

## Chapter 6

Use with Section 2

## ENRICHMENT

## • Why do things fall?

### Mars Pathfinder: Coming in for a landing, and a landing, and a landing . . .

Launching the Mars Pathfinder in December, 1996, was one of the easier parts of that historic mission. The seven month journey to reach Mars progressed without any problems. Landing Pathfinder safely on Martian soil, however, required scientists to use some “low-tech” procedures that you might not associate with a complex space mission—a parachute and air bags.

The force of gravity on Mars is  $3.7 \text{ m/s}^2$ . Though that is less than one third that of Earth, it still exerts a significant pull on objects that enter its atmosphere. The logical solution to preventing Pathfinder from crashing onto Mars would seem to be a combination of rockets, engines, and braking mechanisms that would control the landing in a manner similar to that used for jet planes. But the scientists who built Pathfinder had a limited budget. All those rockets and engines would have been expensive to build and would have required large amounts of fuel.

So Pathfinder became the first “Martian sky-diver.” When it entered Mars’ atmosphere, 130 km above the surface, it was traveling at

$7400 \text{ m/s}$ . At just over 9 km above the ground, a parachute opened and Pathfinder’s speed gradually decreased to  $370 \text{ m/s}$ . As it continued to fall/float toward Mars, the lander that contained Pathfinder was lowered from the base of the parachute by a leash. Its speed continued to decrease, slowing to  $67 \text{ m/s}$ . Ten seconds before it landed, several airbags inflated and formed a protective shield around the lander. The leash was automatically cut 6.2 s later. When Pathfinder finally made contact with Mars, it was traveling at about  $12.5 \text{ m/s}$ . It landed, bounced about 15 m in the air, and then bounced 15 more times like a beach ball before it finally came to a stop about 1 km away. The entire bouncing sequence took about 2.5 min. The air bags were deflated and rolled up, the lander opened, and Pathfinder emerged.

Scientists still had to use some rockets to control the entry, but the parachute/air bag combination helped reduce the costs of the Pathfinder mission to one-fourteenth that of the Viking missions in 1976.

1. Would the same type (size, number) of parachutes and air bags have allowed Pathfinder to land gently on Earth? Why or why not?

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2. A force of 40 N is exerted on each of two objects, one on Mars and one on Earth. What is the mass of each object?

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