Roller Coaster Physics

Ride Energy

- Potential energy – the energy an object has due to its height above ground
- Kinetic energy – the energy of a moving object
- The higher the first hill, the more potential energy the roller coaster will gain for the ride.
- Limitation: Potential energy is limited by air resistance creating a terminal velocity!

Friction

- Friction resists motion.
- To maintain a fast paced ride, friction (including air resistance) should be reduced.
- Friction is also useful in keeping the car on the track.
- Rolling friction occurs during the ride, sliding friction occurs during breaking at the end of the ride, static friction occurs when the ride begins.

Acceleration

- The thrill of the roller coaster is created by drastic acceleration.
- Acceleration can include speeding up, slowing down, or changing direction.
- The more times a roller coaster changes directions, the more thrilling the ride, thus roller coasters tend to have lots of direction changes.

Gravitational force

- Gravitational force on Earth occurs because the Earth exerts a force pulling everything toward the center.
- A g is a unit of acceleration equal to the acceleration caused by gravity.
- Since Earth's normal acceleration is $9.8 m/s^2$, an acceleration equal to 30 m/s^2 would exert 3 times the normal gravity.

G forces

- Under normal circumstances, Earth's gravity is equal to one G.
- Positive G forces create a feeling of increased weight and usually occur when traveling away from earth.
- Humans can safely experience up to about 4 Gs, or an acceleration of just under 40 m/s^2
- Positive Gs can cause blackouts, or a lack of blood to the brain.

G forces

- Negative Gs, or a decrease of acceleration towards earth, creates a feeling of decreased weight.
- Humans can safely experience up to ½ g negative.
- You experience negative g's when you are accelerating downward or toward earth.
- You are experiencing 1 negative g when you stand on your head.
- Negative gs cause redouts where all the blood rushes to your head.

Forces

- Forces are a push or pull.
- Unbalanced forces cause changes in motion.
- It is unbalanced forces that create the fun sensations on roller coasters and all of the thrilling movement.

Centripetal Forces

- Centripetal force is motion around a curve or circle. This motion will cause the object to gravitate inward toward the center.
- Centripetal forces cause the butterfly sensations during a loop or corkscrew of a roller coaster.
- Centripetal force may feel like an outward push due to your inertia but the car is being pulled to the inside.

Inertia and Momentum

- Inertia is the need for an object to resist change.
- A moving ball will want to keep moving until something (friction) stops it.
- Momentum is the amount of motion of an object. The more mass of an object, the more momentum it will have.
- Momentum and inertia are interconnected.

Newton's 3 Laws

- Law of Inertia: An object at rest will stay at rest and an object in motion will stay in motion until acted on by an unbalanced force.
- Law of acceleration: The net force on an object is equal to the mass of the object multiplied by it's acceleration. F=ma (Force equals mass times acceleration)

Newton's 3 Laws

- Law of interaction: To every action, there is an equal and opposite reaction.
- All three laws of motion help govern the happenings and limitations of roller coasters.