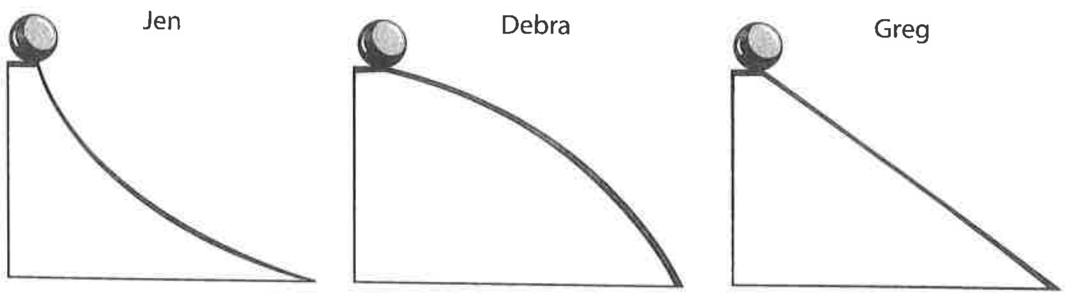
Rolling Marbles

Jen, Debra, and Greg are playing with ramps and marbles. They decide to have a contest to see who can make a marble roll down a ramp the fastest. Each friend uses the same height and identical marbles. They each let go of their marbles at the top of their ramps. (They do not give their marbles a push.)



Circle whose marble will reach the bottom of the ramps first.

A Jen's marble

B Debra's marble

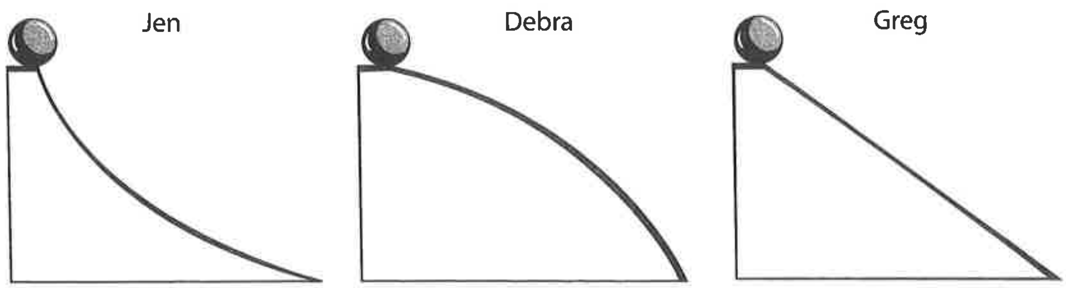
C Greg's marble

D No one will win—it will be a tie.

Explain your thinking. Describe your ideas about the time it takes for the marble to reach the end of the different ramps.

Rolling Marbles

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about motion using marbles and ramps. The probe is designed to reveal students' thinking about the factors that affect the time it takes for a marble to roll down a ramp.

Related Concepts

acceleration, average speed, speed, time, time interval

Explanation

The best answer is Jen's marble. The marble that rolls down the ramp with the steepest incline at the beginning will get to the bottom first. This is because the average speed will be higher as compared to the other two ramps if the ball is moving faster at the beginning of the motion. A steeper ramp will cause the ball to reach a higher speed in a shorter amount of time as compared to a less steep ramp. A higher average speed means that the ball will get to the bottom of the ramp in a shorter period of time as long as the ramps are of similar length.

Administering the Probe

This probe can be used with elementary, middle school, and high school students. When used with elementary students, the focus should be on observation and comparing the shapes of the ramps, not on the explanation of average speed and acceleration. The setup for this probe can be shown with the props used in the probe—for example, use three pieces of flexible PVC pipe that are the same height and ramp length, identical marbles, and three different ramps or a ramp that can be flexibly bent into the three different shapes. Ask students to predict which marble will reach the bottom of its ramp first.

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

K–4 Position and Motion of Objects

- An object's motion can be described by tracing and measuring its position over time.

5–8 Motions and Forces

★ The motion of an object can be described by its position, direction of motion, and speed.

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

K–2 Communication Skills

★ Describe and compare things in terms of number, shape, texture, size, weight, color, and motion.

3–5 Motion

- How fast things move differs greatly.

Related Research

- The words *fast* and *slow* refer to the speed of an object. The words *short* and *long* refer to time intervals. Students often confuse these two related, but different, concepts.
- Naturally, children's ideas and descriptions of motion tend to be less differentiated than those of physicists. Children tend to see objects either at rest or moving; they rarely focus on the period of change. They use everyday terms such as *going faster* in ambiguous ways, sometimes referring to the magnitude of the speed of an object and at other times referring to the speed increasing with time (Driver et al. 1994, p. 155).
- Young children typically start with identifying the direction in which the object moves without regard to the speed of the object. As their ideas progress, they often offer "snapshot" descriptions—that is, a description that is essentially a still photograph of an object, without looking at changes—in which they compare the speed of an object at different locations or instants. Eventually, older children can be led to describe how the speed of an object is changing at a specific location or instant (Dykstra and Sweet 2009).

Suggestions for Instruction and Assessment

- This probe can be used as a P-E-O strategy: commit to a *prediction, explain* the reasoning behind the prediction, test the prediction, and *observe* the results. If observations do not match the predictions, students need to rethink their explanations (Keeley 2008). If this probe is used with younger children, explanations should be based on observations of what may have caused one of the marbles to reach the bottom first; they should focus on what is different about the three ramps. Students can further test their explanations by making additional changes to the ramps.
- A second version of this probe can be used as a follow-up with older students. Ask students which marble will be moving the fastest at the end of the ramp. This question is different from the probe, which asks which marble will reach the end of the ramp first. All three marbles will be rolling at approximately the same speed when they reach the bottom of each ramp. This is because the height of all three ramps is the same, so each marble will have the same gravitational potential energy at the top of each ramp. This gravitational potential energy becomes kinetic energy at the bottom of the ramp. If there are no other forces acting on the marbles (i.e., if friction is negligible) then all three marbles will have

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

the same kinetic energy at the bottom of each ramp. Because they are identical marbles, they will all have the same speed at the bottom of the ramp.

- Advanced students could further investigate the mathematics behind finding the exact shape of a track that yields the shortest time for a ball to roll. This mathematical curve is called a brachistochrone. A web animation for this curve that provides a representation for the "Rolling Marbles" probe can be found at *http://curvebank.calstatela.edu/brach/brach.htm*.
- Provide younger students with additional opportunities to explore balls and ramps. For example, if the ramps are all the same, does the mass of the ball make a difference? What about the height, length, or material the ramp is made of? Encourage students to make predictions and test them.

References

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