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SySTEM Alert!

Tomorrow is almost here.

Taking the plunge

You might say that a roller coaster's supreme moment comes at the top of its first big hill. The cars have been pulled up the hill by a motor-driven loop of chain running below them. At this high spot, the passengers likely have the best view they will have during the whole ride. But in another moment, the riders will be rocketing toward the ground, gaining speed at every moment. They will feel the wind on their faces. Their bodies will experience a force multiple times stronger than they normally feel from gravity.

All traditional roller coasters start with just such a climb and descent. (Some newer ones begin in other ways, but the big hill method is still the classic.) That perfect moment at the crest of the hill sets up everything that follows – the descent, the loops, the twists, the other smaller hills. This is because this is the moment of maximum potential energy.

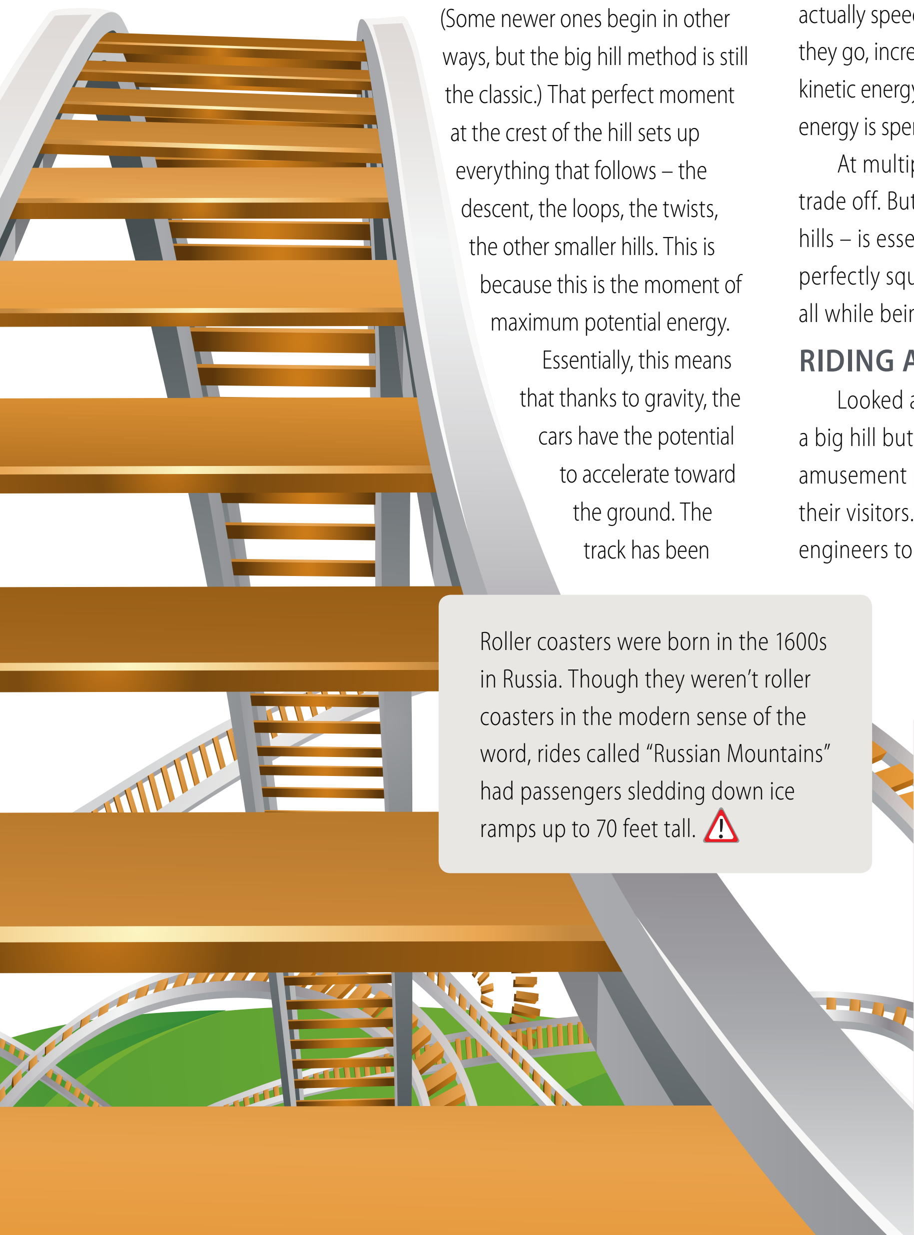
Essentially, this means that thanks to gravity, the cars have the potential to accelerate toward the ground. The track has been holding up the cars, keeping them from freefall. But after the descent begins, gravity gets its way at last. As with other things that fall, the cars don't drop at a steady rate. They actually speed up as they go, increasing their kinetic energy. (This is the name for the energy of motion). As the potential energy is spent in the fall, the kinetic energy ratchets up.

At multiple times during the ride, kinetic and potential energy will trade off. But the energy for the whole ride – its loops, corkscrews, other hills – is essentially gathered in that first climb. Designing a ride that perfectly squeezes every available bit of thrill from this potential energy, all while being safe to ride, is a great feat of engineering.

RIDING AT THE EDGE OF DISASTER

Looked at another way, the true beginning of a roller coaster is not a big hill but a big idea. Every roller coaster has its own concept. Usually amusement parks will have some idea of the type of ride they want for their visitors. The idea might be vague or specific. Either way, it is up to engineers to make this idea into a reality.

(continued on page 4)



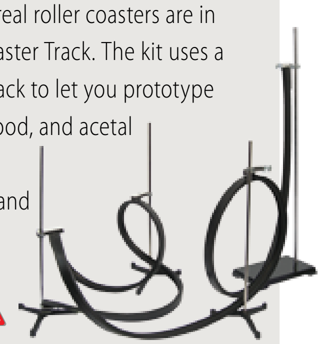
Stayin' alive

Life has a way of being dangerous – and even then, many people seem to love to push the limits, putting themselves in extreme situations for the sake of adventure. In this issue of *SySTEM Alert!* we take a look at several common technologies used to keep people safe when they otherwise would not be.

Roller coasters were born in the 1600s in Russia. Though they weren't roller coasters in the modern sense of the word, rides called "Russian Mountains" had passengers sledding down ice ramps up to 70 feet tall.

CHECK OUT:
www.pitsco.com/
Roller_Coaster_Track

Want a taste of roller coaster engineering now? The same considerations and laws that engineers deal with when designing real roller coasters are in play with Pitsco's Roller Coaster Track. The kit uses a flexible extruded rubber track to let you prototype your own design. Metal, wood, and acetal balls stand in for cars. Experiment with potential and kinetic energy, acceleration and deceleration, gravity, momentum, and more.



Online quiz and electronic version now available. Visit www.pitsco.com/SySTEMalert.

Between you and the **universe**

Fifty miles above the surface of Earth, outside the confines of a spacecraft – this is an absolutely inhospitable place for a human being. There is no air to breathe. Temperatures can be as frigid as -250º Fahrenheit or as blisteringly hot as 250º Fahrenheit. The lack of atmospheric pressure can cause the blood in a human's body to lose oxygen and can lead to a collapse of the lungs. The radiation level is dangerously high. And yet astronauts routinely go into the vacuum of space with only their space suits to protect them. Those must be some pretty special suits.

More than one type of space suit exists. But the type that NASA astronauts typically use to take space walks is called an extravehicular mobility unit (EMU). Every part of the EMU was carefully designed to protect the wearer against the harshness of space.

1. PRIMARY LIFE SUPPORT SYSTEM

The components of the Primary Life Support System (PLSS) are housed in a backpack. In addition to providing oxygen and removing harmful carbon dioxide, the PLSS does other jobs as well. It keeps the whole suit nicely pressurized. It contains communications equipment so astronauts can stay in touch. And it cools water that goes throughout the suit, helping to keep astronauts in a safe temperature. The water is channeled through the nearly 300 feet of tubes in the Liquid Cooling and Ventilation Garment. This is one of the first parts of the suit that astronauts put on, so it is up close to their body. It even has the ability to recycle sweat.

2. CONTROL MODULE

The control panel located externally on the suit gives astronauts the ability to monitor and adjust the conditions of the suit. Because the suits aren't flexible enough to let astronauts look at the module directly, astronauts must wear mirrors on their wrists to inspect it.

3. HARD UPPER TORSO

The Hard Upper Torso is made of fiberglass. It covers the chest and back. It is not flexible, but it serves as an important structural piece for linking other parts of the suit. It also contains a drink bag for when astronauts get thirsty. Astronauts bite on a valve near their mouth to cause the water to flow from the bag.

4. HELMET

In addition to keeping the air in and at a safe pressure, the helmet has a visor tinted with a thin layer of gold. In space where there is no atmosphere, the Sun's rays are very intense.

5. ARMS

The arms are constructed of 14 layers of material. Different layers have different tasks. These range from storing water and air to providing insulation from the extreme temperatures of outer space.

6. GLOVES

Fingers can get cold in space. Heaters in the fingertips of the gloves help keep hands warm and able to do work.

7. LOWER TORSO ASSEMBLY

This is made to allow astronauts a good range of motion. The tether that protects astronauts from floating away is attached here.

Z-series suits

Though the EMU is unquestionably a marvel of technology, the fact is that it is a real pain to get into. Every piece must be put on in just the right order, and some of them have to be donned in different rooms of the space station. Even then, astronauts must first perform a prebreathe, a session during which they expel excess nitrogen from their blood (as this can form into bubbles in space). This can take up to four hours.

The Z-series is a set of suits currently being tested for use in space walks. These suits have features that solve many of the issues with the EMUs. For one, they are easier to get into, the suit being more flexible. Because the suit can also create a higher-pressure environment, the prebreathe stage may be bypassed before a space walk. In fact, the Z-series allows for 84 different pressure settings, whereas the EMU has only two.

Everyday miracles
How vehicle air bags save lives

Career Fields
- Automotive engineer
- Electrician
- Automotive mechanic

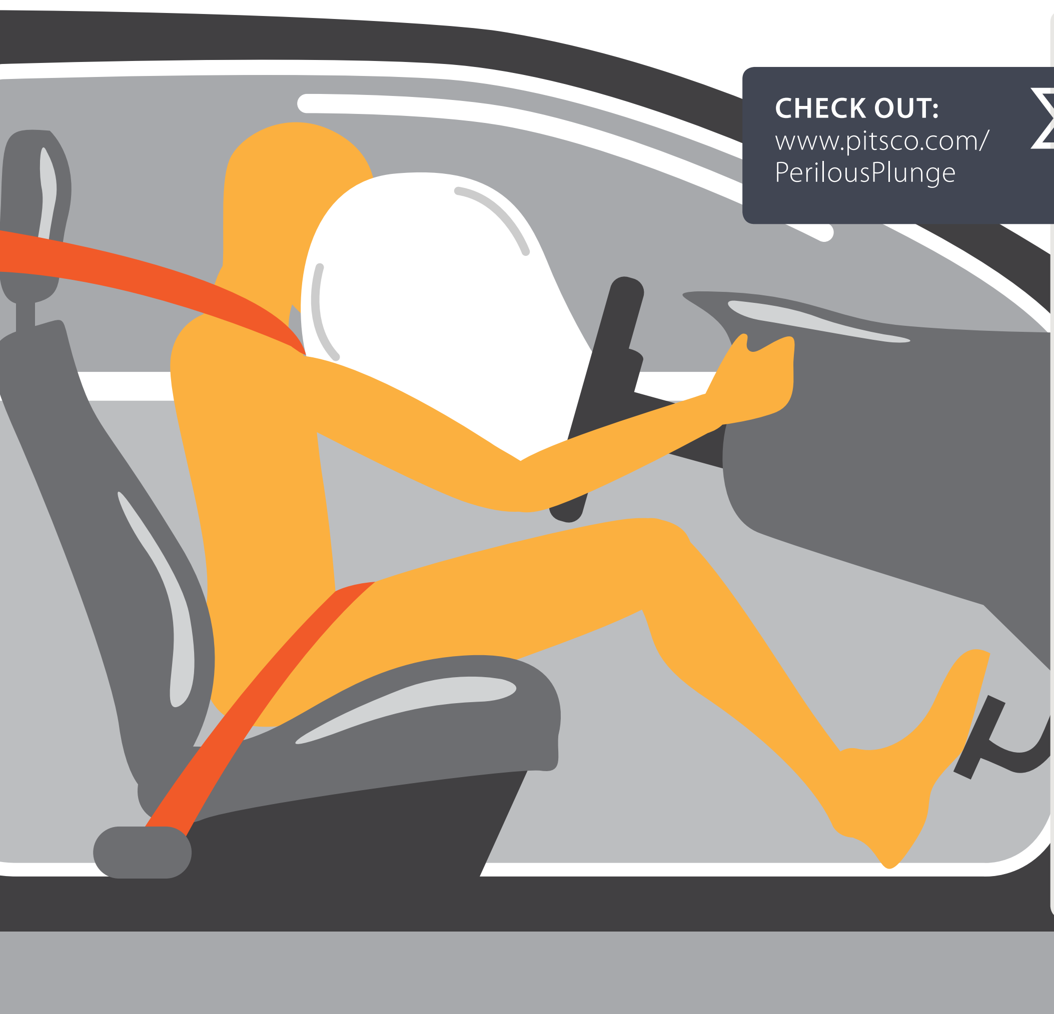
Most of us don't choose to swim with sharks or become stuntpersons in movies. But that doesn't mean everyday life is completely safe. One of the greatest potential dangers we regularly expose ourselves to happens when we ride in automobiles. Though crashes are rare, the extreme physical forces at play in a high-speed collision can be deadly.

This is why modern vehicles come equipped with several features that minimize the damage of an impact. The first line of defense is the structure of the automobile itself. It is made to absorb as much of the shock of impact as possible. The seatbelt is another protective device. But one of the most fascinating pieces of safety-making equipment in a vehicle is an air bag. Air bags are stored in the inner chambers of a car – often in the steering wheel or dashboard – and inflate very quickly when needed to give passengers a soft landing.

Momentum of a moving object is the tendency of that object to keep moving. Just how much momentum the object has is determined by its mass (the amount of matter in it) and its velocity (how fast the object is traveling in a direction). Because a passenger normally moves along smoothly with a car during a car trip, you might think that the passenger and the car share the same momentum. But when a car is stopped suddenly, we see this is not true. A person might continue to move forward even though the car does not.

The goal of an air bag is to counteract the effects of momentum. When a collision happens, numerous sensors in the car detect this. A computer in the car sends a jolt of electricity to a container that holds a solid block of chemicals. This causes the chemicals to combust very rapidly. The resulting chemical reactions typically produce nitrogen gas. This gas (not strictly air, despite the name) is what inflates the bag, and it happens in a matter of milliseconds.

Air bags are not inflated to high pressures. Overinflation could make the bag too firm or cause the passenger to bounce back. For this reason, an important feature of car air bags is that they begin deflating almost immediately. Vents on the side of the bag let out gas even as gas is filling it up. But this happens at a rate that is just slow enough for the bag to keep its shape during the first part of a collision while allowing some give right away after the collision has begun. ⚠



CHECK OUT:
www.pitsco.com/PerilousPlunge

Slow down quickly

Another item that brings a person to a slow stop in a potentially dangerous situation is a bungee cord. A bungee cord uses elasticity to achieve its result. Using the Pitsco Perilous Plunge, you can build a bungee cord out of rubber bands and test its effectiveness with a small doll or weight.

Here's the essence of how a bungee cord works. Before a daredevil leaps from a high platform, he or she has a lot of potential energy. (Read "Taking the Plunge" for an explanation of potential energy.) After the leap, this energy is converted into kinetic energy, the energy of movement. When it is pulled, the bungee cord stretches, converting kinetic energy into elastic energy, eventually bringing the person to a safe stop. ⚠

Making it safe **to breathe**

Gas masks can be used to protect humans in any number of situations in which the air is saturated with toxic chemicals or biological agents. In addition to using some chemical properties, most gas masks work by filtering the air through multiple layers with fine pores. The air molecules can pass through, but contaminants get stuck.

One layer is usually activated carbon, or activated charcoal. This layer has been treated to be especially porous, increasing the overall surface area by texturing it with many tiny holes. (Think of how a square foot of bumpy ground has more surface area than a square foot of flat land.) This increases its adsorptive properties, which means that atoms and bits of material get stuck to its surface. After a while, these filters form a film of material on them, which reduces the filter's effectiveness, and it must be changed.

Fact

Screenshot from The Great Train Robbery *(1903) by Edwin S. Porter. Public domain, commons.wikimedia.org/w/index.php?curid=5061007*

There were stunt performers long before there were movies. Acrobats in traveling circuses learned ways to take a tumble safely. According to Guinness World Records, the first movie stuntperson was Frank Hanaway, who was hired to fall from a horse in the 1903 film The Great Train Robbery.

(continued from page 1)

Taking the plunge

Usually these engineers work in teams and are employed by roller coaster design firms. Roller coasters are some of the largest contraptions in the world, and many types of expertise are needed. Safety is the number one concern. If it weren't, engineering roller coasters would be much simpler!

Extreme speeds and changes in direction can have dramatic effects on the human body. Changes in acceleration produce multiple g's of force. (Two g's is two times the force that gravity normally exerts, three g's is three times, and so on.) The effects of g-force on the body depend on how long the body is exposed to the force.

The body can actually withstand hundreds of g's as long as it is for an extremely short amount of time. But when we are counting multiple seconds, multiple g's can be deadly. Even the most extreme roller coasters in the world rarely expose the riders to more than 6 g's for long. What can out-of-control g-forces do to a person? Compression of the body, temporary or permanent blindness, lack of oxygen to the brain, and even death.

For the safety of riders, engineers must understand the physical forces at play. Every ride on a roller coaster is a delicate balance between danger and thrill. Rides are designed to push the human body right to the edge of comfort. It is the way that engineers skillfully use the laws of physics that makes this not a disastrous experience but a fun one.

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Student Name: ______________________ **Class/Hour**: __________

SySTEM Alert! Quiz (Volume 4, Number 5)

This quiz covers the information in *SySTEM Alert!* Volume 4, Number 5. Circle the letter of the correct answer or write the letter by the question number.

1. What type of gas typically inflates a car air bag?
   A. oxygen
   B. carbon monoxide
   C. nitrogen
   D. xenon

2. What is momentum?
   A. the tendency of a moving object to keep moving
   B. the force required to lift a heavy object
   C. a gas mixture used during an astronaut's prebreathe before a space walk
   D. a patented technique for making effective gas masks

3. The visor of the helmet for NASA's extravehicular mobility units is tinted with what mineral?
   A. copper
   B. bronze
   C. silver
   D. gold

4. If your body is moving fast enough to experience 3 g's of force, it is experiencing three times what?
   A. the force of Earth's gravity
   B. ground force
   C. atmospheric pressure
   D. Earth's normal acceleration

5. In a bungee jump, kinetic energy is converted into _______.
   A. potential energy
   B. elastic energy
   C. chemical energy
   D. solar energy

6. The activated charcoal used in gas masks is treated to be very _______.

A. porous
B. cold
C. smooth
D. hot

7. What is the name for the next generation of suits designed to take the place of the EMUs?

A. control module
B. space walk assembly
C. EVU
D. Z-series

8. According to Guinness World Records, the first movie stunt appeared in what year?

A. 1891
B. 1903
C. 1915
D. 1926

9. How many layers of material make up the arms of an extravehicular mobility unit?

A. 13
B. 14
C. 15
D. 16

10. When you're riding a roller coaster, when is the moment of maximum potential energy?

A. at the height of a loop
B. at the bottom of the last hill
C. at the top of the first big hill
D. right before a loop

Bonus question:

List as many safety devices or pieces of safety equipment in your school as you can.