Newton's Laws of Motion:
An Overview and Christian Perspective

Introduction

Galileo wrote that mathematics is the language with which God wrote the universe. In other words, God usually operates the natural world according to patterns that can be described with mathematics. A simpler way to explain this to younger students is, "God usually makes nature obey mathematical rules." Newton's laws of motion are examples of these mathematical patterns or rules.

It is important to emphasize the word *usually* in the statements above. For a number of reasons, including success at explaining many aspects of the universe's structure and function, natural science has achieved privileged status in much of the world today. It is easy to assume that real knowledge comes from scientific inquiry, and other areas of human endeavor such as theology and philosophy or poetry and the arts are *less useful*. However, Christians do not consider the universe a closed system; it is always under the care and direction of God. The patterns we study with science are only part of the picture; God can and does do as he pleases with the natural world. Sometimes we give the name "miracle" to events that startle us and fall outside these patterns. However, God might be doing undetectable things that fall outside these patterns at any time. So we must say the universe *usually*, but not always, follows mathematical patterns. For an exploration of how the normal patterns in nature are a gift from God, see "Activity 4: Boring or Blessing."

Determining whether other ways of knowing are less useful than science also depends on the expected *purpose*. If one needs a heart transplant, science is indeed more useful for determining proper technique. However, if wrestling with whether one's life is worth extending with a transplant, then theology and philosophy, poetry and the arts are more useful. Newton's laws took astronauts to the moon; they are a gift from God. But they are neither complete descriptions of how objects move (see the conclusion, below) nor can they answer life's larger questions.

Law #1: Inertia

Newton's first law of motion is easier to state than it is to understand. Do not be surprised if it takes time for students to get the idea. Simply stated, the first law is, *an object's mass makes it resist changing its motion*. This resistance is called inertia and is measured in kilograms (or any other unit of mass). A 4-kg rock has twice the inertia of a 2-kg rock. Another version of the law is, "An object at rest tends to stay at rest and an object in motion tends to stay in motion in a straight line and at the same speed." The longer version points out that a change in motion can take the form of a change in speed or direction.

Before Galileo and Newton, people assumed it was natural for moving objects to slow to a stop, and that they would only continue moving if they were pushed or pulled. This is what happens on Earth, where friction with surfaces, air, or water gradually slow and stop moving objects left to themselves. Newton, building on Galileo's work, overturned this idea and argued that neither being at rest nor being in motion are natural states for objects; rather, objects naturally maintain whatever motion they presently have and the more massive the object, the greater this tendency.

Inertia makes extended space travel possible, or at least easier to accomplish. It was not necessary for the Apollo spaceships to carry large amounts of fuel to drive them to the moon and back, a round trip of about one half million miles. Once a craft is at proper speed and beyond the frictional drag of Earth's atmosphere, it simply continues at that speed without additional propulsion. Of course, additional propulsion is needed to adjust direction and to land on and escape from the moon. When astronaut William A. Anders was asked who was driving the Apollo 8 module on its way back from the moon the day after Christmas in 1968, he replied, "I think Isaac Newton is doing most of the driving now" (http://www.nmspacemuseum.org/halloffame/detail.php?id=71).

Law #2: F=ma

Newton's second law of motion explains the mathematical rule God uses to overcome inertia and to cause objects to change their motion. The relationship is expressed in the equation $F = ma$, where F is an unbalanced force on an object (a push or pull *on* the object from outside, not a force *from* the object itself like a person pulling her own arm), m is the object's mass (the measure of its inertia), and a is how quickly the object's motion changes (its acceleration: how quickly it speeds up, slows down, or turns). The equation is more intelligible when written in the form $a = F/m$. In this form, students more readily see that a greater force causes motion to change more quickly (increasing the numerator of a fraction makes the quantity's value greater) while a larger mass does the opposite (increasing a fraction's denominator decreases the quantity). In other words, an object must be *forced* to change its motion against the resistance of its mass. God's wisdom in building this rule into creation becomes obvious with two simple observations: If objects changed their motion or, for example, slowed down on their own, how would planets continue in orbit? On the other hand, if inertia could not be overcome, how would planets continue in orbit? Earth's curved orbit is the result of the planet constantly changing direction due to the sun's gravitational pull. Human life would not be possible without this orbit.

Law #3: Action-Reaction

Newton's third law of motion, "For every action, there is an equal and opposite reaction," is fun to explore. It explains many things we observe daily, and also serves to review and reinforce the first two laws. However, it is counter-intuitive. Students might be slow to grasp and/or accepts its implications, so be patient.

The third law of motion springs from the second. If objects only change their motion in response to an unbalanced *outside* force (not a force *from* the object but *on* it from something else), than how can we explain a bouncing ball? The ball cannot throw itself back up off the ground. Newton's second law indicates that the ball bounces upward because the ground hit it, at the very moment the ball hit the ground, with no delay. Obviously the ground must have hit the ball in the opposite direction so the ball accelerated upward. The part about the ground hitting the ball equally hard (as hard as the ball hit it) is less obvious, because the ball does not bounce as high as it fell. There are other reasons for that energy loss, but it is clear that the ground did not hit it *harder* because the ball does not bounce *higher* than it fell.

Implications can make the law seem bizarre. You walk forward not because your foot pushes you, but because the *ground* does. (You cannot push yourself; you push the ground and it pushes back.) You can break your hand by punching a wall, because the wall hits you back. You cannot break a hand punching a piece of tissue paper because the tissue cannot push back hard enough before it tears. How does an object "know" to push back at the exact moment it is pushed, and to stop pushing the instant the first push stops? It seems like the law treats objects as having awareness. It does *not* do that, but this is fun to explore with students. Remind students that the way the universe works is sometimes mysterious and surprising and this is exactly what we should expect from the God described in the Bible, who is so much more than we can imagine. Strange things in nature, such as relativity, quantum mechanics, and the wave-particle duality of light are not threats to faith. They remind us that we are *not* God and that the God who exists is so far beyond us as to be beyond imagining. Taken in conjunction with the Bible's message of God's incarnation and love for us in Christ, all of this is truly wonder-full!

Conclusion: Laws of Nature

Some people, including some scientists, assume the physical universe or even a multiverse, is all that exists. Christians disagree, believing the universe to be the temporal creation of a timeless and infinite God. When an atheist speaks of a *law of nature*, supported by abundant experimental data, the term itself might bolster her conviction that belief in a God who violates such laws is unscientific nonsense. It is therefore important, at the end of a unit like this one, for students to be reminded of what Christians mean when they refer to Newton's *laws* of motion. Christians regard laws of nature as highly consistent patterns in the way God governs nature, but not properties inherent in the universe itself that prevent God from doing unusual things, such as raising Jesus from the dead. These patterns are not *laws* in the sense that God must obey them; they are merely consistent patterns scientists observe in the way God operates his creation. When God does otherwise, as in Jesus' resurrection, God does not violate any law; he simply operates the universe differently than usual.

In general terms, a scientific law is a statement about the universe and how it behaves that is made based on abundant observations which indicate the statement applies in appropriate circumstances, at all times and everywhere. From a Christian perspective this means God is dependable and operates his universe in consistent ways for which we can be grateful. The consistency of these laws means that we can state many of them mathematically. If students ask about how Newton's laws of motion are mathematical, the first law of inertia is mathematical because the measure of an object's inertia is its mass. The first law thus overlaps with the equation for the second law ($F = ma$; m is the mass of the object). The third law can be stated mathematically as $F1 = -F2$ if the negative sign denotes a direction for F2 that is opposite that of F1.

It is important to note that laws of nature, despite their abundant observational support and usefulness in appropriate situations, are not the final word. God's governance of the universe is more complex than the patterns we call laws of nature imply. For example, scientists have long realized that Newton's laws by themselves do not predict the orbital motion of Mercury with pinpoint accuracy. It took Einstein's theory of general relativity to explain why. Mercury is so close to the massive sun that the relativistic warping of space and time in that region causes a noticeable effect on its orbit; replacing Newton's equations with Einstein's clears up the discrepancy. (This five-minute video is helpful: https://www.youtube.com/watch?v=hSXNE0pNtr8.) Another example of the need for Einstein's mathematics is in correcting signals from GPS satellites; the result is a level of accuracy in GPS measurements that would not be possible otherwise. (A helpful explanation is at http://www.astronomy.ohio-state.edu/~pogge/Ast162/Unit5/gps.html.) Bizarre examples of the limitations of otherwise well-supported scientific ideas can also be drawn from quantum physics. The observation that very tiny objects seem to exist in two places at once, at least until observed in one place or the other, stretches the imagination. (An interesting article describing some of this "quantum weirdness" is found at http://www.nytimes.com/2015/02/22/opinion/sunday/the-reality-of-quantum-weirdness.html?_r=0. Advanced students might discuss what implications quantum weirdness has for the notion that the physical universe is just a predictable machine and for how we understand the distinction between natural processes and miracles.)

Science continues to find there is more to how God sustains and operates the universe than is captured by the laws of nature as presently understood. This does not mean natural laws do not exist to explain these new twists; it merely means that we have yet to discover all the patterns in God's governance of creation. The patterns we presently understand are very useful but there are certainly surprises to come. Christians in the sciences find that exploring the natural world promotes humility and worship.