Motion

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When you place a book on a table, why does the book stay there and not suddenly scoot off to the side? When you drop a rubber ball, why does it fall and then bounce? The answers to these questions belong to the science called *mechanics*, the branch of physics concerned with how and why objects move—that is, with the forces that cause objects to move and the principles that guide their movement. This knowledge has important applications in everything from building safe roads to launching satellites into space.

Newton's Laws of Motion

Isaac Newton developed three basic principles, or laws, that are still used to analyze forces and their effects.

First Law of Motion

Newton's first law of motion is usually stated as follows: *A body at rest stays at rest, and a body in motion continues in motion at a constant speed in a straight line unless acted upon by a net force*.

This law describes the concept of *inertia*—the tendency of an object to remain at a constant velocity. In the case of an object at rest, the velocity is zero. As stated previously, an object at rest is in equilibrium and stays that way unless the forces acting on it become unbalanced. The same principle applies equally to moving objects. Moving objects also maintain their velocity—their speed and direction of movement—until some net force acts to change it. Another way to state Newton's first law is that when the forces acting upon a body are balanced, there is no acceleration.

At first glance, this may not seem to be so obvious a proposition. If Newton's first law holds true, shouldn't an automobile traveling down a straight, level road keep traveling at the same speed when the motor is shut off (instead of gradually slowing)? The answer is that when an automobile moves along a road, it is continually held back by the resisting forces of road friction and air resistance (*Figure 4*). To counteract these resisting forces, there must be a balancing force, originating in the motor and applied at the wheels. The automobile can travel at a constant speed in a straight line only when the driving force at the wheels balances the resistance of the air and the road.

Two factors affect the ability of a car or any other moving object to resist change. One is its velocity; the other is its mass. It is difficult to stop the motion of a bullet because of its extreme velocity. It is also difficult to stop the motion of a slowly moving automobile because of its mass. The two factors of mass and velocity, when multiplied together, give objects *momentum*. The mass of a body is constant. Hence, to change the momentum, it is necessary to change the velocity. To change the velocity (either the rate of speed or the direction or both), and thus cause an acceleration, requires a force.

You may experience Newton's first law of motion firsthand if you are a passenger in a car that stops suddenly. When the driver applies the brakes, the wheels stop turning: the force of road friction stops the car. But there is no such force acting on you, the passenger, to change your state of motion. Your body shoots forward due to inertia—unless, of course, you are properly restrained with a seat belt or, in a collision, by an air bag. Newton's first law is sometimes called the law of inertia.

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