Apple in a Plane

David is sitting in an airplane, flying over the Atlantic Ocean. The plane is moving very fast at a constant speed. He pulls an apple out of his bag and places it on the tray in front of him. Put an X next to all the major forces that are acting on the apple.

____ **A** A force by the tray pushing up on the apple

____ **B** A force by the Earth pulling down on the apple

____ **C** A force by the air pushing down on the apple

____ **D** A force by the air pushing up on the apple

____ **E** A force by the plane in the direction that the plane is moving

____ **F** A force by the apple holding it onto the tray

____ **G** No forces are acting on the apple because it is at rest on the tray.

____ **H** No forces are acting on the apple because it is inside a fast-moving plane.

Explain your thinking. Describe any rules or evidence that you have to support your answer.

Apple in a Plane

Teacher Notes

Purpose

The purpose of this assessment probe is to elicit students' ideas about force related to the interaction between inanimate objects. The probe is designed to determine which forces students think act on an object at rest when it is inside a fast-moving object.

Related Concepts

active action, contact force, gravitational force, interaction, normal force, passive action

Explanation

The best answers are A and B: "A force by the tray pushing up on the apple" (a type of contact force that is called a "normal force" because the force acts perpendicular to the surface) and "A force by the Earth pulling down on the apple" (gravitational force). These forces balance each other so that the motion of the apple is not changing (in this case, the motion of the apple is not changing even though it is inside a fast-moving plane). Some students may answer that the air also exerts a force on the apple. However, because this force is exerted in all directions, cumulatively it is very small and is pointed upward (a buoyancy force) and not downward.

Administering the Probe

This probe is best used with middle school and high school students. Make sure students recognize the apple is sitting on a tray inside a fast-moving plane. It is this feature—an object at rest inside a fast moving object—that distinguishes this probe from the "Apple on a Desk" probe in Keeley, Eberle, and Dorsey (2008).

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.

5–8 Motions and Forces

- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another.

9–12 Motions and Forces

★ Whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

- Gravitation is a universal force that each mass exerts on any other mass.

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

3–5 Forces of Nature

- The Earth's gravity pulls any object toward it without touching it.

6–8 Forces of Nature

- Every object exerts gravitational force on every other object.

9–12 Motion

★ Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.

Related Research

- Students tend to distinguish between active objects and objects that support, block, or otherwise act passively, such as a table. Students tend to recognize the active actions as forces but often do not consider passive actions to be forces. Teaching students to integrate the concept of passive support into the broader concept of force is challenging, even at the high school level (AAAS 1993).
- Some students believe that if a body is not moving, there is no force acting on it (AAAS 1993). Elementary students typically do not understand gravity as a force. If students do view weight as a force, they often think it is the air that exerts a downward force (AAAS 1993).
- Sjoberg and Lie (1981) found that the state of rest is widely regarded by students as a natural state in which no forces are acting on an object. Furthermore, Minstrell (1982) used a question (which this probe was based on) that asked students to describe the forces acting on a book resting on a table. He found that students had several ideas about the stationary object: gravity kept the book in place; air pressure kept the book in place; the table was "in the way" of the book's falling; an object in contact with the Earth, like a book on the ground, no longer experiences the force of gravity; and a downward force on the book must be greater than an upward force (otherwise, the book would float away). He found the table "being in the way" was the most widely held view (Driver et al. 1994, p. 156).

Suggestions for Instruction and Assessment

- This probe can be combined with the "Apple on a Desk" probe in *Uncovering Student Ideas in Science, Vol. 3* (Keeley, Eberle, and Dorsey 2008). In that probe, the apple is at rest on a table in a house (although the Earth is also moving quite fast) whereas in this probe the apple is on a tray inside a fast-moving object. It may be useful to administer both probes to see if students answer differently depending on whether the apple is on a stationary object or in an airplane moving at a constant, fast speed.
- Provide students with a sequence of scenarios that demonstrate that all surfaces deform in a springlike fashion when objects are placed on them and that the tendency of surfaces to return to their original shape

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

causes them to exert force on the object. This type of bridging analogy is especially effective with high school students (Clement 1993; Minstrell 1982).

- It is difficult to convince some students that any forces at all are acting in the situation given in the probe. Ask them, *What would happen if you took the tray away?* They should reply that the apple would fall. To "feel" that a force is exerted by the tray on the apple to keep the apple at rest, ask students to hold out one hand, palm flat and upward, and pretend the hand is the tray. Then put a heavy object in the palms of their hands and ask them to hold their hands so the object is not moving. They will notice how they must continually push upward on the object in order for it not to move, Help them see how this force balances the force of gravity, which would cause the object to fall if they removed their hands. If they push harder on the object or relax their muscles, the forces would be unbalanced and the object would move upward or downward.
- It is often difficult for students of all ages (K–12) to grasp that force is an interaction between a pair of objects. To help them internalize this concept, encourage them to identify all the forces in the probe situation as *interactions* instead of just naming the forces. For example, instead of naming gravity as one of the forces, have them describe the interaction as "gravitational force by the Earth on the apple."

References

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

American Association for the Advancement of Science (AAAS). 2009. Benchmarks for science literacy online. *www.project2061.org/publications/bsl/online*

Clement, J. 1993. Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching* 30 (1): 1241–1257.

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London: RoutledgeFalmer.

Keeley, P., F. Eberle, and C. Dorsey. 2008. *Uncovering student ideas in science: Another 25 formative assessment probes, vol. 3.* Arlington, VA: NSTA Press.

Minstrell, J. 1982. Explaining the "at rest" condition of an object. *The Physics Teacher* 20: 10–14.

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

Sjoberg, S., and S. Lie. 1981. *Ideas about force and movement among Norwegian pupils and students.* Institute of Physics Report Series: Report 81-11. Oslo, Norway: University of Oslo.