Lesson: “Could you knock down a building using only dominoes?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hi, it's Doug! Have you ever accidentally knocked something over? I'm sure you have. We all have. But have you ever accidentally knocked over something really, really big? Some years ago, there was this forklift driver who was working in a warehouse in Russia, and he—well, let's just say he did not have a very good day. All of this was caught on camera. Watch what happened. Amazingly, he was OK. No one was badly hurt. But it's incredible to see something like this, isn't it? How could something like this happen? Well, you probably noticed he bumped first into one side of the shelves pretty hard, so hard they fell over, and that knocked into the other side of the shelves next to them causing the whole thing to collapse. The way that one thing knocked over another and then another and then another, all of this might remind you of lining up a bunch of dominoes. If you've ever done that, it's a similar situation. You line them all up, and then if you bump into the first one, they all go tumbling down. Stuff like this can be so fun to watch. Check out this example. This was at a library using books instead of dominoes, but it's the same idea. Watch. They line them up, and they just keep going and going and going, all from one little push at the start. Sure, one thing bumps into the next, but why do they keep going on and on and on for as long as you've got them lined up? For example, say instead of books or dominoes, we lined up a bunch of little marbles. You push the first one into the next, and the first few marbles will bump into each other, but eventually, they stop. These two didn't

get bumped into at all. So marbles don't keep going if you push them, but when you have a bunch of falling dominoes, why do they keep going for so long? There's not something special about dominoes. It works just the same for books, even for lockers. Watch. Now, as you might imagine, what matters to having things like lockers and dominoes keep going is that things like lockers and dominoes and books, they're all objects that can be tipped over. And that means that one has to be set upright. You have to lift each one up. When you do that, you're putting part of each domino up high. You're giving it height. Does that remind you of anything? Can you think of any other situation where something is put up high and that does something special?

EXPLORATION VIDEO 2

When you set up a domino, you're putting part of it up high. Does that remind you of anything? I hope it reminds you of the idea that putting something up high, giving something height, is one way to store energy in it. One example we've seen in previous Mysteries was a roller coaster. By moving a roller coaster car up to the top of a very tall hill, you store energy in it, energy that gets released as the coaster car rolls along the rest of its track. With dominoes, you have to set them up. You have to lift them. Some of the energy you use to lift them up gets stored in the domino. So, with this in mind, why is it that when you knock down a row of dominoes, they just keep going and going? Well, the reason it just keeps going is because when you set them up, you gave them height. So you stored energy here and here and here. You stored energy all along the way. When you push on the first domino, at the point that it begins to tip over, you release its stored energy, and as it falls, it transfers some of that energy to the second domino, enough energy to tip it over. As the second domino begins to tip over, then it releases its stored energy and transfers some of that to the third domino, which tips it over and so on, all the way down the line. This will happen for as many dominoes as you want to set up. It's fun, and you're

probably dying to go play with some dominoes right now. But let me get you to think about something even more surprising. Now, so far, we've just been considering dominoes that are all the same height. Does that matter? Will this only work if they're all the same height? Like, what do you think would happen if we had a normal-sized domino next to a really tall one? Well, there's an easy way to find out. Let's try it. What do you think is going to happen? Make a guess in your head right now about whether or not you think the tiny domino can push the big one over. I'll give you a few seconds to think about it to yourself. OK, are you ready? I'm going to go ahead and do it now. Let's give it a push. Nothing, right? The small domino had some stored energy from being lifted upright, but it's not enough energy to tip over the second domino. That second domino, because it weighs more and it's bigger, it requires a little more energy in order to get tipped over. But how much energy does it really take in order to tip something over? Sure, a regular domino can't knock down a huge one. But could a regular domino knock down one that's only slightly bigger? Try it yourself if you can. You can use books if you don't have dominoes.

EXPLORATION VIDEO 3

How much energy does it really take to knock something over? Sure, a regular domino can't knock over a huge one, but it can knock over one that's slightly bigger. Other people have noticed this before and wondered, what if each domino you set up was just slightly bigger than the last one, like this setup you see here. Now, do you think a small domino could be used to knock over a really big one? This is a science teacher who's tried. Now, look how he's got it all set up here. Are you ready? Boom. OK, that worked pretty well. But could we do something more impressive than that? Could it be possible to knock down something huge, something as tall as a building even? Let's see what happens when some people tried this. What you're about

to see is the Guinness World Record for the largest domino to be toppled over. Look at how big it is compared to these people standing back here. It's not quite the size of a building, but it's at least the same height as a small house. You see this one in the background? OK. Watch what happens when they start with the small domino. This huge domino at the end gets toppled over, all with the start of a single domino about the size of a brick getting knocked over. How is that possible? Can you explain what's going on in terms of energy?

EXPLORATION VIDEO 4

What makes it possible for a small domino to knock down a huge one has to do with stored energy. You already understand that each domino is slightly bigger and taller than the last one. But you might not have thought about what a domino's size has to do with its stored energy. Think about where the energy in each domino comes from. To find where it comes from, it's helpful to imagine going back in time. If we go back in time and watch this whole set of dominoes being set up in the first place, we can see that each domino had to be lifted up by someone. That required that people use energy. As they lifted each domino up high, they stored some of that energy they were using into the domino. Now for the bigger dominoes, setting them up required a lot more energy. In this case, special equipment was needed, like this crane. Now, it may seem almost magical that a single brick could knock down something the size of a house. But when you go back in time and watch all the pieces being set up, now you can realize, the energy comes from the people and the machines lifting each domino. Each domino stores more energy than the last one because each domino is bigger and higher up than the last one. So along the pathway, as each domino is bigger and taller, there's more energy stored in each one. Pushing that first small domino simply releases all the energy stored up along the pathway. Now, this action of one thing causing another to move, and then another, and another,

and so on, scientists call it a chain reaction. Have you ever heard that phrase, chain reaction? Why do you think they call it that?

EXPLORATION VIDEO 5

Dominoes aren't the only example of a chain reaction. This guy is named Joseph Herscher. And he's an inventor. He invents machines. But these machines aren't meant to be helpful. They're meant to make you smile. It's a chain reaction machine. Check it out. So this is an example of a chain reaction machine invented by Joseph Herscher. This one is meant to help keep him awake when he's at the office. Now, do you see what he did here? Think about everything you just saw. But let's watch it again. This time, pay attention to where the energy is stored and transferred. So, just like with dominoes, in a chain reaction machine, if you go back in time, there are places where energy is stored, just like you see the energy stored in dominoes. Even though Joseph didn't use dominoes in this machine at all, he did use height to store energy. Like, check out this part. Notice the hammer? It's been lifted up, like a domino, and is now standing like it could topple over. It has energy stored up. Watch when the ball hits it. Now, speaking of the ball, it's high up, too, on a ramp. So it has stored energy and is ready to roll. Watch. Altogether, the ball high up on the ramp, the hammer standing up, have enough stored energy to send this orange ball back here flying. Watch one more time. See that? So, chain reaction machines, they're mostly just for fun. But there's one way that they are actually useful. By looking at them and playing with them, you can figure out different ways energy can be stored. And by watching all the parts move, you can also figure out ways energy can be transferred from place to place. As we're going to see over the next few Mysteries, chain reaction machines can help us understand how our own real-world machines work. We'll see that in the real world, we have to find ways to store energy, and we have to find ways to transfer

that energy from place to place in order to power the moving parts that we find in our homes, our schools, our offices, our hospitals, and more. But for today, you're going to think about how you can store energy to make a chain reaction machine go. Have fun.

ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to build a chain reaction starter kit. It has everything you need to eventually create an entire chain reaction machine of your own. Now, the starter kit contains a ramp for a marble to roll down. This ramp is made out of paper, and you can see it's supported by a cup. The height of the ramp lets the marble up on top store the energy that it needs to power the machine that you're eventually going to make. Now, to release that stored energy, you need to start the marble rolling. For that, there's a little platform at the top of the ramp. You could start the marble rolling by lifting the platform with a finger, like this. But that's much too simple, and let's face it, that's boring for a chain reaction machine. So, you'll make a ramp lifter, one of these. A scientist would call this a lever. Levers don't store energy, but they are useful for transferring energy, and by that I just mean moving energy from one place to another. Let me show you how it works. When something pushes down on one end of the lever, the lever pushes up with the other end. You're going to have to figure out how to make your lever lift your platform and start your marble rolling down the ramp. Once you've figured that out, then you can use your machine for something that rolling marbles in chain reaction machines are really good at, and that's colliding with stuff at the end and making things move. The experiments you do today will help you in the next Mystery when you'll work with a team to build an entire chain reaction machine. But first, for today, let's make this important chain reaction starter kit. I'll walk you through all the steps to make one, and then you'll try some experiments.

ACTIVITY STEP 1

Get these supplies. You'll get a marble later.

ACTIVITY STEP 2

Start with this worksheet. Write your name on the ramp, then cut on the thick black lines.

ACTIVITY STEP 3

Use your ruler to fold all the solid lines on both the tilt platform and the ramp, like this. Run a fingernail over each fold to make a good crease.

ACTIVITY STEP 4

Cut on the six dashed lines, like this.

ACTIVITY STEP 5

Find the dotted line with the diamond on the tilt platform. Fold on the dotted line, like this. Then make two tiny cuts to cut out the triangle. When you unfold it, you'll have a hole. That's where your marble will rest.

ACTIVITY STEP 6

On the tilt platform, fold the side flaps in, like this. And the back flap up and over, like this. After that, slide on a paperclip to secure it, like this.

ACTIVITY STEP 7

Find a friend to help with the next steps.

ACTIVITY STEP 8

Set the gray end of the tilt platform on the gray part of the ramp, like this. Line it up carefully and have your partner add a sticker. Now your ramp and tilt platform are one piece.

ACTIVITY STEP 9

Set the tilt platform on the cup, like this. Hold the paper flaps against the cup. Make sure the tilt platform is flat against the cup, then fold back the ramp. Have your friend add stickers at the bottom of the flap to secure the ramp, like this. When you're done, make sure to push down on the tilt platform to double-check that it's flat against the top of the cup.

ACTIVITY STEP 10

Now you're going to turn your ruler into a lever that you can use to tilt the tilt platform. Hold the ruler and marker like this. Then loop the rubber band around the marker, over the ruler, and then around the marker, like this.

ACTIVITY STEP 11

Make sure the sides of your ramp are sticking up so that a marble can roll down it. If they aren't sticking up, fold it again like this to fix it. Again, make sure the tilt platform is flat against the cup.

ACTIVITY STEP 12

Set the lever down by your cup, like this, with one end under your tilt platform. Push down on the end of the lever. Does the other end go high enough to bump the tilt platform? Try it out, then go to the next step.

ACTIVITY STEP 13

Here's your first challenge as a chain reaction inventor. Can you change the lever so that it can bump the tilt platform? Remember, you have to use the lever as a lever, you can't just lift it off the table. Now, here's a hint. You can do this without adding anything to the lever. You have three minutes to figure something out. Are you ready? Your time is up. Go to the next slide.

ACTIVITY STEP 14

How did you do? Discuss.

ACTIVITY STEP 15

Here's what we did. There are other solutions. Use one that works for you. One thing you could have done was to move the marker, the pivot point, and move it back. That lets the lever reach higher and hit the ramp, see? Or maybe you put some books under the lever—that works too, see? Or maybe you thought of something else. OK—go to the next step.

ACTIVITY STEP 16

Fold the Marble Corral on the solid lines, like this. Set it up at the end of the ramp, with the ramp inside the Dixie cup, like this. You want the Dixie cup ready to catch a marble.

ACTIVITY STEP 17

Get a marble and set it on your tilt platform. Use your lever to tilt the platform and make the marble roll. How far does the Dixie cup move? Try it a few times.

ACTIVITY STEP 18

Discuss. When you're done, watch the final video.

WRAP-UP VIDEO

Maybe you're wondering why you'd want to move a Dixie cup. Well, in the next Mystery, you can build a chain reaction machine that delivers a message using Dixie cups just like these. Watch our chain reaction machine, and you'll see what we mean. Now, to make this chain reaction machine, we used stuff that we found around the office. We used books and boxes to make some parts of the machine higher so that we could store more energy by putting marbles up high. And rather than only using marbles, we also found a little orange car and a supercharged shark car, and we used those as rollers. So that's what we did. But think about what you want to do for your machine. Can you think of something that would make a good substitute for a rolling marble, something you could use instead? And do you have anything that would work as dominoes? If you have a chance, check out some other chain reaction machines in the

Extensions that follow this Mystery. They'll give you more ideas that you can use when you want to build your own machine. Have fun, and stay curious!