Watch Your Weight

Overview: If you could stand on the Sun without being roasted, how much would you weigh? The gravitational pull is different for different objects. Let's find out which celestial object you'd crack the pavement on, and which your lightweight toes would have to be careful about jumping on in case you leapt off the planet.

What to Learn: Weight is nothing more than a measure of how much gravity is pulling on you. Mass is a measure of how much stuff you're made out of. Weight can change depending on the gravitational field you are standing in. Mass can only change if you lose an arm.

Materials

- Scale to weigh yourself
- Calculator
- Pencil

Experiment

1. We need to talk about the difference between weight and mass. In everyday language, weight and mass are used interchangeably, but scientists know better.
2. Mass is how much stuff something is made out of. If you're holding a bowling ball, you'll notice that it's hard to get started, and once it gets moving, it needs another push to get it to stop. If you leave the bowling ball on the floor, it stays put. Once you push it, it wants to stay moving. This "sluggishness" is called inertia. Mass is how much inertia an object has.
3. Every object with mass also has a gravitational field, and is attracted to everything else that has mass. The amount of gravity something has depends on how far apart the objects are. When you step on a bathroom scale, you are reading your weight, or how much attraction is between you and the Earth.
4. If you stepped on a scale in a spaceship that is parked from any planets, moons, black holes, or other objects, it would read zero. But is your mass zero? No way. You're still made of the same stuff you were on Earth, so your mass is the same. But you'd have no weight.
5. What is your weight on Earth? Let's find out now.
6. Step on the scale and read the number. Write it down.
7. Now, what is your weight on the Moon? The correction factor is 0.17. So multiply your weight by 0.17 to find what the scale would read on the Moon.
8. For example, if I weigh 100 pounds on Earth, then I'd weight only 17 pounds on the Moon. If the scale reads 10 kg on Earth, then it would read 1.7 kg on the Moon.
   Complete the data table..

Watch Your Weight Data Table

Weight on Planet/Object = Weight on Earth x Gravity Correction

Planet/Object	Weight on Earth	Gravity Correction	Weight on Planet/Object
The Sun		28	
Mercury		0.38	
Venus		0.91	
Earth		1	
Moon		0.17	
Mars		0.38	
Jupiter		2.14	
Saturn		0.91	
Uranus		0.86	
Neptune		1.1	
Pluto		0.08	
Outer Space		0	
Betelgeuse		14,000	
White Dwarf		1,300,000	
Neutron Star (Pulsar)		140,000,000,000	
Black Hole		∞	

Reading

Weight is nothing more than a measure of how much gravity is pulling on you. This is why you can be “weightless” in space. You are still made of stuff, but there’s no gravity to pull on you so you have no weight. The larger a body is, the more gravitational pull (or in other words the larger a gravitational field) it will have.

The Moon has a fairly small gravitational field (if you weighed 100 pounds on Earth, you’d only be 17 pounds on the Moon).The Earth’s field is fairly large and the Sun has a HUGE gravitational field (if you weighed 100 pounds on Earth, you’d weigh 2,500 pounds on the Sun!).

As a matter of fact, the dog and I both have gravitational fields! Since we are both bodies of mass, we have a gravitational field which will pull things toward us. All bodies have a gravitational field. However, my mass is so small that the gravitational field I have is miniscule. Something has to be very massive before it has a gravitational field that noticeably attracts another body.

So what’s the measurement for how much stuff you’re made of? Mass. Mass is basically a weightless measure of how much matter makes you ***you***. A hamster is made of a fairly small amount of stuff, so she has a small mass. I am made of more stuff, so my mass is greater than the hamster’s. Your house is made of even more stuff, so its mass is greater still. So, here’s a question. If you are “weightless” in space, do you still have mass? Yes, the amount of stuff you’re made of is the same on Earth as it is in your space ship. Mass does not change, but since weight is a measure for how much gravity is pulling on you, weight will change.

Did you notice that I put weightless in quotation marks? Wonder why?

Weightlessness is a myth! Believe it or not, one is never weightless. A person can be pretty close to weightless in very deep space, but the astronauts in a space ship actually do have a bit of weight.

Think about it for a second. If a space ship is orbiting the Earth, what is it doing? It’s constantly falling! If it wasn’t moving forward at tens of thousands of miles an hour it would hit the Earth. It’s moving fast enough to fall around the curvature of the Earth as it falls but, indeed, it’s falling as the Earth’s gravity is pulling it to us.

Otherwise the ship would float out to space. So what is the astronaut doing? She’s falling, too! The astronaut and the space ship are both falling to the Earth at the same rate of speed and so the astronaut feels weightless in space. If you were in an elevator and the cable snapped, you and the elevator would fall to the Earth at the same rate of speed. You’d feel weightless! (Don’t try this at home!)

Either now, or at some point in the future you may ask yourself this question, “How can gravity pull harder (put more force on some things, like bowling balls) and yet accelerate all things equally?” When we get into Newton’s laws in a few lessons, you’ll realize that doesn’t make any sense at all. More force equals more acceleration is basically Newton’s Second law.

Well, I don’t want to take too much time here since this is a little deeper then we need to go but I do feel some explanation is in order to avoid future confusion. The explanation for this is inertia. When we get to Newton’s First law we will discuss inertia. Inertia is basically how much force is needed to get something to move or stop moving.

Now, let’s get back to gravity and acceleration. Let’s take a look at a bowling ball and a golf ball. Gravity puts more force on the bowling ball than on the golf ball. So the bowling ball should accelerate faster since there’s more force on it. However, the bowling ball is heavier so it is harder to get it moving. Vice versa, the golf ball has less force pulling on it but it’s easier to get moving. Do you see it? The force and inertia thing equal out so that all things accelerate due to gravity at the same rate of speed!

Gravity had to be one of the first scientific discoveries. Whoever the first guy was to drop a rock on his foot, probably realized that things fall down! However, even though we have known about gravity for many years, it still remains one of the most elusive mysteries of science. At this point, nobody knows what makes things move toward a body of mass.

Why did the rock drop toward the Earth and on that guy's foot? We still don't know. We know that it does, but we don't know what causes a gravitational attraction between objects. Gravity is also a very weak force. Compared to magnetic forces and electrostatic forces, the gravitational force is extremely weak. How come? No one knows. A large amount of amazing brain power is being used to discover these mysteries of gravity. Maybe it will be you who figures this out!

Exercises

1. Of the following objects, which ones are attracted to one another by gravity?
   a) Apple and Banana b) Beagle and Chihuahua c) Earth and You d) All of the above

2. True or False: Gravity accelerates all things differently

3. True or False: Gravity pulls on all things differently

4. If I drop a golf ball and a golf cart at the same time from the same height, which hits the ground first?

5. There is a monkey hanging on the branch of a tree. A wildlife biologist wants to shoot a tranquilizer dart at the monkey to mark and study him. The biologist very carefully aims directly at the shoulder of the monkey and fires. However, the gun makes a loud enough noise that the monkey gets scared, lets go of the branch and falls directly downward. Does the dart hit where the biologist was aiming, or does it go higher or lower then he aimed? (This, by the way, is an old thought problem.)

Answers to Exercises: Watch Your Weight

1. Of the following objects, which ones are attracted to one another by gravity?

a) Apple and Banana b) Beagle and Chihuahua c) Earth and You d) All of the above

2. True or False: Gravity accelerates all things differently

3. True or False: Gravity pulls on all things differently

4. If I drop a golf ball and a golf cart at the same time from the same height, which hits the ground first? (They both hit the ground at the same time.)

5. There is a monkey hanging on the branch of a tree. A wildlife biologist wants to shoot a tranquilizer dart at the monkey to mark and study him. The biologist very carefully aims directly at the shoulder of the monkey and fires. However, the gun makes a loud enough noise that the monkey gets scared, lets go of the branch and falls directly downward. Does the dart hit where the biologist was aiming or does it go higher or lower then he aimed? (The monkey and the dart fall downward at the same rate of speed. So the dart would hit exactly where the biologist aimed! In fact, if the monkey didn't let go, the dart would have hit lower than the biologist aimed.)