ONE THING LEADS TO ANOTHER

Ever watch a Thunder game and witness the most amazing chain of events?

The moment the ball is inbounded from the baseline, a series of actions and reactions occur, some of which hopefully result with scored points for the Thunder. In a game, a lot of things can happen, but one thing we can be sure of is that we can see Newton's Laws of Motion in action the whole time we are watching the game! We can use these laws to create our own series of events, or more specifically a chain reaction machine, to score our own bucket.

Pro-tip: This activity can be done in a home or a classroom. It can be done by an individual student, in a small student group, or by a family.

HERE'S WHAT YOU WILL NEED PER STUDENT OR STUDENT GROUP:

- **Several dominoes or wooden planks that are all the same size. The more the better!**
- **At least one small ball**
- **A small cup**
- **Blocks or books**
- **A ruler or something similar**
- **A stopwatch**
- **Notebook**
- **Pencil**
- **Various objects that can be found around a classroom or home**

WARMUPS

Basketball is a game of motion. Everyone is always moving; sometimes players run into each other. These collisions can have fascinating results. Sometimes a smaller player bounces off a bigger one, but sometimes the bigger player gets knocked over. Sometimes the ball hits the rim and bounces all the way to the free throw line. Sometimes it just falls much closer to under the rim. Why can similar seeming actions have such differently seeming reactions?

A very long time ago, way back in the 17th century, Sir Isaac Newton wanted to know the same thing.

Let's follow in Newton's footsteps and explore motion to see if we can find the answers.
Start by placing a small ball on a flat surface (like the floor or tabletop).



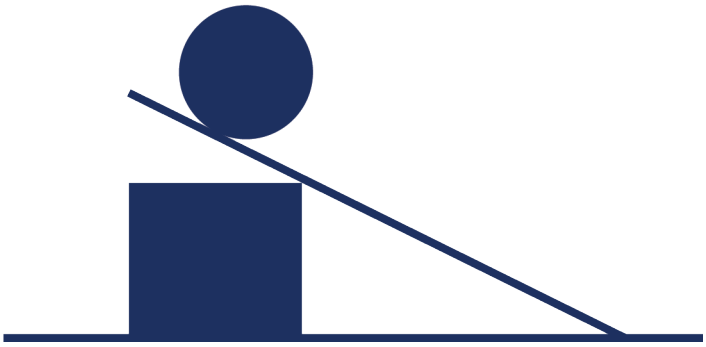
Watch the ball while you slowly count to 10. What happened?

Can you think of a way to make the ball move without touching it? Try it and once it starts moving, carefully watch it as you slowly count to 10. What happened this time?

- What do you think caused the ball to move? What caused it to stop?
- What should you do to make it roll farther?
- What would you have to do to make it move in a different direction?
- Can you think of a way to keep the ball moving forever?

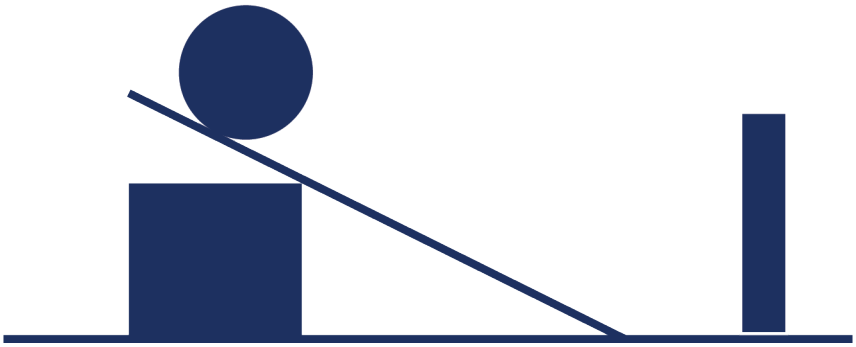
Next, build a short ramp out of a ruler or something similar and some blocks or books.

Set the ball at the top of the ramp and let it go. Watch its path. Where did it go?



Block the path of the ball by placing a domino or wooden plank a small distance, a few centimeters, from the bottom of the ramp.

Place the ball on top of the ramp and let go.



- What happened when the ball collided with the domino?
- Did it fall over?
- Did the ball bounce off?
- What caused this reaction?

If the ball hit the domino and bounced off, what changes can you make to allow it to knock over the domino?

If the ball knocked over the domino, what changes can you make to allow the domino to remain upright and the ball bounce off?

- What do you think would happen if you increased the height of the ramp?
- What would happen if you decreased the distance from the ramp to the domino?
- What would happen if you increased that distance? Try it and see.

Let's use what we've learned so far about motion to create a simple chain reaction.

Carefully stand some dominoes or wooden planks upright in a line. Space them out as evenly as possible, at least a finger's width apart. Once you have your line complete, give the first domino a small nudge. What happened? Why?



What would happen if the dominoes were closer together or farther apart?

When you pushed the first domino, your action, the force that you applied caused the series of events or a chain reaction to occur. In this case the push caused the domino's stored potential energy to become kinetic energy or energy in motion. When the toppling domino collides with the next domino, the potential energy of the second domino became kinetic energy, and this change continued as each domino collides and causes the next to topple over.

Think about the way your small push triggered the line to fall. Can you design another way to start this chain reaction?

GAME TIME

Let's use what we've learned about motion and chain reactions to build a Rube Goldberg machine.

Rube Goldberg was an inventor and cartoonist who became famous for his cartoons of silly inventions that had a lot of steps to do something very simple, like buttering toast or taking off a hat.

Your challenge is to design a complex chain reaction machine with as many steps as you can, just like Rube Goldberg's cartoons, that will send a ball into a cup to score a basket.

In the NBA, the shot clock is 24 seconds long. It's the amount of time a team has to score a basket or hit the rim of the goal once gaining possession of the ball. The goal of this activity is to create a series of events that result in the ball moving into the cup while using up as much of the shot clock as possible.

With your journal, begin sketching ideas. Think back to your motion and energy experiments in the Warm-ups. Which of your discoveries can you apply in your design? How many different steps can you come up with? What order are you going to use them in? The step-by-step plans you're creating are not only like Rube Goldberg's cartoons, but they are also similar to the way a coach draws up plays for his players.

Make sure to look around the room for inspiration. What can you use as a source of potential energy? There are likely a variety of objects that can be used in a chain reaction. Be resourceful. Everyday objects like books can become steps or even a backboard for the ball to bounce off of. Pencils can roll to collide with another object and continue the chain reaction. String can be used to allow an object to swing into another. A spoon can become a teeter-totter. The chain reaction is only limited by your imagination and understanding of the laws of motion!

Once you have designed your chain reaction, gather your supplies and build a prototype, your first model, to try.

When you're finished, test it out. Watch each step carefully to observe where the motion stops or where you could improve your design. Record your results and thoughts. Rebuild the sections that don't work as well as you want them to, then continue to rebuild, revise and retest your machine until the ball ends up in the cup.

Once you are satisfied with your design, use a stopwatch to time how much of the 24 second shot clock you were able to use.

ANALYZE THE REPLAY

What happened?

Did you find that you had to make a lot of alterations to your design before the ball finally moved into the cup?

- Did your improvements work right away or did you have to tweak them a bit more?
- Which pieces did you have the most trouble with?
- What changes did you come up with to make the unsuccessful areas work?
- Which parts worked without any changes?
- How did your journal help with your design changes?

Congratulations! You have been thinking, designing, and working like an engineer. You identified a problem (getting a ball into a cup). You explored and researched energy and motion and then used it to help plan potential designs. You based your designs on the materials you had on hand, built a prototype, tested it, redesigned, rebuilt and retested again. The engineering design process sometimes seems like an endless loop. Engineers know that it's important to revisit and repeat many steps in order to change a prototype into a well working system. In many ways, this process is similar to basketball. All the parts, or plays, must be practiced until they can be done repeatedly and efficiently.

OVERTIME
Let's take it further

In the creation of the series of events that put the ball in the cup, you may have found that you used a ramp, also called an inclined plane, or used a spoon or ruler to be a teeter-totter, also called a lever. Levers and inclined planes are examples of simple machines. There are several other simple machines that can be used in a chain reaction machine. As these simple machines are put together, you may find that you have created a compound machine to meet your objective.

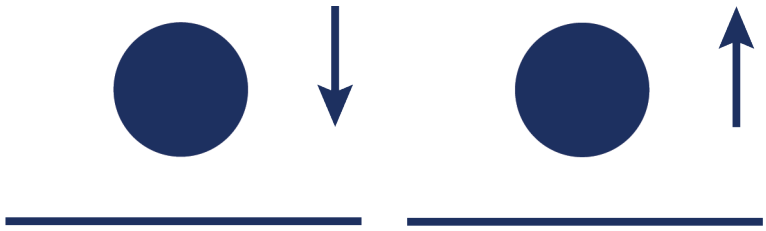
You can take this activity further by seeing how many simple machines you can use in the process. You can even take it outside and use a bucket and a basketball.

COACH'S CORNER
Additional information and explanations for parents and educators

Chain reaction machines are a great way to explore Newton's Laws of Motion. **Newton's first law simply states that an object remains at a state of rest or continues at a constant velocity unless acted upon by another force.** Our first few Warm-up steps delved into that, allowing students to come to their own conclusions about the beginnings of motion.

Students also had the opportunity to find their own understanding of Newton's second law, which you may have seen expressed with the equation F=ma. It explains the movement of an object when forces are unbalanced. F=ma, means force equals mass multiplied by acceleration. In other words, to get an object moving at great speed takes a greater force than getting it moving at a slower speed.

Newton's third law states that for every action, there is an equal and opposite reaction. This law is the one that we probably hear most often and is easy to observe in a basketball game. When the ball is pushed to the floor, it bounces back up. If you want to pass the ball to a player positioned under the goal, you might throw a bounce pass that hits the ground between you and that player. If an arching shot hits the rim, it will bounce off in an arch the opposite way.



Chain reactions have had their place in movies, videos, video games, and even cartoons. In the 1968 classic musical "Chitty Chitty Bang Bang," a series of machines work together to prepare the family's breakfast. In the 1985 sci-fi classic "Back to the Future," a chain reaction machine prepares Einstein the dog's breakfast. Chain reactions are also simulated in video games to make games more challenging. If you have ever played Angry Birds you may have experienced this process. Chain reactions can even be reproduced by the player in games such as Minecraft. Even the popular rock n' roll band OK Go uses amazingly complicated chain reaction machines in their music videos.

Complex chain reaction machines that often incorporate wacky objects, unnecessary steps, and not only take oddly long amounts of time but also depend upon perfect timing are often called Rube Goldberg machines.

Rube Goldberg was born in 1883. He lived until 1970, and over his long life, he was many things. Goldberg was a news reporter, a sculptor, an engineer, an inventor and a cartoonist! Though he is celebrated as cartoonist, he may be best known for inspiring generations of people to create overly complicated machines to do the simplest of tasks.

DO YOU WANT TO LEARN MORE?

Research: Newton's Laws of Motion; simple machines, compound machines, engineering design process, Rube Goldberg

OKLAHOMA ACADEMIC STANDARDS: SCIENCE

STANDARD	4th Grade	5th Grade	6th Grade	7th Grade
SCIENCE				
4.PS3.1: Energy	●			
4.PS3.2: Energy	●			
4.PS3.3: Energy	●			
5.PS2.1: Motion and Stability		●		
7.PS3.2: Energy				●