Don't get me wrong: I love nuclear energy! It's just that I prefer fusion to fission. And it just so happens that there's an enormous fusion reactor safely banked a few million miles from us. It delivers more than we could ever use in just about 8 minutes. And it's wireless!

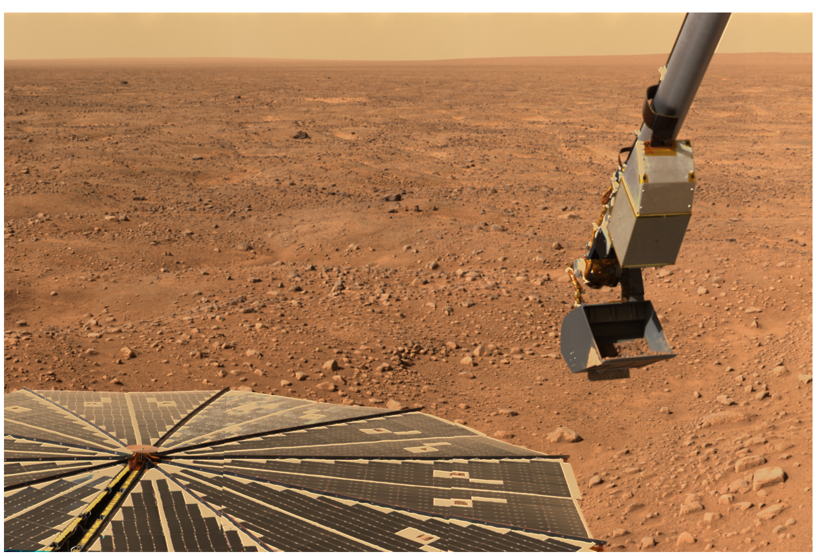
William McDonough

Weightless

Hi there. In this module we're going to talk about how we describe motion, and how is mass different than weight. And as part of that discussion, we'll talk a little bit about the idea of weightlessness. A terrible word. We'll see.

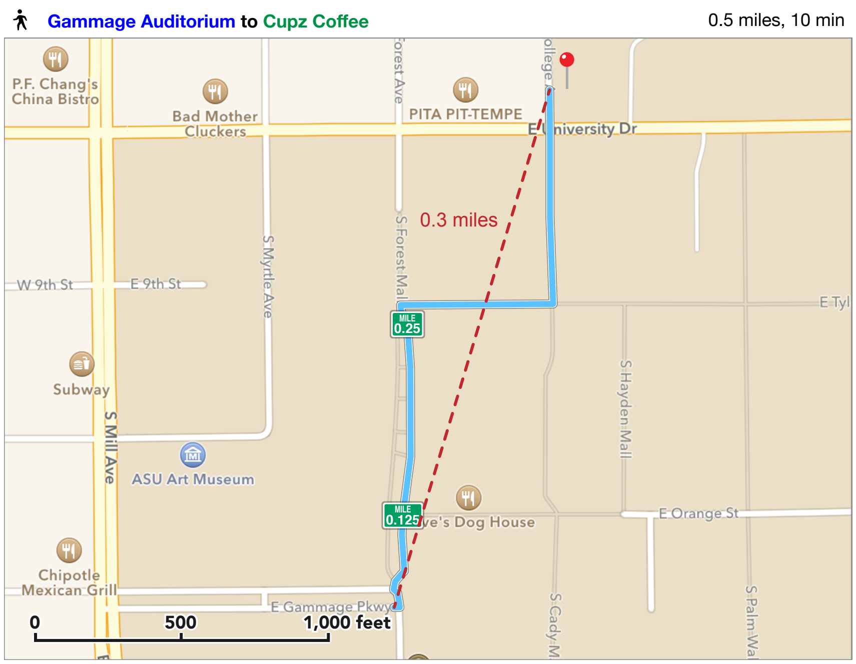
Credit:Wikipedia Public Commons

Think about what happens when you throw a ball to the dog as that dachshund in the image above is doing. When you throw the ball, the dog, after a little bit of learning, learns the trajectory. He learns the gravity. He learns where the ball is going to go, and he's able to go out and catch the ball, usually in the air, and then bring it back to you. That's a pretty good trick. The dog's learning, in some sense, the behavior of thrown object in Earth’s gravitational field.



Credit: NASA

But we can perform an even better trick. We figured out how to predict where the ball will land before we even throw it! And we can use that same trick to predict the motions of objects throughout the universe. We can perform that trick with such extraordinary position that we could land an object on Mars within 10 meters of where you want to put it, after a journey of about 100 million kilometers. So we're going to talk about the different types of motion. We'll get down some definitions of what we mean by motion.



Credit:Google Maps

Distance is a familiar quantity. We measure distances with tape measures, odometers, or other measuring devices. Distance measures how far away things are. Displacement, which might be less familiar, adds information about the direction to how far away something is. For example, 300 meters North or 1 cm to the right. This extra information about direction, essential for everyday life, distinguishes quantities known as “vectors” from quantities specified only by numbers. Distance is just a number. When both the distance and direction from one location to another location are specified, it is a displacement.

Credit:Wikipedia Public Commons

Speed is another familiar quantity. The speedometer in a car tells us how much territory we can cover in given time.

$$\text{speed} = \frac{\text{distance traveled}}{\text{time to travel that distance}}$$

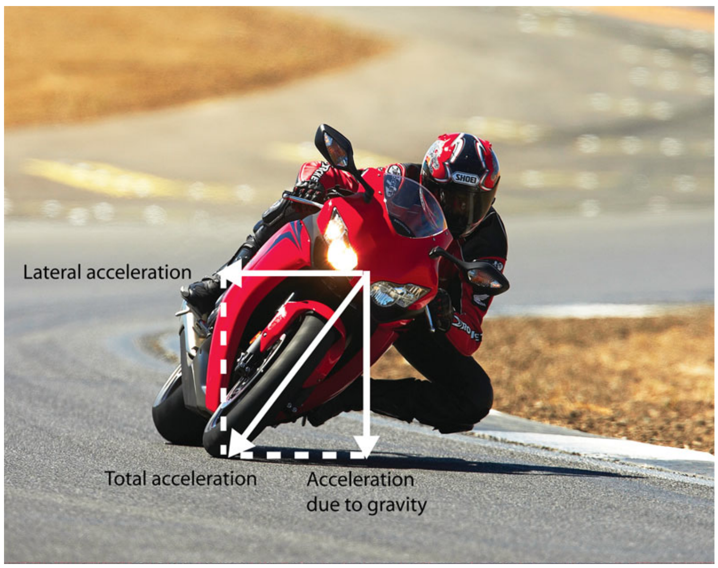
$$\text{velocity} = \frac{\text{displacement}}{\text{time to travel that displacement}}$$

We often use “speed” and “velocity” interchangeably in casual speech. But speed is just a number and velocity is a vector. Specifying a velocity gives the speed and the direction of that speed. 60 miles an hour, headed where? Toward Tucson? Toward Omaha? A velocity is a speed with a direction. 60 miles an hour toward Austin.

Credit: Emirates Motorplex

Acceleration is a measure of how rapidly velocity changes. The “accelerator” allows you to change the speed of the car. The more it is pushed, the greater the rate which your speed changes. The car's brakes are also an accelerator since they change the car's speed, as is the steering wheel since it changes the car's direction. Acceleration, like velocity and displacement, is a vector. We specify the numeric value of the acceleration and the direction of the change in velocity.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time to change the velocity}}$$



Credit: dataMC
http://www.datamc.org/2013/05/28/accelerometer-data-vs-gps-data/

For example, say you are going 30 miles an hour, along a straight line. Hit the accelerator and go up to 60 and that's an acceleration. You can feel yourself being pushed back in your car seat. But you can also get an acceleration by keeping a constant speed, 30 miles an hour, and turning, because you're changing directions. That gives rise to an acceleration, which you feel as you lean over in the car seat as the car goes around the turn, even though you're going constant speed. So acceleration is either a change in speed or a change in direction.

Credit:Wikipedia
Public Commons

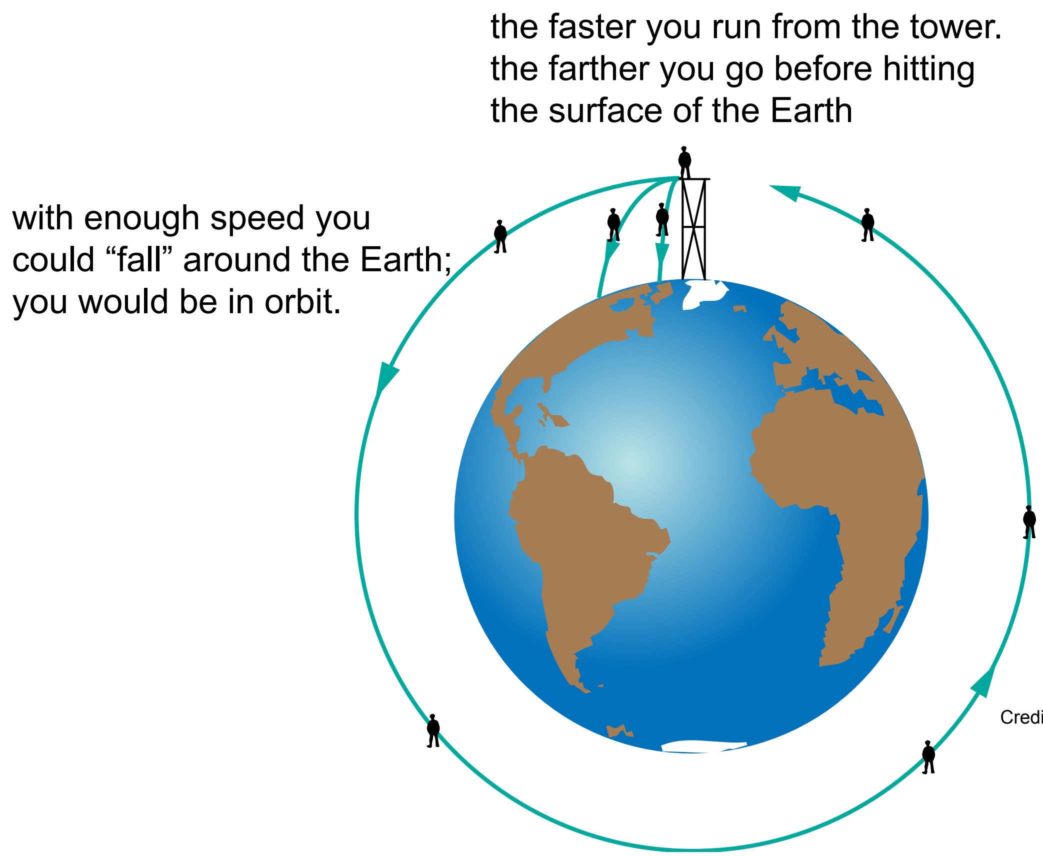
How is mass different than weight? People often confuse the idea of mass with that of weight. Mass is the amount of material in an object. It's the number of atoms that you've got. That never changes. It's the same no matter where it's located, whether it's located on Earth or Jupiter or out between the planets, because it's simply the number of atoms in whatever object we're talking about. Mass does not vary with the strength of gravity.

But the weight of that mass changes with gravity. You have the same number of atoms in your body, but you will weigh differently on Mars than you will on Earth because the strength of gravity is different. For example, the average US adult male has a mass of 81 kg. In Earth's gravitational field this mass has a weight of about 180 lbs but on, say, the surface of the Moon this same mass has a weight that is 6 times less, or 30 pounds: between mass and weight. And

Credit:Wikipedia
Public Commons

So we have to distinguish an object becomes weightless when it is in free fall. Even though it's mass hasn't changed. It still has the same number of atoms.

This might seem trivial, kind of easy - and it is! You'd be surprised then how many people get all confused on the next topic.



Credit: F.X. Timmes

Astronauts orbiting the Earth are weightless because they are continuously falling toward the Earth. They are not weightless because there's no gravity. There's plenty of gravity up where the Space Station is. That's why it's in orbit. They're continually falling toward the earth, but they never reach it. That's why they're weightless.

People get this bad idea that weightlessness means there's no gravity. Well, that's not true at all. Weightless simply means you are falling freely. You're in a state of free fall.

The image above shows that if you jump off a tower, you fall to Earth’s surface. While you fall you achieve weightlessness because you are freely falling. Get a running start and you’ll travel further horizontally before crashing into the surface. Weightlessness will last longer. Now get a super fast running start and you’ll travel much further horizontally, and be weightless longer, before hitting the surface. Finally run with enough horizontal speed off the tower and you will go into orbit, where you continually fall toward the Earth but you never reach it. Like any other free fall you achieve the state of weightlessness as you orbit.

Clear?

Thanks! Bye Bye.