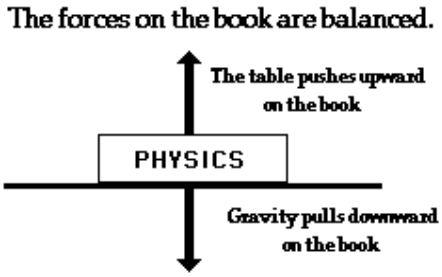
According to Newton's first law, an object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force. It is the natural tendency of objects to keep on doing what they're doing. All objects resist changes in their state of motion. In the absence of an unbalanced force, an oject in motion will maintain this state of motion. This is often called the *law of inertia*.

Consider for instance the unfortunate collision of a car with a wall. Upon contact with the wall, an unbalanced force acts upon the car to abruptly decelerate it to rest. Any passengers in the car will also be deccelerated to rest if they are strapped to the car by seat belts. Being strapped tightly to the car, the passengers share the same state of motion as the car. As the car accelerates, the passengers accelerate with it; as the car decelerates, the passengers decelerate with it; and as the car maintains a constant speed, the passengers maintain a constant speed as well.

If the car were to abruptly stop and the seat belts were not being worn, then the passengers in motion would continue in motion. Assuming a negligible amount of friction between the passengers and the seats, the passengers would likely be propelled from the car and be hurled into the air.

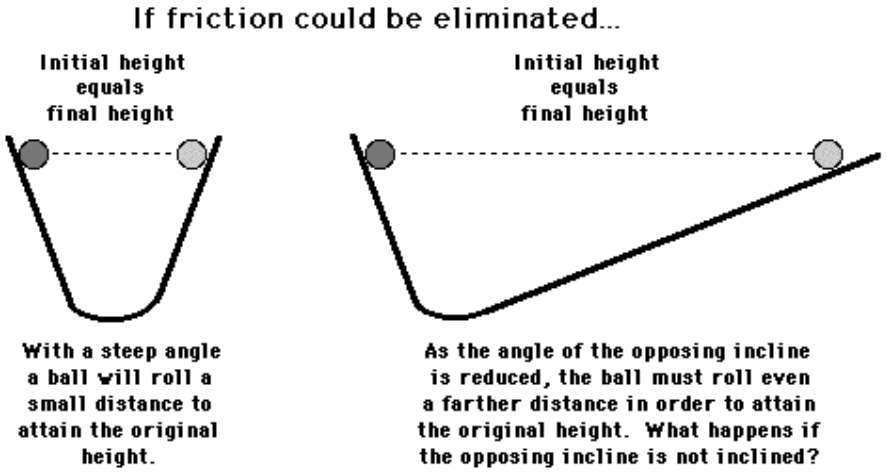
> An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

But what exactly is meant by the phrase **unbalanced force**? What is an unbalanced force? In pursuit of an answer, we will first consider a physics book at rest on a table top. There are two forces acting upon the book. One force - the Earth's gravitational pull - exerts a downward force. The other force - the push of the table on the book (sometimes referred to as a *normal force*) - pushes upward on the book.



Since these two forces are of equal magnitude and in opposite directions, they balance each other. The book is said to be at **equilibrium**. There is no unbalanced force acting upon the book and thus the book maintains its state of motion. When all the forces acting upon an object balance each other, the object will be at equilibrium; it will not accelerated.
Consider another example of a balanced force - a person standing upon the ground. There are two forces acting upon the person. The force of gravity exerts a downward force. The floor of the floor exerts an upward force.

Since these two forces are of equal magnitude and in opposite directions, they balance each other. The person is at equilibrium. There is no unbalanced force acting upon the person and thus the person maintains its state of motion.



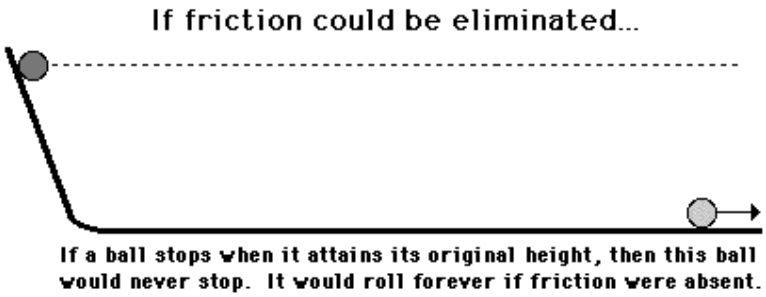
Now consider a book sliding from left to right across a table top. Sometime previous to its motion, it may have been given a shove and set in motion from a rest position. Or perhaps it acquired its motion by sliding down an incline from an elevated position. Whatever the case, our focus is not upon the history of the book but rather upon the current situation of a book sliding across a table top. The book is in motion and at the moment there is no one pushing it to the right.

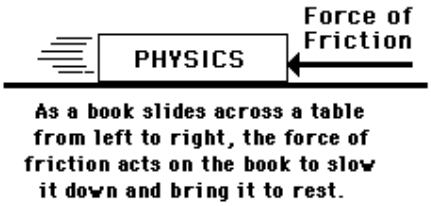
The force of gravity pulling downward and the force of the table pushing upwards on the book are of equal magnitude and opposite directions. These two forces balance each other. Yet there is no force present to balance the force of friction. As the book moves to the right, friction acts to the left to slow the book down. There is an unbalanced force; and as such, the book changes its state of motion. The book is not at equilibrium and subsequently accelerates. Unbalanced forces cause accelerations. In this case, since the unbalanced force is directed opposite the object's motion, it will cause a deceleration (a slowing down of the object).
If two individual forces are of equal magnitude and opposite direction, then the forces are said to be balanced. An object is said to be "acted upon by an unbalanced force" only when there is an individual force which is <u>not</u> being balanced by a force of equal magnitude and in the opposite direction .

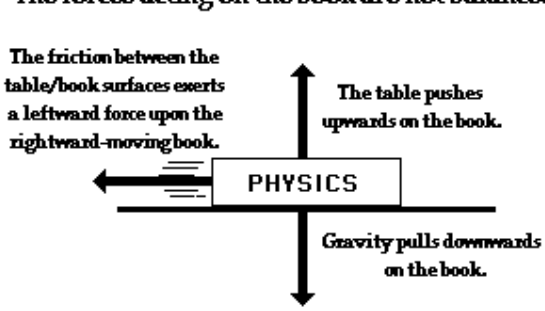
Inertia and Mass

Inertia = the resistance an object has to a change in its state of motion.

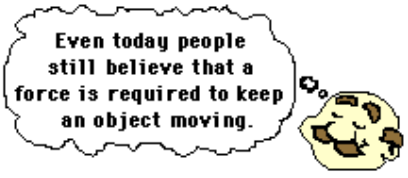
Galileo, the premier scientist of the seventeenth century, developed the concept of inertia. Galileo reasoned that moving objects eventually stop because of a force called friction. In experiments using a pair of inclined planes facing each other, Galileo observed that a ball will roll down one plane and up the opposite plane to approximately the same height. If smoother planes were used, the ball would roll up the opposite plane even closer to the original height. Galileo reasoned that any difference between initial and final heights was due to the presence of friction. Galileo postulated that if friction could be entirely eliminated, then the ball would reach exactly the same height.
Galileo further observed that regardless of the angle at which the planes were oriented, the final height was almost always equal to the initial height. If the slope of the opposite incline was reduced, then the ball would roll a further distance in order to reach that original height.







Isaac Newton built on Galileo's thoughts about motion. Newton's first law of motion declares that a force is <u>not</u> needed to keep an object in motion. Slide a book across a table and watch it slide to a rest position. The book in motion on the table top does not come to a rest position because of the *absence* of a force; rather it is the *presence* of a force - that force being the force of friction - which brings the book to a rest position. In the absence of a force of friction, the book would continue in motion with the same speed and direction - forever! (Or at least to the end of the table top.) A force is not required to keep a moving book in motion; in actuality, it is a force which brings the book to rest.



All objects resist changes in their state of motion. All objects have this tendency - they have inertia. But do some objects have more of a tendency to resist changes than others? Absolutely yes! The tendency of an object to resist changes in its state of motion is dependent upon mass. Inertia is that quantity which is <u>exclusively</u> dependent upon mass. The more mass which an object has, the more inertia it has - the more tendency it has to resist changes in its state of motion.

Suppose that there are two seemingly identical bricks at rest on the physics lecture table. Yet one brick consists of mortar and the other brick consists of Styrofoam. Without lifting the bricks, how could you tell which brick was the *Styrofoam brick*? You could give the bricks an identical push in an effort to change their state of motion. The brick which offers the least resistance is the brick with the least inertia - and therefore the brick with the least mass (i.e., the *Styrofoam brick*).