

Amusement Park Science



PURPOSE

To use experiences at an amusement park to bring real world meaning and application to mathematics and physics.

INTRODUCTION

Our God has created many things to bring us joy. He wants us to have fun and spend time laughing. God has also given his people gifts and abilities to design things that help us to have fun and bring enjoyment to our lives. Rides at amusement parks are a few of those man-made devices God has given us the knowledge to design. For many people, going to an amusement park is a very fun and enjoyable time that brings a lot of laughter and screams of joy. Let's spend some time learning about some of the science behind the rides at an amusement park.

LEARNING

1. Definitions:

- e *Acceleration* — the rate at which an object changes its speed or direction
- b *Apparent Weight* — the sensation a body feels when it is experiencing a force of gravity that is not being balanced by another force
- f *Force* — a push or a pull acting on an object
- h *Gravitational Potential Energy* — energy possessed by an object because of its height above the ground
- g *Kinetic Energy* — energy possessed by an object because of its motion
- a *Speed* — a measurement of how fast an object is moving; calculated by taking distance traveled and dividing by the time it takes
- c *Velocity* — the speed that an object moves and the direction that object moves
- d *Weight* — the force of gravity acting on an object

2. a. You experience the greatest kinetic energy at the point where you are traveling the fastest because that is where you have the most motion; more motion equals more kinetic energy.
- b. You experience the greatest gravitational potential energy (GPE) at the highest point of the ride because GPE is based on how high above the ground you are.
- c. Yes, you are accelerating. An acceleration is ANY change in speed or direction.

- d. The three ways that an object can accelerate are to speed up, slow down, or change direction. The gas pedal, brake pedal, and steering wheel can cause those accelerations.
- e. At the top of the second highest hill, you feel the least apparent weight because this is where you lift off your seat the most and have the least unbalanced weight.
3. Accelerometers are instruments designed by scientists to measure the “g force” felt by a passenger on a ride or an astronaut in a rocket. Accelerometers are calibrated in g's. A reading of 1 g equals an acceleration of 9.8 m/s^2 (9.8 meters per second per second), which is the acceleration due to the Earth's gravitational pull. As you live on Earth, you normally experience 1 g of acceleration. Listed below are the sensations of various g forces. These are rough estimates, but may be helpful in estimating the sensations felt on the various rides at an amusement park.

Accelerometer Reading	Sensation
+3.0 g	Three times heavier than normal <i>(maximum g's pulled by space shuttle)</i>
+2.0 g	Twice normal weight <i>(a very fast sports car getting to top speed in less than 2.5 seconds)</i>
+1.0 g	Normal weight
+0.5 g	½ normal weight <i>(you feel lighter)</i>
0.0 g	Weightlessness <i>(no force between passenger and seat; astronauts feel this in orbit)</i>
-0.5 g	½ normal weight <i>(but directed away from the passenger's seat)</i>

Your apparent weight is determined by the g force you experience. The greater the g-force, the greater the apparent weight.

- a. You experience the *largest* apparent weight (g force) at the bottom when it begins to stop.
- b. You experience the *least* apparent weight (g force) at the top when it begins to stop.
- c. You would have the *greatest* reading on your scale at the bottom when it begins to move upward.

- d. A falling object's apparent weight (g force) is zero, because there is no force to balance out the force of gravity. If you had a bathroom scale under you, there would be no reading on the scale because it is falling at the same rate as you.

DOING

1. Be sure your Cadet rode at least four of the following types of rides: a swinging pendulum ride, a circular motion ride, a rollercoaster without a vertical loop, a rollercoaster with a vertical loop, and a free fall ride.
2. Please note that the italicized answers are for *horizontal* circular motion rides like a carousel or merry-go-round.
 - a. Kinetic energy is highest at the fastest point of the ride; more motion equals more KE.
The kinetic energy will be constant because you do not get faster or slower.
 - b. The highest level of gravitational potential energy occurs at the highest point of the ride; more height equals more GPE.
It will be constant because you do not get higher or lower.
 - c. The greatest g-force is experienced at the bottom of the swing/hill/circle/drop; this is where you press into your seat the most and where the seat has to press against you the most to make you change your motion from going down to going up or stop.
There is not a point where the g-force was higher during the ride; you experience a constant force throughout the ride, except for starting and stopping.
 - d. There is less g-force at the top of the swing/hill/circle/drop; this is where you press into your seat the least and where the seat has to press against you the least to make you change your motion from going up to going down or start. The force of gravity is used to make this change instead of the seat of the ride.

There is not a point where the g-force was lower during the ride; you experience a constant force throughout the ride, except for starting and stopping.

3. Topical summaries:
 - a. Sir Isaac Newton is a famous scientist (and a Christian) who studied motion of various objects (including planets) as well as various other topics (like theology). His three laws are:
 - 1) An object at rest stays at rest and an object in motion stays in motion unless acted upon by an external net force.
 - 2) The acceleration of an object is directly proportional to the net force acting on that object and inversely proportional to the mass of that object.
 - 3) For every action there is an equal and opposite reaction.
 - b. Air-time is the sensation of lifting off your seat at the top of a hill on a rollercoaster. This sensation is due to your body trying to keep moving with the motion it had (up) while the seat moves away from you (down).
 - c. Wind/Air resistance and friction are both forces that work against the motion of an object that is moving. Both forces slow down the cars of rollercoaster and transfer some of the GPE and KE into heat energy that is dissipated and cannot be reused in the ride.
 - d. Circular loops have a constant radius/diameter, whereas a clothoid loop is more tear-shaped. The circular loops require a greater entry speed into the loop in order to keep the riders in their seats at the top of the loop and subjects the riders to greater g-forces. By using a clothoid loop, a smaller speed can be used and the riders experience more comfortable g-forces.