Basketball on the Moon

During one of the last missions to the Moon (1971, Apollo 14), astronaut Alan Sheppard hit two golf balls, one of the most iconic "human moments" of lunar exploration. This fun demonstration highlighted how low gravity affects motion. Now, after more than 50 years, NASA plans on returning to the Moon with the Artemis missions. This might get you wondering, will an astronaut play basketball on the Moon?

Here's what you'll need:

- Table
- 3-4 Books
- Small Ball
- Basketball
- Broomstick, or something similar
- 3 ropes that can be cut to size
- Duct Tape
- 16 oz. Water Bottle

WARM-UPS

Warm-ups: Gravity on the Moon

- Gravity is a force that pulls objects toward each other. On Earth, gravity pulls everything downward. The strength of gravity depends on how much mass an object has. Because the Moon is much smaller and has far less mass than Earth, its gravitational pull is weaker, about one-sixth (⅙) as strong as Earth's gravity. Lower gravity means objects:
- Weigh less
- Fall more slowly
- Travel higher or stay in the air longer when jumping or thrown.
- Land more softly

These effects directly impact how basketball would work on the Moon.

The Moon is nothing like Earth. It is much smaller, almost airless, covered with dust and craters from meteor strikes, is sunny or dark for long periods of time, and is very far away. Smaller size and less mass means the Moon has much less gravity.
That low gravity means the Moon cannot hold a layer of gases like the earth's atmosphere. The Moon's very thin atmosphere is made up of heavy gases like argon and neon. It also consists of a few atoms of helium that are temporarily near the surface before it drifts away into space.

Meteor craters are the main feature of the Moon that can be observed from earth. Here on earth that layer of atmosphere protects us from meteors, most of them burn up and break up due to friction from the atmosphere as they speed quickly through the air on their way to the ground. The Moon is in danger of being hit by any space rock in the neighborhood. Without wind or water to cause erosion, any craters that result are around for a very long time. The broken rock and dust from those impacts are still there coating the Moon with a layer of Moon dust.

Optional Discussion Prompts

You might show your students a video of astronauts on the Moon before guiding them through a brief discussion about gravity and the Moon. Consider asking:

- Could you play basketball on the Moon?
- How would basketball be different on the Moon?
- What would the effects of lower gravity be?

Math Fact: The Moon's gravitational pull of only ⅙ that of the Earth means that you can throw things 6 times higher and that they stay in the air 6 times longer. If you throw a basketball straight up and it goes 15 feet, it would go 90 feet up on the Moon. Jumping high enough to dunk would be easy on the Moon. When the gravity is decreased, how high you can throw increases.
If you wanted to throw the same height, you would need to toss the ball with 1/6th the force in 1/6th the gravity.

GAME TIME

Build an Anti-gravity Machine

Now that students have a better understanding of the differences between the Moon's and the Earth's gravity, they can explore these concepts in the real world with the following activities that simulate the gravity of the Moon here on earth.

You usually don't notice or think about gravity unless you see something falling. Everything you see that is not falling, is not falling because something is holding it up. Sitting at your chair, the chair is holding you up. It is holding you with the exact same force that gravity is pulling you down. So the chair is like an anti-gravity machine. If the chair is pulled out from under you, gravity takes over and you fall on the floor.

Pro Tip: Anti-gravity machines may seem like something straight out of science fiction, but in reality they are everywhere. Elevators, stairs, airplanes, and helicopters all move us upward, overcoming the force of gravity. Even everyday items like tables and chairs can hold you up even though gravity is pulling you downward. These are true anti-gravity machines.

In order to simulate the Moon's gravity here on earth, we need to take away most (⅚), but not all of the gravity. One of the ways you can do that is to tilt the surface and turn it into a ramp. When you are sitting on a flat chair the forces from gravity and the chair are balanced. But if the chair is tilted you begin to slide off of it, slowly at first and then faster as it tilts more and more. That sliding force is what we will use to simulate the Moon's gravity.
For this you will need a ball, a table and some books. Lift one side of the table and put the stack of books under the table legs on one side to turn the table into a large ramp. Take the ball and roll it up the table. Watch how it moves up and down in a curved path that looks just like a ball tossed through the air only slower and on a ramp instead of straight up and down.

Pro Tip: To achieve the exact 1/6th ratio of the Moon's gravity, measure the distance between the table leg on the ground and the table leg on the books and divide it by six. The number y y y y y y is the height that your stack of books under the table leg should be. So add or take away books until the stack of books is close to that number and the ball will roll up and down the table ramp just as fast as the same ball tossed straight up and down on the Moon.

The ramp is a type of simple machine. There are other types of simple machines that can be used to change the amount of force. The ramp is not a very good simulation for playing basketball in the Moon's gravity because it limits the motion to things on the ramp.

We can also use other simple machines like the lever. Time to build the second anti-gravity machine, and this time it is for a basketball.

Take your broomstick and the rope and tie the rope around the center of the broomstick so it is pretty well balanced, this rope is the handle.. Use the duct tape to hold the rope in place so it doesn't slip back and forth on the broomstick. Then tie the other pieces of rope to each end of the broomstick. Fasten a basketball to the rope on one end of the broomstick by wrapping and taping it so it will not come off, and then use the rope and tape to attach the 16 oz. water bottle to the other end. Get a friend to lift everything by the rope handle in the middle and you have made an anti-gravity machine that will let students experience what dribbling on the Moon would be like.

Since a regulation basketball weighs 22 oz. and the water in the bottle only weighs 16 oz. the basketball will still be pulled down by the earth's gravity. But the weight of the bottle on the other side of the stick is also pulled down, balancing out some, not all, of the gravity on the ball.

With a student holding firmly onto the rope, have another student try to dribble the basketball attached to the stick. It may be helpful to start close to the ground and gradually lift the rope higher.

Ask students if they notice how the basketball seems to move in slow motion.

Math Fact: To find the weight of a basketball on the Moon, take the weight of a basketball, 22 oz. and divide by 6. And you get between 3 and 4 oz. If you take the weight of the water bottle and the basketball and turn them into a fraction- 16/22, it is easy to see 6 of the 22 ounces of the ounces are left pulling the basketball down. So if you want to make this a perfect representation of the Moon's gravity you will need to measure and add in the weight of the bottle and likely add a couple of ounces of water. Another neat math fact is that you can also divide your own body weight by 6 to find out how much you would weigh on the Moon.

ANALYZE THE REPLAY

At this point, the students have built two anti-gravity machines, a ramp or inclined plane, and a lever, to show what basketball is like on the Moon. These machines are just two types of simple machines, some others include the wheel and axle, the screw, pulleys, and the wedge. These machines can all manipulate forces. The way they work is simple, they change the force by changing the distances that the force has to act. For example on the ramp, when the ball rolls up the ramp it moves a very long distance along the ramp but actually only moves a very small distance up.

Peer Review and Reflection

Invite students to pair up or form small groups for discussions. Provide prompts to start their discussions such as:

- What suggestions would you have for how to play the game of basketball on the Moon?. Share these ideas with your friends.
- Would you need to change the rules? The uniforms? The height of the basket? The length of the court? Why would those changes be needed on the Moon?

OVERTIME

As an optional opportunity for students to extend their learning, discuss basketball on other planets. Some have stronger gravity like Jupiter. Some are hotter like Venus. Or what about Saturn? How would they play basketball on a planet made of Gas?

Guiding Questions

- **What will NASA be doing when they return to the Moon?**
- **How would other activities be different on the Moon? Think about things like eating or brushing your teeth.**
- **Could you design a simple machine to allow you to play Moon basketball here on earth?**

COACH'S CORNER

Gravity is not the only thing different about the Moon, and there is much more to experiment with than just simple machines and force. There are many other effects, for example, the friction with the ground is also ⅙ of Earth so slips and falls would be more common while cutting and changing directions would be more difficult. The lack of air means that moving objects don't slow down as fast and also means you need some sort of enclosure or spacesuit to hold in air you can breathe. The sunlight is scorching and the shadows are freezing without being blocked or insulated by clouds. And there are also rocks and dust, not just the ones on the surface, but also the ones that are zipping through space which could be dangerous.

Skills / Standards Alignment

This activity can be used to support students with developing the following skills and/or content.

Skills / Content	Grade 3	Grade 4	Grade 5
Numbers and operations • Solve real-world problems with addition, subtraction, multiplication and division. • Use and justify fractional representation in real-world mathematical problems.	X	X	X
Motion and Stability: Forces and interactions • Support an argument, with evidence, that the Earth's gravitational force pulls objects toward the center of the earth. • Plan and conduct an investigation about balanced and unbalanced forces	X	X	X