mystery science

Lesson: “How high can you swing on a flying trapeze?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi. It's Jay from the Mystery Science Team. One of my favorite ways to challenge myself is by taking on obstacle courses. Sometimes, a course will include one of these, a trapeze. Here's a trapeze I got some practice on recently. In the obstacle courses I do, you often have to swing and leap off a trapeze to get from one side of the course to the other. But that's just one thing people do with trapezes. Check this out. These are circus performers at the Moscow International Circus. They almost look like they're actually flying through the air like birds or superheroes. But if you look closely, you'll see that each person is swinging on a trapeze. These are trapeze artists. Performance who do incredible tricks while swinging high in the air. Take a look at what they can do. Can you even imagine doing something like that?
Actually, I think you can. Even if you've never swung on a trapeze before, I bet you've done something at least a little bit similar. Like how about swinging on a swing at a playground?
Or maybe you've tried a swing like this before. Maybe you've swung from two people's hands like this. Maybe you've swung along monkey bars or maybe you've seen actual monkeys or other animals swinging and leaping from branch to branch in a tree. I wonder what you think. How are these things similar? How are they different?

EXPLORATION VIDEO 2

You might not think a playground swing set has much in common with a circus trapeze. Just for starters, a playground swing is way closer to the ground. But maybe you also noticed some things these two have in common. They both move back and forth, back and forth. They share the same movement or motion and they move that way again and again and again. It's a pattern. Let's imagine you're swinging on a swing. You swing forward? You swing back. You swing forward, what do you think the swing is going to do next? It's going to swing backward. Right? Yep. There it goes. Okay. But hang on. How did you know that? How did you know where the swing was going to swing next?

EXPLORATION VIDEO 3

Maybe this seems clear. Of course, the swing keeps swinging forward and back, forward and back. That's just what swings do. Again, and again. It's the pattern of how they move. Their pattern of motion. Because you know a swing's pattern of motion, you can predict how it will move next because that's how it always moves. The same is true for a trapeze. When this trapeze artist starts to swing, she goes forward, Then back, then forward, then back. Her swing follows the same pattern of motion as the playground swing. Still predicting the motion of a flying trapeze is a bit more complicated than predicting the motion of a playground swing. Like, imagine you're a trapeze artist and you wanna do a trick that involves a catch like this, where one person leaps off their trapeze and the other person catches them. You climb up to the top of a high platform. You grab your trapeze. You take a deep breath. You try not to look down. And you start to swing. The world whooshes by. You're moving so fast that everything around you is a blur. You know you're swinging forward and back, forward and back, and so is

your partner. You know you should leap at just the right moment. When you are as close to your partner as possible. But what's the right moment? As a trapeze artist, you have to know your pattern of motion really well. More than just the basic pattern of swinging back and forth back and forth. You have to know exactly how high you'll swing in each direction. And exactly how long each swing will take down to the second. If your timing is even a tiny bit off, this will happen. Oops. This performer slipped through his catcher's hands and fell. Luckily, he landed safely in the net below. Let's watch it again. They're swinging. He leaps. Oh, so close. With a playground swing, it's easy to predict exactly how it will move because you've seen swings like that many times before. You've made many observations of swings which helped you notice patterns. But it's kind of hard to make observations and notice patterns while you're speeding through the air high above the ground. And what if you change something about the trick? Like, what if you started swinging from an even higher platform? Or what if one trapeze had long ropes and the other had short ropes? Or what if instead of one person swinging on the trapeze, you had two. You'd probably still swing forward and back, forward and back. But would your pattern of motion change in other ways? Would your swing slow down, speed up, would you swing higher or lower? It would help if you could figure out how this works before you start swinging.

So how could you do that? How could you figure out how a trapeze artist will swing in different situations without practicing on an actual trapeze? I wonder if you have any ideas.

ACTIVITY INTRODUCTION VIDEO

In today's activity, you and a partner are going to explore the swinging motion of a flying trapeze. There probably isn't enough space in your classroom to build a real trapeze. So you and the partner are going to create a model, a tiny version of the real thing. Your model won't

look exactly like a real trapeze, but it should move in very similar ways. Once you build your model, you'll experiment to explore what happens when you change different parts of it. Like the number of trapeze artists swinging or the length of the trapeze's string. Your goal is to find patterns in how your model trapeze moves. You can then use those patterns to make predictions about how a real trap freeze will move. Are you ready for your trapeze training? We'll show you how to get started, step by step.

ACTIVITY STEP 1

In today's activity, you'll work with a partner. Decide on your trapeze nickname. You can be the Astonishing Acrobat or the Phenomenal Performer. When you're done with this step, click the arrow on the right.

ACTIVITY STEP 2

Get your supplies. Each pair of students needs two pencils for the model, plus pencils to write with.

ACTIVITY STEP 3

First, you need to create a place for your model track piece to hang from the side of your desk. You'll need your ruler, two pencils, and tape. Acrobat: Lay the ruler on your desk near the edge, like this. Then, Performer: Place a pencil at each end of the ruler with the erasers facing toward you.

ACTIVITY STEP 4

Now you'll attach the pencils to your desk. Acrobat: Pull one pencil toward you so that part of it is hanging off the desk about three inches, or eight centimeters, which is a little more than the length of your pointer finger. Performer: Add one sticker or piece of tape to the far end of the pencil, making sure to push down near the edges. Then add another sticker near the edge of the desk, like this. Put a heavy book on top to make sure it stays in place. Repeat this for the other pencil. It should look like this when you're done.

ACTIVITY STEP 5

Now it's time to make the swings for your model. Both you and your partner need to get one piece of string and one of the binder clips. Make sure the binder clip looks like this so you can open it easily. Then take your string and push it through the loops of the binder clip, like this. Hold it up so it looks like a little trapeze swing.

ACTIVITY STEP 6

Now you need to attach the string to the support pencil. This can be a bit tricky, so we suggest watching the entire step first. Acrobat: Drape the string ends over the pencil, like this. Make sure there's some space between the two string ends. Let the two tails of the string hang, like this. The exact length of the string doesn't matter just yet. Performer: Get another binder clip and clip it over the string and the pencil. It will be a bit snug. Make sure to do this for both pencils.

ACTIVITY STEP 7

Now you need to add a person to your trapeze. Today, a penny is going to represent a person.

So take one penny and clip it within one of the hanging binder clips, like this. Make sure to do this for each trapeze.

ACTIVITY STEP 8

So that you can observe your tiny trapeze model more clearly, go ahead and take a seat on the floor. Before you get started with your experiments, check to make sure your model trapeze is set up correctly. Check that the pencils are sticking straight out. If they're not, you may need to readjust them. Also, check the binder clips and the end of the swings to make sure they're hanging in the center of the string.

ACTIVITY STEP 9

Now you'll practice how to release the trapeze. You want the string to be straight, but you also don't want to pull it too hard because that can cause the model to break or not work correctly. Explore how gentle you need to be to make a nice, smooth swinging motion. When you release the penny, try to hold the string in line with the table, like this. You can also try holding your hand against the table to steady it. You can even try timing it just right to make a catch where the two pennies bump into each other. When you're done with this step, click the arrow on the right.

ACTIVITY STEP 10

Okay, now it's time to start experimenting. In this first experiment, you will make observations about the height of where the trapeze is released. Can you figure out the best place to jump from if you want to swing as high as possible on the other side? Go ahead and work with your partner, gently releasing your penny from different heights and carefully observing what happens each time. Look for patterns of how the trapeze moves.

ACTIVITY STEP 11a

Discuss. On a real trapeze, where's the best place to jump from if you want to swing as high as possible on the other side? Why do you think that?

ACTIVITY STEP 11b

Here's what we noticed. When we released the penny from a low height, the trapeze didn't go very high on the other side. When we released the penny from a higher height that was in line with the top of the table, then we noticed that it swung higher. It almost reached the top of the table on the other side. When we tried to go even higher, it went high, but it was also much more difficult to control, and would sometimes swing into the desk. Not very safe for our trapeze artist. Trapeze artists have made these observations too. So that's why with the real trapeze, they usually start their swing from a high place, like this. Or this. Click the arrow on the right to go on to the next step.

ACTIVITY STEP 12

Okay. It's time for your second experiment. A real trapeze sometimes has long ropes and sometimes they have shorter ropes. Does the length of the rope change how the trapeze swings? To figure this out, you'll make some observations with your model. Work with your partner to adjust one trapeze so that the string is much shorter than the other one, like this. You want the string to be about half the length of your other trapeze. When you're ready, click the arrow on the right.

ACTIVITY STEP 13a

Both of you: Make observations of your two trapezes. Watch carefully for any differences or similarities in how they move. Take a few minutes to explore and observe with your partner. When you're ready to move on to the next step, click the arrow on the right.

ACTIVITY STEP 13b

Here's what we noticed. The trapeze with the shorter string seemed to move a little faster than the trapeze with the long string. But it was difficult to tell. Let's try using a timer to help us measure how fast each one is swinging. First, let's just practice so I can show you how the timer works. We're going to put a ten-second timer on the screen. When I say start, you count the number of swings on this animation, like this. One, two, three, and so on. You'll stop counting when I say stop. Let's practice together. Count how many swings you see, Ready, set, start. Stop. We counted seven swings for this one. Okay, now that you know how the timer works, go to the next step to observe how your model trapeze swings.

ACTIVITY STEP 14

Okay, now it's time to count the number of swings using your model trapeze. Let's start with the longer string. We're going to time this for ten seconds. Before the timer starts, make sure you're ready. You'll pull the string up to the height of the desk and hold it there, like this. When I say start, you release your penny and then count the number of swings until the time is up. Okay, now it's your turn. Pull the string up to the height of the desk and hold it there. Ready, set, start. Stop. Okay, time's up. Record the number that you counted here on your worksheet. If you need

to count the number of swings again, we'll keep repeating the timer. Go to the next step when you're done.

ACTIVITY STEP 15

Now let's try the same thing, but this time you'll observe the trapeze with the shorter string. You'll count how many times the trapeze swings in ten seconds. Make sure you're ready, and pull the string up to the height of the desk and hold it there. Ready, set, start. Stop. Okay, time's up. Record the number that you counted here on your worksheet. If you need to count the number of swings again, we'll keep repeating the timer. Go to the next step when you're done.

ACTIVITY STEP 16a

Now that you've observed your model, it's time to make a prediction of how a real trapeze will move. The trapeze on the right has ropes that are shorter. The trapeze on the left has ropes that are longer. Discuss and make a prediction with your partner. Will one of these swing faster than the other? Why do you think that? Then answer question number three on your trapeze training worksheet.

ACTIVITY STEP 16b

Here's what we noticed. In our models, we counted eighteen swings for the trapeze with the long string and twenty-five for the trapeze with the shorter string. You might have slightly different numbers, but the higher number of swings for the short string means it was moving faster. So we predicted that a real trapeze with shorter ropes would also swing faster than one with longer ropes. Let's watch and see if we were able to predict correctly. We'll show how many

times each trapeze swings. We predicted correctly. The shorter trapeze did swing faster. Click the arrow on the right to go to the next step.

ACTIVITY STEP 17

Okay. It's time for your final experiment. On a real trapeze, sometimes one person is on the trapeze. But what if there are multiple people? Do extra people change how the trapeze swings? To test this, you'll change the number of pennies that are on the trapeze. For this experiment, you want to make sure that the string length stays the same. So we suggest that you use only the trapeze with the longer string. You'll change the number of pennies in the bottom binder clip. You should have five pennies, so you can test one penny the first time and then five pennies the second time, or you can test two pennies the first time, and then three pennies the second time. You can choose whatever number of pennies you'd like to test against each other. Decide with your partner the different number of pennies that you'll test and write those two numbers here and here on the worksheet.

ACTIVITY STEP 18

Add the number of pennies that you chose to test first. Once you've added your pennies, then, just like before, you'll pull the string up and get ready to release it once I say start. Then, count the number of swings that you see happen during the ten-second timer, just like before. I'm going to start playing the timer on-screen. But don't worry if you're not ready yet. I'll play the timer again and again. Use the timer once your binder clip has the number of pennies you chose attached. Afterward, record the number of swings that you counted here on your worksheet. We'll repeat the timer again. Ready, set, start. Stop. Go to the next step when you're done.

ACTIVITY STEP 19

Find the number of pennies you chose for the second test. Add or remove pennies so that you have that amount in the binder clip. Then get ready to count the number of swings. You'll record that number here on your worksheet. We're going to time this for ten seconds again. Make sure you're ready, and pull the string up to the height of the desk and hold it there. When I say start, you'll release your penny and then count the number of swings until the time is up. Ready, set, start. Stop. Okay, we'll repeat the timer again. Go to the next step when you're done.

ACTIVITY STEP 20a

Now that you've observed your model, it's time to make a prediction of what will happen with a real swing. This will make a prediction for a swing that's not quite a circus trapeze, but is a giant swing. This swing has two people on it. And this swing has three people on it. Discuss and make a prediction with your partner. One of these swings faster than the other; why do you think that? Then answer question number six on your trapeze training worksheet.

ACTIVITY STEP 20b

Here's what we noticed. In our model, we tested two pennies versus five pennies. When we counted the number of swings, the trapeze with two pennies swung seventeen times and the trapeze with five pennies also swung seventeen times in ten seconds. Your numbers might be slightly different, but you probably noticed that the number of swings between the two tests was about the same. So we predicted that a real swing with different numbers of people on it would swing at about the same speed. Let's watch and see if we were able to predict correctly. We'll show how many times this giant swing goes back and forth when it has two people, and when it

has three people on it. One, two, three, they're the same, just as we predicted. Click the arrow on the right to go on to the next step.

ACTIVITY STEP 21

Congratulations. You're done with your experiments, and you have completed your trapeze training. Work with your partner to clean up. Go ahead and take a seat back in your chair, then discuss. How is your model the same as a real trapeze? How is it different? How is the pattern of motion of your model the same as a real trapeze? How is it different?

WRAP-UP VIDEO 1

Your tiny trapeze was a model of the real thing. By observing your model, you noticed patterns that are similar to how a real trapeze moves. For instance, you probably noticed that shortening the string of the trapeze made it swing faster. But adding more pennies didn't change the speed much at all. Predicting the motion of a swing can help trapeze artists do more complicated tricks in the air. Like, check this out. These two trapeze artists are about to try a trick. Aha, a successful catch. Let's watch it again. It's hard to see from down here, but the ropes on this trapeze are shorter than the ropes on this one. And just like in your model trapeze, the trapeze with shorter ropes swings back and forth faster. These trapeze artists knew this would happen, so they planned for it. The goal of a catch is for both swings to meet in the middle like this.
As you observed your model, maybe you noticed that because the short and long trapezes move at different speeds, They don't always move in the same rhythm. Trapeze artists know this too. So watch what they do. This person waits to swing until this person has just started to swing backward. That way, they both swing in the right rhythm so they can meet in the middle.

Because they could correctly predict how they would swing, these trapeze artists were able to make a really tough trick a little bit easier. So that this could happen. You might wonder what makes this so easy to predict? What makes these patterns repeat again and again and again? For example, every time you pulled your Model trapeze back and let it go, It swung back and forth, back and forth. Why? When you see objects move in your everyday life, it's usually because something makes them move. When a wagon rumbles down the road, there's usually someone pulling it along. When you speed forward on a bike, the bike moves because you are pushing the pedals. When a flag waves in the air, It's moving because the wind is blowing on it, pushing it from side to side. Each of these objects started moving because the force pushed or pulled on So what force made your tiny trapeze start swinging when you let it go? I wonder what you think.

WRAP-UP VIDEO 2

It's easy not to think much about why things around you move the way they do. I mean, a trapeze just swings. That's what it always does. Right? But what if I told you that the force that makes your model trapeze start swinging is the same force at work here and here? And here, all these things have the same invisible force pulling down on them. That same force is pulling down on you too. Maybe you've even heard of this invisible force before. It's gravity. When you lift your model trapeze in the air, you use a small amount of force to pull it up. But when you let it go, gravity pulls it down. So like this and this and this, the trapeze moves. Once an object starts moving, it keeps moving until something stops it. But this trapeze artist doesn't fall all the way to the ground. Why not? Gravity isn't the only force pulling on this trapeze. The ropes are pulling on the bar of the trapeze. Those ropes stop the trapeze artist from falling all the way down to the ground or flying off the side. But the ropes don't stop the motion completely. So the trapeze

keeps going up until gravity pulls it back down. This is why your model swings and why a real trapeze swings and why playground swing swings. But unless you keep pumping your legs, eventually, the swing slows down and stops. You might have noticed this happen with your model trapeze too. So what makes this happen? To stop a bicycle or a car, you use the brakes. But a swing doesn't have brakes. If objects keep moving until something stops them, what's stopping this swing?

WRAP-UP VIDEO 3

Imagine being on a swing. Think about what you feel and hear. As the swing moves back and forth, You probably feel air rushing past you. Right? And maybe you hear the sound of the wind whistling or maybe a creaking sound like this. Those sounds and feelings are actually signs of another invisible force. As you swing, you bump into the air around you. As you swing this way, the air pushes against you in the opposite direction. That push slows you down. And that creaking sound, that sound comes from the swing itself. Pieces of the chains rubbing against each other and against the top bar of the swing set as they move. When those parts grind together, that pushes against the motion of the swing too. That also slows you down. These pushes are invisible force called friction. As you move in one direction, Friction with the materials around you pushes in the opposite direction. That's why the swing slows to a stop. Just like you can't see gravity but you know it's there because things like this happen, you can't see friction. But you can see the results of friction. It's what makes a swing slow down and what makes the brakes on a bike work. And what makes a baseball player sliding into home plate stop sliding? Imagine what would happen if friction weren't there. Without friction, this swinging might go on forever. A baseball player might keep sliding forever. What we think of as normal is shaped by the invisible forces all around us. Understanding how forces like gravity, and friction

create patterns in the way things move can help us make predictions far beyond the swing set or even a circus. Whether it's a trapeze artist flying high in the air or a baby swinging on a swing set on a playground, or a skateboarder racing down a halfpipe, a figure skater gliding across the ice, or a construction worker swinging a wrecking ball into a building. Being able to predict how something will move can make a big difference. Where in your life do you see motion repeating the same way again and again? How might it help you to be able to predict how the things around you will move? Pay attention to the patterns around you, and stay curious.