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Thrill Seekers

1884: FIRST U.S. ROLLER COASTER OPENS AT CONEY ISLAND

One bright spring morning in 1999, a crowd gathered at Busch Gardens in Williamsburg, Virginia, for the opening of the park's new roller coaster, Apollo's Chariot. On hand as a special celebrity guest was the male model Fabio—he of the flowing blond locks, chiseled jaw, and impeccably sculptured torso. Best known for posing in strategically ripped shirts on the covers of mass-market romance novels, and for hawking butter substitutes on television, Fabio had the Apollonian good looks that made him an obvious choice to usher in the new ride.

But halfway through the initial 210-foot drop, disaster struck: a wild goose flew into the coaster's path and smashed into Fabio's face. The impact gashed Fabio's nose and killed the goose, whose broken body was later fished out of a nearby river. Fabio ended the ride with his face covered in blood (whether his own or that of the goose, no one could say)—a gruesome testament to the impressive forces a simple thrill ride can generate.

Affectionately dubbed the "great American scream machines," roller coasters derive from the giant ice slides that first appeared in

the seventeenth century in Russia, near Saint Petersburg. The slides were built out of lumber covered with a sheet of ice several inches thick, and featured drops of 50 to 80 feet. Riders would walk up a ladder or set of stairs to the top of the slide, climb into wooden sleds, and shoot down the slope, crashing into sand piles at the base of the slope to stop the ride. The slides were a favorite diversion of the Russian upper class. Catherine the Great was such a fan that she had a few built on her estate.

Roller coasters have come a long way since those rudimentary ice slides, but both rely on the same underlying principles of physics: inertia, gravity, and acceleration. A roller coaster is always shifting between potential (stored) and kinetic (released) energy. Compressing a spring stores potential energy in the coils, which is released as kinetic energy when the spring pops back out to its original shape. Roller coasters build up a large reservoir of potential energy while being towed up the initial "lift hill." Initially they were towed manually; modern roller coasters are pulled up lift hills by chain-and-pulley systems, powered by small electric motors. After that initial tow, physics takes over.

The key factor at play is gravity, which applies a constant downward force on the coaster's cars; the tracks channel this force by controlling the way the cars fall. The higher the coaster train rises, the greater the distance gravity must pull it back down, and the greater the resulting speeds. As the train starts down the first hill, the potential energy is converted into kinetic energy and the train speeds up, building up enough kinetic energy by the time it reaches the bottom to overcome gravity's pull and move up the next hill—and so on for the rest of the ride. But the laws of thermodynamics dictate that no machine can operate indefinitely without getting an extra influx of energy from somewhere. Roller coasters are no exception. That's why the hills in most modern coasters tend to decrease in height as the ride progresses; the total energy reservoir built up on the lift hill is gradually lost to friction between the train and the track—entropy in action.

Most historians credit the French with building the first wheeled coasters. Although the French loved the concept of the Russian ice slides, the warmer climate in France would melt the ice for all but a few months of the year. So they started building waxed slides instead, and to help the sleds move down the slides, they added wheels. Later, they substituted a wooden track for the waxed slide. By 1817 there were two bona fide roller coasters in France, both of which featured cars locked to a track through wheel axles fitted into a carved groove.

In 1846, the world's first looping coaster—in which riders are turned upside down—was unveiled at Frascati Gardens in Paris. The ride featured a 43-foot lift hill and a 13-foot-wide loop. The speeds were slow compared with those of modern rides, but the basic physics remained the same. When a coaster loops the loop, centripetal force comes into play. It's the same underlying principle as in the merry-go-round: the forces generated by the spinning platform push riders out and away from the center of the platform, but those forces are countered by a restraining bar accelerating riders back toward the center.

A roller coaster loop-the-loop is, in essence, a merry-go-round turned on its side—although most modern loops are teardrop-shaped (not perfect circles), to better balance the various forces acting on the body. At the bottom, the acceleration force pushes riders down in the same direction as gravity, so they feel especially heavy. As the ride moves up the loop, gravity pulls the riders into their seats while acceleration pushes them into the floor. At the top, when the riders are completely upside down, gravity pulls them out of their seats toward the ground, while the stronger acceleration force pushes them into their seats toward the sky; the two forces effectively cancel each other out. As a result, the riders experience a momentary feeling of weightlessness or "free fall," suspended in midair for a split second.

An early attempt to bring roller coasters to the United States failed because of an accident during the trial run. Then along came an American inventor, La Marcus Thompson, who would ultimately revolutionize the amusement industry in the United States. Thompson was born in 1848 in Jersey, Ohio, and was a natural at mechanics, designing and building a butter churn for his mother and an oxcart for his father when he was only 12. After finishing college, he worked in the wagon and carriage business before making his fortune as a manufacturer of women's hosiery. After selling his stake in the hosiery business, he turned back to his first love: inventing.

When he was in the manufacturing business, Thompson had ridden on the Mauch Chuk Switchback Railway in Pennsylvania, a former mine track that had become a popular tourist attraction. The track was originally built as an easy way to send coal down the mountain to the railway 18 miles away. But then the railway built a new tunnel, bringing the freight trains much closer to the coal mine. So the switchback railway was reconfigured as a "scenic tour." For $1, tourists got a leisurely ride up to the top of the mountain, followed by a wild bumpy ride back down.

Thompson decided to build his own Gravity Pleasure Switchback Railway at Coney Island in New York, the previous location of a track for horse races. Completed in 1884, it was the first roller coaster to be built in the United States. It incorporated undulating hills and a flat steel track nailed onto several layers of wooden plank, connected to two towers. The maximum speed was a poky 6 miles per hour, and the cars had to be manually towed to the top of the hills at the start of both tracks. Still, the ride was an instant success with the public, who had little to compare it with, and Coney Island mushroomed into a full-scale amusement park. No one knows when the rides became known as "roller coasters"; they were initially called switchback railways or centrifugal railways. Thompson received a U.S. patent for his "rolling coaster" ride in January 1885. His wasn't the first. Three other similar patents were issued in 1884, and some historians believe that Thompson actually based many features of his design on a patent issued in January 1878 to Richard Knudson for "improvements in inclined railways."

Within four years, Thompson had built approximately 50 more such coasters across the nation and in Europe and then designed his most famous attraction, the Scenic Railway. It opened in 1887 in Atlantic City and featured artificial scenery illuminated by lights triggered by the approaching cars—a precursor of the elaborate rides at Disneyland and other modern theme parks and amusement parks.

Improvements and innovations came fast on Thompson's heels. Later in 1884, Charles Alcoke designed a coaster with a continuous track, so that the ride ended where it began, and in 1885 Phillip Hinckle was the first to use a mechanical hoist to raise the cars to the top of the lift hill. That same year saw the debut of a coaster called the Flip-Flap, which rolled cars through a loop-the-loop 25 feet in diameter, but it closed in 1903 because the passengers frequently suffered neck and back injuries. The ride was slow but far from smooth, and the sharp, jerking motions as passengers were flipped upside down often resulted in severe whiplash.

By the end of the nineteenth century, all the basic elements of the modern roller coaster were in place, although the coasters were still frustratingly slow. The early 1900s brought numerous innovations in roller coaster design that increased the speeds by better manipulating the various forces: higher lift hills, sharper turns, and sharp spiraling drops. The 1920s were the golden age of roller coaster design, with more than 1500 rides opening in North America alone. But the Great Depression put an end to such frivolity, and many coasters were torn down. From 1930 to 1972, only 120 roller coasters were built in the United States, while more than 1500 were destroyed.

The technology languished until 1955, when the opening of Disneyland in southern California marked the introduction of tubular steel tracks. The earlier coasters were wooden, similar to traditional railroad tracks. They were too inflexible to enable designers to construct complex twists and turns, and the cars tended to rattle as they rolled over the joints connecting the track. The new tracks were made of long steel tubes supported by a superstructure made of slightly larger tubes, and the pieces were welded together. Not only did this make for a smoother ride, but tubular steel coasters allowed more looping, higher and steeper hills, greater drops and rolls, and faster speeds.

This led to a second roller coaster boom in the 1970s and early 1980s, which revitalized the industry with the introduction of all sorts of innovative designs, like the corkscrew track. Today, catapult launch systems, suspended train designs (in which the riders' feet dangle, and the "cars" swing from side to side), elaborate ride themes, and other twists have come fast and furiously, making roller coasters more popular than ever. There are coasters in which you lie flat against the train car and have the sensation of flying, and coasters that shoot you down long stretches of spiraled track. In 1997, a coaster opened at Six Flags Magic Mountain in California that was 415 feet tall and could reach record-breaking speeds of 100 miles per hour.

Thanks to the continual variation in forces, roller coasters put the human body through a number of exhilarating physical sensations in a matter of seconds. These are the so-called "g forces," which indicate how much force the rider is actually feeling. The riders' inertia is separate from that of the car, so when the car speeds up, they feel pressed back against the seat because the car is pushing them forward, accelerating their motion. When the car slows down, a rider's body tends to continue forward at the same speed in the same direction, but the harness or restraining bar decelerates it—that is, slows it down.

A "g" is a unit for measuring acceleration in terms of gravity. It also determines how much we weigh, as opposed to our mass (how many atoms make up our body). Weight is determined by multiplying an object's mass by the force of Earth's gravity. The g forces arise because a roller coaster is accelerating: forward and backward, up and down, and side to side. This produces corresponding variations in the strength of gravity's pull. For example, 1 g is the force of Earth's gravity: what the rider feels when the car is stationary or moving at a constant speed. Acceleration causes a corresponding increase in weight, so that at 4 g, for example, a rider will experience a force equal to four times his weight.

At high speeds, the g forces can be considerable. Fabio endured a lot of ridicule in the media after his encounter with the kamikaze goose; people were amused that the 6-foot 3-inch, 220-pound hunk fared so poorly against a 22-pound waterfowl. But assuming the collision lasted a hundredth of a second, and the coaster was traveling at a speed of about 70 miles per hour, Fabio would have absorbed an impact equivalent to a hard tackle by the football player Mean Joe Green, delivered with a force equivalent to a solid punch from the heavyweight champ Mike Tyson. Yet not one reporter said, "That Fabio, he can really take a punch!"

So there is a dark side to all this merry mayhem: accidents and injuries do happen, and coaster-related (human) deaths number between two and four per year. Compared with the hundreds of millions of visitors who crowd amusement parks every year, this might seem insignificant; fatalities occur for about one in

450 million riders. But the statistical anomaly is small comfort to the victims and their families. The federal Consumer Products Safety Commission reported in 1999 that there had been an 87 percent increase in injuries on amusement park rides from 1994 to 1998; it attributed the increase in part to the steadily increasing acceleration forces generated by the rides. The newest coasters can reach top speeds of 100 miles per hour with g ratings as high as 6.5. For comparison, astronauts typically experience 4 g while traveling up to 17,440 miles per hour on liftoff, and NASCAR drivers have reported feeling dizzy after experiencing 5 g. Coaster designers counter this by pointing out that astronauts and NASCAR racers experience sustained g forces; riders on a roller coaster are typically exposed to high g forces for only 1 second or less.

Mechanical failure is sometimes the culprit, but some of the most spectacular accidents occur because riders ignore basic safety precautions. Thrill seekers have been known to remove the safety harness; this act can chuck riders out of the car and send them flying through the air at high speeds. Standing up during the ride has also caused numerous riders to fly out of cars, or to strike their heads on low beams, usually suffering fatal injuries. In 1996, at Six Flags Great America, a man wandered into a restricted track area to retrieve his wife's hat, which had blown off in the high winds. A rider on the Top Gun suspension coaster kicked him in the head, killing him instantly. The rider suffered a broken leg. Six years later, a rider on the Batman suspension coaster at Six Flags Over Georgia leaned out of the car and nearly lost his head when a rider in a train traveling in the other direction on an adjacent track kicked it. The man who leaned out of his car was killed immediately by the impact. And in a bizarre incident in May 2003, an 11-year-old girl choked to death on her chewing gum while riding a coaster at Six Flags Great America.

More insidious are the injuries many riders may not even be aware they've suffered; some doctors believe that the sharp jerks and jostles of high-speed rides could have the same brain-battering effects as professional football. The strong g forces generated by high-speed coasters can cause headaches, nausea, and dizziness—possibly harmless, but also symptoms of mild concussion—simply because the body doesn't have sufficient time

to adapt to the rapidly changing environment. The effect can be similar to what happens to the brain during a car accident, or when a person is violently shaken. As the head whips sharply back and forth, the brain can pull away from one side of the skull and smash into the other side with sufficient force to rupture tiny blood vessels. The trickling blood accumulates in the small space between the brain and the skull, and the resulting pressure can lead to permanent brain damage or death if left untreated. In the summer of 2001 alone, three women suffered fatal brain injuries on roller coasters in California, although two of those victims had a preexisting aneurysm—a weak spot on a blood vessel in the brain—which ruptured during the ride.

Some of these physical effects are admittedly speculative, and none are likely to dissuade any diehard coaster fans, for whom the potential dangers are part of the thrill. But Fabio's encounter prompted him to call for increased safety measures on roller coasters. And he isn't the only naysayer. Concerned doctors, legislators, and consumer groups continue to lobby for tighter regulation of the amusement park industry, in hopes of preventing similar fowl incidents, thus ensuring the future well-being of children and wild geese everywhere.