Catalog

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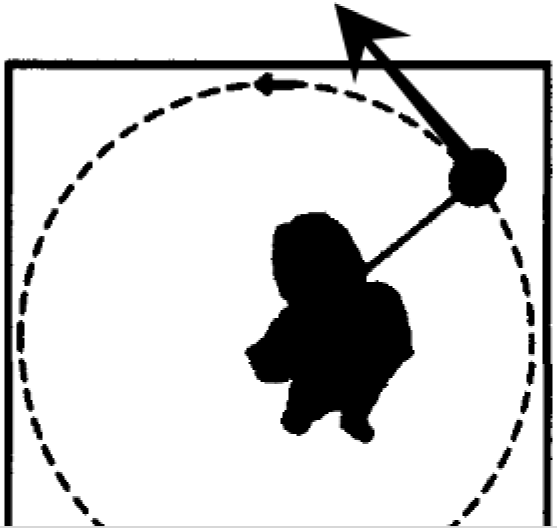
Student Exploration: Uniform Circular Motion

https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=423

Directions: Follow the instructions to go through the simulation. Respond to the questions and prompts in the orange boxes.

[redacted]: acceleration, centripetal acceleration, centripetal force, Newton's first law, Newton's second law, uniform circular motion, vector, velocity



Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. A boy is whirling a yo-yo above his head in a counter-clockwise direction. At the exact moment shown at left, he lets go of the string. In which direction will the yo-yo travel? ✎ Draw an arrow on the image to show the yo-yo's direction. Click on the image to select **EDIT** to use the drawing tool.a

2. Do you think the released yo-yo's path will be straight or curved? Explain.

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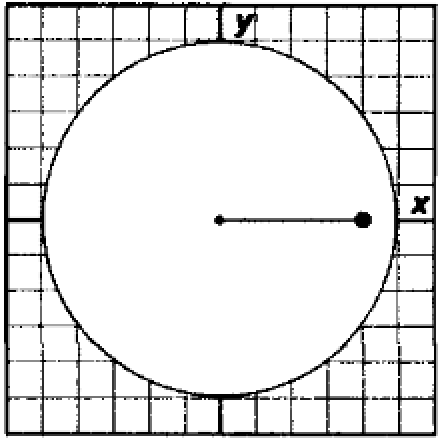
It wii be curved.

Gizmo Warm-up

The *Uniform Circular Motion* Gizmo shows a pink puck that is floating above a circular air table. The puck is held to the center of the table by a string so that it travels in a circle at a constant speed.



Check that the **radius** is 8.0 m and the **mass** is 5.0 kg. Set the **velocity** to 5.0 m/s.

1. Turn on **Show puck position (m)**. What are the coordinates of the puck's position?

(x,y) = (8.00, 0.00)

2. Click **Play** (▶), and then click **Pause** (⏸) when the puck is close to the *y*-axis. What is the puck's position now?

(x,y) = (8.00, 0.00)

2. Click **Play** (▶), and then click **Pause** (⏸) when the puck is close to the *y*-axis. What is the puck's position now?

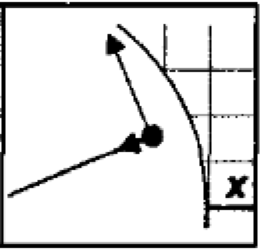
(x,y) = (0.33, 7.99)

3. Click **Reset** (↺). Select the BAR CHART tab and select **Velocity** from the dropdown menu. The three bars represent the magnitude, the *x* component, and the *y* component of the puck's [redacted].

   A. Click **Play**. Does the magnitude of the velocity change over time?

   no

B. Do the *x* and *y* components of the velocity change over time? yes

Activity A: **Velocity, acceleration, and force**	<u>Get the Gizmo ready</u>: • Click **Reset**. • Select the DESCRIPTION tab. • Turn on **Show velocity and acceleration vectors**.	

Introduction: Velocity is a [redacted] quantity that describes both the speed and direction of an object's motion. Vectors are represented by arrows. While the speed of the puck is constant, its direction changes continually as it travels in a circle. Because its direction is changing, the puck undergoes [redacted] even though its speed is constant.

Question: How is the velocity of a revolving body related to its acceleration?

1. <u>Observe</u>: On the SIMULATION pane, observe the directions of the velocity (green) and acceleration (purple) vectors.

1. <u>Observe</u>: On the SIMULATION pane, observe the directions of the velocity (green) (purple) vectors.

   A. What do you notice?

   The velocity and acceleration vectors are perpendicular and constant

   B. Click **Play**. What do you notice about the vectors as the puck moves in a circle?

   The velocity and acceleration vectors keep on changing in direction.

2. <u>Infer</u>: [redacted] states that a force will cause objects to accelerate in the direction of the force.

   A. Given the fact that the puck is accelerating, what can you conclude?

   The change in direction causes a change in acceletation even though the speed is constant

   B. What is the direction of the force on the puck as it travels in a circle?

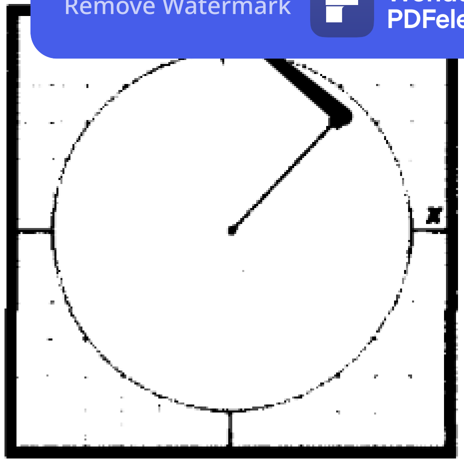
   Perpendicular to the direction of the puck.

3. <u>Compare</u>: Think about the force that causes a planet to orbit the Sun and the direction of this force. How does the puck on the table relate to a planet orbiting the Sun? What forces are acting on the puck and what forces are acting on the planet?

3. <u>Compare</u>: Think about the force that causes a planet to orbit the Sun and the direc does the puck on the table relate to a planet orbiting the Sun? What forces are act forces are acting on the planet?

The puck relates to the earth since both are orbiting around a point, at a certain radius from the centre. The forces acting on the puck are centripetal force and gravity while the force acting on the earth is centripetal force.

4. <u>Infer</u>: [redacted] states that an object will continue at the same velocity (speed and direction) unless acted upon by an unbalanced force. Click **Pause** when the puck is in approximately the position shown at right. Imagine at this moment the string connecting the puck to the center is cut.



A. Is any force acting on the puck now?

None

B. ✎ Draw an arrow on the image to represent the direction of the puck's motion. Click the image to select **EDIT** to use the drawing tool.

C. Would the path of the puck be straight or curved?

Straight

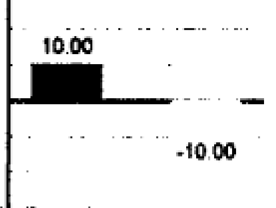
5. Apply: If the string connecting the puck to the center is cut, there will be no net for force of gravity is offset by the turntable.) The puck will not accelerate or change d a constant speed in the direction it was moving at the time the string was cut.

How does this relate to the boy whirling a yo-yo given at the start of this Exploration sheet?

The boy also whirls the stone in a horizontal position. Since the stone is in air, it will be pulled towards the ground in a horizontal path by the force of gravity.

6. Think and discuss: If you are sitting in the back seat of a car that makes a hard left turn, you will feel pushed toward the right side of the car. Why does your body move to the right?

Since the body was in a state of motion in a certain direction. The body tends to resist the change due to the force of inertia.

Activity B: **Centripetal acceleration**	Get the Gizmo ready: • Click **Reset**. • Set the **radius** to 2.0 m, the **mass** to 1.0 kg, and the **velocity** to 10.0 m/s.	

Introduction: The acceleration toward the center that keeps objects in [redacted] (circular motion at a constant speed) is called [redacted]. An understanding of centripetal acceleration was one of the key elements that led to Newton's formulation of the law of universal gravitation.

Question: How is centripetal acceleration related to radius, mass, and velocity?

1. Record: Select the BAR CHART tab, select **Acceleration** from the dropdown menu, and turn on **Show numerical values**. The bar on the left shows the magnitude of the acceleration, or |*a*|. The units of acceleration are meters per second per second, or m/s^2. What is the current magnitude of the acceleration?

50m/s^2

T

2. Predict: How do you think the magnitude of the acceleration will depend on radius,
Record your predictions by completing each sentence.

When the radius increases, the centripetal acceleration will	Decrease
When the mass increases, the centripetal acceleration will	Increase
When the velocity increases, the centripetal acceleration will	increase

3. Gather data: Keeping the **mass** at 1.0 kg and the **velocity** at 10.0 m/s, record the magnitude of centripetal acceleration for each given radius value. Include units.

Radius:	2.0 m	4.0 m	6.0 m	8.0 m	10.0 m
Acceleration:	50.0m/s2	25.0m/s2	16.67m/s2	12.50m/s2	10.0m/s2
Radius factor:	1	0.5	0.32	0.25	0.2
Acceleration factor:	1	0.5	0.32	0.25	0.2

4. Calculate: To calculate the radius factor, divide each radius by the original radius (2 acceleration factor, divide each acceleration value by the original acceleration (50.0

5. Analyze: How does the acceleration change when the radius is multiplied by x?

Increase

6. Explore: Move the **mass** slider back and forth. Does the puck's mass have any eff
Explain.

No. Since gravity does not affect a puck the turntable, which cancels out gravity

7. Gather data: Set the **radius** to 2.0 m and the **velocity** to 1.0 m/s. Keeping the radius the same, record the magnitude of centripetal acceleration for each given velocity. Include units.

Velocity:	**1.0 m/s**	**2.0 m/s**	**3.0 m/s**	**4.0 m/s**	**5.0 m/s**
Acceleration:	0.50m/s2	1.00m/s2	1.33m/s2	1.00m/s2	0.80m/s2
Velocity factor:	0.50	1.00	1.50	2	2.5
Acceleration factor:	2.00	4.00	6.00	8.00	10.00

8. Calculate: To calculate the velocity factor, divide each velocity by the original velocity (1.0 m/s). To calculate the acceleration factor, divide each acceleration value by the original acceleration (0.50 m/s^2).

9. Analyze: How does the acceleration change when the velocity is multiplied by x?

Increases

10. Make a rule: Based on your investigations, create an equation for centripetal acceleration (a_c) based on the velocity and radius. Test your equation using the Gizmo.

a_c =

11. Apply: Without using the Gizmo, use your equation to calculate the acceleration of a puck that is in uniform circular motion with a radius of 3.0 m and a velocity of 9.0 m/s:

9*9/3= 27

Check your answer with the Gizmo.

12. <u>Challenge</u>: Newton's second law states that force is equal to the product of mass
Based on Newton's second law, what is the [redacted] (F_c) on a puck in uniform circular motion with mass *m* and velocity *v*?

F_c = mv.v/r