

## Exploring Ideas About Circular Motion

### Purpose and Expected Outcome

In this activity, you will begin studying circular motion more formally than you have until now. You already know all the concepts about the motion of objects and their interactions with the world. You need to review what you have learned so far, and learn how to apply concepts to more complicated situations.

### Prior Experience / Knowledge Needed

You need to know basic motion concepts, such as *velocity* and *acceleration*, as well as ideas related to interactions, such as *free-body diagrams*, *force*, and *net force*.

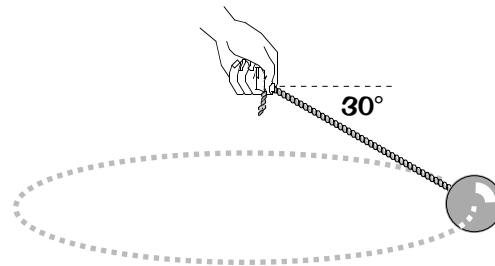
### Explanation of Activity

There are two parts in this activity. In the first part, you will draw free-body diagrams for objects moving along circular arcs. In the second part, you will analyze the acceleration of objects moving along circular arcs.

## PART A: Drawing Valid Free-Body Diagrams

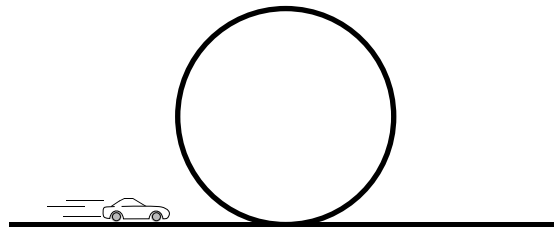
For each of the following situations, draw a free-body diagram showing all the forces exerted on the object going in a circle. Be prepared to explain your drawings to your classmates.

- A1.** A ball is swung in a horizontal circle as shown. Draw the free-body diagram for the ball when it is at its rightmost point in the circle.

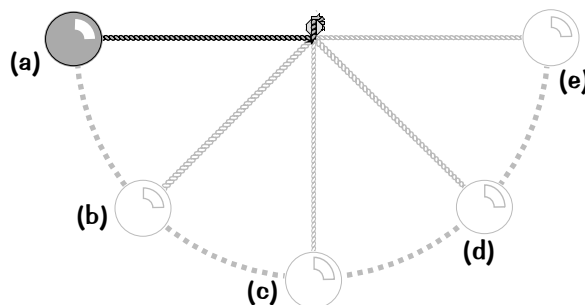


- A2.** A car is traveling at constant speed around a curve in the road.
- A3.** A race car is traveling at constant speed around a banked curve. The angle of the banked curve is about  $15^\circ$ .
- A4.** The Earth is traveling around the Sun.
- A5.** You are at rest on a spinning Earth. In addition to drawing a free-body diagram for yourself, draw the Earth and indicate the North and South Poles as well as your location on the Earth.

- A6.** A toy race car travels in a vertical circle around a curved length of track as shown. Draw the free-body diagram for the car when it is at its highest point.



- A7.** A pendulum is held horizontally as shown and released from rest. Draw a free-body diagram for the ball at each of the five locations indicated.
- Just after being released.
  - At  $45^\circ$  below the horizontal.
  - When the string is vertical.
  - Again, at  $45^\circ$  below the horizontal.
  - When the ball is at its highest point on the right-hand side.

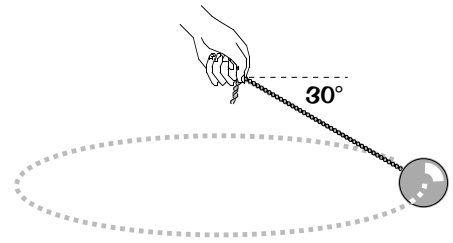


## PART B: Analyzing the Acceleration

For each of the following situations, (a) indicate the direction of the acceleration, and (b) answer a question about the forces exerted in the situation. Be prepared to discuss your answers with your classmates.

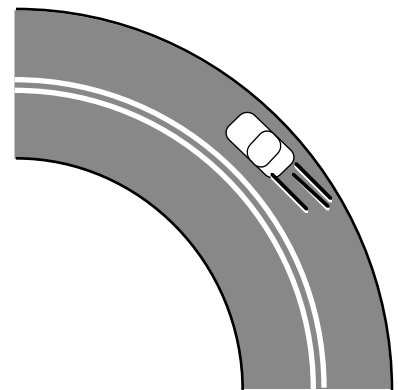
**B1.** A ball is swung in a horizontal circle as shown.

- (a) At the instant shown, what is the direction of the acceleration of the ball?
- (b) Which force is most responsible for keeping the ball traveling in a circle?



**B2.** A car is traveling at constant speed around a curve in the road.

- (a) What is the direction of the car's acceleration?
- (b) What force(s) must be present to allow the car to go around the curve without going off the road?

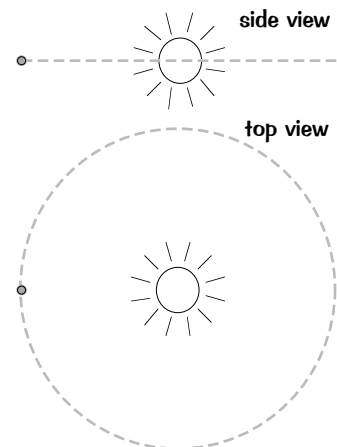


**B3.** A race car is traveling at constant speed around a banked curve. The angle of the banked curve is about  $15^\circ$ .

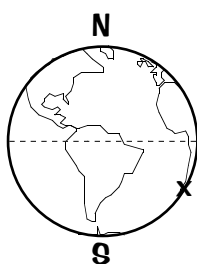
- (a) What is the direction of the car's acceleration?
- (b) Which forces on the car must be present?

**B4.** The Earth is traveling around the Sun as shown in the side and top views to the right.

- (a) What is the direction of the Earth's acceleration?
- (b) How many forces are exerted on the Earth?



**B5.** You have a friend in South Africa located at the **x** in the drawing below. When your friend is at rest on a spinning Earth,



- (a) what is the direction of his acceleration?
- (b) what force(s) must be present in order to cause the observed acceleration?

## Reflection

- R1.** (a) Make a list of all the forces in your free-body diagrams in part A.  
(b) Compare your list to the forces described in Table of Common Forces at the end of **Book 2: Interactions**. What forces in your list are not found in the table? Why are these forces missing from the table?
- R2.** In situation B1, the acceleration of the ball is horizontal, yet neither of the two forces on the ball (ignoring air resistance) is horizontal. This means that none of the forces on the ball is parallel to the acceleration. In part B, there are two more situations for which there is no force parallel to the acceleration.  
(a) Identify these two other situations.  
(b) How is it possible for the acceleration to have a direction different than every force exerted on the object?  
(c) Describe two examples of straight-line motion in which there is no force parallel to the acceleration.
- R3.** Reconsider situation B5, in which a person at rest in South Africa is traveling in a circle. Now imagine another person at the equator, also at rest.  
(a) Which person is traveling in the larger circle? Explain.  
(b) Which person has the larger speed? Explain.  
(c) Which person has the larger acceleration? Explain.
- R4.** Reconsider situation A7, in which a ball is attached to a string and is released from rest.  
(a) What is the direction of the net force on the ball just after the ball is released?  
(b) What must be the direction of the acceleration just after the ball is released?  
(c) How is this possible? What are some of the features of this situation that are different from all the other situations?