Forces and Motion

Force

- You must have a force to change motion
- Things will continue in motion unless another force acts on the object

- **Force** = push or pull, any action that can change the acceleration (*or motion*) of an object.

Force

- In 1687, **Sir Issac Newton** developed 3 Laws of Universal Motion
  - Essentially, he was the first person to mathematically describe motion or gravity correctly.

Newton's First Law

- An object at rest will stay at rest, and an object in motion will stay in motion unless a force acts on it.
  - Force is needed to change motion

- Forces could be a gravity, friction, push, a pull, a kick, wind resistance, etc…

Newton's First Law

- Object at rest (human) stays at rest, until acted upon by an outside force (kangaroo).

Newton's First Law

- Object stays in motion (the crash test dummy) stays in motion until an outside force acts on it (the windshield).
  - Just because the car stops, doesn't mean the dummy will stop instantly
  - Dummy keeps moving until a seatbelt, or airbag, or steering wheel (etc…) stops it

Newton's First Law

- And this one is just funny…

Newton's First Law: Inertia

- Inertia – property of an object to **resist** a change in motion or acceleration
- The inertia of an object cannot change
  - It depends on mass of the object
  - Large mass

    = Large Inertia

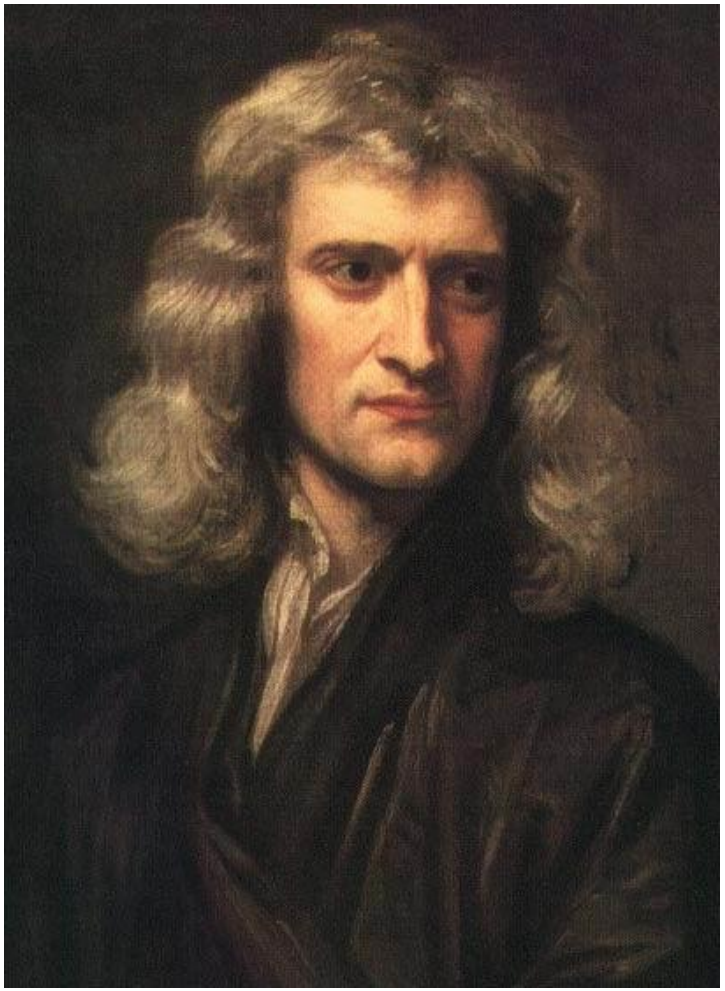
    = Hard to stop

Which of these has a greater inertia?

Newton's 2nd Law

- We already know:
  - Force causes acceleration
  - Mass resists acceleration
- SO…
- **Force = Mass x Acceleration**
  - **F=MA**

How do we measure force?



- Force is measured in Newtons
- In science talk:
  - a force of 1 N causes a 1kg object to accelerate at a rate of 1 m/s^2
  - **1kg * 1 m/s^2**

Newton's 2nd Law

PRACTICE PROBLEM:

- What is the acceleration of a boy on a skateboard if the net force acting on the boy is 15N, assuming the total mass of the boy and the skateboard together is 58kg?

Newton's 2nd Law

PRACTICE PROBLEM:

- What is the mass of an object if a force of 34N produces an acceleration of 4.0 m/s^2?

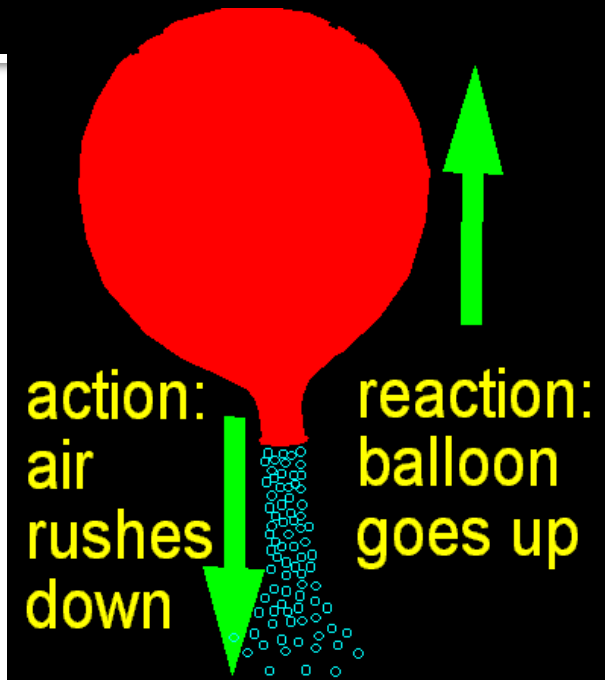
Newton's 2nd Law

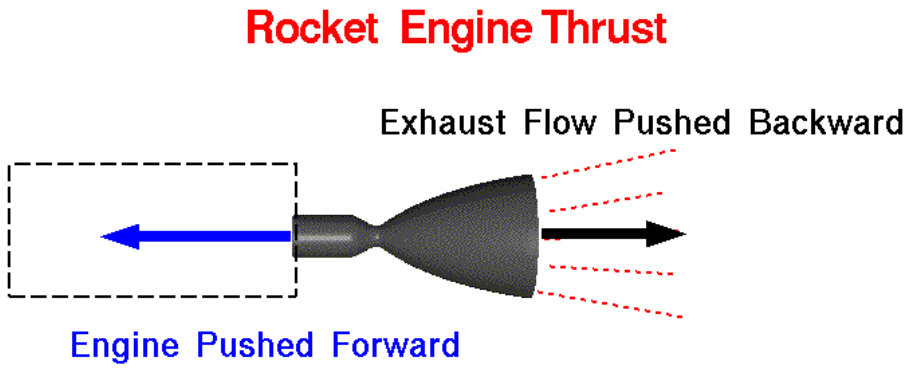
- The more mass you have, the bigger the force required to move you
  - The less mass you have, the less force required to move you.

Newton's 3rd Law

- **For every action, there is an equal and opposite reaction.**
  - Forces always act in pairs
  - Forces are equal and opposite

- Newton's 3rd law includes the forces acting on two objects instead of just one.
  - The forces DO NOT cancel out because they are acting on different objects.
- Can you think of an example of this in real life?





For every action, there is an equal and opposite re-action.

Newton's 3rd Law

- **For every action, there is an equal and opposite reaction.**
  - Forces always act in pairs
  - Forces are equal and opposite

Newton's 3rd Law: Examples

- Dog walking on a float in the pool (2 min)
  - http://www.youtube.com/watch?v=HFDPwFrn_KU
- Jumping out of a boat (2 min)
  - http://www.youtube.com/watch?v=4-vF_Vby-nQ
- Newton's 3rd Law: USC Lecture (4 min)
  - http://www.youtube.com/watch?v=Xx9kiFoorts
- **DEMO – "Bottle rocket"**

Quick Recap: Which law is it?!?!

- A force of 18 newton's will cause a larger acceleration on a golf ball than a bowling ball.
  - Newton's 2nd Law
- A bowling ball, once thrown down a greased up bowling lane, will continue traveling unchanged until it hits the pins or the backstop.
  - Newton's 1st Law
- Cannon fires a cannonball. The cannon moves backward as it is fired, while the cannonball shoots forward.
  - Newton's 3rd Law

Quick Recap: How can you explain each law?

- 1st Law (Boy's head)?
  - Head stays still until hit by water
- 2nd law?
  - Force of water bottle = mass of bottle * acceleration of bottle
- 3rd law?
  - Water shoots backward, rocket moves forward

Quick Recap: How can you explain each law?

- 1st Law?
  - Ball will continue until it an outside force acts on it (the kid)
- 2nd law?
  - Force of kick = mass of ball time acceleration of ball
- 3rd law?
  - When ball hits kid, the ball applies a force on the kid. The kid applies an opposite (and equal) force on the ball