Forces

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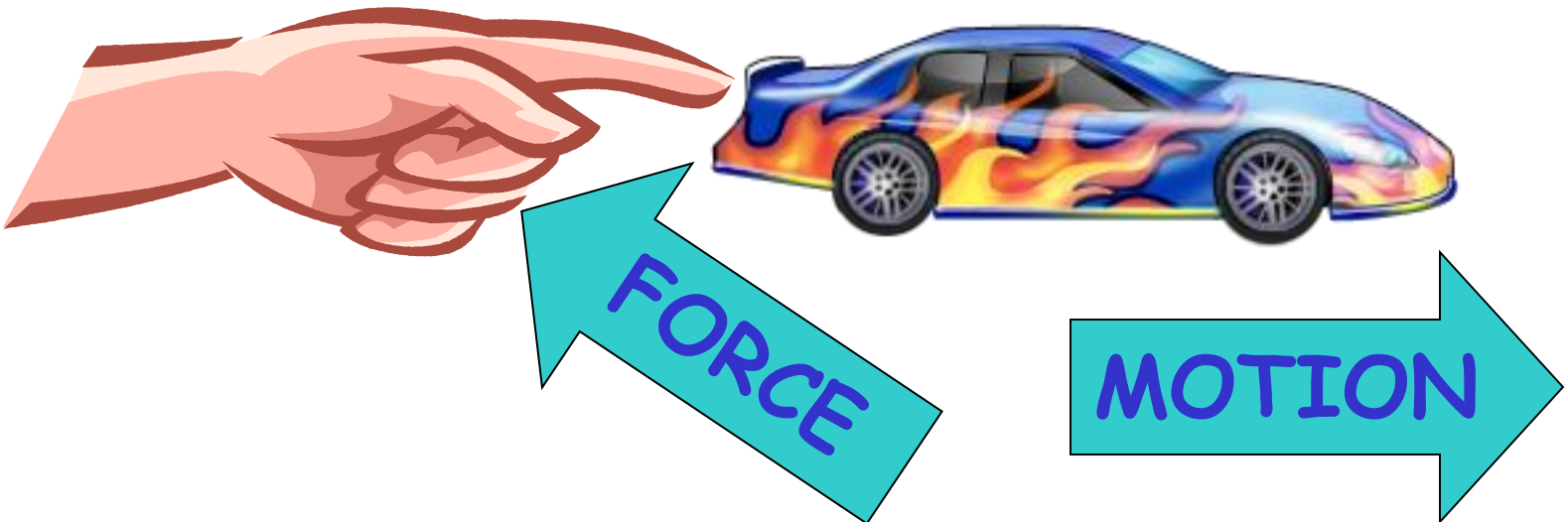
Chapter 3

What is Force?

- **What causes an object to move?**
  - A FORCE!
  - ALL motion is due to forces acting on objects!
- **What is a force?**
  - A push or a pull

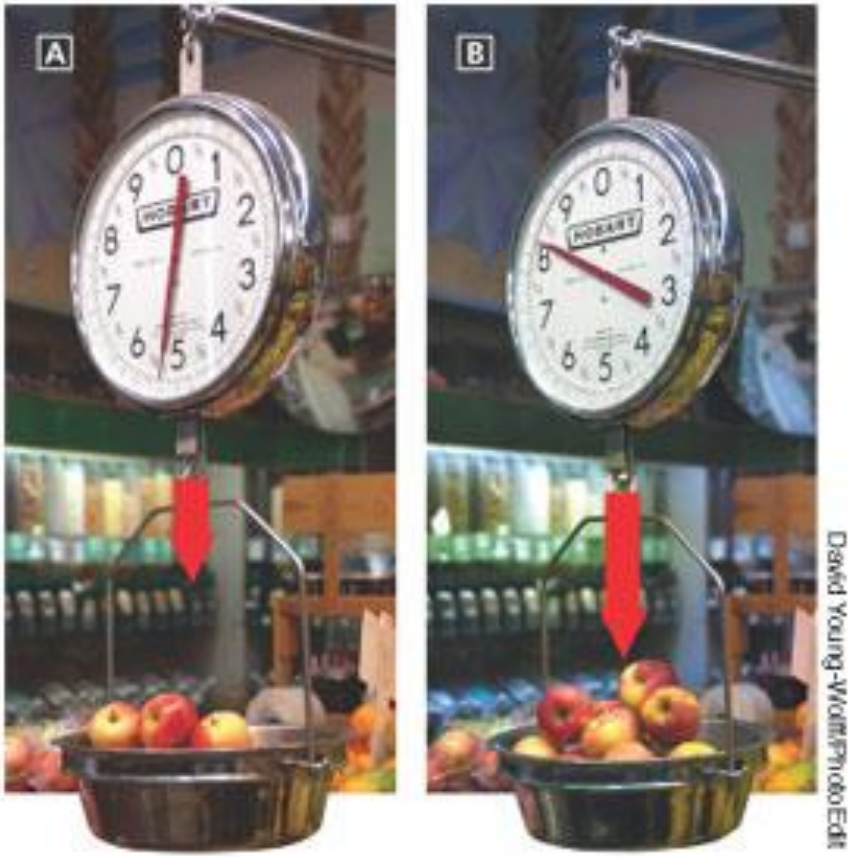


How is force measured?

- **Unit of Force**
  - **Newton (N)**
  - 1 kg to accelerate 1 m/s^2
  - $1N = \frac{kg \bullet m}{s^2}$

How is force represented?

- Use arrows
  - Direction
  - Strength
    - Length represents strength or magnitude



  - The scale with more apples, greater mass, has a longer arrow. The arrow is pointed downward due to mass is below the balance pulling downwards.

Combining Forces

- Forces in the same direction are added together
- Force in the opposite direction are subtracted
- Net Force
  - Sum of all forces acting on an object

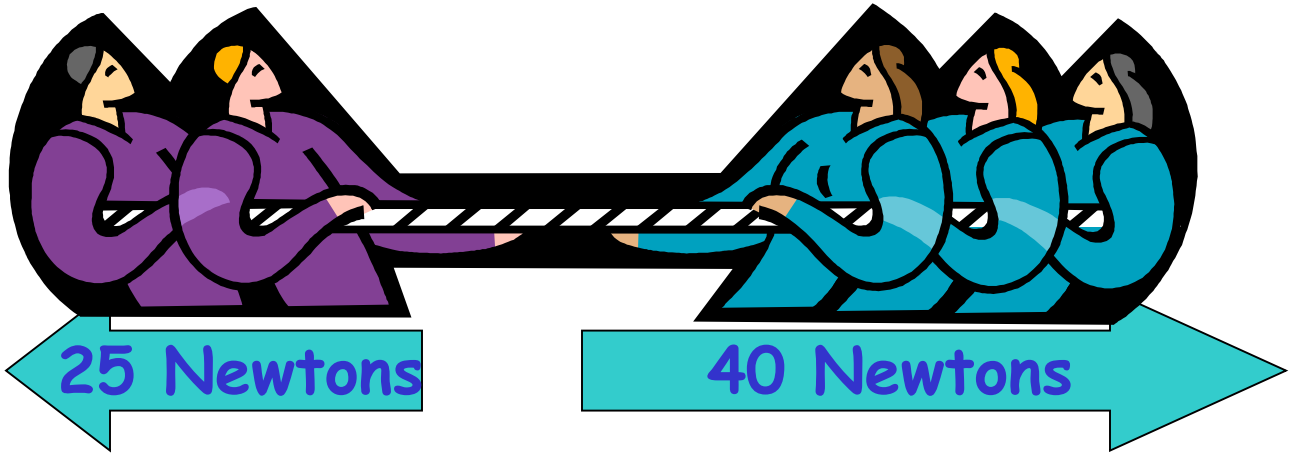
The total combination of the forces (opposites – and same direction +) acting on an object is called NET FORCE.

Balanced vs. Unbalanced Forces

- Balanced
  - Combine to produce a net force of zero
  - No change in the object's motion

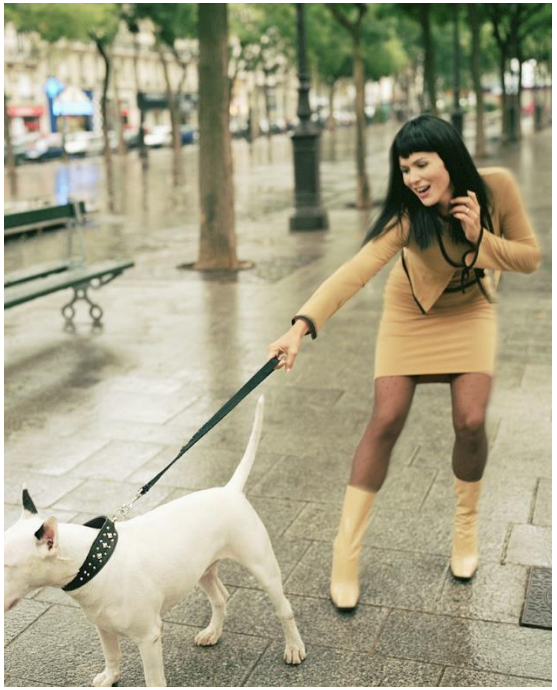
Balanced vs. Unbalanced Forces

- Unbalanced
  - Net force equals the size of the larger force minus the size of the smaller force
  - Net force does not equal zero
  - Causes an object to move (accelerate)



Only an unbalanced force can change the motion of an object.

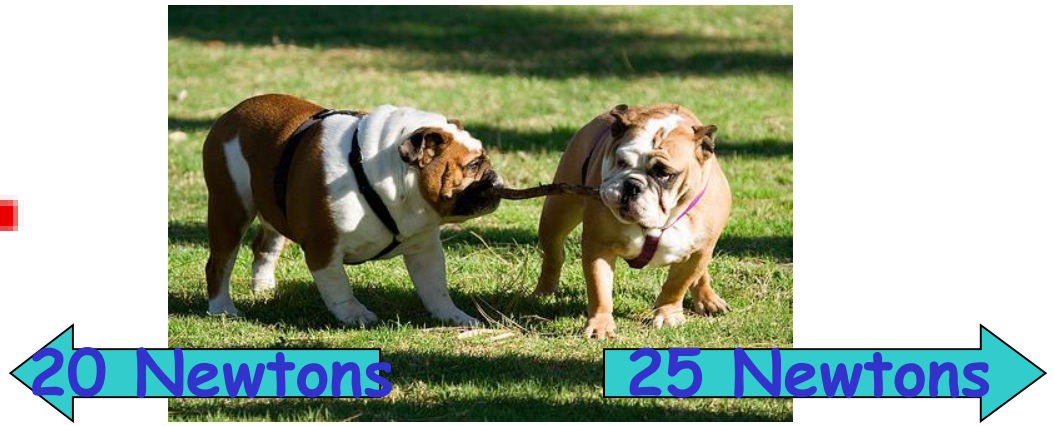
- Example: Your dog can cause you to move if he pulls with enough force.
  - His force is greater than the force you're using to stay in place



Representing Forces

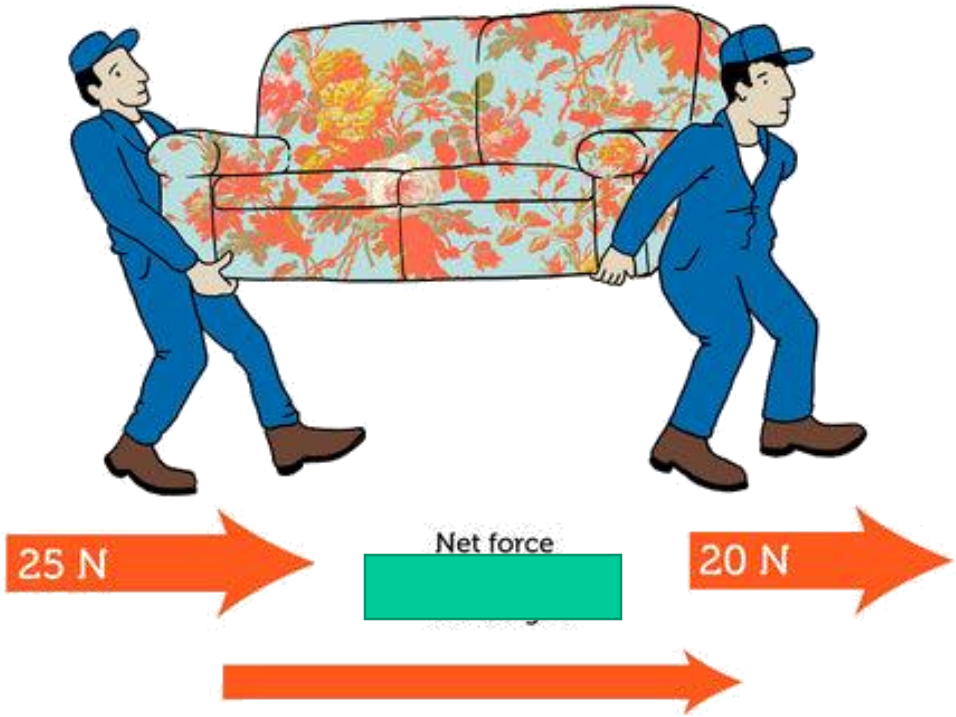
A Adding forces

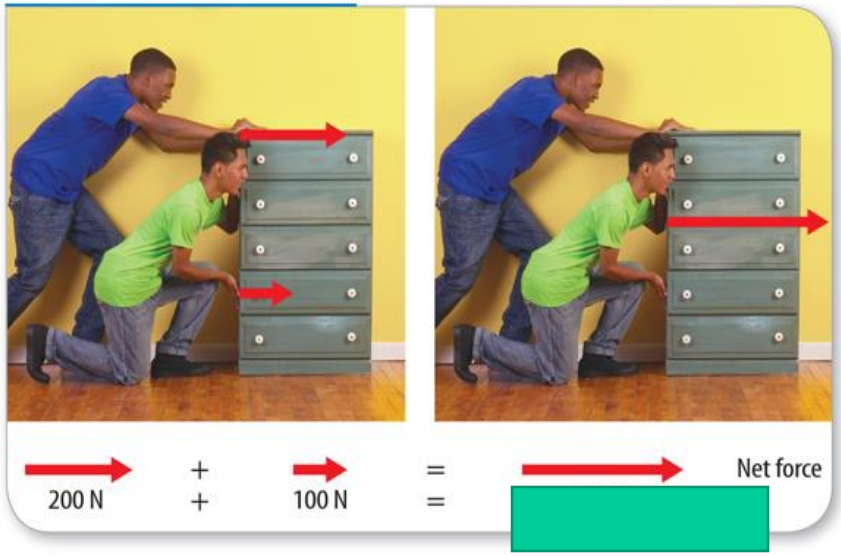
B Subtracting forces



C Equal and opposite forces

Bell Ringer



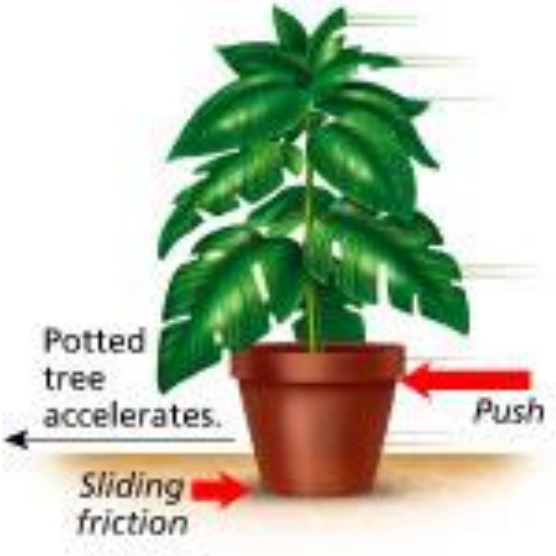


Friction

- Force that opposes the motion of objects that touch as they move past each other
- Acts at the surface where objects are in contact
- 4 types of friction

4 Types of Friction

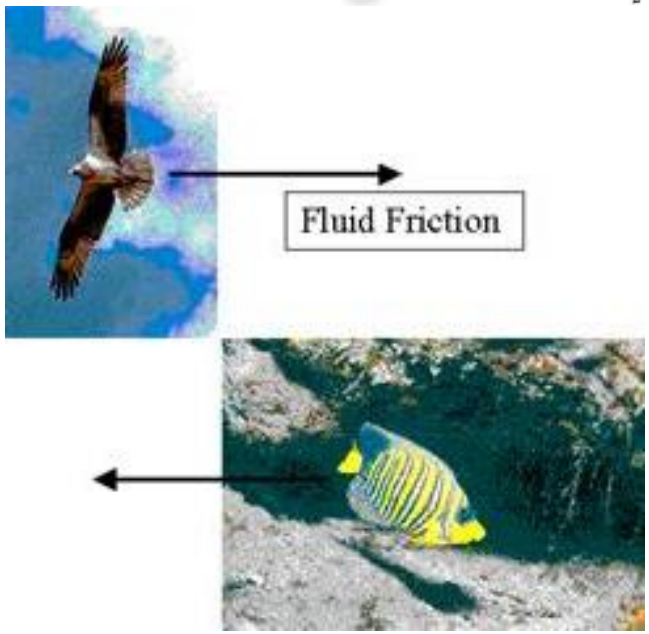
- Static friction
  - Force that acts on objects that are not moving
  - Always acts in the direction opposite to that of the applied force
- Sliding friction
  - Force that opposes the direction of motion of an object as it slides over a surface



4 Types of Friction

- Rolling friction
  - Change in shape at the point of rolling contact

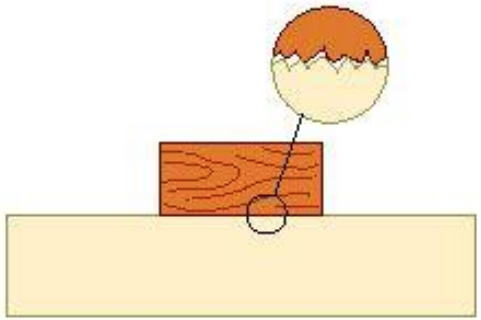
- Fluid friction
  - Opposes the motion of an object through fluid
  - Increases the speed of the object moving through the fluid
  - Fluids (gas and liquids)



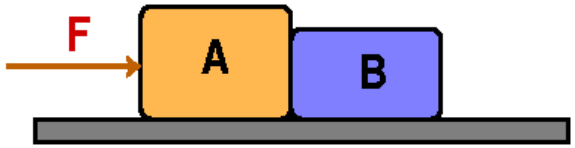
What affects the amount of friction?

- **The force of the push/pull**
  - The harder you push, the longer it's going to take friction to stop the object.

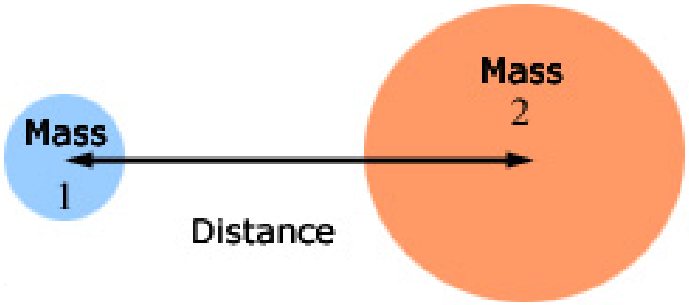
- **The roughness of the surface**
  - The rougher the surface, the more friction.



- **The weight of the object**
  - The heavier the object, the more friction.



- **What is gravity?**
  - The force of attraction between all objects.
- **The amount of gravity depends on two things:**
  - The objects' masses
  - The distance between the two objects



Gravity is a force that acts between any 2 masses.

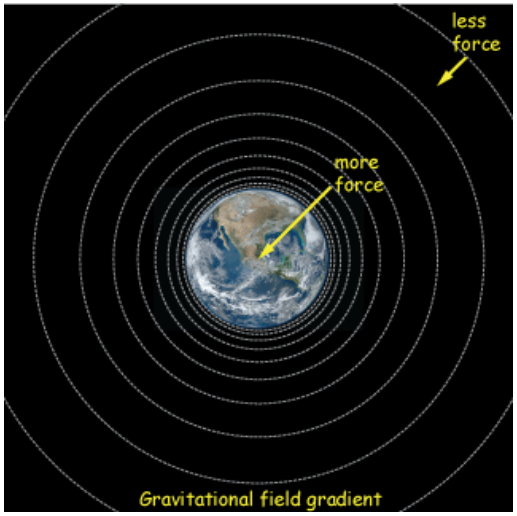
Two factors affect the gravitational attraction between objects: mass and distance.

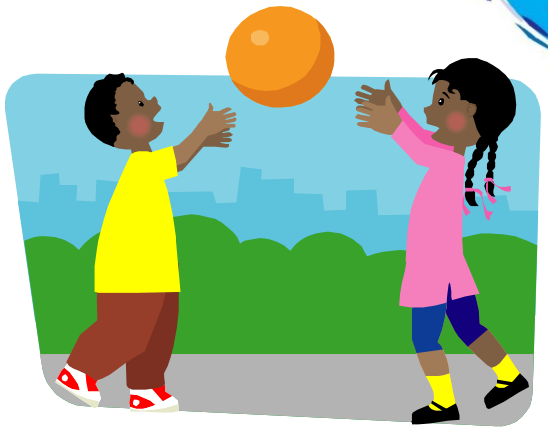
The force of gravity acts between all objects.

If mass increases, the force of gravity increases.

If distance increases, the force of gravity decreases.

- Since the earth is so large, everything on it is attracted to it even if they're not touching!
- Example: Throwing a ball.
  - You throw a ball up, but gravity pulls it back down to earth.
  - You can counteract gravity by catching the ball before it hits the ground (you provide the outside force!)





Weight and Mass

- Weight & Mass are Different
- Weight
  - The force of gravity acting on an object
  - Product of the mass and acceleration due to gravity
  - Unit is Newtons (N)

Weight Formula

$$\text{Weight} = \text{Mass} \times \text{Acceleration due to gravity}$$

$$W = mg$$

Weight and Mass

AP/ Wide World Photos

A **Astronaut on Earth**
Mass = 88.0 kg; Weight = 863 N

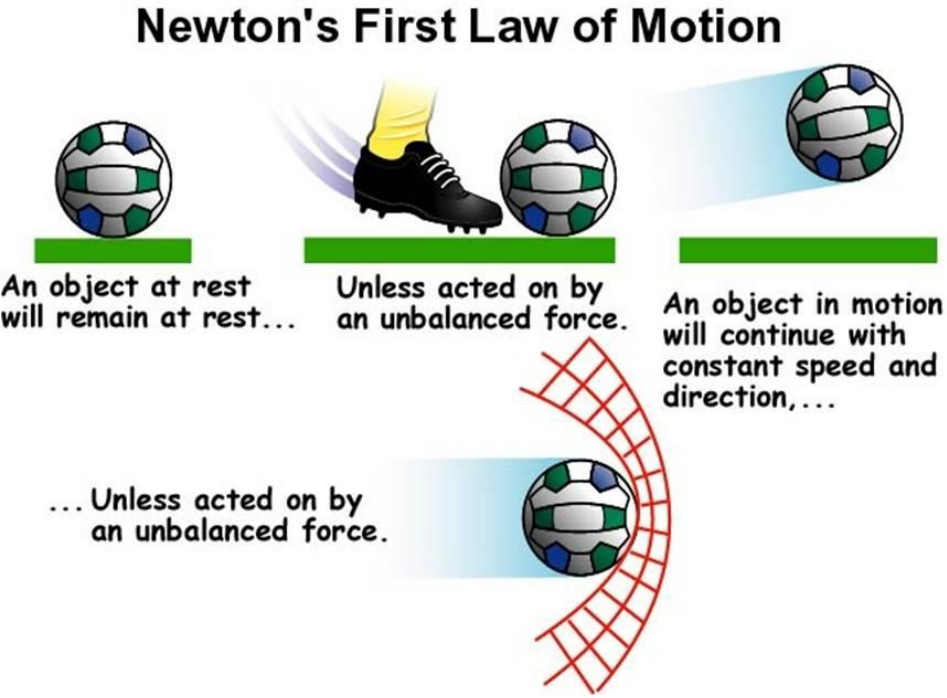
Bettmann/Corbis

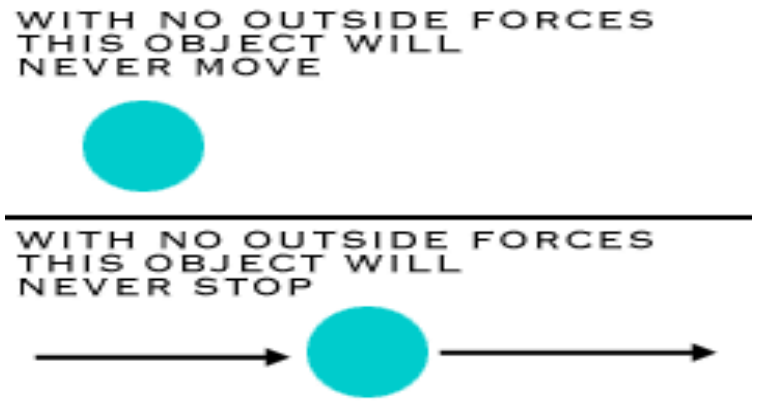
B **Astronaut on Moon**
Mass = 88.0 kg; Weight = 141 N

Newton's 3 Laws of Motion

1st Law of Motion:

Things that are still stay still and things that are moving keep moving with a steady speed unless a force of some kind pushes or pulls on them.



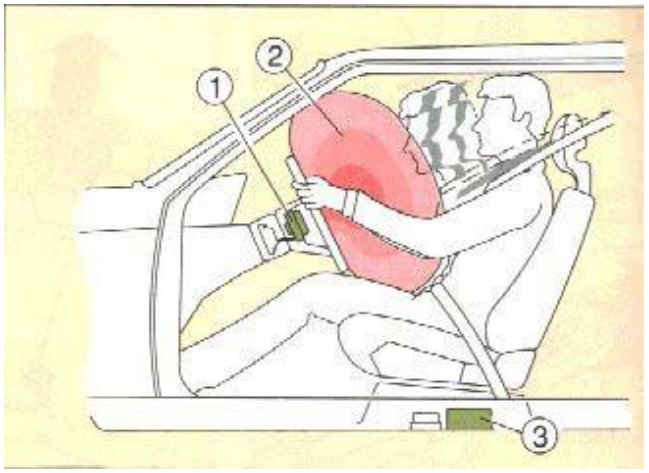


Mass and Inertia

- **Newton's 1st Law: The Law of Inertia**
  - An object at rest will remain at rest, unless acted upon by an unbalanced force
  - An object in motion will continue moving, in the same direction, at the same speed, unless an unbalanced force acts on it.

Inertia

- Inertia is the tendency of objects to resist a change in motion.
- Example: seatbelts!




INERTIA
Your truck has brakes...the massive hunk of stone doesn't.

Mass and Inertia

- If a car is going 50 kilometers per hour and it comes to a sudden stop, the people inside continue moving 50 kilometers per hour unless a force prevents their forward motion through the windshield

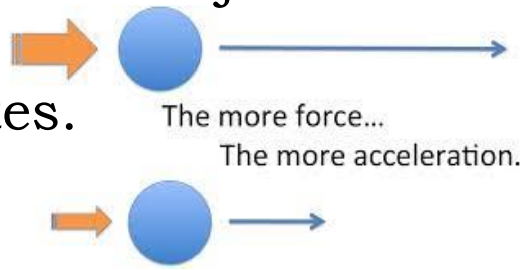
Which is why WE wear SEATBELTS!!

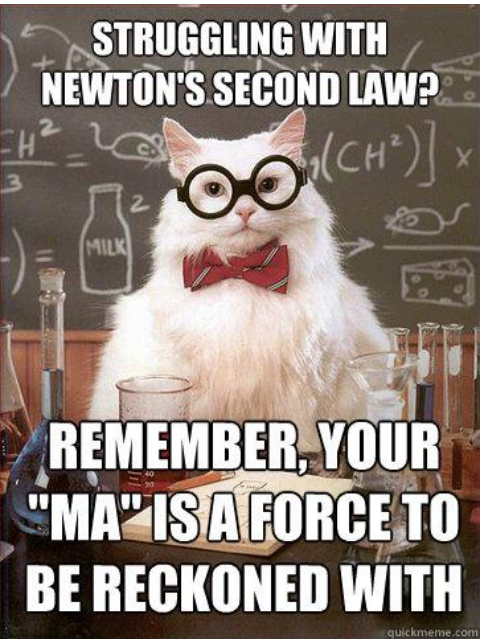
Newton's 3 Laws of Motion

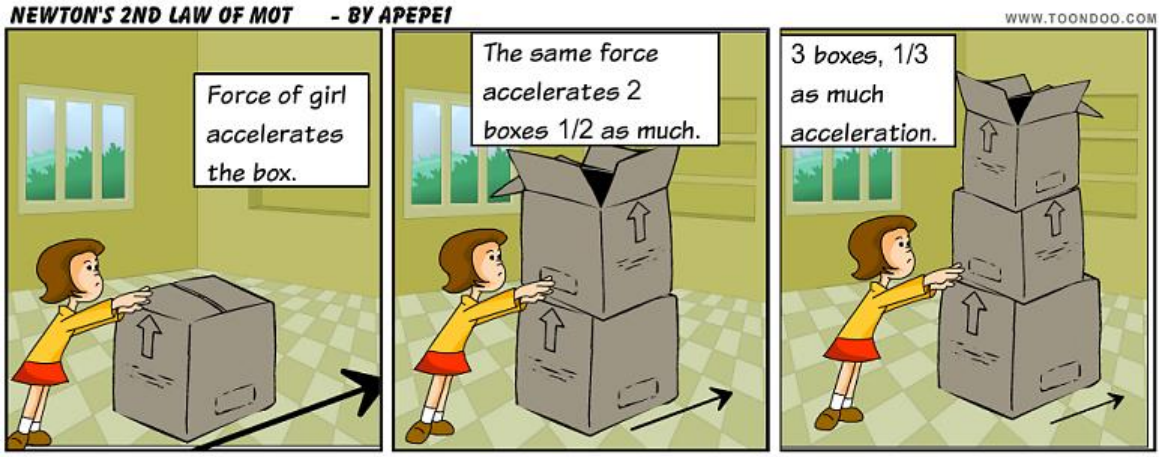
2nd Law of Motion:

When a force acts (pushes or pulls) on an object, it changes the object's speed or direction (in other words it makes the object accelerate).

The bigger the force, the more the object accelerates.







Newton's 2nd Law of Motion

- The acceleration of an object is equal to the net force acting on it divided by the objects mass
  - Mass
    - Measure of inertia of an object and depends on the amount of matter the object contains

F = ma

Force = mass * acceleration

Newton's 2nd Law of Motion

- The acceleration of an object is always in the same direction as the net force
- Net forces in the opposite direction of object's motion
  - Force produces deceleration and reduces speed
  - Ex. Seat belts
- Units for Acceleration are equivalent
  - $N/kg = m/s^2$

Newton's 2nd Law of Motion

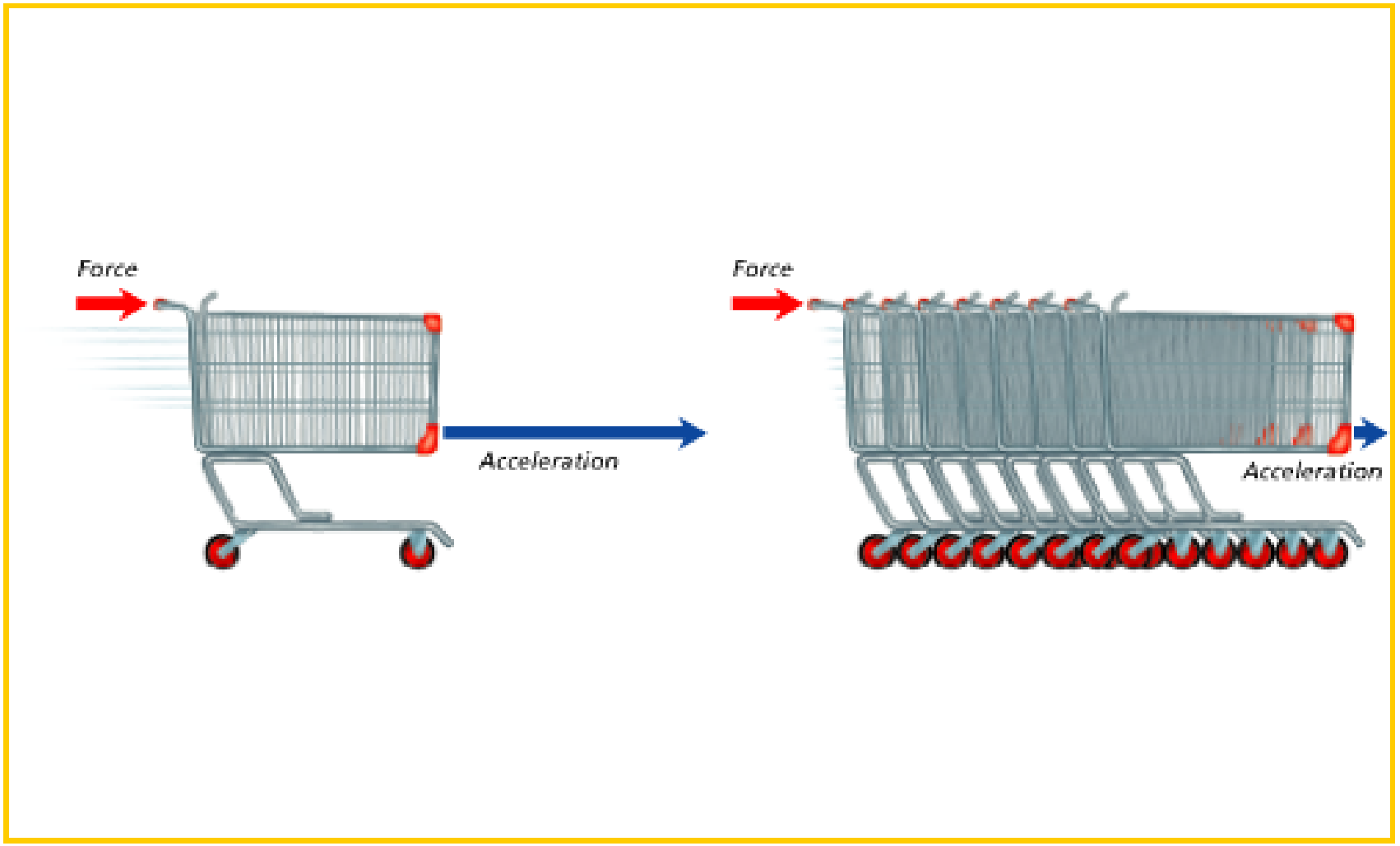


Figure 13 Acceleration depends directly on force and inversely on mass. Neglecting friction, when the same force acts, the single cart accelerates eight times faster than the chain of eight carts.

Newton's 2nd Law of Motion

1. A boy pushes forward a cart of groceries with a total mass of 40.0 kg. What is the acceleration of the cart if the net force on the cart is 60.0 N?

- 2. What is the upward acceleration of a helicopter with a mass of 5000 kg if a force of 10,000 N acts on it in an upward direction?

Newton's 2nd Law of Motion

3. An automobile with a mass of 1200 kg accelerates at a rate of 3.0 m/s^2 in the forward direction. What is the net force acting on the automobile? (*Hint:* Solve the acceleration formula for force.)

4. A 25-N force accelerates a boy in a wheelchair at 0.5 m/s^2 What is the mass of the boy and the wheelchair? (*Hint:* Solve Newton's second law for mass.)

Section 2 Practice Problems

5. During a test crash, an air bag inflates to stop a dummy's forward motion. The dummy's mass is 75 kg. If the net force on the dummy is 825 N toward the rear of the car, what is the dummy's deceleration?

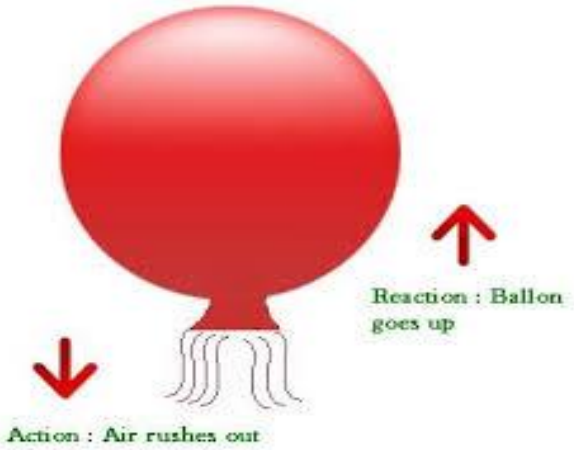
Section 2 Practice Problems

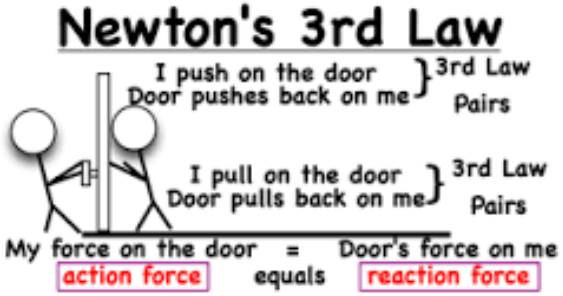
6. A bicycle takes 8.0 seconds to accelerate at a constant rate from rest to a speed of 4.0 m/s. If the mass of the bicycle and rider together is 85 kg, what is the net force acting on the bicycle? (*Hint:* First calculate the acceleration.)

Newton's 3 Laws of Motion

3rd Law of Motion:

When a force acts on an object, there's equal for
(called a reaction) acting in the opposite directio
This law is sometimes written that "actions are
equal and opposite."





Newton's 3rd Law of Motion & Momentum

- 3rd Law – when an object exerts a force on a second object, that object exerts an equal and opposite force on the first object
- Momentum
  - Product of an object's mass and its velocity
  - Objects momentum at rest is zero
  - Unit kg m/s

Momentum Formula

$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$

Law of Conservation of Momentum

- If no net force acts on a system, then the total momentum of the system does not change
- In a closed system, loss of momentum of one object equals the gain in momentum of another object

Law of Conservation of Momentum

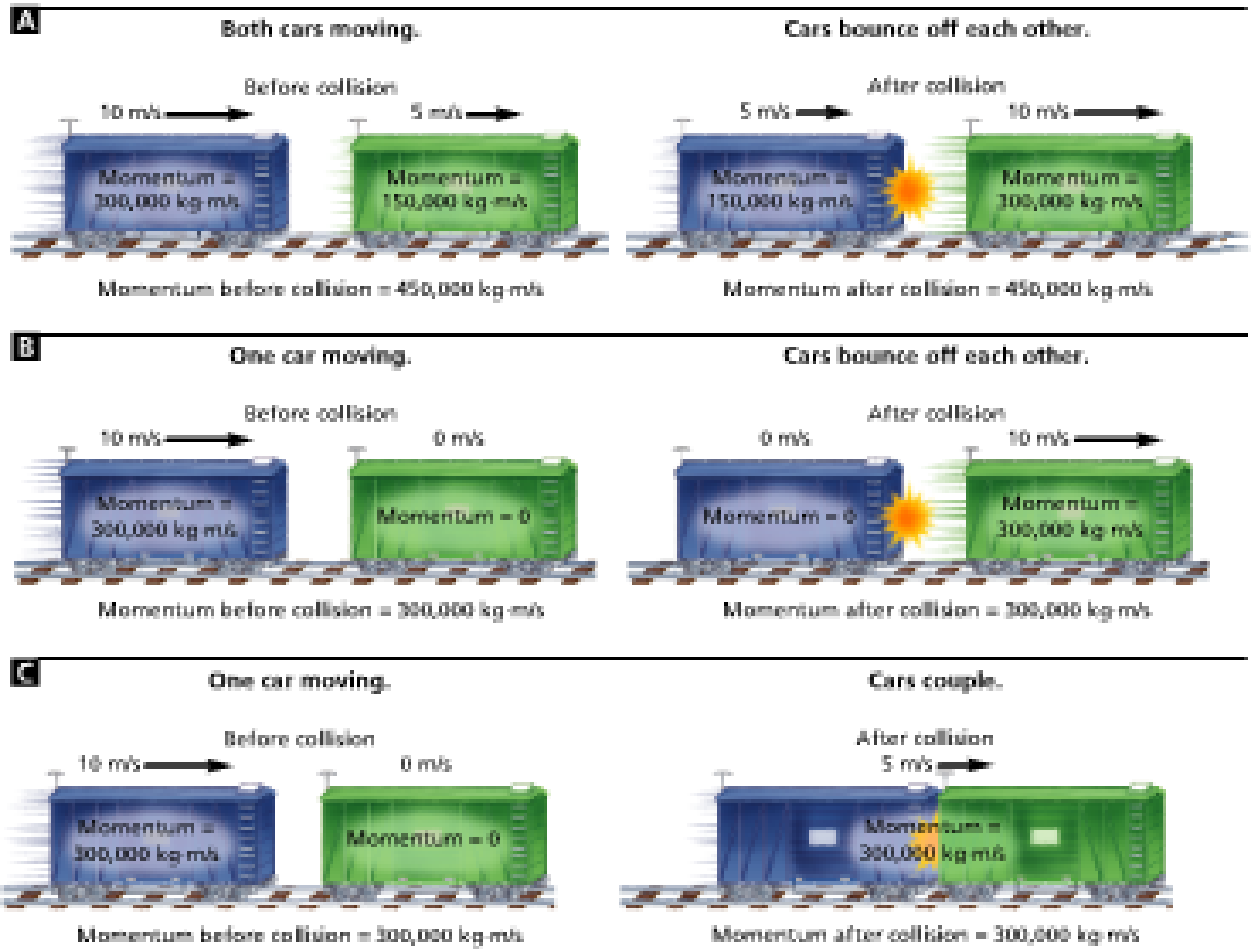


Figure 17 Three different collisions between equal-mass train cars are shown above. The different collisions between equal-mass train cars are shown above. In each collision, the total momentum of the train cars does not change—momentum is conserved.

1. _____ kinetic
2. _____ centripetal
3. _____ mass
4. _____ acceleration
5. _____ velocity
6. _____ weight
7. _____ gravity
8. _____ inertia
9. _____ speed
10. _____ momentum
11. _____ newton

a) amount of matter in an object

b) amount of force exerted on an object due to gravity

c) distance covered per unit of time

d) rate at which velocity changes over time

e) speed in a given direction

f) unit of measurement for force

g) energy of motion

h) tendency of a moving object to keep moving

i) depends on the mass and velocity of an object

j) type of force that keeps objects moving in a circle

k) attractive force between two objects