The Biggest Misconceptions In Science Textbooks…and What To Do About It.

By Aurora Lipper, Supercharged Science

I'm getting ready to give a teleclass on the biggest *oops!* found in science textbooks, and I thought you'd enjoy an excerpt from my notes. If you've found one or more of these in your books, it's not the end of the world, but this may raise your awareness a few notches.

This article will outline the basic fundamental concepts in physics and give you real hands-on experiments you can share with your child that they will love. I've been teaching physics from grade school through college, and in this article I am going to address the common myths and misconceptions about physics and help you set the record straight.

Satellites don't move in orbit. If you drop a ball, it falls 16 feet the first second you release it. If you throw the ball horizontally, it will also fall 16 feet in the first second, even though it is moving horizontally… it moves both away from you and down to the ground.

Now consider another object, like a bullet shot horizontally. It travels a lot faster than you can throw – about 2,000 feet each second. But it will still fall 16 feet during that first second. Gravity pulls on all objects (like the ball and the bullet) the same way, no matter how fast they go.

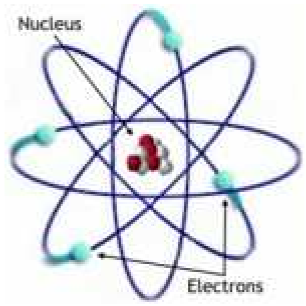
What if you shoot the bullet faster and faster? Gravity will still pull it down 16 feet during the first second, but remember that the surface of the Earth is round. Can you imagine how fast we'd need to shoot the bullet so that when the bullet falls 16 feet in one second, the Earth curves away from the bullet at the same rate of 16 feet each second?

Answer – that bullet needs to travel nearly *5 miles per second*. This is how satellites stay in orbit – going just fast enough to keep from falling inward and not too fast that they fly out of orbit. Satellites need to constantly course-correct to keep on track.

If an object is at rest, no forces are acting on the object. Every object on Earth is held together by at least one of the Four Fundamental Forces of Nature: the Strong force, the Weak force, the Electromagnetic force and Gravitation. These four forces are found within atoms and between objects, and they dictate the interactions between individual particles and the large-scale behavior of all matter throughout the universe. (Since the first two forces, the Strong and the Weak, require the use of a nuclear power plant, we'll focus on the second two forces.)

Gravitation is the force that is always attractive (never repels or pushes away). This is the force that pulls matter together and keeps your feet stuck to the sidewalk. Gravitation causes comets to sling through our solar system, binds the moon to its orbit around the Earth, and is the sworn enemy of major league baseball pitchers everywhere. We still don't know *why* gravitation works… only that it does. (Is gravity made up of tiny particles called *gravitons*? We really have no idea…)

Sit in a chair. If the Earth wasn't counteracting the gravitational downward pull, you'd fall to the center of the earth. You have a pair of forces acting on you –'gravitational' and 'normal'. ('Normal' is just the name scientist use to name this force and has nothing to do with your sanity.)



Positively charged objects gain protons. The reason you get a shock by scuffing along the carpet is in the realm of the Electromagnetic Force. This force determines how electrically charged particles interact, and is attractive or repulsive. Similar charges ("like charges") repel each other (two positive or two negative charges). Electromagnetic force is the dynamic behind blenders, dishwashers, aircraft engines, solar flares, and lasers… and is solely responsible for bad hair days worldwide.

When you scuff along the carpet, you are gathering additional electrons into your body and building up a negative charge, which stays with you until you touch the nose of your cat. (Although you will lose some through air leakage, but ignore that for now.) The electrons are the particles that orbit a nucleus of protons and neutrons. The forces that glue together the nucleus are the strongest forces ever found (hence called the 'Strong Force'), but the strength of this force depends on how far apart the objects are.

Energy and force are the same thing. Energy is a fuzzy concept and one of the most mis-defined concepts across the textbook spectrum. Put simply, energy is the amount of work that can be performed by a force, usually measured in Joules (J), Calories (cal), or British Thermal Units (BTU). The rate at which work is performed is called power, and is measured in Horsepower (hp) and Watts (W or kW).

When a marble sits on top of an icy hill, it has potential energy (energy *waiting* to be converted into power) and no kinetic energy (energy in motion). As the ball rolls and slides down the hill, the potential energy decreases and kinetic energy increases until you hit the bottom of the hill, when the potential energy has completely converted to kinetic energy.

Things 'use up' energy. Energy is always conserved, and this has nothing to do with running out of global resources. The conservation of energy is the idea that "*you get out what you put in"*. When you fuel your vehicle with gas or electricity, that energy is converted into work you can see (the car cruising down the road) as well as things you may have not noticed (heat from the engine, headlights, sound energy, recharging your electrical battery, etc.). But not all machines are as complex as the internal combustion engine – chances are you are using several simple machines every day in your home.

Simple machines make our lives easier. They make it easier to lift, move and build things. Chances are that you use simple machines more than you think. If you have ever screwed in a light bulb, put the lid on a jam jar, put keys on a keychain, pierced food with a fork, walked up a ramp, or propped open a door, you've made good use of simple machines.

The only natural motion is for an object to be at rest. Take a look at the first law of motion. When you place a ball on the floor, it stays put. A science textbook will tell you this: *An object at rest tends to stay at rest… unless acted upon by an external force.* Your foot is an external force… so kick the ball!

Will the ball go on forever? Inside the house, the ball can hit a wall or window, so when you check with the science textbook you also read: *An object in motion tends to stay in motion unless acted upon by an external force.* After you kicked the ball (external force), it flies through the air until it smacks into something (another external force).

What about outer space? If you tossed your ball in space (away from any nearby gravitational pulls like black holes or galaxies), it would continue in a straight line forever. Since there aren't any molecules to collide with, and no gravitational effects to pull it off-course, the ball zooms through the space until something else makes it zoom off-course. Nothing unnatural about being in motion, is there?

But there are two other forces acting on the ball that you can't see. One force is air resistance. The ball smacks into tiny air molecules as it flies through the air. The other force is gravitational. Gravity is inherent in anything that has mass (including you!), but you need something the size of a planet before you can begin to see the effect this has on other objects. So the universe is a dynamic place, full of motion and interacting forces.

Centrifugal and centripetal acceleration are the same thing. These two terms constantly throw students into frenzy, mostly because there is no clear definition in most textbooks. Here's the scoop: **centripetal** (translation = "center-seeking") **force is the force needed to keep an object following a curved path.**

Remember how objects will travel in a straight line unless they bump into something or have another force acting on it (gravity, drag force, etc.)? Well, to keep the bucket of water swinging in a curved arc, the centripetal force can be felt in the tension experienced by the handle (or your arm, in our case). Swinging an object around on a string will cause the rope to undergo tension (centripetal force), and if your rope isn't strong enough, it will snap and break, sending the mass flying off in a tangent (straight) line until gravity and drag force pull the object to a stop. This force is proportional to the square of the speed… the faster you swing the object, the higher the force.

Centrifugal (translation = "center-fleeing") force has two different definitions, which also causes confusion. **The inertial centrifugal force is the most widely referred to, and is purely mathematical**, having to do with calculating kinetic forces using reference frames, and is used with Newton's laws of motion. It's often referred to as the 'fictitious force'.

The other kind, **reactive centrifugal force, happens when objects move in a curved path.** This force is actually the same magnitude as centripetal force, but in the opposite direction, and you can think of it as the reaction force to the centripetal force. Think of how you stand on the Earth… your weight pushes down on the Earth, and a reaction force (called the "normal" force) pushes up in reaction to your weight, keeping you from falling to the center of the Earth. A centrifugal governor (spinning masses that regulate the speed of an engine) and a centrifugal clutch (spinning disk with two masses separated by a spring inside) are examples of this kind of force in action.

One more example: Imagine driving a car along a banked turn. The road exerts a centripetal force on the car, keeping the car moving in a curved path (the "banked" turn). If you neglected to buckle your seat belt and the seats have a fresh coat of Armor-All (making them slippery), then as the car turns along the banked curve, you get "shoved" toward the door. But who pushed you? No one – your body wanted to continue in a straight line but the car keeps moving in your path, turning your body in a curve. **The push of your weight on the door is the reactive centrifugal force, and the car pushing on you is the centripetal force.**

What about the fictitious (inertial) centrifugal force? Well, if you imagine being inside the car as it is banking with the windows blacked out, you suddenly feel a magical 'push' toward the door away from the center of the bend. This "push" is the fictitious force invoked because the car's motion and acceleration is hidden from you (the observer) in the reference frame moving within the car.

There are more misconceptions – lots more, in fact, including: velocity and speed are the same thing, the seasons are caused by the earth's distance from the sun, all metals are attracted to magnets, mirrors reverse everything, how light is instantaneous, gasses don't have mass, sound travels faster in gases than solids, all elements have three phases, and so on. But life is full of opportunities which are driven by curiosity, and you now have the seven biggest physics myths set straight to get you started on your learning adventure. Are you ready?