

CREW CHIEF NOTES: Gs

Introduction

A “G” is a unit. Just as we call twelve eggs a dozen, we likewise can measure acceleration in units of the earth’s gravitational pull. The G is one of the most misunderstood units, however, and it often is used incorrectly.

Gs

A ‘G’ is a unit of acceleration equal to the acceleration of the Earth’s gravity. Acceleration is how fast you’re changing speed, so its units are speed over time.

Anything falling with only the force of the Earth’s gravity will accelerate at a rate of 9.80 meters per second each second. (i.e. 32.2 feet per second every second)

$$1G = 9.81 \frac{\text{m}}{\text{s}} = 32.2 \frac{\text{ft}}{\text{s}} = 22.0 \frac{\text{mph}}{\text{s}}$$

We can also write this as

$$1G = 9.81 \frac{\text{m}}{\text{s}^2} = 32.2 \frac{\text{ft}}{\text{s}^2}$$

When a television broadcaster tells you that a driver experiences “2Gs”, it means

$$2G = 2 \times \left(9.81 \frac{\text{m}}{\text{s}^2} \right) = 19.9 \frac{\text{m}}{\text{s}^2}$$

To give you some feel for how big a “G” is: an average sneeze is an acceleration of 3 G, a cough is about 3.5 G, a moderate slap on the back is 4 G and jumping off a step produces about 8 G. Most amusement park rides top out at about 3G; however, some roller coasters go up to 4G (Sheikra Rollercoaster at Tampa) or 4.5G (e.g. the Titan Rollercoaster in Texas).

Large accelerations can cause physical problems due to the effect of the acceleration on blood pressure. Aerobatic and fighter pilots may sometimes experience 6 to 9 g, which can cause temporary loss of color vision, tunnel vision, or an inability to interpret verbal commands.¹

¹ http://www.woodbrothersracing.com/team_news2.cfm?ID=1201

Direction

Because we use a unit of acceleration that comes from gravity, it seems like a G should always pull downward, but acceleration can be in any direction. When you're on a roller coaster coming down a hill, or if you're falling, the acceleration is downward; however, when you're taking a corner, the acceleration is sideways. The arrows in Figure 1 show the direction of the acceleration for a car turning in a circle.

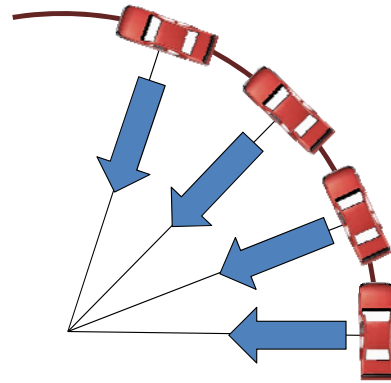


Figure 1: The force that makes a car turn in a circle always points toward the center of the circle.

“G-Force”

G-force is a commonly used term and sometimes it's used in confusing (and incorrect) ways. Newton's second law of motion tells us that acceleration produces a force proportional to the mass of the object times the acceleration.

$$F = ma$$

As you're sitting in your chair reading this, you're experiencing the acceleration due to Earth's gravity, so you're experiencing 1G. The force that corresponds to this acceleration is equal to your mass (in kilograms) times 1G, which happens to be equal to your weight. A drag racer who experiences 5G of acceleration feels a force five times his or her weight. The number before the “G” unit is the multiplier for how much force you feel in terms of your weight. So you might use “G-Force” to mean the force that results from the G's of acceleration. Just don't forget that force comes in units of newtons or pounds and acceleration in units of m/s^2 or ft/s^2 .

One reason for using Gs is because you can talk about accelerations independent of mass. Let's say two astronauts – one that weighs 150 lbs and one that weighs 300 lbs – experience 3 Gs when the space shuttle lifts off. The lighter astronaut experiences a force of 1500 lbs, while the heavier astronaut experiences a force of 3000 lbs, even though they both feel the same acceleration.

This is a case in which the difference between mass and weight in the British and metric systems can be confusing. Our two astronauts have masses of 68.0 kg and 136 kg. The forces they feel are their masses times the acceleration due to gravity (which gives us their weight), times the number of Gs they experience. The forces they experience are 1999 N and 3,998 N respectively.