Summary

THE BIG IDEA **Forces cause changes in motion.**

3.1 Aristotle on Motion

Aristotle, the foremost Greek scientist, studied motion and divided it into two types: *natural motion* and *violent motion*.

- During Aristotle's time, natural motion on Earth was thought to be either straight up or straight down: It was "natural" for heavy things to fall and for very light things to rise.
- Violent motion was imposed motion and it was the result of forces that pushed or pulled.
- The proper state of objects was thought to be one of rest, unless they were being pushed or pulled or were moving toward their natural resting place.

3.2 Copernicus and the Moving Earth

Copernicus reasoned that the simplest way to interpret astronomical observations was to assume that Earth and the other planets move around the sun.

- Copernicus' idea of motion in space was extremely controversial at the time, because most people believed that Earth was at the center of the universe.
- Copernicus worked on his ideas in secret to escape persecution. At the urging of his close friends, he published his ideas.

3.3 Galileo on Motion

Galileo argued that only when friction is present—as it usually is—is a force needed to keep an object moving.

- One of Galileo's greatest contributions to physics was demolishing the notion that a force is necessary to keep an object moving. A force is any push or pull.
- **Friction** is the force that acts between materials that touch as they move past each other.
- Galileo found that a ball rolling on a smooth horizontal plane has almost constant velocity, and if friction were entirely absent, the ball would move forever. Galileo also stated that the tendency of a moving body to keep moving is natural and that every object resists change to its state of motion.
- The property of a body to resist changes to its state of motion is called **inertia.**

3.4 Newton's Law of Inertia

Newton's first law states that every object continues in a state of rest, or of uniform speed in a straight line, unless acted on by a nonzero net force.

- Isaac Newton's laws of motion replaced the Aristotelian ideas that had dominated thinking for about 2000 years.
- **Newton's first law** is usually called the **law of inertia.**
- Forces are needed to overcome any friction that may be present. Forces are also needed to set objects in motion initially.
- Once an object is moving in a force-free environment, it will move in a straight line indefinitely.

3.5 Mass—A Measure of Inertia

The more mass an object has, the greater its inertia and the more force it takes to change its state of motion.

- **Mass** is the quantity of matter in an object. Mass is a measure of the inertia of an object. Mass is measured in the fundamental unit of **kilograms.**
- **Weight** is the force of gravity on an object. Weight depends on an object's location. The mass of an object is the same whether the object is located on Earth, on the moon, or in outer space.
- Mass and weight are proportional to each other in a given place. Objects with great mass have great weight; objects with little mass have little weight.
- In most parts of the world, the measure of matter is commonly expressed in units of mass. The SI unit of mass is the kilogram and its symbol is kg.
- The SI unit of *force* is the **newton.** The SI sym*bol for th*e newton is N and is written with a capital letter because it is named after a person.

3.6 The Moving Earth Again

The law of inertia states that objects in motion remain in motion if no unbalanced forces act on them.

- Copernicus announced the idea of a moving Earth in the sixteenth century. This controversial idea stimulated much argument and debate.
- Newton's work showed that objects on Earth move with Earth as Earth moves around the sun. The law of inertia also shows that objects within moving vehicles move with the vehicles.
- Notions of motion today are very different from those of our distant ancestors.