FORCES

PES 1000 – PHYSICS IN EVERYDAY LIFE

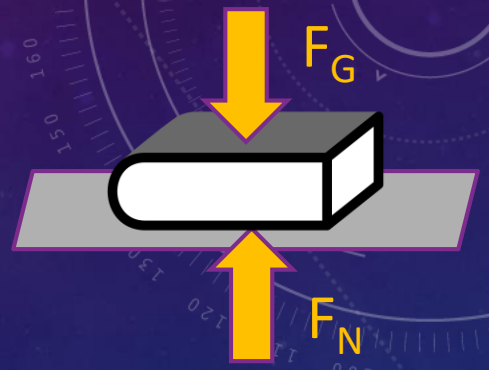
DEFINITION OF FORCE

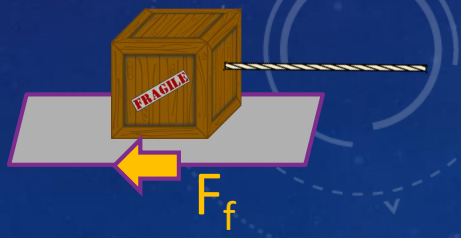
- A ***force*** is a push or a pull in some direction
- Force is a vector quantity, so it has a magnitude and a direction
- The magnitude is measured in a unit called the *Newton* (N) in the SI system, and the *pound* (lb) in the US Customary system
- The variable used is often $\vec{F}$
  - Sometimes W is used for weight, which is a force caused by gravity that is downward
  - In this course, I tend to use $\vec{F}$ with a subscript to indicate the source of the force (i.e. $\vec{F}_G$ for force due to gravity)

A LIST OF SOME OF THE FORCES IN NATURE

Anything that causes a push or a pull is a force. Here is a partial list of some forces that we can measure in nature:

- Gravitational force
- Normal Force – prevents objects from passing through each other. It is perpendicular, or normal, to the surfaces in contact (e.g. table holding up a book)
- Binding force – keeps solid objects together (e.g. a rope, a tire, a spring, etc.)
- Frictional force – opposes rough surfaces sliding against each other

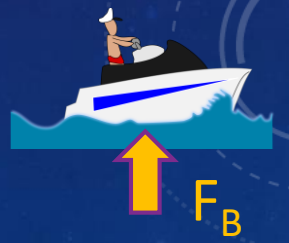




A LIST OF SOME OF THE FORCES IN NATURE

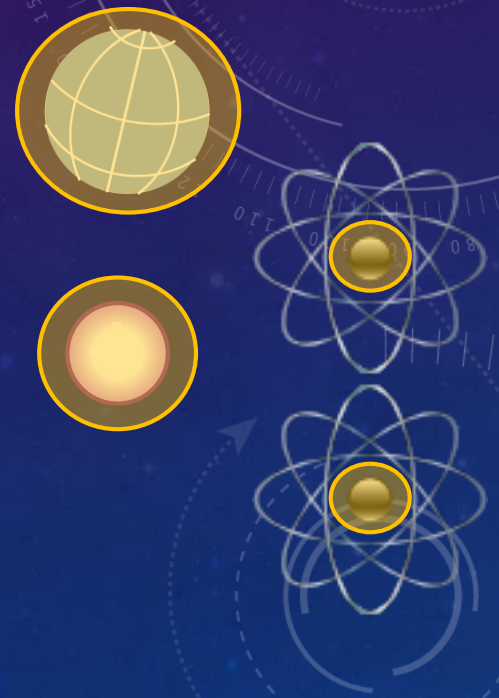
List continued:

- Drag force – opposes an object moving through a fluid like air or water (e.g. a moving car, boat, or ball)
- Atomic forces – operate at or below the size of atoms
- Forces due to pressure – Fluids (like air and water) exert buoyant forces on immersed surfaces
- Electric and Magnetic forces – attraction/repulsion between electrical charges or magnetic poles
- …and the list goes on.



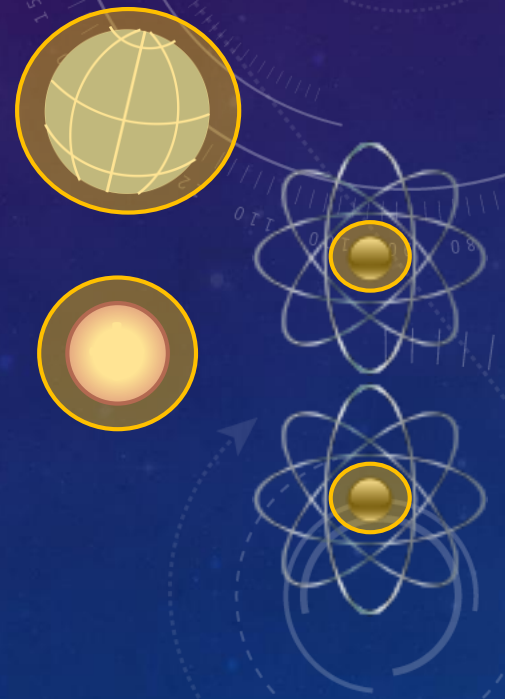
THE FUNDAMENTAL FORCES OF NATURE

- Physicists like to find a short list of forces that explain all of the forces from the previous list.
- In our current universe, all of the previously listed forces can be reduced to one of the four fundamental forces. These will be listed in order of *weakest* to *strongest*.
  - **Gravitational Force** – At first this seems strong, but realize that with the whole Earth attracting you, you can still jump away from the Earth (a little ways, at least).
  - **Weak Nuclear Force** – This force is important to nuclear decay, but we don't sense it directly.
  - **Electro-magnetic Force** – Just about every force in our list of forces in nature can be reduced to some aspect of the force of attraction or repulsion between electric charges at the molecular level!
  - **Strong Nuclear Force** – This force holds together the protons in the nucleus of atoms against their electrical repulsion.



THE FUNDAMENTAL FORCES OF NATURE

- Physicists are searching for a way to reduce the list even smaller by finding conditions in which the fundamental forces merge:
  - For example, in the early stages of the Big Bang, the Electro-Weak Force split and became the Electro-magnetic and Weak Forces.
  - Electro-Strong-Weak is theorized to have occurred even closer to the Big Bang.
  - Physicists seek a Grand Unifying Theory (GUT) that reduces the list to a single force theory. Gravity is so weak that it is difficult to combine with the rest of the forces.



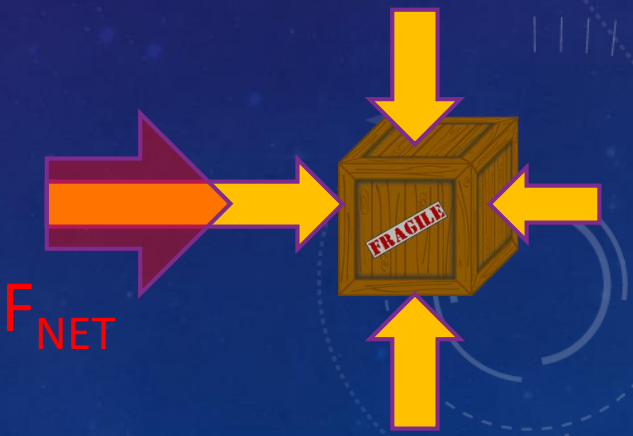
REDUCING THE LIST OF FORCES

From our previous list:

- Gravitational force (Gravitational)
- Normal Force – The molecules at the surface of object repel the molecules at the surface of another object (Electro-magnetic)
- Binding force – Molecules in a solid are attracted to each other (Electro-magnetic)
- Frictional force – Molecules along a rough surface bump into the other rough surface as they slide (Electro-magnetic)
- Drag force – Molecules in the fluid bump into the object passing through them (Electro-magnetic)
- Atomic forces – Protons in the nucleus are attracted in spite of their electrical repulsion (Strong Nuclear)
  - Sometimes nuclei will split apart, causing radiation (Weak Nuclear)
- Forces due to pressure – Fluid molecules press against other molecules and against the sides of their containers but can't pass through each other (Electro-magnetic)
- Electric and Magnetic forces – attraction/repulsion between electrical charges or magnetic poles (Electro-magnetic)

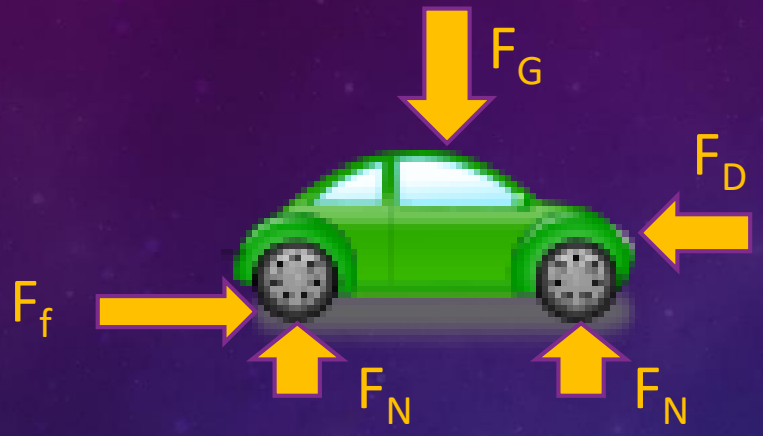
ADDING FORCES TOGETHER

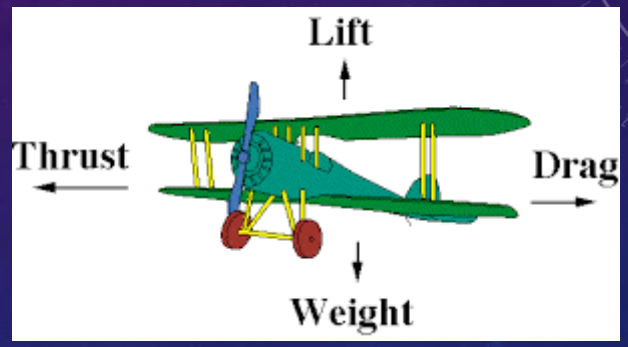
- Because forces are vectors, when we examine the overall effect of many forces acting on an object, we need to take into account the direction of each force.
- Opposing forces can partially or entirely cancel each other out
- To help visualize the result of many forces, we can draw the object of interest and indicate the size and direction of forces with arrows
- We add forces together by placing them together tip-to-tail. The resulting force, called the *net force*, is the arrow that goes from the tail of the first force to the tip of the last force.
- The motion of the object is a result of the net force acting on it.

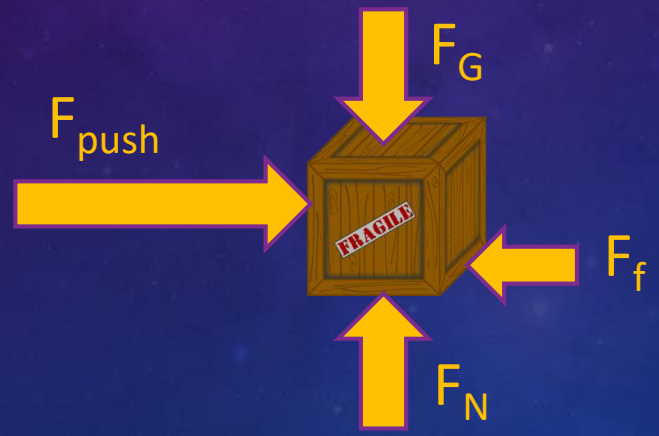


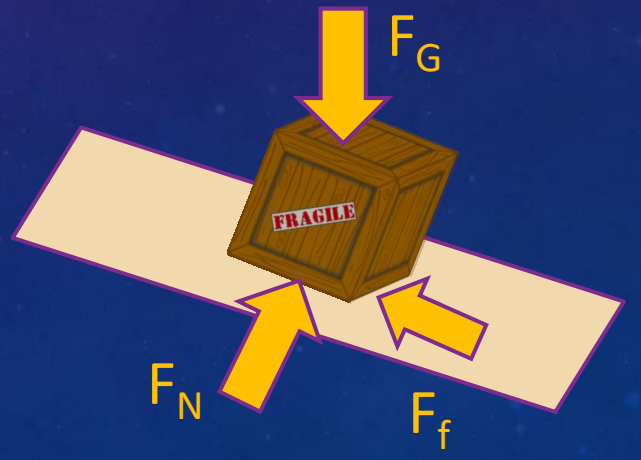
EXAMPLES OF FORCES ON AN OBJECT

- Car
- Airplane
- Box on the floor
- Box on a plane









CONCLUSION

- A force vector represents a push or a pull on an object.
- There are many types of forces that can affect an object. Each of these forces is the result of one of the four fundamental forces of nature.
- Forces are added together by taking into account both their size and direction.
- The net force on an object determines the motion of the object