NEWTON’s LAWS of MOTION

Newton's 1st law sometimes called "Law of Inertia"

Inertia: the tendency of all objects to resist any change in motion


1st Law

- Once airborne, unless acted on by an unbalanced force (gravity and air – fluid friction), it would never stop!

1st Law

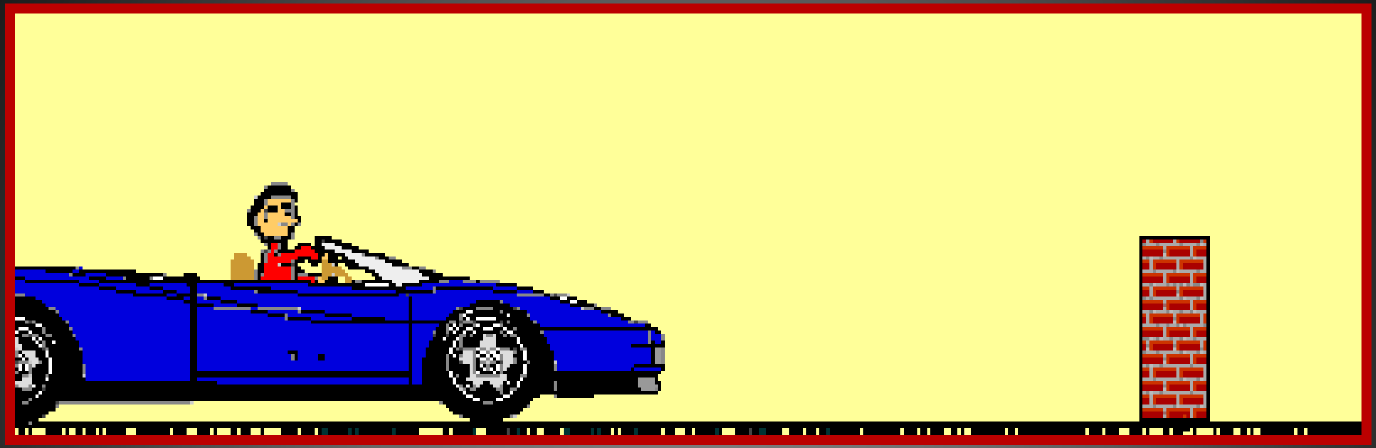
- Unless acted upon by an unbalanced force, this golf ball would sit on the tee forever.

Why then, do we observe every day objects in motion slowing down and becoming motionless seemingly without an outside force?

<u>It’s a force we sometimes cannot see – friction.</u>

Objects on earth, unlike the frictionless space the moon travels through, are under the influence of friction.

Newtons’s 1st Law and You



Don’t let this be you. Wear seat belts.

Because of inertia, objects (including you) resist changes in their motion. When the car going 80 km/hour is stopped by the brick wall, your body keeps moving at 80 m/hour.

Newton's 2nd Law:
The acceleration of an object depends on the mass and the amount of force

Force = mass x acceleration

2^{nd} Law

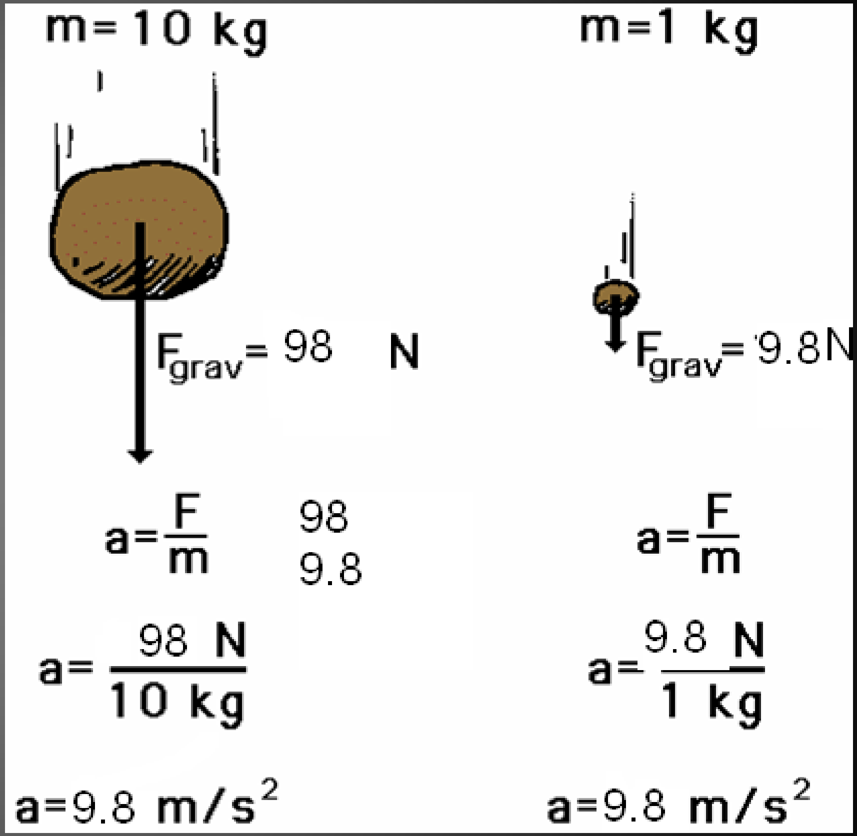
- When mass is in kilograms and acceleration is in m/s/s, the unit of force is in newtons (N).
- One newton is equal to the force required to accelerate one kilogram of mass at one meter/second/second.

2^{nd} Law (F = m x a)

- How much force is needed to accelerate a 1400 kilogram car 2 meters per second/per second?
- Write the formula
- F = m x a
- Fill in given numbers and units
- F = 1400 kg x 2 meters per second/second
- Solve for the unknown
- 2800 kg-meters/second/second or **2800 N**

Newton's 2nd Law proves that different masses accelerate to the earth at the same rate, but with different forces.

- We know that objects with different masses accelerate to the ground at the same rate.
- However, because of the 2nd Law we know that they don't hit the ground with the same force.



F = ma

98 N = 10 kg x 9.8 m/s/s

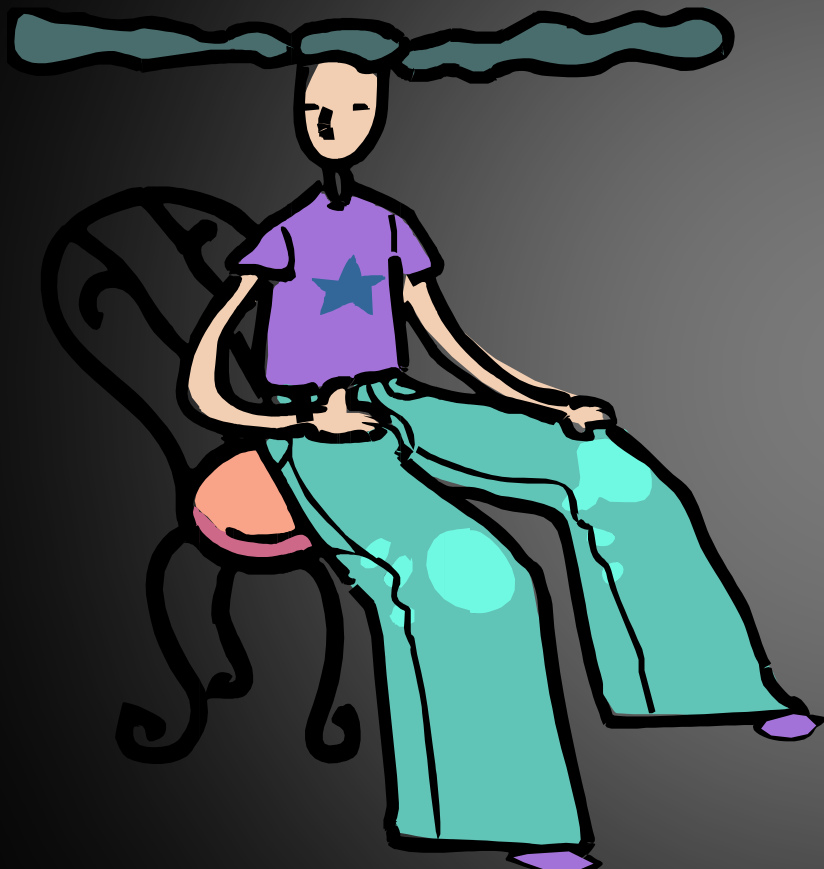
F = ma

9.8 N = 1 kg x 9.8 m/s/s

Newton's 3rd Law:

When one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

3rd Law



According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body.

3^{rd} Law

There are two forces resulting from this interaction - a force on the chair and a force on your body. These two forces are called *action* and *reaction* forces.

Newton's 3rd Law in Nature

- Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. In turn, the water *reacts* by pushing the fish forwards, propelling the fish through the water.
- The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards).

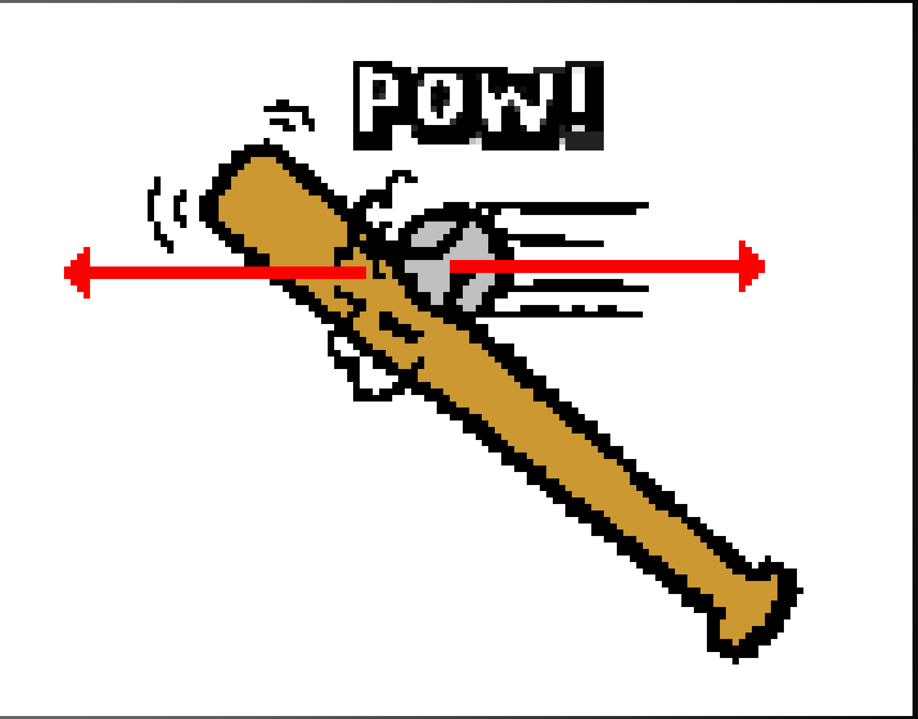
3rd Law

Flying gracefully through the air, birds depend on Newton's third law of motion. As the birds push down on the air with their wings, the air pushes their wings up and gives them lift.

- Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air downwards. In turn, the air reacts by pushing the bird upwards.
- The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards).
- Action-reaction force pairs make it possible for birds to fly.

Other examples of Newton's Third Law

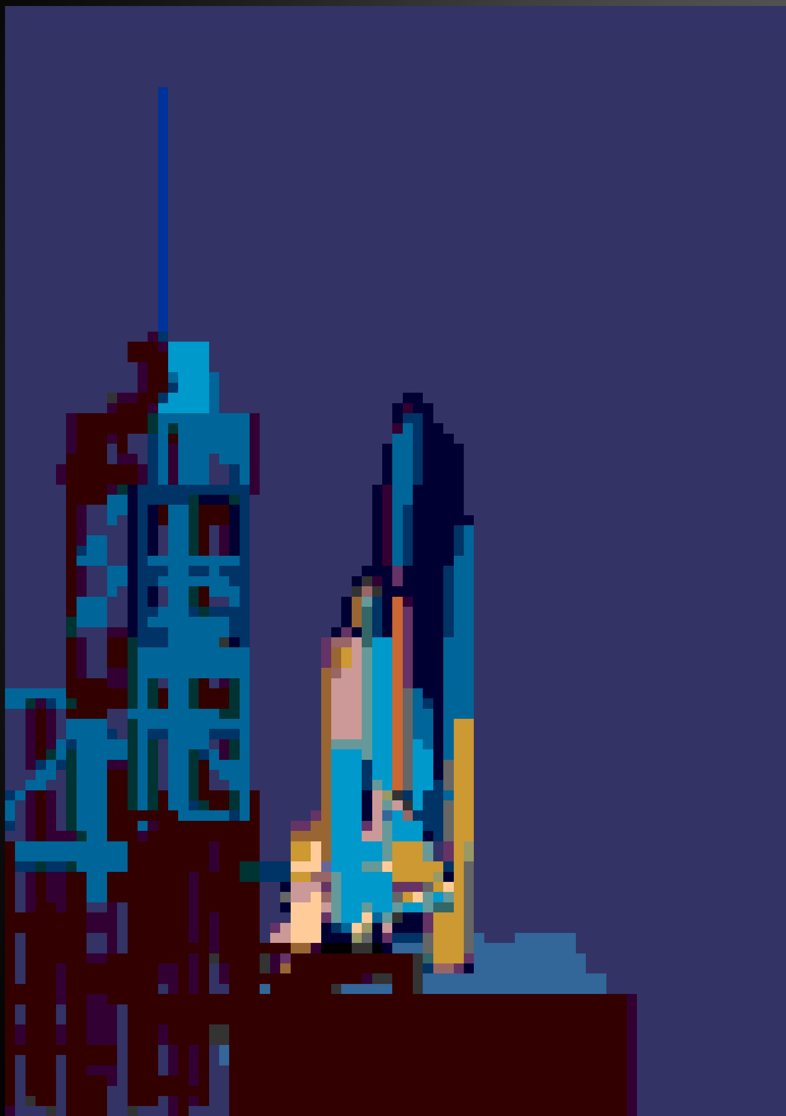
- The baseball forces the bat to the left (an action); the bat forces the ball to the right (the reaction).



3^{rd} Law

- Consider the motion of a car on the way to school. A car is equipped with wheels which spin backwards. As the wheels spin backwards, they grip the road and push the road backwards.

3rd Law



The reaction of a rocket is an application of the third law of motion. Various fuels are burned in the engine, producing hot gases.

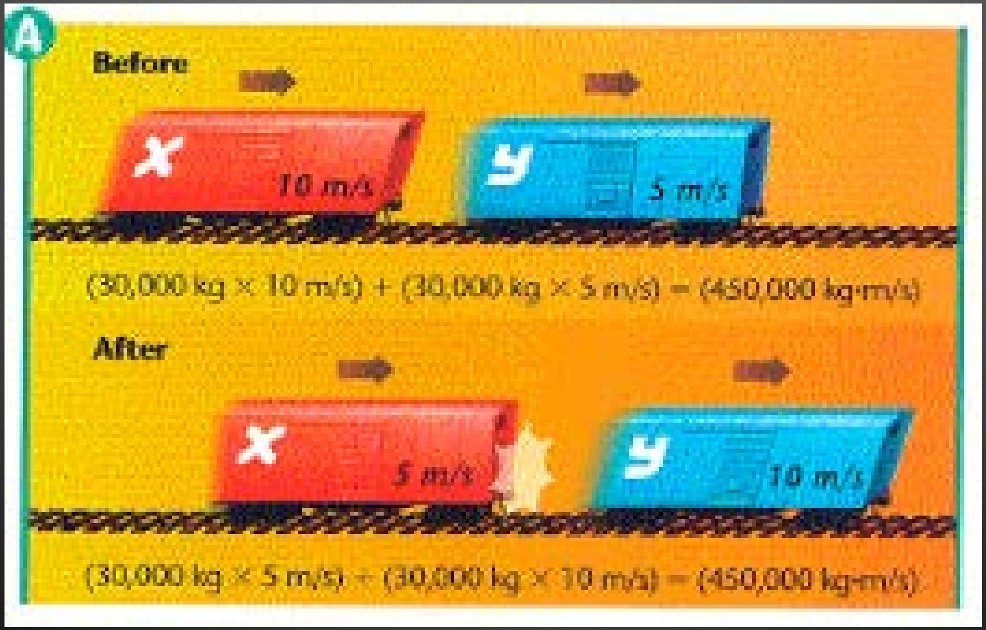
The hot gases push against the inside tube of the rocket and escape out the bottom of the tube. As the gases move downward, the rocket moves in the opposite direction.

Momentum

- An object's momentum is directly related to both its mass and velocity.
- **Momentum = mass x velocity**
- momentum is designated as "*p*".
- Therefore: **$p = mv$**
- The unit for mass is kg, the unit for velocity is meter/second, therefore the unit for momentum is kg m/sec
- **Conservation of Momentum**:
  - When two or more objects interact (collide) the total momentum before the collision is equal to the total momentum after the collision

Momentum – 2 moving objects

- During this collision the speed of both box cars changes. The total momentum remains constant before & after the collision. The masses of both cars is the same so the velocity of the red car is transferred to the blue car.



Momentum – 1 moving object

- During this collision the speed red car is transferred to the blue car. The total momentum remains constant before & after the collision. The masses of both cars is the same so the velocity of the red car is transferred to the blue car.

Momentum – 2 connected objects

- After this collision, the coupled cars make one object w/ a total mass of 60,000 kg. Since the momentum after the collision must equal the momentum before, the velocity must change. In this case the velocity is reduced from 10 m/sec. to 5 m/sec.