

ART OF CIRCULAR MOTION

ABOUT THIS CHALLENGE

In this challenge, students will learn about the processes of uniform circular motion by exploring the process of creating spin art. Note, we chose to highlight the set of topics and standards below as a list that closely connects with this challenge.

CONTENT AREA

Grade: 9-12

Content Area: Science, Physics, Art

Context for learning: Before starting this lesson, students will need to know how to solve a mathematical equation with variables and have basic knowledge of academic vocabulary related to movement in physics (such as acceleration, motion, mass, force).

TOPICS

Uniform Circular Motion

Velocity

Acceleration

Tangent Lines

Forces



STANDARDS

Science Standards (NGSS):

HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Note: This lesson plan may align with other sets of standards not included here.

LEARNING OBJECTIVES

Students will be able to:

- Make connections between art and physics processes
- Understand the basic concepts behind uniform circular motion
- Work with Newton's Second Law

GETTING STARTED

Show the "This" music visualizer. Get students excited about the STEAM concepts in this video.

Following this, watch the "Art of Circular Motion" video, and prompt the students to focus on the spin art portions of the video.



MATERIALS

Pencils

Pennies

Tape

Yo-yo or ball attached to string

Lazy Susan(s) or revolving tray(s)

Canvases or paper

Paint (acrylic or washable)

Gloves

Paint clothes

PART ONE: INQUIRY

Introduction to Circular Motion

Explain the vocabulary and concepts to the students. Emphasize how mass and force impact the acceleration of an object.

Yo-yo or ball on string example: Spin a yo-yo around in a circle. Explain that the string can only have pulling forces, not pushing forces. While in the circular motion, the string pulls the end of the yo-yo in, this is the **centripetal force**. At the same time, the end of the yo-yo (or ball) just wants to go in a straight line, so it pulls back on the string. Relatively, the ball or yo-yo will feel an outward force which is commonly called a centrifugal force. It is recommended that you do not bring up this terminology because this force is only relative--it is what the yo-yo (or ball) "feels" but does not contribute to the circular motion itself.

Answer any questions the students may have about this process.

Ask the students to shout out or brainstorm other examples of circular motion.



PART TWO: EXPLORATION

Students further explore more examples of circular motion using pennies

Note: It is ideal to have multiple revolving trays and have the students go through this example in groups, but if this is not possible it can be done as a whole class demonstration.

In groups or as a class, guide the students through activity one on their worksheet, which includes the following:

1. Place a penny at the very outside edge of a revolving tray and spin the tray until the penny flies off.
2. Place a penny closer to the center of a tray and spin it again until it flies off
3. Place a penny at the center of a tray and spin it so it does not fly off.

Discuss the differences between these three cases and do more penny examples if needed. Students should work through the questions and note the differences down on their student guide.

Student Guide Answers: **1:** $F=(mv^2)/r$. **2:** increase mass or velocity. **3:** increase the radius. **4, 5, 6:** Student Observations. **7:** .0042 Newtons **8:** It would triple.

Make sure to note the motion of the penny as it flies off. This is straight-line motion and is the direction that the penny will go unless a centripetal force acts strongly enough on it to keep it in circular motion.

The centripetal force, in this case, is friction.



PART THREE: CHALLENGE

Students apply their knowledge of circular motion to art

Start with an example. Secure a canvas or piece of paper to the revolving tray with tape. Start spinning the tray. While it is spinning, drop a dot of paint in some location that is not the center.

Before, during or after this example, explain how spin art takes advantage of the concepts behind circular motion to create a unique kind of artwork, like in the “This” Music Visualizer.

In this case, the paint will act like the pennies did. No matter what, there will be some portion of the paint not at the exact center that will want to remain in straight-line motion. Centripetal force combats the straight-line motion, so as the paint flows outward towards the edge, it will still have a circular shape to it as the force pulls it in.

Have the students plan out and prepare three distinct spin art pieces by adjusting certain aspects of the centripetal force equation, $Force = (Mass * Velocity^2) / Radius$. Suggest slight changes like: speed of spinning (velocity), amount of paint (mass), location of paint drop (radius), and more.

Next, help each group of students create three spin art pieces of their own while applying the concepts of circular motion.

Have the student groups pair up and discuss their results with one another. What did they change? How did that impact the spin art?

Discuss the process afterward as a class using the guiding questions.



VOCABULARY

Centripetal Force: The force that pulls an object from straight-line motion into circular motion. An example of this force is gravity or friction.

Acceleration: A change in speed or direction. In the case of circular motion, the acceleration is called centripetal acceleration, and causes a change in direction.

Radius: The distance from the center of a circle. This impacts the centripetal force.

GUIDING QUESTIONS

What is the centripetal force in the case of the yo-yo?

How did the change in radius impact the penny flying off?

What is the centripetal force on the revolving tray?

If you increase the speed of the spinning, what happens to the painting?

Why does the paint move outwards?

How does the amount of paint impact the final product?

How does changing the starting location of the paint change the spin effect?