Chapter Five: Force

- 5.1 Forces
- 5.2 Friction
- 5.3 Forces and Equilibrium

Chapter 5.1 Learning Goals

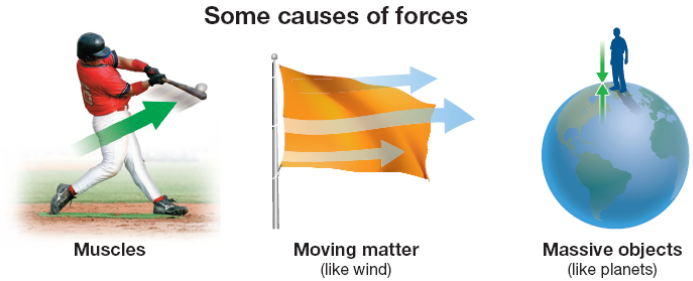
- Define force as a vector and describe how it is measured.
- Explain how forces are created.
- Compare and contrast types of forces.

5.1 The cause of forces

- A force is a push or pull, or an action that has the ability to change motion.
- Forces can increase or decrease the speed of a moving object.
- Forces can also change the direction in which an object is moving.

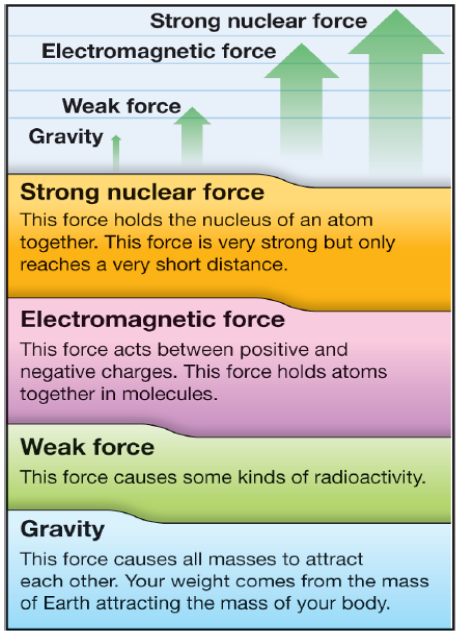
5.1 How are forces created?

- Forces are created in many ways.
- For example, your muscles create force when you swing a baseball bat.



5.1 Four Elemental Forces

- All forces in the universe come from only four basic forces.
- Electromagnetic forces are important to technology.
- Gravity is a universal force.

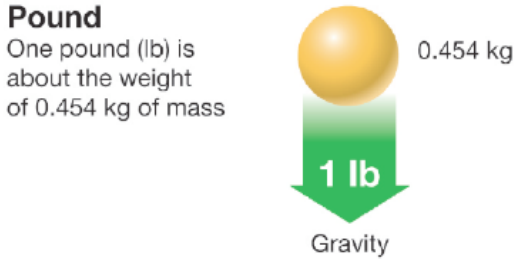


5.1 Units of force

- The pound is a unit of force commonly used in the United States.
- For smaller amounts, pounds are divided into ounces (oz.).
- There are 16 ounces in 1 pound.

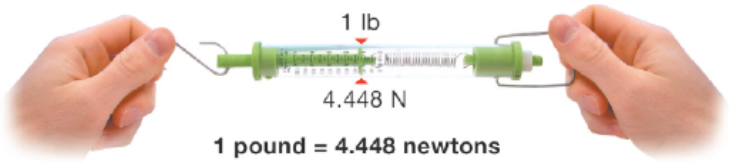
5.1 Pounds

- When you measure weight in pounds on a postal scale, you are measuring the force of gravity acting on an object.



5.1 Newtons

- Although we use pounds all the time in our everyday life, scientists prefer to measure forces in newtons.
- The newton (N) is a metric unit of force.

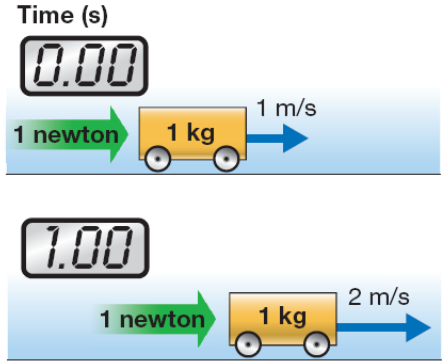


1 pound = 4.448 newtons

Newton and Pound Definition

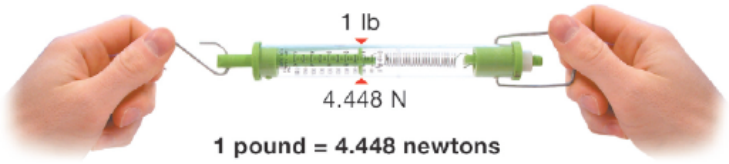
Pound
One pound (lb) is about the weight of 0.454 kg of mass

Newton
One newton (N) is the force it takes to change the speed of a 1 kg mass by 1 m/s in 1 second.



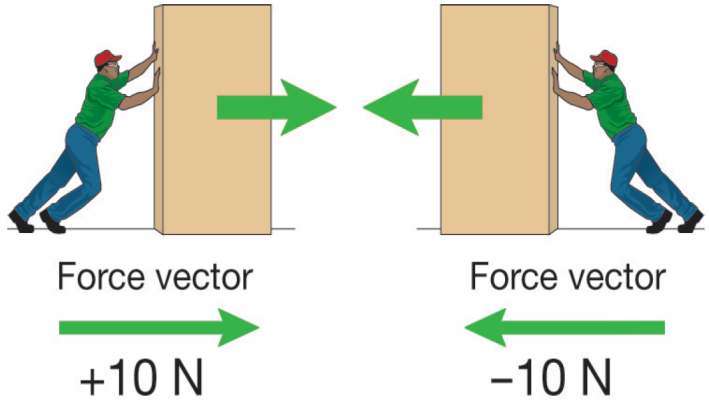
5.1 Unit conversions

- The newton (N) is a smaller unit of force than the pound (lb).
- If one pound of force equals 4.448 newtons, then a 100 lb person weighs 444.8 newtons.



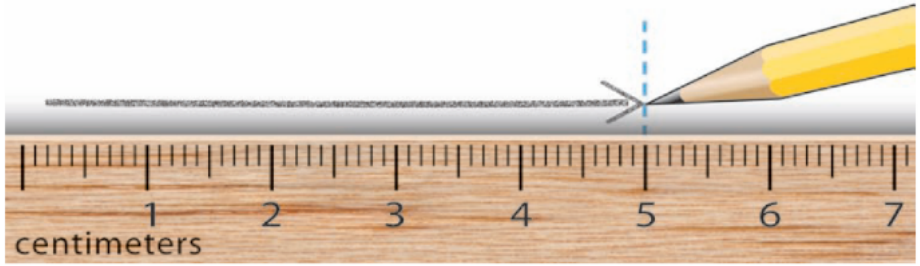
5.1 The force vector

- The direction of a force makes a big difference in what the force does.
- That means force is a vector, like velocity or position.
- Arrows are often used to show the direction of forces in diagrams.



5.1 Drawing a force vector

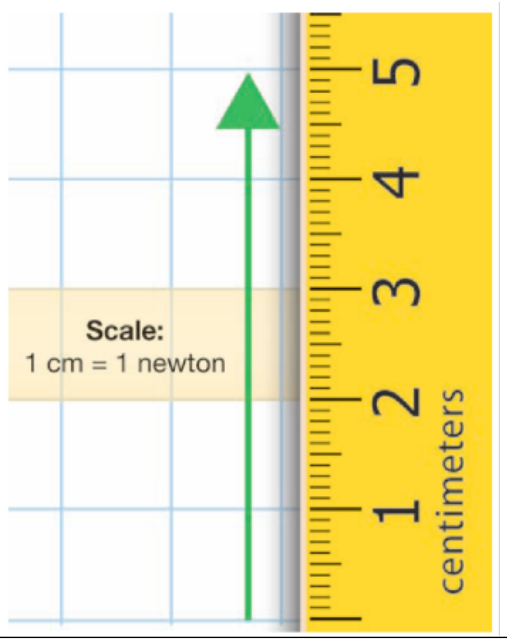
- The arrow points in the direction of the force.



5.1 Drawing vectors

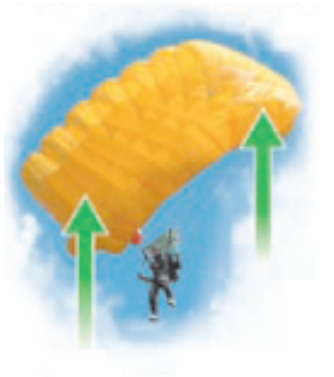
- The x- and y-axes show the strength of the force in the x and y directions.
- When drawing a force vector to show its strength, you must also choose a scale.

Can you draw the x-axis vector?

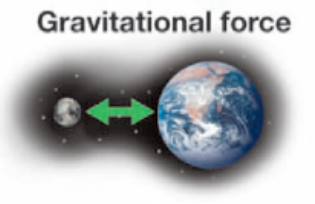


5.1 How forces act

- One way forces act is the result of direct contact.
- A contact force is transmitted by matter directly touching other matter such as wind acting to slow a parachute.



5.1 How forces act



- The force of gravity between Earth and Moon appears to be what people once called “action at-a-distance”.
- Today we know that the gravitational force is carried from the Earth to the Moon by a force field.

Classify these forces as contact forces or the result of force fields.

Two Categories of Forces

Contact Forces	"At-a-distance" Forces
friction	gravity
normal force	electricity
tension, air resistance, spring	magnetism

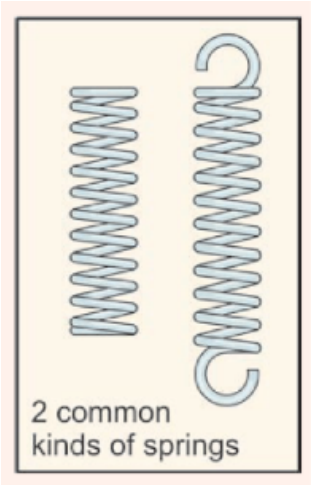
5.1 Contact forces from ropes and springs

- Ropes and springs are often used to make and apply forces.
- Ropes are used to transfer forces or change their direction.
- The pulling force carried by a rope is called tension.
- Tension always acts along the direction of the rope.

Each person pulls with a force of 100 newtons, so the tension is 100 newtons.

5.1 Spring forces

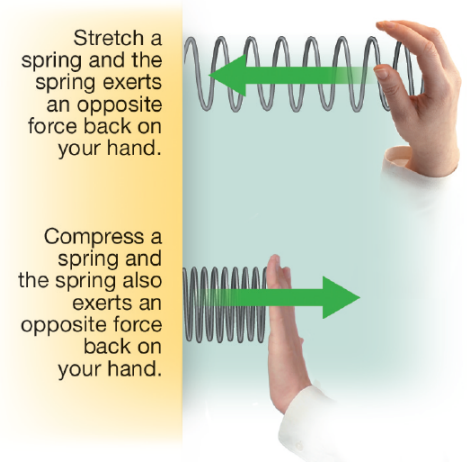
- Springs are used to make or control forces.
- The force from a spring always acts to return the spring to its resting shape.



2 common kinds of springs

Which of these springs is designed to be stretched?
Which is designed to be compressed?

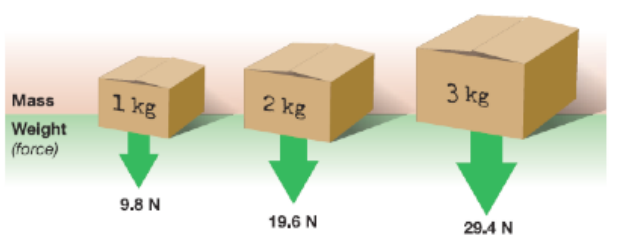
5.1 Spring forces



- The force created by a spring is proportional to the ratio of the extended or compressed length divided by the original (resting) length.
- If you stretch a spring twice as much, it makes a force that is twice as strong.

5.1 Gravity

- The force of gravity on an object is called weight.
- At Earth's surface, gravity exerts a force of 9.8 N on every kilogram of mass.



5.1 Weight vs. mass

- Weight and mass are not the same.
- Mass is a fundamental property of matter measured in kilograms (kg).
- Weight is a force measured in newtons (N).
- Weight depends on mass and gravity.

Weight depends on mass and gravity

A 10-kilogram rock has the same mass no matter where it is in the universe. On Earth, the10 kg. rock weighs 98 N.. On the moon, the same rock only weighs 16 N.

Solving Problems: Weight and Mass

WEIGHT

Weight (N) $W = mg$

Strength of gravity (N/kg)

Mass (kg)

5.1 Calculating weight

- **The weight equation can be rearranged into three forms to calculate weight, mass, or the strength of gravity.**

Use. . .	if you want to find. . .	and you know. . .
$W = mg$	weight (W)	mass (m) and strength of gravity (g)
$m = W/g$	mass (m)	weight (W) and strength of gravity (g)
$g = W/m$	strength of gravity (g)	weight (W) and mass (m)

Calculating Weight