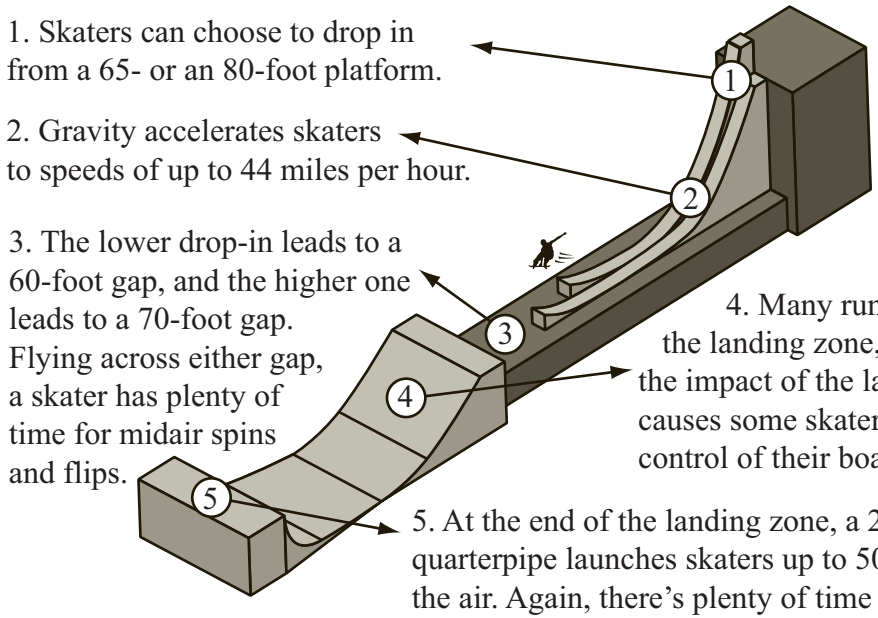
"Ramp It Up" describes the MegaRamp, one of the biggest skateboarding ramps in the world, and explains how it works. Read the article and then answer the questions that follow.

Ramp It Up

by Pearl Tesler

Up in the Air

Nine stories tall and longer than a football field, the MegaRamp earns its name.



'Gravity Rules!'

1 . . . Does skateboarding really defy physics?

2 "Nope, sorry," says Paul Doherty, a physicist at the Exploratorium in San Francisco. "There's no escaping the laws of physics."

3 Skateboard ramps are in fact the perfect place to see physical laws in action, says Doherty. And the number-one law at work on the MegaRamp is the law of gravity. "Gravity rules!" says Doherty. "When these guys step off the ledge, every atom in the planet is pulling them down—and there are *lots* of atoms in the planet.

4 "As skaters plunge down the ramp, they convert energy from one form into another," says Doherty. "At the top of the ramp, the skaters have what we call *gravitational potential energy*—energy due to height above the ground. As they go down, it gets converted into *kinetic energy*, the energy of motion."

5 Kinetic energy means speed—in this case, a lot of it. At the bottom of the first steep descent, skaters move at 44 miles per hour—as fast as if they had simply jumped from the platform. The MegaRamp's immense height confers such sizzling speed. On a standard 12-foot skateboard ramp, top speeds are confined to well under 20 miles per hour.

6 Are skaters then just pawns in gravity's game? Can they control their descent speed at all? "Slightly," says Doherty. Besides gravity, the other significant force acting on a descending skater is *air resistance*, a force exerted by air molecules that tends to slow any moving object. Air resistance increases with speed and with the frontal area a skater presents to the wind. "If you stand up tall and wear floppy clothes, you'll go slower," says Doherty. "But if you tuck down and make a smaller cross-sectional area, you'll go faster."

Need for Speed

7 Maximum speed is a necessity on the MegaRamp. The smoothly arcing curve at the bottom of the big descent leads to the immense, 70-foot gap. Any loss of energy—any mistake that robs a skater of speed—can result in a potentially fatal failure to clear the gap. "If a skater bobbles on the way down, fails to keep a straight line, or touches his toe down, it could be very, very bad," says Doherty. "Because once you're in the air, it's too late."

8 As testimony to the big risks of big air, paramedics are standing by at the base of the giant ramp. Meanwhile, in preparation for the rough ride, competitors suit up with helmets, elbow pads, knee pads, wrist guards, and shoulder pads. Although the MegaRamp has claimed no lives, within an hour I see at least a dozen spills nasty enough to draw a collective "Oooooohhh!" from the fans. But every time a competitor falls, he leaps up and hustles back to the elevator, eager for more.

Bigger Air?

9 After nailing several more soaring backflips, [Danny] Way seals a gold-medal victory in the big-air competition, his third in the three years that the competition has existed. But Way isn't one to rest on his laurels. The wheels of his battered skateboard have barely quit spinning before he announces his desire to build a new—and possibly bigger—ramp. "There's so much more possible," he told ESPN.

10 Way's announcement leaves skaters and fans alike wondering: Exactly how big can a skate ramp get? Could future skate ramps climb high into the stratosphere? Is the sky the limit?

11 Three factors put major limits on the height of a skate ramp, says Doherty. The first factor is *g-forces*, the body-squashing sensations familiar to astronauts and pilots. Whenever your body *accelerates*—that is, changes speed or direction—you experience a force. When that acceleration is extreme, the body can experience a force equal to or even greater than the downward force exerted by gravity. Such an extreme force due to acceleration is called a g-force, where *g* is short for *gravity*. During a space launch, astronauts are pinned to their seats by a force equivalent to three times the force of gravity—3 g's.

12 The skaters rocketing down the MegaRamp feel g-forces too. They feel the worst of them at the base of the steep initial descent, where the ramp curves from vertical to horizontal, a change in direction that puts about 2.5 g's of force on a skater. "For a 200-pound skater, this feels like suddenly weighing 500 pounds," explains Doherty. "It feels like you're being squashed into the ground."

13 The g-forces a skateboarder feels in a curve are directly related to speed. "If you double speed, the g-forces actually quadruple," says Doherty. A taller MegaRamp would increase skaters' speeds and thereby increase the g-forces they experience in the curve at the bottom. For example, doubling the height of the MegaRamp would expose skaters to about 5 g's. "For a 200-pound athlete, that's like bench-pressing 1,000 pounds with the legs just to stand up. Few athletes can actually do that." So to keep g-forces bearable, a taller MegaRamp would have to have more gradual curves.

Terminal Speed

14 The second factor limiting the height of a skate ramp is its *terminal velocity* (natural speed limit), a phenomenon familiar to skydivers. It is imposed by air resistance. When skydivers jump out of a plane, they gain speed at a constant rate because of gravity. But air resistance slows them, and air resistance increases with speed. As the skydivers fall and their speed increases, the downward force of gravity is eventually balanced by the upward force of air resistance. Skydivers then reach their maximum speed, or terminal velocity. Depending on how divers hold their body, their terminal velocity can range from 120 to 200 miles per hour.

15 "When you jump out of an airplane," says Doherty, "you reach terminal velocity after about 1,000 feet. So any skateboard ramp more than 1,000 feet high is pointless. After about 1,000 feet, you won't gain any more speed, no matter how tall the ramp is. So if you run a ramp down the side of the Empire State Building—that's 1,200 feet—that's as big as you need to go. You'll reach terminal velocity—around 120 miles per hour—just before you reach the bottom."

Fear Factor

16 The final factor to consider isn't physical but psychological—the fear factor. If Way builds an even taller skate ramp, will anyone be brave enough to ride it? Would you? Amazingly, Way himself has admitted to a fear of heights: "There's no question I get butterflies when I'm on the edges of the top of the tower," he told the *Los Angeles Times*.

17 For now, the only permanently installed MegaRamp in the world is located at the home of Bob Burnquist, bronze medalist in the big-air competition, who is famous for having jumped his skateboard off the edge of the Grand Canyon (wearing a parachute, of course). Despite an obvious knack for aerial stunts, even Burnquist finds the MegaRamp daunting. "It's scary," he told *The New York Times*. "You calculate as much as you can, and you try to assess everything that you possibly can, but sometimes it's just 'close your eyes and go.'"