

## Horizontal Circle Simulation

**Purpose:** To analyze the motion of objects moving in a horizontal circle.

**Getting Ready:** Navigate to the **Horizontal Circle Simulation** found in the **Physics Interactives** section at **The Physics Classroom**.

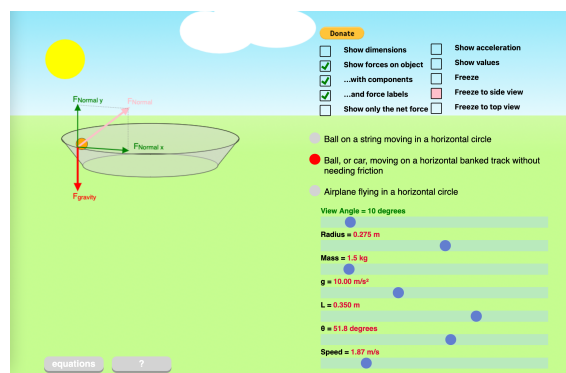
<https://www.physicsclassroom.com/Physics-Interactives/Circular-and-Satellite-Motion/Horizontal-Circle-Simulation>

Navigation:

[www.physicsclassroom.com](http://www.physicsclassroom.com) => Physics Interactives => Circular Motion and Gravitation => Horizontal Circle Simulation

### Getting Acquainted/Play:

This interactive consists of a simulation on the left side of the screen and a series of controls on the right side of the screen. The controls include **check boxes**, **radio buttons**, and **sliders**. By default, Horizontal Circle Simulation opens showing a ball hanging from the end of a string and swinging in a circle. By tapping on the **radio buttons**, you can select two other options: a ball moving along a banked turn and an airplane flying in a horizontal circle. Experiment with each.



Observe the **check boxes** that control the various displays. Experiment with the various display options, turning each on and off by tapping on the check boxes and observing what they do.

Finally, the **sliders** at the bottom right side of the screen are motion parameters that can be changed. Beginning with the **View Angle** (an important one), experiment with the sliders by dragging them left and right and observing their effect upon the simulated motion. We will be studying these cause-and-effect relationships later in this activity.

### Part 1: Ball on a String Moving in a Horizontal Circle

1. Tap on the radio button to shown the motion of a ball on a string. We recommend a **View Angle** of about  $10^\circ$ . Tap the check boxes that Show Acceleration and Net Force only. In the provided **Data Table**, indicate the direction of these two vectors. Use a word/phrase such as towards center, away from center, tangent to circle, downward, or upward at angle.
2. Deselect **Show Only Net Force**. Then select **Show Forces on Object, ... and Force Labels**. Observe the forces and record their symbols in the Data Table (3<sup>rd</sup> row). Draw the free-body diagram (4<sup>th</sup> row) that is displayed. (It may help to **Freeze to Side View**.)
3. Select the **... and Components** option to show the forces with labels and x- and y-components. Observe the two vertical components –  $F_{\text{grav}}$  and  $F_{\text{tension-y}}$ . How do their relative size or strength compare? Use a symbol – greater than ( $>$ ), less than ( $<$ ), or equal to ( $=$ ) in the blank to make a comparison:

$$F_{\text{grav}} \text{ \_\_\_\_\_\_ } F_{\text{tension-y}}$$

4. Use the sliders to modify several parameters – speed, mass, radius, etc. Is the above relationship (in Q#3) always true? \\_\\_\\_\\_\\_\\_

5. Which force component supplies the inward force for the object to move in the circle? Report your answer in the 5<sup>th</sup> row of the Data Table. You can use a force symbol.
6. Make changes in the speed at which the object moves. What effect does it have and how is it correlated to the magnitude or size of other quantities? Record your observations in the Data Table (6<sup>th</sup> row).
7. Repeat this cause-effect/correlation study by making changes in the object mass and the radius of the circle along which the ball moves. Report your observations in the Data Table (7<sup>th</sup> row and 8<sup>th</sup> row).

**NOTE:** It may be a bit deceiving to observe speed and forces increasing when radius is increased. To maintain the motion in a circle with a greater radius, the object must travel with a greater speed.

**Part 2: Ball (or Car) Moving on a Horizontal, Banked Track (without needing friction)**

1. Tap on the radio button to show the motion of a ball (or car) moving on a horizontal banked turn (without needing friction). Once more, we recommend a **View Angle** of about 10°.
2. Repeat the procedure that was performed in Part 1 and record all observations in the Part 2 column of the Data Table.

**Part 3: Airplane Flying**

1. Tap on the radio button to show the motion of a ball (or car) moving on a horizontal banked turn (without needing friction). Once more, we recommend a **View Angle** of about 10°.
2. Repeat the procedure that was performed in Parts 1 and 3 and record all observations in the last column of the Data Table.

**Analysis Question:**

Write a summary in which you describe two findings from this activity. Be detailed.

Data:

	Part 1: Ball on a String	Part 2: Ball (Car) on Banked Turn	Part 3: Airplane Flying in Circle
Acceleration Dir'n			
Net Force Dir'n			
Individual Forces Present (Symbols)			
Free-Body Diagram (with labeled forces)			
The inward force is supplied by ...			
As the Speed of the object increases ... *	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Tens-y}$ _____ $F_{Tension-x}$ _____ $F_{tens}$ _____	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Norm-y}$ _____ $F_{Normal-x}$ _____ $F_{norm}$ _____	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Lift-y}$ _____ $F_{Lift-x}$ _____ $F_{lift}$ _____
As the Mass of the object increases ... *	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Tens-y}$ _____ $F_{Tension-x}$ _____ $F_{tens}$ _____	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Norm-y}$ _____ $F_{Normal-x}$ _____ $F_{norm}$ _____	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Lift-y}$ _____ $F_{Lift-x}$ _____ $F_{lift}$ _____
In order for the radius of the circle to increase ... *	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Tens-y}$ _____ $F_{Tension-x}$ _____ $F_{tens}$ _____	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Norm-y}$ _____ $F_{Normal-x}$ _____ $F_{norm}$ _____	Accel'n _____ $F_{net}$ _____ $F_{grav}$ & $F_{Lift-y}$ _____ $F_{Lift-x}$ _____ $F_{lift}$ _____

\* = Fill in blanks using ↑ for increases, ↓ for decreases, and = for remains the same.