

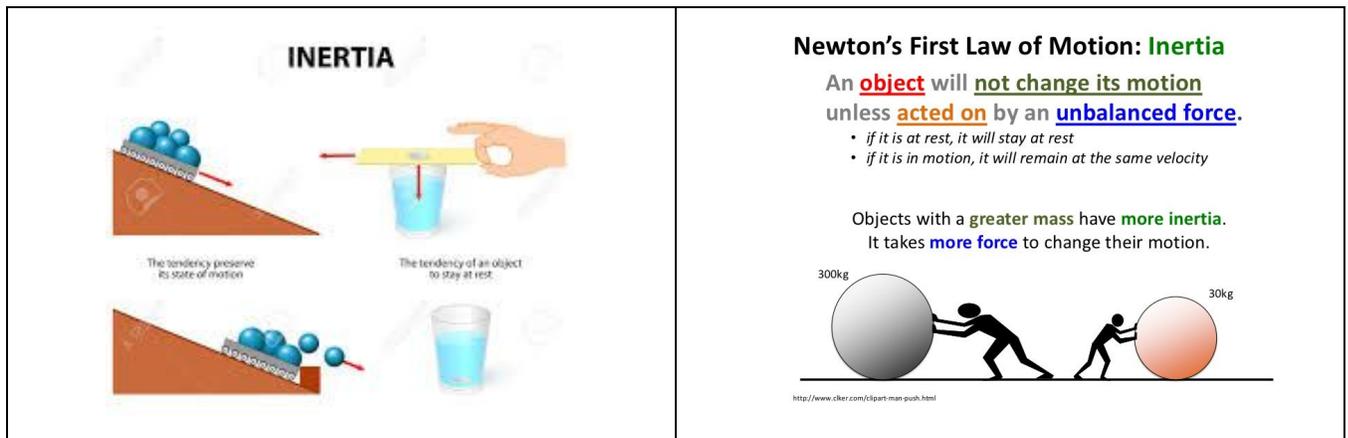
Newton's Laws of Motion

See, I have this day set you over the nations and over the kingdoms, To root out and pull down, To destroy and to throw down, To build and to plant." Jeremiah 1:10

- Galileo Galilei recognized that motion can be described in terms of: speed, velocity, and acceleration; forces determine how objects move
- Sir Isaac Newton built upon Galileo's ideas and formulated three laws of motion which describe how objects move

Newton's First Law of Motion

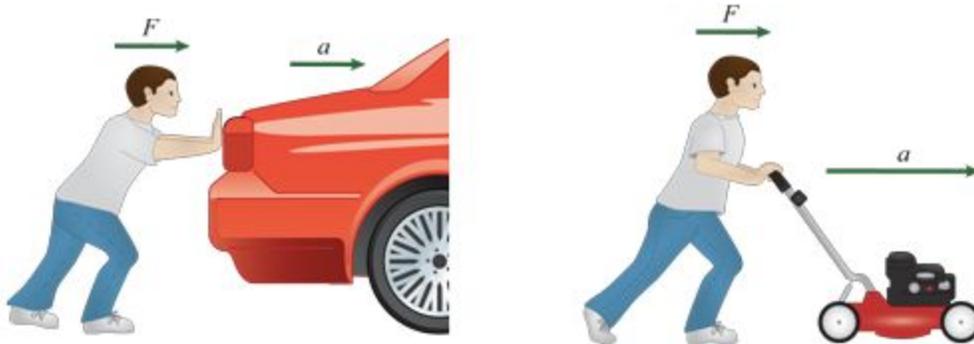
- Objects do not move independently; something must provide a push or a pull to move them
- The pushing or pulling action of one object upon another is called a force
- there can be no change in motion without a force to cause it; if an object is to speed up, slow down, or change direction, a force must cause acceleration
- First law of motion: an object at rest tends to remain at rest unless acted upon by an external force; an object in motion tends to stay in motion at the same velocity (speed and direction) unless acted upon by an external force
- Inertia: tendency of matter to resist changes in motion; Newton's first law also called law of inertia



Newton's Second Law of Motion

- Applies to motion of all objects regardless of acceleration
- Force required to accelerate an object at a certain rate equals the object's mass times the desired acceleration:
Force = mass x acceleration OR **F = ma**
- Force is a vector quantity, having both magnitude and direction; → direction of force is same as direction of acceleration
- SI unit of force = **Newton (N)** = $\frac{\text{kg} \cdot \text{m}}{\text{s}^2}$

- Force is directly proportional to acceleration → stronger forces will accelerate an object more quickly
Force required to accelerate an object is also proportional to mass → stronger force needed to move a larger object
- [Application p. 226]



Newton's Third Law of Motion

- For every action there is an equal and opposite reaction
- When one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object
- Ex: rocket engines propel spacecraft in space: hot exhaust gases are accelerated out of rocket nozzle by force of expanding gases <--> thrust shoves the rocket in the opposite direction of the nozzle

