# Lesson: “Can you build a chain reaction machine?”

# VIDEO TRANSCRIPT

## EXPLORATION VIDEO 1

Hi, it's Doug! This is a kid who calls himself Berlag Awesome on YouTube. He started making chain reaction machines when he was in about fourth grade. Now he's a teenager who has his own YouTube channel full of videos of his machines. Let's watch one. Let's watch part of that again. Seeing all these videos of chain reaction machines, they're so fun, I'm inspired to make one of my own. But I have to tell you, they look so hard to make. Like Berlag Awesome said, it took him 29 hours to make this one that you saw. Now luckily, I happen to work with Pat Murphy. You may have seen her occasionally in the activity videos we produce here at Mystery Science. Pat does what we call engineering. She invents things. Now, that might make you think of inventing light bulbs or inventing smartphones, but Pat has a somewhat unusual engineering job. She spent about a decade, over 10 years, actually, engineering toys, specifically science kits. And as luck would have it, Pat loves chain reactions. She even wrote a book about them. I get to talk with Pat every day since I work with her. It's awesome. So let's go get Pat's advice. That way, you and I can make our own chain reaction machines today.

-**Doug:** Pat Murphy.

-**Pat:** Hey, Doug. How are you?

-**Doug:** Look at this. You've got all these chain reaction machines set up. I love it.

-**Pat:** You know what I like.

-**Doug:** So I've got to tell you, I love chain reaction machines. I want to make one. They're kind of complicated. They look complicated. There's a lot going on. It's a little intimidating. Can you help me uncomplicate it?

-**Pat:** Sure. The reason they look complicated is because you're looking at the whole thing at once. Now, when I made this machine and when I watch machines, I think of them as a series of steps. I like taking complex problems and breaking them up into parts. It's making it smaller parts that you can understand that helps me.

-**Doug:** OK, I can see where that would be helpful. So, what, to you, are the parts involved in this?

-**Pat:** Well, let's take a closer look at the machine in action. OK, you want to come pull out the—

-**Doug:** Yes, can I do it?

-**Pat:** —pull out the string?

-**Doug:** OK, all right. Here we go.

-**Pat:** Come all the way around here.

-**Doug:** OK, here we go. 3, 2, 1. Hey!

-**Pat:** Yay, nice.

**[Repeated in slow motion]** *3, 2, 1. Hey! Yay, nice.*

-**Pat:** Now that we've seen it, we can break it down into steps to make it simpler. Let's rewind. OK, so here's the first thing that happens. You pull out the rod that holds the tire in place. I'd call that step one. Now it's step two. The tire swings around and hits the hammer. I've frozen the action here because two things are going to happen at the same time. The hammer is going to hit the lever here. That's step three, and it's going to hit the

marble here. That's step four. OK, let's see it. The hammer hits the lever. Hits the marble. Sign pops up. Marble hits the dominoes. The dominoes fall, and that is step five.

-**Doug:** So it is pretty complicated. There are lots of pieces or parts to it. But you're saying just look at it each individually—one part, one part, one part—and then they all work together?

-**Pat:** That's right.

-**Doug:** OK.

-**Pat:** And the other thing that's really useful to think about is energy. It's the energy that makes things move. And when I talked about the different steps, each step includes energy that's stored and gets transferred, or sometimes energy that just gets transferred. So let's look at the different steps and see if we can figure out where the energy is.

## EXPLORATION VIDEO 2

-**Doug:** OK, so Pat, I get the idea now that a chain reaction machine isn't that complicated if you break it up into steps.

-**Pat:** That's right.

-**Doug:** But I want to make a chain reaction machine myself. Where do I even begin?

-**Pat:** Well, it's strange. It may seem strange, but I start with the ending.

-**Doug:** You start with the ending?

-**Pat:** Yeah. Start with the ending because I think of the chain reaction machine as kind of a joke, and the punch line is the ending. I need to know the punch line before I can tell the joke.

-**Doug:** I see.

-**Pat:** So let me show you this. Because you're kind of a beginner at this, I thought a good ending might be a message, delivering a message.

-**Doug:** That's pretty simple.

-**Pat:** So I created the sign that pops up.

-**Doug:** That's a sign?

-**Pat:** I have two signs that pop up here. Behind this question mark, if everything goes well, the question mark will reveal the message behind the question mark.

-**Doug:** Interesting.

-**Pat:** And the way we'll get there is, I'll push on this lever, the marble will roll down this ramp, the marble will hit the dominoes, which will all fall. The car will roll down the ramp and land in the cup. At the same time, the car's going to pull on this string, yanking out the paperclip that holds the shark car in place. The shark's going to roll down the ramp into the cup. Let's see if it works. Yeah, it all worked!

## ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to make a chain reaction machine. You're going to start with the ending—a sign popping up. That's funny, Pat wrote, “Hi Doug” on this sign for me. So you'll make a sign, too. You can write anything you want on it. Then you're going to work backward from there. In front of the pop-up sign, you're going to put your marble ramp, which you made in a previous Mystery. You'll use the marble to give the sign the energy it needs to pop up. See? You'll need to test it out to make sure the marble has enough energy to do that. Once you have the ramp and the sign set up, you'll have a 2-step chain reaction machine. You'll get creative and add another step of your choice to make a three-step chain reaction machine. And then

finally, you'll add in other steps until you have a chain reaction machine that's totally fun and all your own. We'll help you get started, step by step.

## ACTIVITY STEP 1

If you're in a class, find a partner to work with. If you're working alone, that's OK too. When you're done with this step, click the arrow on the right.

## ACTIVITY STEP 2

Get your first batch of supplies. Each group needs these things.

## ACTIVITY STEP 3

With your partner, decide who will be the Folder and who will be the Cutter. You have 10 seconds to decide. OK, ready? Go. OK, time’s up. Go to the next step.

## ACTIVITY STEP 4

Folder: fold the worksheet in half. When you're done, it should look like this.

## ACTIVITY STEP 5

Cutter: cut on the four dashed lines. You'll be cutting through two pieces of paper, so you'll see two flaps with each cut. When that's done, Folder: fold the flaps of paper up on the three solid lines, like this. It will look like this when you're done.

## ACTIVITY STEP 6

Cutter: turn the paper over and cut on the dashed line to cut off the striped rectangle. It will look like this when you're done.

## ACTIVITY STEP 7

Folder: fold down the flap with the question mark. Be sure you only fold the top flap, not both flaps. Run your fingernail over the fold to make a crease, like this.

## ACTIVITY STEP 8

With your partner, decide on the punch line or message for your chain reaction machine to end on. You have 30 seconds to decide. Are you ready? OK, go. OK, time's up. Go to the next step.

## ACTIVITY STEP 9

Folder: write the message on the flaps, like this.

## ACTIVITY STEP 10

Cutter: tape the Dixie cup to the edge of the table, like this. Make sure you press the tape firmly on the cup. When you're done with that, make sure you can flip it up and down.

## ACTIVITY STEP 11

Folder: hold the paper so that the three "Table" lines are at the edge of the table, like this. Cutter: tape the tabs in place, like this. Make sure the paper is all the way against the table. You can slide your finger to smooth the paper against the table before you tape each flap.

## ACTIVITY STEP 12

Now you're going to use gravity to your advantage. Cutter: lift up the bottom of the sign. And Folder: add two paperclips to the "question mark" flap. Make sure you don't clip your message to the "question mark" flap.

## ACTIVITY STEP 13

Cutter: tip the cup so that it rests on the paper, like this. Folder: give the bottom of the sign a small push, like that. You want the paper to be balanced so that it just takes a small push to open the sign. If your sign opens up before you push it, add another paper clip to the question mark flap.

## ACTIVITY STEP 14

Get a marble and one of the ramps you made last week. Set it up so that the ramp leads into the cup. When you're set-up, go to the next step.

## ACTIVITY STEP 15

Take a minute to test your sign. Make your marble go down the ramp into your cup. Wait, wait, wait—stop. I don't know about you, but I need some help.

-**Doug:** Pat, I need your advice.

-**Pat:** What's wrong?

-**Doug:** I tried to doing this, and I cannot get the sign to work.

-**Pat:** OK, show me.

-**Doug:** OK, see—

-**Pat:** Hey, you're right. It didn't work. So, this is where it gets fun because now you have to figure out how to make it work. And that's actually one of the joys of engineering. Take a look at what you think might be going on.

-**Doug:** You know, I can do this with my hand, right? So if I pushed really hard on this, now it comes down. So I need this Mystery Science part to go down all the way, like that, but it's just not doing it.

-**Pat:** Now, I'm going to tell you something that you may not have thought of. I think of this sign as a lever, because when you push on a lever, when you push down on one end, the other end comes up. I'm pushing down on this end, and then it should come up. But you see how far I pushed down, and it's still not coming up.

-**Doug:** Yeah, because this thing is floppy. This thing is—it's not—

-**Pat:** Yeah.

-**Doug:** Yeah.

-**Pat:** It's, kind of, sagging.

-**Doug:** It's like spaghetti or something.

-**Pat:** Yeah, it's saggy. It's sagging backward. And you want it—if it were to stay totally stiff, it would be all the way up now and it would be falling down.

-**Doug:** If you made it—if you made this whole thing stiff like a lever.

-**Pat:** Exactly. I'm going to let you try to solve the problem, and at the same time let whoever's watching try to solve the problem too.

## ACTIVITY STEP 16

Discuss.

## ACTIVITY STEP 17

Here's what we came up with.

-**Pat:** So what'd you come up with?

-**Doug:** Here's what I figured out, using your idea that this—thinking of this as a lever, that was really helpful. So if this is a lever, then I could just stick this index card—I'll put it that way—in there, like that, and now see, it's a little more stiff.

-**Pat:** And that worked for you?

-**Doug:** I mean, I tried it once. You want to see?

-**Pat:** Well, yeah. Let's give it a try.

-**Doug:** OK.

-**Pat:** Get it set up.

-**Doug:** OK, here we go. That's not really staying down.

-**Pat:** Wait a second. Before you go on, you've got another opportunity to experiment. This isn't staying down the way you want it to.

-**Doug:** No, I wish it would stay down a little more.

-**Pat:** What might make it stay down? Think of this. Again, it's a lever. It's like a teeter-totter. This end is going down. More weight on this end.

-**Doug:** Yeah, exactly. I could put more weight. I mean, I could try putting more paper clips. I would worry about it getting too heavy, but—

-**Pat:** Well, you know, this is all about experimenting. Engineering is all about experimenting, trying different things, seeing if it works. Hey, if it doesn't work, take off the paper clips, try something different.

-**Doug:** That's a good point. I guess it can't hurt to try. OK, so that does hold it down more, but now, let's see that actually—

-**Pat:** There you go. Now it revealed your index card. You need another message.

-**Doug:** Oh that's right, I'm covering up the old message. Well, that's a problem.

-**Pat:** Well, you can write a message on the index card.

-**Doug:** That's true.

## ACTIVITY STEP 18

If you want to use our solution to fix your sign, then rewrite your message on an index card and slip it in your sign, like this, then use extra paper clips to make the question mark flap stay down. If you had a different solution that worked, that's awesome. Keep it as it is and send your idea to Mystery Science. We want to hear about it.

## ACTIVITY STEP 19

Find out what supplies you have and add at least one more step to your machine. If there's time, you can add two or three more steps. Now, there are so many different ways to do this. If your machine needs more energy, by the way, use books and boxes to put things up high. I'm telling

you, your machine won't work the first time. It probably won't even work the first 20 times. We didn't show you all the times that our machines failed, but they did a lot. Check this out. Oh, darn you. Darn you. OK. It's all part of the engineering process. It's all about problem-solving. Have fun, and stay curious!