

Roller Coaster Physics

What are *g*-forces?

People accelerate when they ride such things as roller coasters, fast elevators, swings, and slides. The feeling this acceleration produces is due to the inertia (resistance to change in motion) of the body. The mass of the body resists acceleration and makes it feel like a force is pushing on the body. The inertia of the blood inside the body causes an additional effect.

- *Positive g*-forces cause extra blood to collect in the feet.
- *Negative g*-forces cause extra blood to collect in the head.

So, *g*-force is a way to describe how acceleration *feels*.

- 1*g* is the feeling we have when we stand on the ground, or sit in a roller coaster seat at rest in the station.
- 0*g* feels like there is no gravity. This is the feeling we get when we fall. You experience 0*g* on a roller coaster when you “fall” with no resistance – like “falling” down the first hill. You do not feel the seat at all.
- When experiencing an acceleration of 2*g*, you would feel twice as heavy as your normal weight. When you reach the bottom of a hill on a roller coaster and the track causes your car to rapidly change direction to go up the next hill (accelerate), you feel positive *g*-forces (usually between 2.5 and 4*g*). While accelerating, the liquid part of your body (blood) lags behind the solid part. This happens because of the inertia of the blood. As the body accelerates, the blood tends to stay where it was and so it collects in the feet and legs. You are pushed down into your seat.
- Accelerating downward faster than free fall will cause one to experience negative *g*-forces. While accelerating, the liquid part of your body (blood) lags behind the solid part. This happens because of the inertia of the blood. As the body accelerates, the blood tends to stay where it was and so it collects in the head. This happens when you rapidly go over the top of a hill and start back down again. You feel yourself coming off your seat. The liquids in your stomach will tend to rise causing nausea in some people.

Note that the “3” in 3*g*'s is a unit-less or dimensionless number. It's just a *positive* number that indicates how many “normal gravities” you are experiencing *and in what direction*. The term *Force Factor* rather than *g-force* is often used in Roller Coaster Physics.

$$\# \text{ } g \text{'s felt} = \frac{\text{acceleration felt}}{\text{acceleration of gravity}}$$

The concept of *g*-force (a measure of how we *feel*) in Lateral (side-to-side) acceleration is difficult. However, we will consider an increase in speed as positive acceleration and a decrease as negative acceleration. Thus, for lateral motion, we will consider acceleration as positive *g*'s and deceleration as negative *g*'s.