many times you see the star go around, like this. One, two, three. Now you try it. Now that you've practiced, go to the next step.

ACTIVITY PART 2 STEP 3

Get your supplies.

ACTIVITY PART 2 STEP 4

If you're in a class, your teacher has set up some experiment stations with a heat source. Your teacher will decide what order you'll go to a station. When your group is not at a station, you'll be working at your desks discussing and inventing on paper. If you're working alone, you can decide what to do first.

ACTIVITY PART 2 STEP 5

Okay, it's time to do your worksheet and experiments. Start with the discuss and invent questions one through four at your desk, or do question five if it's your turn at the station. A video for question number one is on the next slide.

ACTIVITY PART 2 STEP 6

When you're doing question one on your worksheet, watch this. When everyone's done with the activity, be sure to go to the final video.

WRAP-UP VIDEO

In the activity, you created a heat spinner that transforms heat into movement. Your spinner started moving when you held it over something hot, like a light bulb in a lamp or a cup of hot water or a heat pack. Maybe you noticed your spinner didn't spin as much when you held it

beside the heat source or below the heat source. Why is that? Well, you probably know that hot air rises. This is also why hot air balloons float. There's a source of heat inside the balloon and that heat rises. You know, in a way, you can think of your heat spinner as a kind of chain reaction machine. Something hot like this light bulb makes the air nearby it hot. As that hot air rises, it pushes on the spinner. Then, the spinner moves. Take a look at Hero's toy again, but now consider it in the same way, like a chain reaction machine. Step one, fire heats up water inside the device. Step two, water starts to boil and turns into steam. The air and steam inside are super hot. Step three, that super hot air and steam rush out of the device through the pipes on either side, and that makes it move. At each step, energy is transferred from one part to the next. From the fire, to the air and water, to the container. The device starts with a source of heat and ends up with movement. Heat can cause things to start moving. So heat is yet another form of energy. Today, scientists have a special name for any device that turns heat energy into movement. They call it a heat engine. Hero's device is known as Hero's engine. Hero may have built it just for fun, but over 2,000 years later, it inspired inventors to develop a heat engine that was even more useful: this, the steam engine. This video shows a miniature version of a steam engine someone created out of glass so that you can see what's going on inside. It does the same basic thing as Hero's engine. First, a flame is lit under a container of water, which starts to boil. Heat makes steam and air rise and move through the tubes. Then, the steam pushes on a piece in here back and forth, which pushes on a rod that's connected to the wheel. Each time this container fills up and releases steam, it turns the wheel. Check it out. By attaching steam engines to the wheels on trains, the steam locomotive or modern train was born. This meant, for the first time ever, people could travel across an entire continent using machines instead of on foot or being pulled by horses. Using a steam engine, a trip from one side of North America to the other, a trip that used to take six months, now could be completed in only four days—and

you know that's not the end of the story. Travel has only continued to get faster and cheaper, with modern forms of transportation like cars and airplanes. For example, on a train, it takes about four days to travel from San Francisco to New York City—but now, you can fly that same distance in just five hours. The engines inside cars and airplanes use other fuels instead of steam power, but they still run on the same basic idea that Hero's engine did, the heat engine. They use heat energy from burning fuel to make things move. We'll talk more about modern fuels and energy in the next Mystery. Until then, have fun, and stay curious!