Lesson: “How could you win a tug-of-war against a bunch of adults?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi, it's Doug! In today's Mystery, I'm going to give you three tough problems involving something called *force*, and I want you to think about how you can solve them. Let's take them one at a time. Here's the first problem you face: could a bunch of kids beat a bunch of adults in a game of tug-of-war? That might seem impossible. I mean, what if the adults you were up against were all weightlifters, like her? Or, what if they were all in the Army? Even if you had a whole bunch of kids on your team, like 25 kids, you're still not going to come close to beating a team this strong. But this is a little unfair. I mean, adults like these devote their whole lives to being strong. So, let's make it more fair, shall we? Let's say that you and your friends, maybe even an entire class of kids at school, are going to play tug-of-war against a bunch of teachers. Then what would happen? Well, let's watch people do just that. This is a class about to play tug-of-war against dozens of teachers at their school. OK, the students put up a really good fight, but the teachers still won—they're just stronger. Now, you might think that there's nothing you can do to change that. The adults will just win every time. But not so fast. Let's think it through. You could think of tug-of-war as a game of pulling—you pull on a rope to make the other team move in the direction of your pull. The adults are pulling on the rope to move your team this way. I'm using an arrow to show the direction of that pull. Your team is pulling on the rope to move the adults this way. So, I'll show that with another arrow. But the adults are way stronger than your team,

so I'm going to show that by using a longer arrow for the adults' pull, meaning they can pull harder. And a shorter arrow for your team's pull. “Shorter” meaning you guys can't pull as hard as the adults can. The adults' pull is stronger, and so your team loses. So sad. Is there anything you could do about it, though? Well, you could get more kids to help pull. And, if you got enough kids, you could eventually pull even harder than the adults. That's one way you could win. But the challenge here is, could you beat the adults with just a classroom of kids? So let's pretend that you can't bring in anyone else to help you—you can't increase the overall strength of your group. Is there anything else you could do to win this tug-of-war against the adults? See if you can come up with some ideas.

EXPLORATION VIDEO 2

I want to show you something you might not have noticed or thought about. Look at the adults’ feet. Now, let me show you part of the video again, and pay attention to their feet. You see what they're doing there? Do you see what's going on? In order to pull the rope, they have to push their feet against the ground. I can show that using this arrow, which I colored red, meaning it's a *push*. Now, the kids’ team, they have to do this as well. They have to push against the ground in order to pull the rope. You would think of tug-of-war as being a game of pulling, but we can see that in order to pull on the rope, you have to be able to push backwards against the ground. So it's just as much a game of pushing as it is a game of pulling. Does that give you any ideas? Take a few moments to stop and think about this. Is there some way to stop the adults from being able to push against the ground? Come up with any ideas you can, even if your ideas are a little silly.

EXPLORATION VIDEO 3

There definitely are some things you could do: what if you could put something slippery under the adults? You know, like a patch of ice. Now maybe that's a little unfair, but let's think about it for a second. It would work, and that's interesting. When the adults try to push backwards against the ground, their feet would slip. Now, another idea is that you could also put the adults in roller skates. If you do that, now the adults are going to struggle because roller skates roll, meaning the adults won't be able to push themselves against the ground. Your team would have the advantage and you'd win. So what we did here to solve this problem, to figure out how a bunch of kids could beat a bunch of adults in a game of tug-of-war, is we thought about not just the obvious pulling that's involved, but also the pushes too. By spotting all the pushes and pulls, we were able to see a new solution to a tough problem. As you're going to see today and over the course of the next few Mysteries, being able to spot the pushes and pulls around you is what helps us to see and do some amazing things. You'll see that pushes and pulls are actually everywhere around you. Just about every action you can think of is some form of a push or pull. Think about it. A shove—that's a push. A stretch—that's a pull. Tug, smack, drag. You know verbs, right? Pick almost any action verb—squeeze, pinch, yank, lift—you'll see what I mean. Think about each action. It's either a push or a pull.

EXPLORATION VIDEO 4

Behind every action—whether shoving, stretching, or yanking—is a push or a pull. Now, if we keep having to say “push” and “pull” so much over and over, it's a bit of a mouthful. So scientists like to use a single word for both of them: *force*. Thinking about things in terms of pushes and pulls, in terms of force, can help you tackle some pretty extraordinary problems. Like this, our

next challenge: could you make a watermelon explode or burst without smashing it and without using a bomb? Using your own body strength to squeeze it, the answer is no. I can't do it, not even with my feet—watch. Now, why is that? Why can't I squeeze a watermelon until it bursts using my hands or my feet? You could totally squeeze a water balloon and make it burst—watch. No problem. So, notice how when you go to squeeze the water balloon, like I'm doing with my hands here, at first the balloon is fighting back—up to a point. The balloon's outer layer has a certain amount of strength to it. It doesn't burst right away—watch. You push in on it. And when you let go, you can see it pushes back out. I push in, and then as I let go, it pushes back out. But when you push enough, like what I did when I had my feet on it, your strength is stronger than the balloon's strength, so the balloon bursts and water rushes out. Well, just like a water balloon, a watermelon has an outer layer. We call it the *rind*. So getting a watermelon to burst is just a matter of using a force that's stronger than the watermelon's rind. Not even my foot can squeeze on it hard enough to do it. But you know what's really good at squeezing? These: rubber bands. Here is a rubber band squeezing on a woman's hair to make a ponytail. If you've got a whole bag of rubber bands here, what do you think? What would you do? Could you use rubber bands to make a watermelon burst?

EXPLORATION VIDEO 5

When I squeeze the watermelon, like with my foot against the pavement, sure, I push on it. But it's strong enough; it doesn't give way, it pushes back. It's like a very well-matched tug-of-war between my foot and the watermelon. We need a squeezing force where we could keep increasing the strength until it's strong enough to finally break the watermelon's rind. Well, a couple of guys, Gavin and Daniel, who call themselves “The Slo Mo Guys,” they got clever about this using rubber bands. I'll show you now and let them explain what they did.

[Slo Mo Guys video clip]

- Hello, internet. How are you doing?

- Hi, internet.

- Yeah. So, I saw a crazy Japanese video where people were putting—oh, that was a good shot—putting rubber bands around a watermelon. And I'm quite thirsty for watermelon right now, so we're going to cut one open using the classic Japanese method by the sounds of it. There we go. Start doing it.

- Yeah?

- Yeah. Just pile them on.

- This might take a while.

- It's going to take some time. Should I put it on top as well and the sides? Oh, it's starting to crack everywhere. Ooh. It's perspiring. Oh! [WATERMELON EXPLODES] Whoa!

- Whoa! It went, just severed it in half.

- Whoa! Oh, my god! Wow! That's incredible!

So, you see what they did. They started putting rubber bands on the watermelon. Now, just a measly rubber band or two, that's not going to do anything. But each rubber band adds strength. It adds a pushing force on the watermelon. In terms of force arrows, like we've been drawing, we can imagine that, with each rubber band, that the arrows pushing inwards are getting bigger and bigger. And so these two guys, they kept going, and going, and going. And by the time they had over 100 rubber bands on there, that's a lot more force. And so, what happened? Boom! All those rubber bands together, those easily overpowered the strength of the watermelon's rind. When we put the rubber bands on the watermelon, they only squeeze on a watermelon because we've stretched them. Stretching a rubber band, like this, creates a tug-of-war situation—you

have to pull on it, and the rubber band pulls back on you. So, here's the next challenge. Make use of a rubber band tug-of-war, but instead of using the force to make a thing burst, use the rubber band's force to make a thing jump or leap up into the air, like a frog. You'll find out more about how to do this in the next video.

ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to make one of these: a little invention we call a “Hopper Popper.” Now, when you flatten one out, you can launch it high into the air, like this. See? After you make your Hopper Popper, you'll measure how high it goes and figure out the forces that make it jump. Are you ready? I'll show you how to make one, step by step.

ACTIVITY STEP 1

Get your supplies. You'll get a rubber band later. When you're done with this step, press the arrow on the right.

ACTIVITY STEP 2

Using your ruler, draw diagonal lines between the corners, like this, making an X.

ACTIVITY STEP 3

Put your cardboard rectangle so it covers the "MAKE IT" box on your handout, like this.

ACTIVITY STEP 4

Using your ruler, draw lines that connect A to A, B to B, and C to C, like this.

ACTIVITY STEP 5

In each corner of the cardboard, the lines make a triangle. Cut those triangles out.

ACTIVITY STEP 6

Using your ruler, run your pencil over the center line a few times. Then fold it in half over your ruler, like this.

ACTIVITY STEP 7

Get a rubber band. Loop it around the end of the folded cardboard, like this. Make sure the rubber band is in the notches and goes around both sides of the rectangle.

ACTIVITY STEP 8

Just for fun, draw a quick picture of a jumping animal on your hopper. Make it quick, you only have a minute. Are you ready? Go. Time's up.

ACTIVITY STEP 9

Find a partner to work with. Decide who will be Mission Control and who will be the Launcher. Don't worry, you'll switch jobs later.

ACTIVITY STEP 10

Place the Launch Pad on the desk and put on some safety glasses if you have a pair. It's time for a trial run.

ACTIVITY STEP 11

Mission Control, grab the sides and pull them apart so the hopper is flat on the Launch Pad. Launcher, hold it down with your ruler. Keep your ruler there and go to the next step, where you'll countdown and launch.

ACTIVITY STEP 12

Mission control, in a minute, you're going to count down together, saying, “Three, two, one, blast-off,” like that. Launcher, when you hear “blast-off,” slide the ruler off the hopper. OK, are you all ready? Everyone start counting down together. Here we go: three, two, one.

ACTIVITY STEP 13

How did you do? It takes practice to release the hopper just right, so try it again. Remember, slide off your ruler, don't lift it up.

ACTIVITY STEP 14

Switch jobs and launch two more times so that both people get a chance to practice.

ACTIVITY STEP 15

Discuss these questions as a group.

ACTIVITY STEP 15b

Here's what we think. Did you draw anything differently? What do you think about the arrows we drew?

ACTIVITY STEP 16

Discuss these questions as a group.

ACTIVITY STEP 16b

Here's what we drew. Did you draw anything differently? What do you think about the arrows we drew?

ACTIVITY STEP 17

Now do your “High Hop Scorecard.” First, you'll see how high it can jump and fill in a chart. Then, at the bottom, you'll change your hopper to see if you can make it jump higher. Have fun, stay curious, and see you next Mystery!