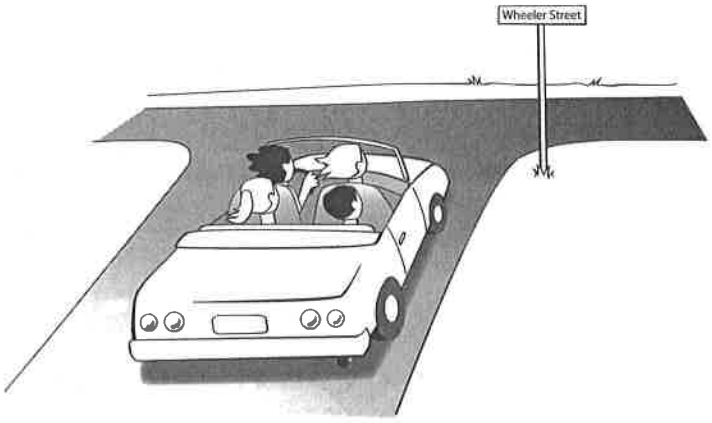
Riding in a Car

Ina, Rie, Kris, and Roberto were sitting in a car. The car suddenly went around a sharp corner. After the car came out of the turn, they wondered about the forces involved. This is what they said:



Ina: "Wow! Did you feel that force pushing us outward? I was pushed against the passenger door."

Rie: "I don't think we were pushed outward. I think we were pushed inward. Otherwise we wouldn't be turning."

Kris: "I could only feel the force pushing us forward. The force must be in this direction because that is the direction we are moving."

Roberto: "Actually, when we started to turn, I think we slowed down a bit, so I think I felt a push backward."

Whom do you most agree with? _____

Explain your thinking about the direction of force on the passengers when the car went around the sharp corner.

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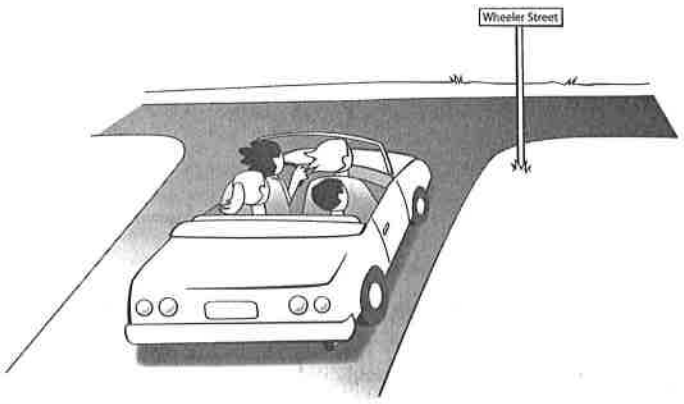
Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about circular motion and forces. The probe is designed to reveal whether students understand that turning requires a force toward the center of the curve.

Related Concepts

circular motion, Newton's first law

Explanation

Rie has the best answer: "I don't think we were pushed outward. I think we were pushed inward. Otherwise we wouldn't be turning." For a car to turn a corner, there must be a force acting on the passengers toward the inside of the corner. When the car begins to turn a corner, you move outward relative to the car until you bump into a person or the door of the car and feel a push. This sensation of being pushed toward the person or car door arises from the fact that we are sensing our motion relative to the car, and not to the road. Relative to the car, we feel we are pushed outward, but relative to the road, the push is inward.

Administering the Probe

This probe is best used with middle school and high school students. Ask students to recall a time they were riding in a car or bus and turned a sharp corner.

Related Ideas in *National Science Education Standards* (NRC 1996)

K–4 Position and Motion of Objects

- The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.

5–8 Motions and Forces

★ An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993, 2009)

3–5 Motion

- Changes in speed or direction of motion are caused by forces.

6–8 Motion

- An unbalanced force acting on an object changes its speed or direction of motion, or both.
- ★ If a force acts towards a single center, the object's path may curve into an orbit around the center.

9–12 Motion

- ★ Any object maintains a constant speed and direction of motion unless an unbalanced outside force acts on it.

Related Research

- In situations where there is uniform circular motion, some students think there is a centrifugal force pushing the object out rather than a center-directed centripetal force (Roth, Lucas, and McRobbie 2001).
- Many students think that objects in circular motion are being "thrown outward." This is because of the sensation they feel when they are in vehicles traveling around curves (Arons 1997, p. 121).

Suggestions for Instruction and Assessment

- Students need to experience the forces required to move an object in a circle. One method is to roll a bowling ball in a straight line and then have students use a small hammer to exert forces on the ball in order to make the ball turn a corner.
- Have students consider the motion of a car turning a corner from a vantage point above the car (not moving with the car). From this frame of reference, it can be seen that a person in the car is trying to move in a straight line and it is the car that is pushing on the person. Computer simulations of this situation have been found to be effective with students.

References

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

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Arons, A. 1997. *Teaching introductory physics.* New York: John Wiley and Sons.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

Roth, W., K. Lucas, and C. McRobbie. 2001. Students' talk about rotational motion within and across contexts, and implications for future learning. *International Journal of Science Education* 23 (2): 151–180.

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