

Newton's Laws of Motion

Unit: Dynamics (Forces) & Gravitation

NGSS Standards: HS-PS2-1

MA Curriculum Frameworks (2006): 1.4

AP Physics 1 Learning Objectives: 3.A.3.1, 3.A.3.2, 3.A.3.3, 3.A.4.1, 3.A.4.2,
3.4.C.1, 3.4.C.2

Knowledge/Understanding Goals:

- Newton's three laws of motion

Language Objectives:

- Understand and correctly use the terms "at rest," "in motion," and "force."
- Accurately describe and apply the concepts described in this section, using appropriate academic language.
- Set up and solve word problems relating to forces.

Labs, Activities & Demonstrations:

- Mass with string above & below.
- Tablecloth with dishes (or equivalent).
- "Levitating" globe.
- Fan cart.
- Fire extinguisher & skateboard.
- Forces on two masses hanging (via pulleys) from the same rope.

Notes:

force: a push or pull on an object.

Use this space for summary and/or additional notes.

Newton's First Law: (the law of inertia)

Everything keeps doing what it was doing unless a force acts to change it. "An object at rest remains at rest, unless acted upon by a net force. An object in motion remains in motion, unless acted upon by a net force."

For example, a brick sitting on the floor will stay at rest on the floor forever unless an outside force moves it.

Wile E. Coyote, on the other hand, remains in motion...



Inertia is a property of mass. Everything with mass has inertia. The more mass an object has, the more inertia it has.

Newton's Second Law: Forces cause acceleration (a change in velocity). "A net force, \vec{F} , acting on an object causes the object to accelerate in the direction of the net force." In equation form:

$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m}$$

Newton's second law is probably the most important concept regarding forces.

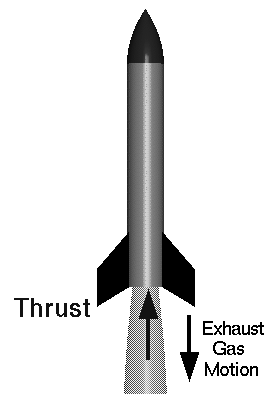
- If there is a net force, the object accelerates (its velocity changes). If the object's velocity is changing (*i.e.*, if it accelerates), then there must be a net force acting on it.
- If there is no net force, the object's velocity will not change (Newton's First Law). If the object's velocity is not changing (*i.e.*, if it is not accelerating), there must be no net force. (If there are no net forces, either there are no forces acting on the object at all, or all of the forces on the object are equal and opposite, and their effects cancel.)

Use this space for summary and/or additional notes.

Newton's Third Law: Every force involves two objects. The first object exerts a force on the second, and the second object exerts the same force back on the first. "For every action, there is an equal and opposite reaction."

Burning fuel in a rocket causes exhaust gases to escape from the back of the rocket. The force from the gases exiting (the action) applies thrust to the rocket (the reaction), which propels the rocket forward.

If you punch a hole in a wall and break your hand in the process, your hand applied the force that broke the wall (the action). This caused a force from the wall, which broke your hand (the reaction). This may seem obvious, though you will find that someone who has just broken his hand by punching a hole in a wall is unlikely to be receptive to a physics lesson!



Systems

system: the collection of objects being considered in a problem.

For example, gravity is the force of attraction between two objects because of their mass. If you jump off the roof of the school, the Earth attracts you, and you attract the Earth. (Because the Earth has a lot more mass than you do, you move much farther toward the Earth than the Earth moves toward you.)

If the system is you, then the Earth exerts a net force on you, causing you to move. However, if the system is you plus the Earth, the force exerted by the Earth on you is equal to the force exerted by you on the Earth. Because the forces are equal in strength but in opposite directions ("equal and opposite"), their effects cancel, which means there is no net force on the system. (Yes, there are forces within the system, but that's not the same thing.)

Use this space for summary and/or additional notes.