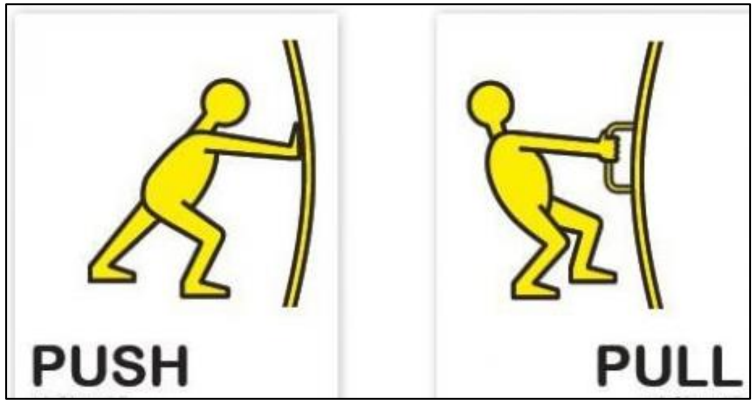
Forces

Lesson 26

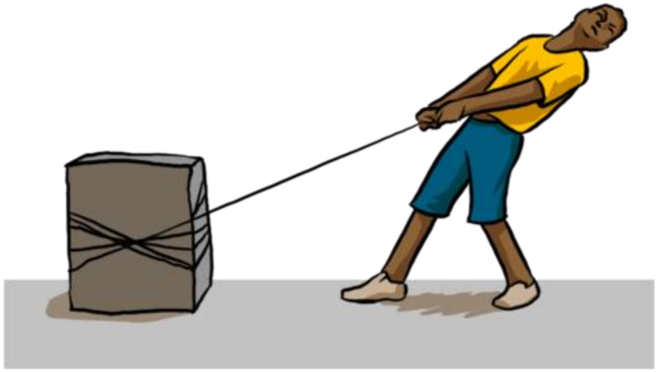
Forces

- A **force** is a push or a pull that acts on an object
  - Can use a force to cause an object to ***move***, such as a magnet ***pulls*** an iron nail, gravity pulls a basketball down to the ground
  - Can use a force to ***stop*** an object, such as when you catch a baseball
  - Can use a force to ***change the motion*** of an object, like returning a soccer pass
  - Can use a force to ***change the shape*** of an object, such as when you use muscle force to shape clay into a bowl or crumple an empty pop can



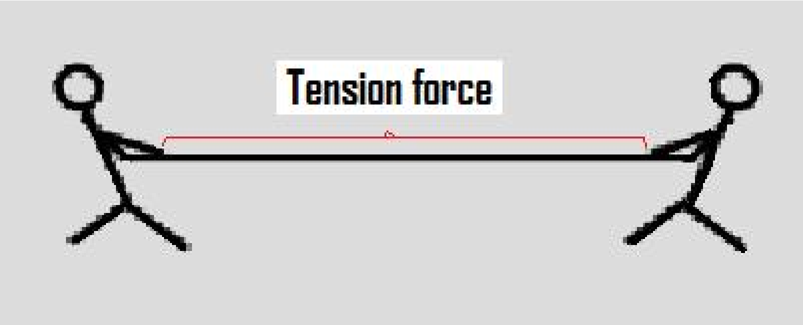
Types of Forces

- Forces come in many different types, and are generally classed in two categories:
  - **Contact forces**
    - Tension force
    - Friction force
    - Elastic force
  - **Action-at-a-distance forces**
    - Gravitational force
    - Electrostatic force
    - Magnetic force



Contact Forces

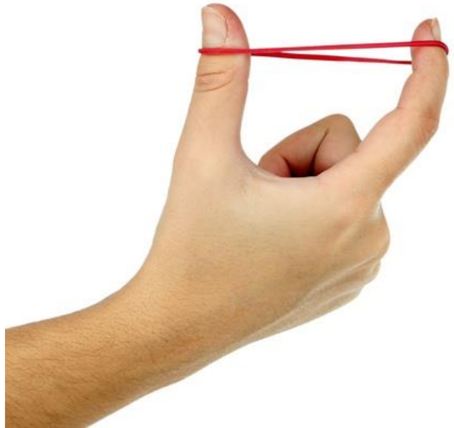
Types of Forces



- Contact forces can only have an effect on objects that they touch
  - E.g. when you push, pull, lift, drag a box to move it
- You might apply a contact force to bend, tear, stretch, compress, or twist an object

Three types of contact forces:

  - **Tension force** = the type of force experienced by a wire or a rope when it is pulled at either end
  - **Friction force** = works to slow down or stop motion due to surfaces rubbing against each other. i.e. bicycle breaks
  - **Elastic force** = is exerted when a spring-like object such as a trampoline restores itself to normal shape after it has been compressed or stretched. i.e. elastic band



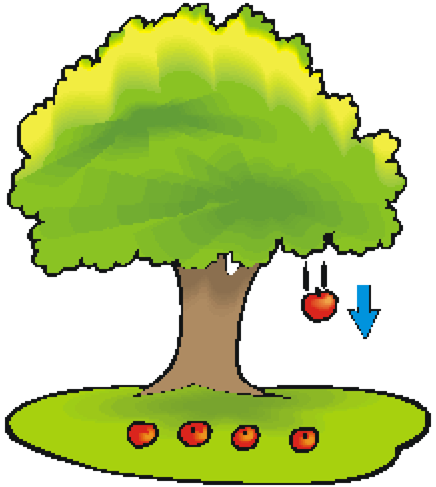
Action-at-a-distance Forces

Types of Forces

- ***Action-at-a-distance*** forces are forces that can be applied to an object WITHOUT touching it

<u>Three types of action-at-a-distance forces:</u>

- **Gravitational force**
- **Electrostatic force**
- **Magnetic force**



Gravitational Force

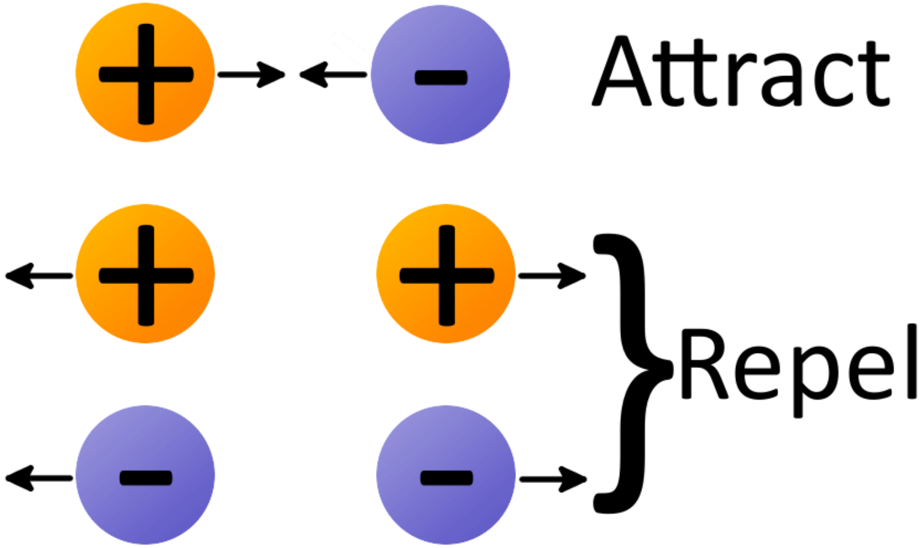
Action-at-a-distance Forces

- The force of attraction between objects because they have mass
- The force of **gravitation** between two objects depends on both the masses of the two objects and the distance between them
  - The closer the objects are to each other, and the more massive the objects are, the stronger the force of gravity they exert on each other
- We do not notice the gravitational force from ourselves and other objects because Earth is so massive, and its gravitational influence is much larger

Electrostatic Force

Action-at-a-distance Forces

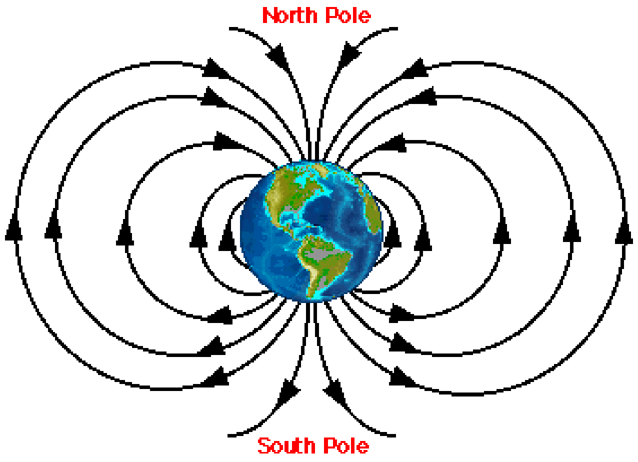
- Also called **static electricity**
- Causes pushing and pulling force
- All matter is made of small particles, some of which are electrically charged (atoms)
    - These charged particles can be positive (protons) or negative (electrons)
    - Charges that are the same repel
    - Charges that are different/opposite attract

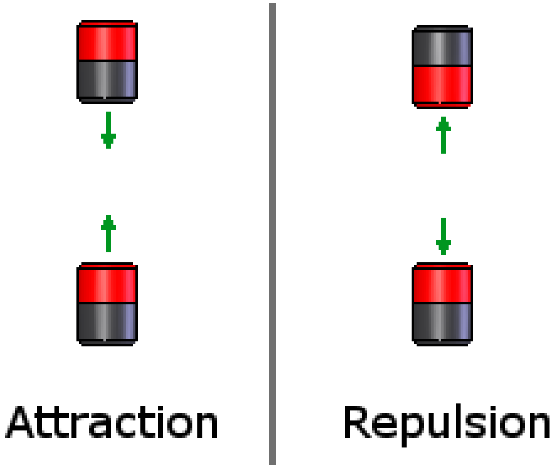


Magnetic Force

Action-at-a-distance Forces

- The attraction or repulsion that arises between electrically charged particles
- Magnetic force acts on certain metals and compounds
  - Iron, nickel, cobalt
- Natural magnetics, including Earth, and electromagnets have a field around them that can exert pushing and pulling forces





Measuring Mass

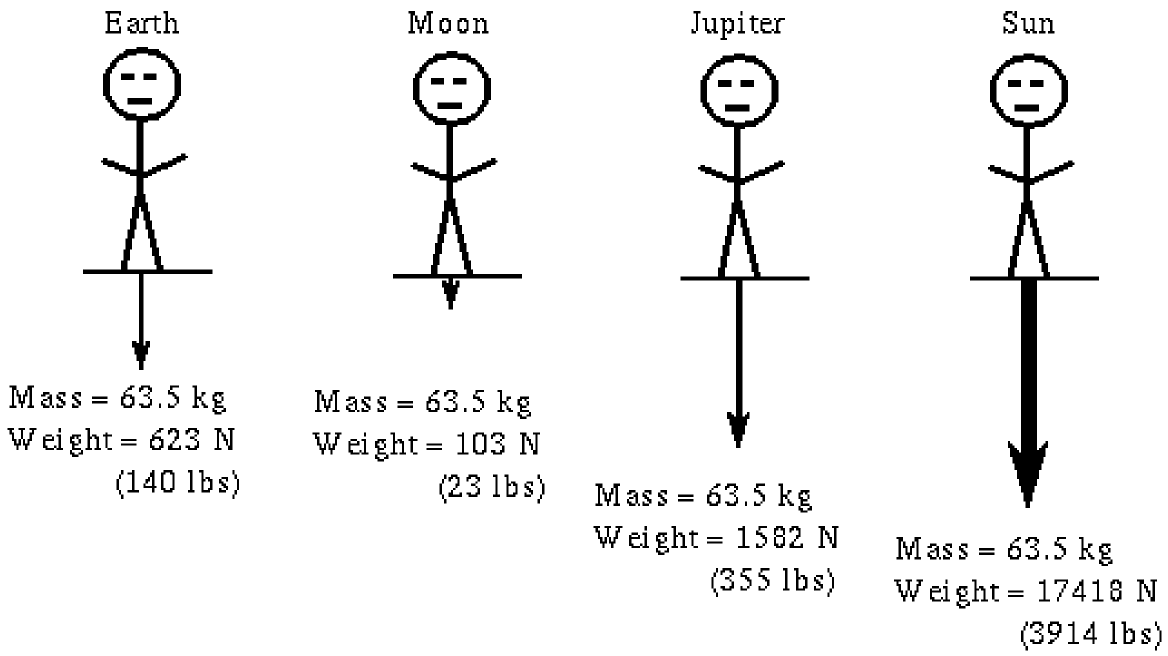
<u>How is force measured?</u>

- First we need to understand how to measure mass and weight
- **Mass** is the amount of matter in an object
  - E.g. an ostrich egg, at 1.5kg, has much more mass than a typical chicken egg because it has more particles
- Measuring mass is best done with a balance scale where a known mass is used to determine the unknown mass on the other side of a scale (think of a teeter totter)

Measuring Mass

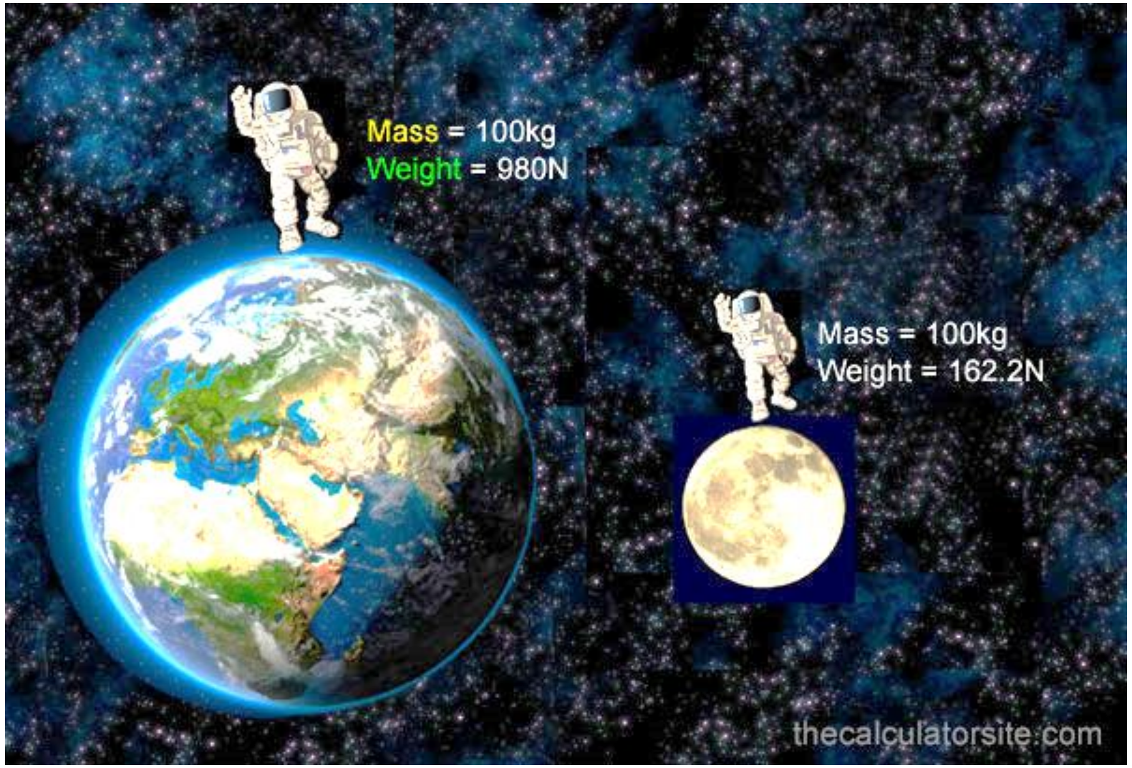
<u>How is force measured?</u>

- Gravity pulls equally on objects of equal mass, so it does not matter where you use a balance scale
  - The mass of 1 L of water on Earth is 1kg
  - If you measured the mass of water on Jupiter where gravity is 2.35 times greater than on Earth, 1 L of water would still balance against 1kg mass

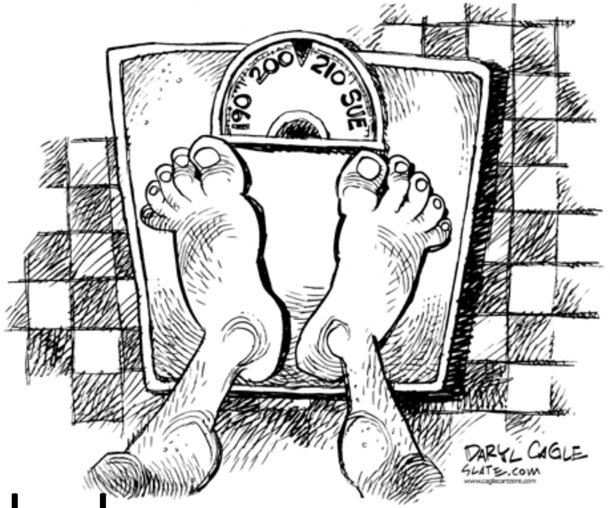


Weight Depends on Gravity

- Weight is different from mass
- **Weight** is the amount of force on an object due to gravity
  - If you travelled to the Moon, you would weight approx. one sixth the amount you weigh on Earth because the gravitational pull is one sixth as strong on the Moon
  - On Jupiter, you would weigh 2.35 times more than you do on Earth, because Jupiter's gravity is 2.35 times stronger

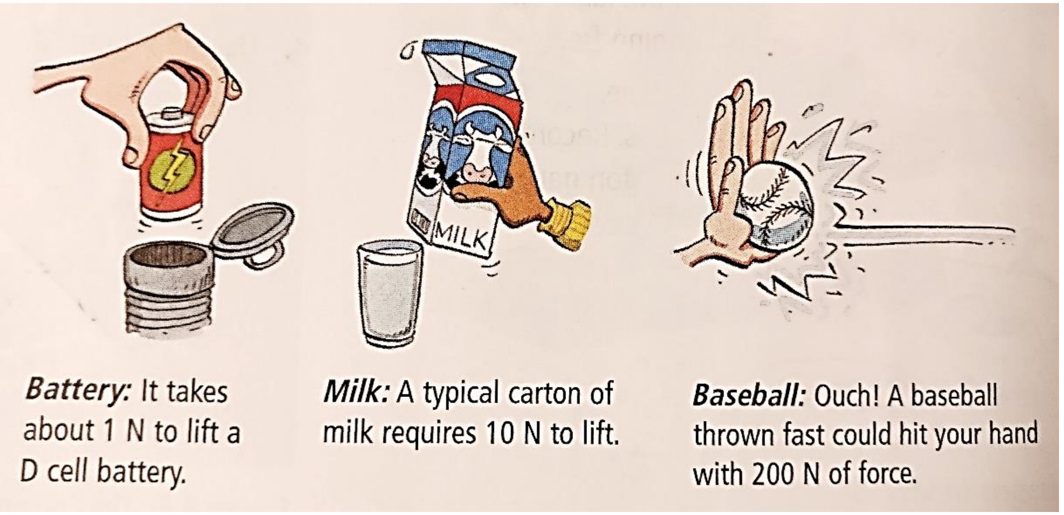


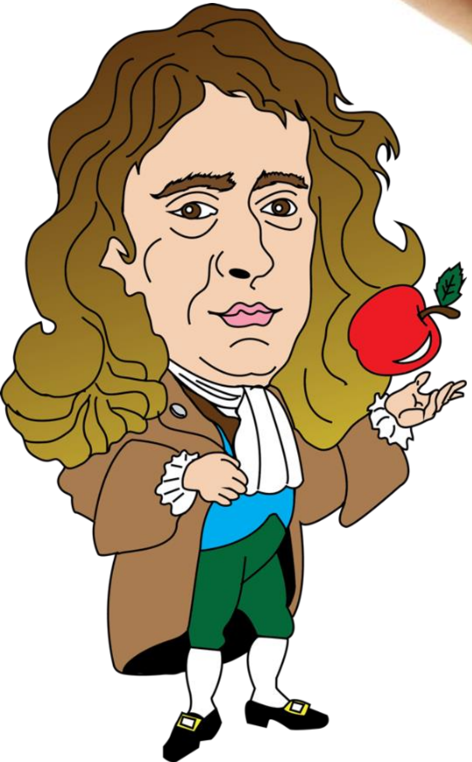
Weight Depends on Gravity



- Bathroom scales actually measure ***force***, not mass
  - Inside a bathroom scale, is a spring that is stretched when you stand on it
  - The more mass a person has, the more gravity pulls down on the person, and the more the spring is stretched
  - Therefore, the bathroom scale measures force exerted by an object downward due to gravity
  - The bathroom scale is really a *weight* scale, not a *mass* scale

The Newton





- The measuring unit of force is the **newton** (N)
  - Named after Sir Isaac Newton
- The newton is a small amount of force
  - Approximately the amount you would have to exert to hold up a medium-sized apple
- Weight is a force
  - Therefore it is properly expressed in newtons, not kilograms

Most people are accustomed to reading a scale marked in kg or lbs, so that is how the scale is marked!

Measuring Force

- Measuring force is quite simple
- **Force metres** are equipped with a spring or similar elastic device that stretches or compresses in response to being pulled or pushed
    - Newton gauge or spring scale

Measuring Force

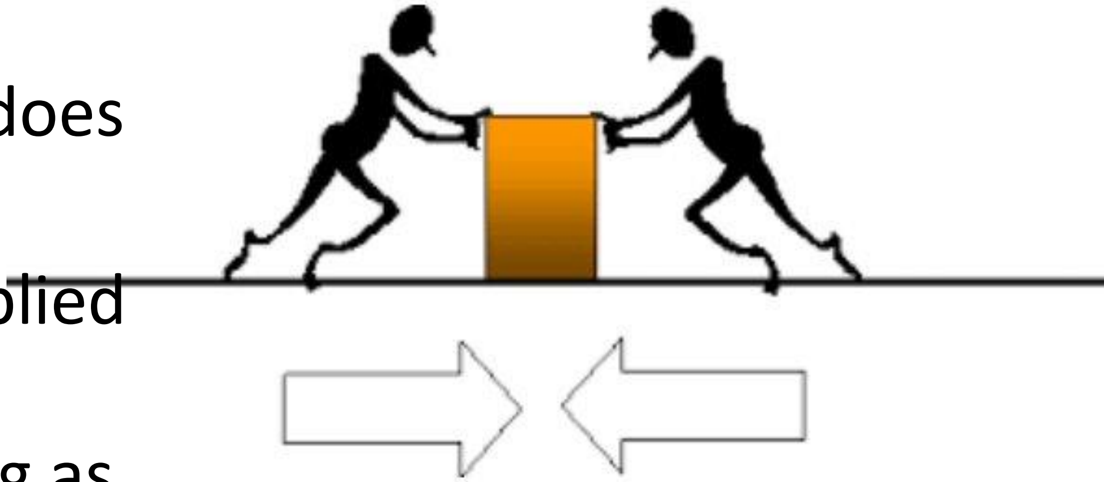
- **Mass** and **weights** are ***directly proportional***
- If you hang a 1kg mass from a newton gauge, you will find that it will read 9.8N
  - This means that by multiplying by $9.8m/s^2$, you can easily convert mass to weight

Example:

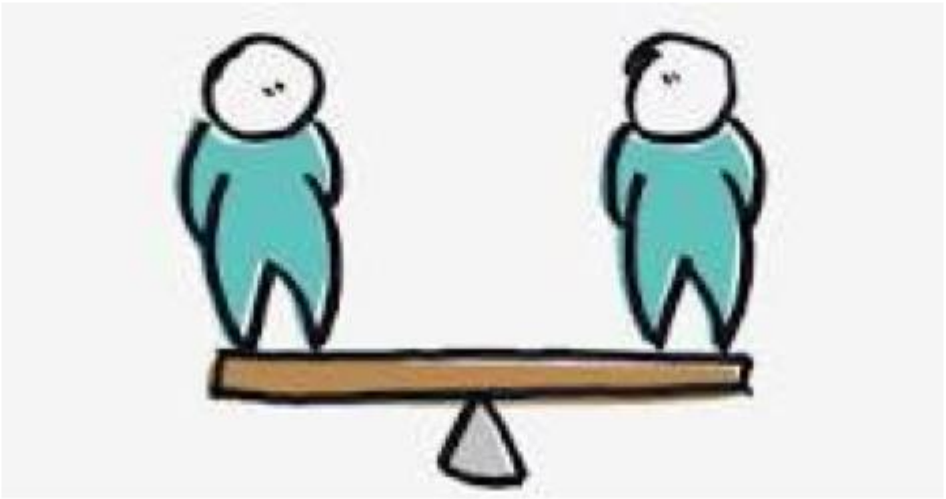
50kg person has a weight of 490N → 50kg x $9.8m/s^2$

60kg person has a weight of 588N → 60kg x $9.8m/s^2$

Forces and Motion – Balanced Forces

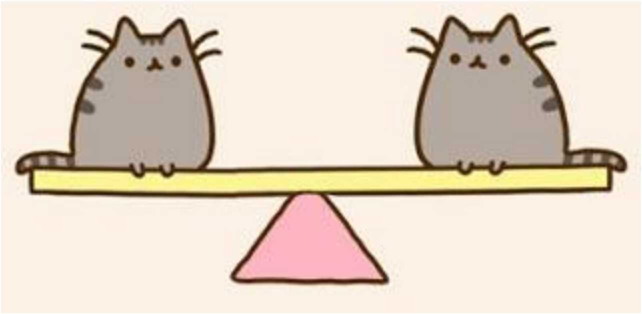


- Every time you apply a force to an object, does the object move?
- Imagine two equal and opposite forces applied to a large box
  - The people cannot move the box as long as the forces they produce are **equal**, **opposite**, and **perfectly balanced**
- **Balanced forces** are equal in strength and oppose each other in direction



Forces and Motion – Balanced Forces

- **Balanced forces** sometimes keep an object stationary



Forces and Motion – Balanced Forces

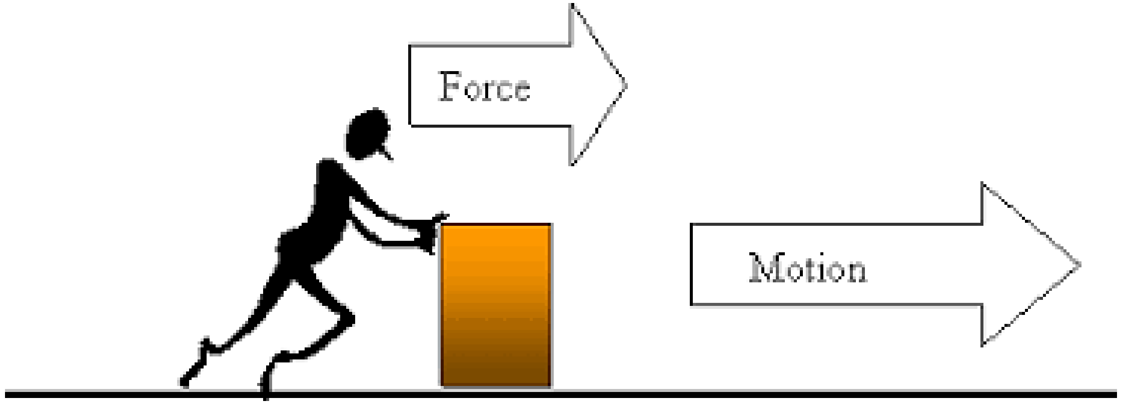
- **Balanced forces** keep an object moving at a constant speed and direction

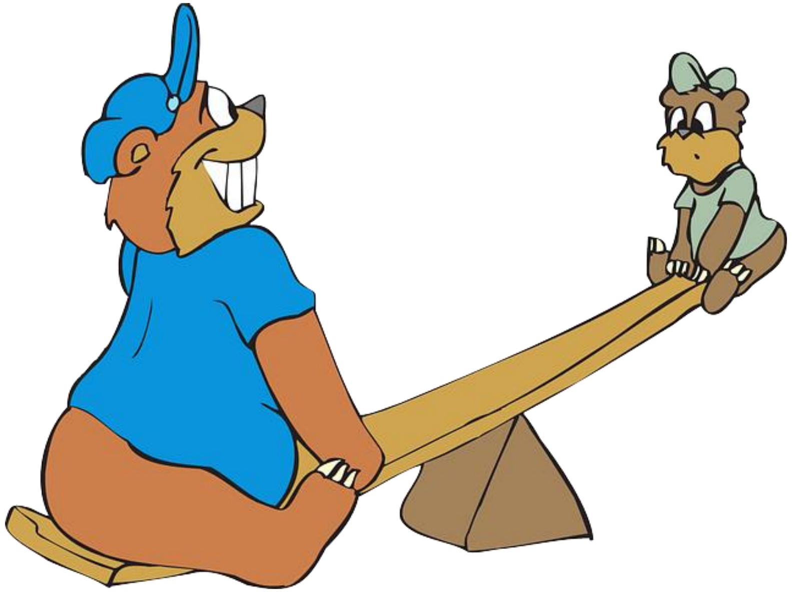
<u>For example:</u>

- Picture a cyclist riding at a constant speed
- There are many forces at work
  - The cyclist applies a force on the pedals
  - There is friction force between the tires and the road
  - There is the force of air friction ("wind resistance")
- As long as the forces remain balanced, the cyclist will continue at the same speed
- However, if the cyclist stops pedaling, the forces will no longer be in balance
  - Friction will begin slowing the cyclist down

Forces and Motion – Unbalanced Forces

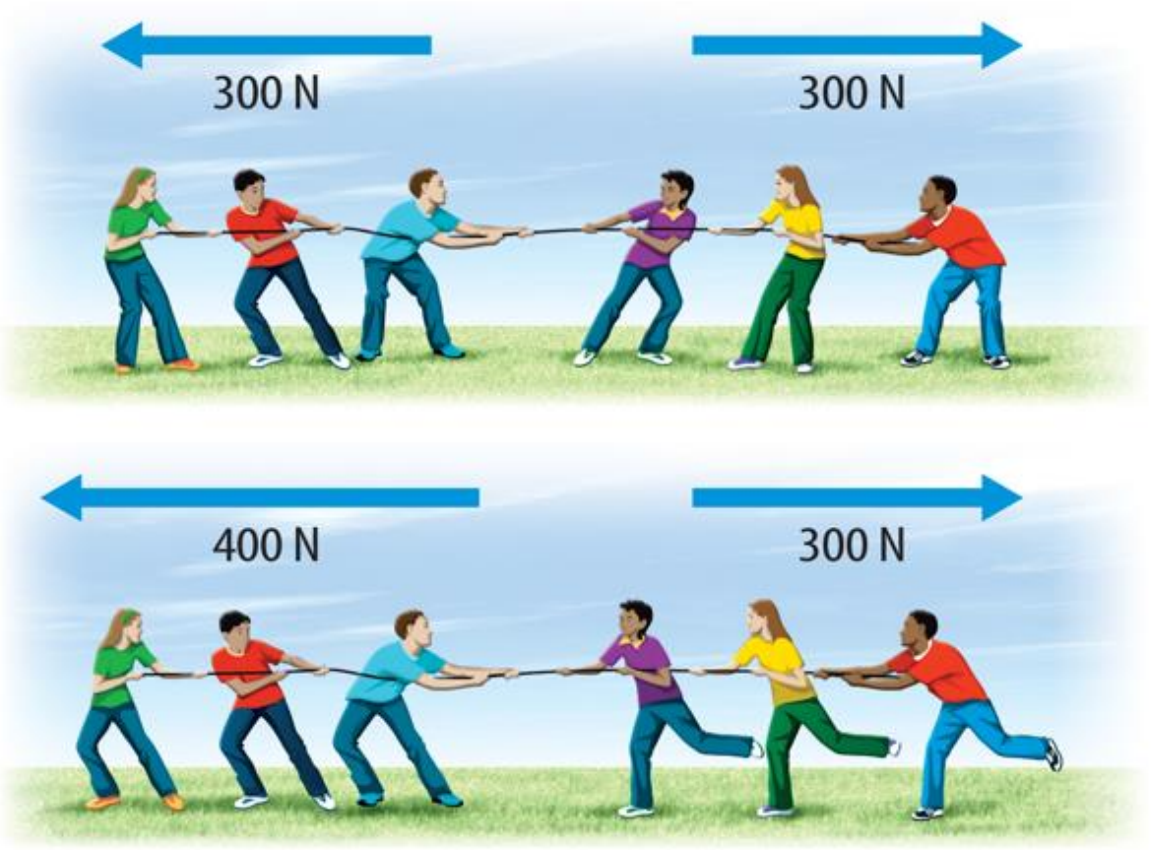
- **Unbalanced forces** cause a change in the speed or direction of an object
- Imagine an unequal force applied in opposite directions on a large box
  - The box will begin moving in the direction it is pushed by the stronger force
  - If the forces remain unbalanced, the box will continue to increase in speed





Forces and Motion – Unbalanced Forces

- We can keep track of and analyze forces by using arrows
  - Draw an arrow in the direction of the force
  - When comparing forces, draw longer arrows to represent larger forces



Summary

- A **force** is a ***push*** or a ***pull*** that acts on an object
- **Contact forces** can only have an effect on objects that they <u>touch</u>
  - Tension force
  - Elastic force
  - Friction force
- **Action-at-a-distance** forces can apply forces to an object <u>without</u> touching it
  - Gravitational force
  - Electrostatic force
  - Magnetic force
- **Weight** is the amount of force on an object due to gravity
- The forces on an object can be **balanced** or **unbalanced**