The Turning Car

Use force models to predict circular motion.

PHY.2.2 "Use models such as free-body diagrams to explain and predict the motion of an object according to Newton's law of motion, including circular motion."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the forces acting on the car, circle words that tell their directions, and number the two changes made in the trials so you can use a force model to predict what happens.

A Car on a String

1. A model can turn motion into a few testable claims. In a free-body diagram, draw the object as a dot and show only forces acting on that object. Arrow direction gives each force's direction, while arrow length can suggest its size. When forces balance, the net force is zero and velocity does not change. When forces do not balance, Newton's second law says the net force equals mass times acceleration. Acceleration can mean a change in speed, direction, or both. For circular motion at constant speed, the required acceleration points toward the circle's center.

2. Imagine a small toy car tied by a light string to a fixed post on a smooth, level tabletop. An earlier push has set the car moving at constant speed in a circle, and the string stays horizontal and taut. The table pushes up on the car, Earth pulls it down, and the string pulls along its length toward the post. Treat resistance from the tabletop and air as negligible. The car never rises or sinks, and its distance from the post stays the same. At each instant, its velocity points along the circle, not along the string.

3. The car receives no further push, and its mass stays constant. In one trial, the string is cut while the car is moving. In another trial, a stronger starting push makes the car travel at twice its original speed along the same circular path. A useful model for motion in a circle is inward acceleration equal to speed squared divided by radius. For a fixed mass and radius, the needed inward net force therefore changes with speed squared. These trials let you test whether a force changes an object's speed, its direction, or both.

2 ANSWER WITH EVIDENCE

Use the passage

1. For the car moving in a circle, name the three forces you would draw in a free-body diagram and give each arrow's direction.

2. The car's speed is constant. Is the net force on it zero? Use the force model to explain.

3. In the faster trial, how must the string's pull compare with its pull at the original speed? Explain using the circular-motion model.

4. Just after the string is cut, which forces remain on the car, and which way does it move?

3 YOUR TURN

Your own words

A bicycle rider turns at steady speed on a flat road. Sketch a free-body diagram for the bicycle and rider treated as one object, labeling all three forces. Then write two sentences predicting the motion if the road suddenly provides no sideways friction.

ANSWER KEY

The Turning Car

PART 1 · READ AND MARK

Underline the forces acting on the car, circle words that tell their directions, and number the two changes made in the trials so you can use a force model to predict what happens. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	For the car moving in a circle, name the three forces you would draw in a free-body diagram and give each arrow's direction.	**Table's normal force upward, Earth's gravitational force downward, and string tension toward the post.**
2	The car's speed is constant. Is the net force on it zero? Use the force model to explain.	**No. The upward and downward forces balance, but tension provides a net force toward the post that changes the car's direction.**
3	In the faster trial, how must the string's pull compare with its pull at the original speed? Explain using the circular-motion model.	**It must be four times as large. At the same radius, doubling speed makes the required inward acceleration, and thus the tension, four times as large.**
4	Just after the string is cut, which forces remain on the car, and which way does it move?	**Gravity and the table's upward force remain. With no horizontal force, the car moves in a straight line tangent to the circle at the cut.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The sketch shows a dot with an upward arrow labeled normal force, a downward arrow labeled gravity, and an arrow toward the center of the turn labeled friction. Without sideways friction, there is no force to keep the bicycle and rider turning. They move approximately straight ahead along the tangent to the turn at that instant.

Accept equivalent force names, including weight for gravity and tension for the string's pull. For the open task, the friction arrow must point toward the center of the turn, not in the direction of travel.