Lesson: “How can marbles save the world?”

VIDEO TRANSCRIPT

EXPLORATION VIDEO 1

Hey, it's Jay from the Mystery Science Team. There's a kind of object you can find in ancient Egyptian tombs, and in ancient Aztec cities, and buried under volcanic ash in the ancient Roman city of Pompeii, and in modern-day New Jersey. What could all those places possibly have in common? It's a set of marbles. People all over the world have enjoyed playing games with marbles for thousands of years. Though marbles aren't as popular today as they once were, many kids still play games with marbles. When I was a kid I learned to play marble games with my dad, who played a lot when he was a kid. Even today, teams from around the US gather in New Jersey every year to compete in the National Marbles Tournament. So, what's the deal with marbles? Why do you think so many people have loved playing with them for so many years?

EXPLORATION VIDEO 2

There are lots of reasons marbles have been popular for so long. They're simple, easy to carry, easy to play with, and also just fun. Even if you've never played a marble game before, I bet you've played some kind of game that's similar. Think about bowling, or pool, baseball, ping pong, pinball, even this sport called curling. These games all involve objects crashing into each other. They all involve collisions. That might not be a coincidence. Imagine how it would feel to

do this, hitting a home run in baseball? Or this, a bowling ball strike? Or this, spiking a volleyball over the net? Or this, pool balls scatter? Games just look and feel and sound cooler when you get to smash stuff together. And as different as these games are, on a super basic level, the goal is similar. You throw, or roll, or crash one object into another to make the second object move. But have you ever thought for a second about why all these collision games work? Why does this marble move when the other marble hits it? For that matter, why do any of these things move when something else hits them? In science, we know that it takes energy to move an object, even a small object like a marble. Where does the red marble get the energy to move?

EXPLORATION VIDEO 3

Right now, the red marble is still, but the blue marble is moving. It has energy. But watch what happens when the blue marble hits the red marble. See that, after the two marbles collide, the blue marble slows down. Now it has less energy. But after the crash, the red marble starts moving. Now that marble has more energy. The energy went from the first marble to the second marble. It transfers from one to the other. Now, watch this. I'm going to show you collisions from two different games of pool, but we'll pause right before the collision actually happens. Okay, here's the first one, you ready? And here's the second. Try making a prediction here. Do you think the results of these two collisions will be the same or different? Why?

EXPLORATION VIDEO 4

Ready to see what happened? Okay, here's the first collision. And here's the second one. In the first collision, the ball moves slowly. When it reaches the others, it just kind of taps them. They move a little, but not a lot. But this one moves fast. So fast it's hard to see it. When this ball

collides with others, they really move. The faster an object is moving, the more energy it has. The more energy an object has, the more energy transfers when it crashes into other objects, and then the faster and farther those objects move too. If you've thought about how energy works in other lessons before, this might be something you already know. And even if you've never thought about collisions in terms of energy before, I bet you were thinking about something to predict what would happen. Maybe you've actually played pool yourself, or maybe you made your prediction based on other experiences watching different objects bump and crash and collide over your whole life. You can use collisions you've seen before to predict what will happen in other collisions. The more information you have, the better you'll be at making good predictions even in games you've never seen before. Like, check out this collision game. This is called a marble relay race. These races are set up to look like a relay race at the Olympics but for marbles. There are marble competitors, marble fans sitting in the stands, even a serious sports announcer describing the game live.

> [Commentator] But here come the speeders in the lane right next to 'em. It's gonna be the speeders that get the win.

See how at the end, the marbles roll over the finish line into this flat area at the end of the racetrack? Try making another prediction here. What would happen if instead of staying flat, the end of the racetrack went uphill?

ACTIVITY INTRODUCTION VIDEO

In today's activity, you're going to be playing a brand new marble game called Bumper Jumper. The way it works is you'll roll one marble down a ramp. That's your bumper marble. This bumper marble will collide with another marble on the track. This is your jumper marble. If the jumper marble has enough energy, it will go flying over the jump, and onto the landing zones. Bumper

Jumper is a game all about predictions. You and a partner will work together to predict which zone the marble will land in based on what you know about energy and collisions. Will the jumper marble land in zone one, zone two, zone three, or will it not even make it off the tracks? If you predict correctly, you score a point. The game is played in three rounds. You'll have to use what you learned in previous rounds to help you predict the correct answer in the next round. Can you and your teammate use what you know about energy to make the best predictions and score the most points? We'll get you started, step by step.

ACTIVITY STEP 1

You'll work with a partner to build and play Bumper Jumper. Decide who will be Crash and who will be Pow. If you're working alone, you'll do both jobs. When you're ready to move on, click the arrow on the right.

ACTIVITY STEP 2

Get your supplies. Each pair needs these things.

ACTIVITY STEP 3

You're going to start with making the ramp of your bumper jumper. Crash: roll a piece of paper up longways into a tube. It should be big enough to wrap around three fingers like this. Once you roll the tube, tap it on the table to even out the ends. Pow: use three small stickers to tape the paper tube together. Put one sticker on each end of the tube and one in the middle. Press down on the stickers with your finger to make sure they stay on. Put this off to the side for now.

ACTIVITY STEP 4

Next, it's time to make the track for your bumper jumper. First, Pow: gently fold your track printout on the thick black line, like this. Make sure to line up the edges and corners of your paper, then press down on the fold with your finger to make a good crease. Crash: fold the page on the thin line, like this. Line up the edges and corners of your paper, then press down on the fold with your finger to crease the paper. Your track should look like this when you're done.

ACTIVITY STEP 5

Now it's time to make the walls of your track. Watch the whole step first before you try it. Crash: fold one side of your track so that it barely covers the gray area like this. Don't crease the fold. Just hold down the corners. Pow: once the fold is lined up, crease it with your finger. Then lift the fold up gently so that it sticks straight up like a wall. Then do the same thing for the other side. When you're done, it should look like this.

ACTIVITY STEP 6

Next you're going to attach your track to the ramp. Pow: stick half of a long sticker on the box that says tube. And leave the other side unconnected for now. Crash: push that end of your track up against your tube like this. The end of the track should touch the end of the tube. Pow: now attach it. Press down on the other side of the sticker inside the tube like this. Try your best to make a smooth connection between the two parts for your marble to roll over.

ACTIVITY STEP 7

Now finish making your ramp. Crash: put a finger on the top of the track so it stays flat, then lift up the tube. The walls should just barely tuck inside the tube like this. Pow: stick half of a long sticker to the inside of the lifted tube, like this. Then tape the other half to an upside-down large cup, like this. Press down on the sticker to make sure it's firmly attached.

ACTIVITY STEP 8

Now you'll make the jump for your bumper jumper. Crash: cut your small cup in half like this. If your cup has a seam that runs from top to bottom, you can cut along that. Make sure to watch out for your fingers when cutting. Pow: cut off the bottom part of one of the halves like this. Do your best to cut in a straight line as close to the bottom of the cup as you can.

ACTIVITY STEP 9

Pow, now you're going to attach the piece you just cut to your track. Put half of a long sticker in the middle of the cup like this. Then, put the other half in the black box that says jump at the end of your track just like this. Make sure that the cup's edges are on the outside of the track like this. Do your best to line it up so that there is no gap between your cup and the collision track. Then push down on the connection between the jump and the track to make sure the sticker is attached well.

ACTIVITY STEP 10

The last thing you need to do is lift up your jump so that marbles can fly off of it. Crash: take the other half of the small cup you cut and put it underneath your jump. Propping it up slightly like

this. Try to put the middle of this support cup just underneath the tip of your jump like this. Don't make it too steep. Pow: make a tape roll with the sticky side of the tape on the outside. Stick it between the jump and the support cup like this.

ACTIVITY STEP 11

Pow: lay pencils over the pencil lines and hold them in place. Crash: tape them down with long stickers to make barriers between each zone, like this. Next, lift up the end of your bumper jumper, and slide the landing zone sheet underneath it. Line up the end of the jump with the thick black line like this. Finally, tape the top corners of your landing zone sheet down with two small stickers so it won't move. Congratulations, you've finished making your bumper jumper. Now it's time to see it in action.

ACTIVITY STEP 12

Get these supplies. Each pair needs four marbles.

ACTIVITY STEP 13

Test your bumper jumper to make sure it's working like it's supposed to. Only use one marble for the test. If everything is working, the marble should make it over the jump. Pow, drop the marble down the ramp. Make sure you just drop it, don't push it. Crash, watch closely to see which zone the marble lands in and collect the marble. Then switch jobs. You'll have one minute to test your bumper jumper. If your marble doesn't make it over the jump and onto the landing zones, that's okay. Try to fix it. You may need to make sure the tube, track, and jump are taped together smoothly and in a straight line. I'll put a one-minute timer on screen in case that helps. Time's up. When you're ready to move on, click the arrow.

ACTIVITY STEP 14

Now, it's time to play Bumper Jumper. The game has three rounds and each round has three trials. Before each round, you and your partner will use what you know about energy and collisions to predict which zone your jumper marble will land in. Then you'll test it. You'll get a point for each correct prediction. Remember, you have to make a prediction before testing to get the points. Now, make your prediction for the first round. Round one will look like this. Where do you think the jumper marble will land? Zone one, zone two, zone three, or no jump. Discuss and write your prediction here.

ACTIVITY STEP 15

Now it's time to test your prediction for Round 1. Let's do this first trial together. Crash, place a marble on the star symbol, like it shows on your worksheet. Make sure it isn't rolling. Then, head over to the landing zones. Your job is to watch closely to see where it lands and stop it from rolling away. Pow, drop a marble down the ramp. Remember to just drop it, not push it. Circle where the jumper marble landed on your sheet. If it bounced into another zone, circle the zone that it landed in first. Repeat this two more times. Switch roles each time so that both partners get a chance to do both jobs. Click the arrow when you're ready to move on.

ACTIVITY STEP 16

Now it's time to score your points for round one. Put a point in the score box for each trial that matched your team's prediction. Here's an example. If you predicted zone one and your marble jumped into zone one twice then your score is two points. If you didn't predict the correct

answer, that's okay. Use what you learned about energy and collisions in this round to help you next round. Click the arrow when you're ready to move on.

ACTIVITY STEP 17

Now it's time to make your prediction for the second round. Round two has an extra marble on the collision track, which means there'll be one more collision than in the last round. Where do you think the jumper marble will land? Zone one, zone two, zone three, or no jump? Discuss and write your prediction.

ACTIVITY STEP 18

Put one marble on the star and one on the heart symbol like this. Then play all of round two with your partner. Remember to circle on your sheet where the jumper marble lands in each trial. I'll set a timer for two minutes in case that helps. All right, time's up. Add a point to your score box for each trial that matched your team's prediction. Click the arrow when you're ready to move on.

ACTIVITY STEP 19

Now it's time to make your final prediction. Round three has another marble on the collision track, which means there will be one more collision than in the last round. Discuss with your partner, and write your prediction on your sheet.

ACTIVITY STEP 20

Add one marble to the star, one to the heart, and one to the lightning bolt symbols on your collision track like this, then play all of round three with your partner. Remember to circle on your

sheet where the jumper marble lands in each trial. I'll set a timer for two minutes in case that helps. All right, time's up. Add a point to your score box for each trial that matched your team's prediction, then add up all the points across the three rounds and write down your final score. Click the arrow when you're ready to move on.

ACTIVITY STEP 21

Discuss. When there were more collisions how did that affect how far your jumper marble flew? Why do you think that happened?

ACTIVITY STEP 22

Here's what we said. When there was only one marble on the track, it mostly landed in zone one. But when we added two and even three marbles to the track, our jumper marble didn't have enough energy to make it over the jump at all. Watch this. It seems like the more collisions there are, the less energy the jumper marble has, but I wonder, would the same thing happen if we use different objects? Discuss with your partner. What do you think would happen if the jumper marble wasn't as heavy?

ACTIVITY STEP 23

Get the rest of your supplies. Once you have your aluminum foil, roll it into a ball, about the size of a marble.

ACTIVITY STEP 24

You're going to play bumper jumper again except this time you'll swap your jumper marble for an aluminum foil ball. Do you think the foil ball will land in the same place the glass marble did?

Round one. Place the foil ball on the star on the collision track. Discuss and write your prediction for which zone you think the foil ball will land in. Then play all of round one with your partner just like before. Remember to circle on your sheet where the foil ball lands in each trial. I'll set a timer for three minutes in case that helps. All right, time's up. Add a point to your score box for each trial that matched your team's prediction. Click the arrow when you're ready to move on.

ACTIVITY STEP 25

Round 2. Place the foil ball on the star and a marble on the heart on the collision track. Discuss and write your prediction for which zone you think the foil ball will land in. Then play all of round 2 with your partner. I'll set a timer for three minutes in case that helps. All right, time's up. Add a point to your score box for each trial that matched your team's prediction. Click the arrow when you're ready to move on.

ACTIVITY STEP 26

Round three. Place the foil ball on the star, a marble on the heart, and another marble on the lightning bolt on the collision track. Discuss and write your prediction. Then play all of round three with your partner. I'll set a timer for three minutes in case that helps. All right, time's up. Add a point to your score box for each trial that matched your team's prediction. Then add up your total score. Click the arrow when you're ready to move on.

ACTIVITY STEP 27

Discuss, did you notice anything different about playing the game using the foil ball versus using only marbles? Did you notice anything similar?

WRAP-UP VIDEO 1

In the activity, you predicted how far the jumper marble would move after colliding with other marbles. Your marbles didn't collide exactly the same way each time, but maybe you noticed that the jumper marble tended to go farther in some rounds and less far in others. As you got more and more information from each test, predictions probably got easier to make. Maybe you even noticed that your score was higher in later rounds as you collected more information. Here's what we noticed. When our bumper marble collided with more than one marble, the jumper marble didn't fly as far. Most of the time, it didn't even make it over the jump. When marbles collide, energy transfers from one marble to the next, right? But it seems like when there were multiple marble crashes, less energy made it all the way into the jumper marble. But where did that energy go? Energy never disappears, but it can move a lot of different places. When the marbles collide, a lot of the energy in the bumper marble transfers to the jumper marble, but some of the energy stays in the first marble. You can see it's still moving, just not very fast, and some of the energy transfers to other things the marbles are touching, like the paper under the marbles and even into the air. Take a look back at these games, and if you can, don't just look, listen.

WRAP-UP VIDEO 2

Whether it's a bowling ball smashing into a bunch of pins, a great shot in a game of pool, or a baseball connecting with the bat, you always hear a sound right at the moment of collision. Those sounds are a sign that energy is transferring from the moving object into the air. Each time your marbles collide, there's a click, a sound. That means each time the marbles collide, some energy transfers into the air. Energy transferred to the air doesn't transfer to the next

marble. So the jumper marble ends up with a little less energy than the bumper marble had. But what about that foil ball? When we used a foil ball as our jumper, we noticed it usually made it over the jump even after multiple collisions. Nothing had changed about the bumper marble. It was the same marble going down the same ramp at about the same speed every time. So we know it had about the same amount of energy every time too, but somehow the foil ball jumper moved like it had more energy than the glass marble jumper. Maybe you have ideas about why this happens. You might have even predicted it during the game. Think back to your predictions. What did you predict would happen in the collisions with the foil ball? Why did you make that prediction?

WRAP-UP VIDEO 3

Maybe this was a situation where you thought of collisions you'd seen before to help make your prediction. Like imagine you rolled a marble at a car. Do you think the car would move? Probably not, right? A car is so much heavier than a tiny marble. There's not enough energy stored in that tiny marble to move that huge heavy car. Take a look at what happens if the foil ball rolls into a glass marble. The glass marble doesn't move much, right? The glass marble is heavier than the foil ball. There's not enough energy in the rolling foil ball to move the glass marble. But when the glass marble hits the foil ball, the foil ball flies far. The glass marble is much heavier than the foil ball. When it rolls down the ramp and collides with the foil ball, it transfers enough energy to make the foil ball move fast and far. The glass bumper marble even has enough energy left to make it over the jump too. Knowing how energy transfers in collisions can be really helpful for getting better at collision games, but is it ever useful outside of a game? I wonder what you think?

WRAP-UP VIDEO 4

I don't know how you answered, but maybe you thought of situations where knowing how collisions work can help keep people safe. Scientists and engineers use what they know about how energy transfers in collisions to build equipment like airbags, helmets, even shoes that can keep people safer when crashes, bumps, and bounces happen, and that's not all. Imagine there's a huge asteroid in space, and it's hurtling toward the Earth. If it keeps going at its current speed and direction, it will crash into the Earth. Don't worry, this isn't actually happening right now, but if someday the world is threatened by an asteroid, what should we do? How could we keep it from crashing into Earth? We can't just move the Earth out of the way. Scientists at NASA have been working on this exact problem. Their solution? This. This is NASA's DART spacecraft, and these are real photos taken by the NASA DART spacecraft. In these images, the DART spacecraft is pointed straight at this asteroid. There's no one on board the spacecraft, which is a good thing because watch what it's about to do. NASA crashed a spacecraft into an asteroid on purpose. When the spacecraft collided with the asteroid, energy transferred from the spacecraft to the asteroid. The asteroid was much bigger and heavier than the spacecraft. So the collision didn't affect the asteroid very much, but there was a tiny change. After the collision, the asteroid’s speed changed, and it started moving in a slightly different direction. Now, this particular asteroid wasn't actually headed toward Earth. NASA was just doing a test. Still, the DART mission proved that if the asteroid had been a real threat, the energy transferred in one little collision would be enough to knock it out of our way. The same strategies people have used for thousands of years to play marbles with their friends could one day be responsible for saving the entire planet. So keep an eye out for how things move and collide in the world around you.

The more you see and experience, the more you'll know about how to do everything from bowling to rocket science. Keep playing, and stay curious.