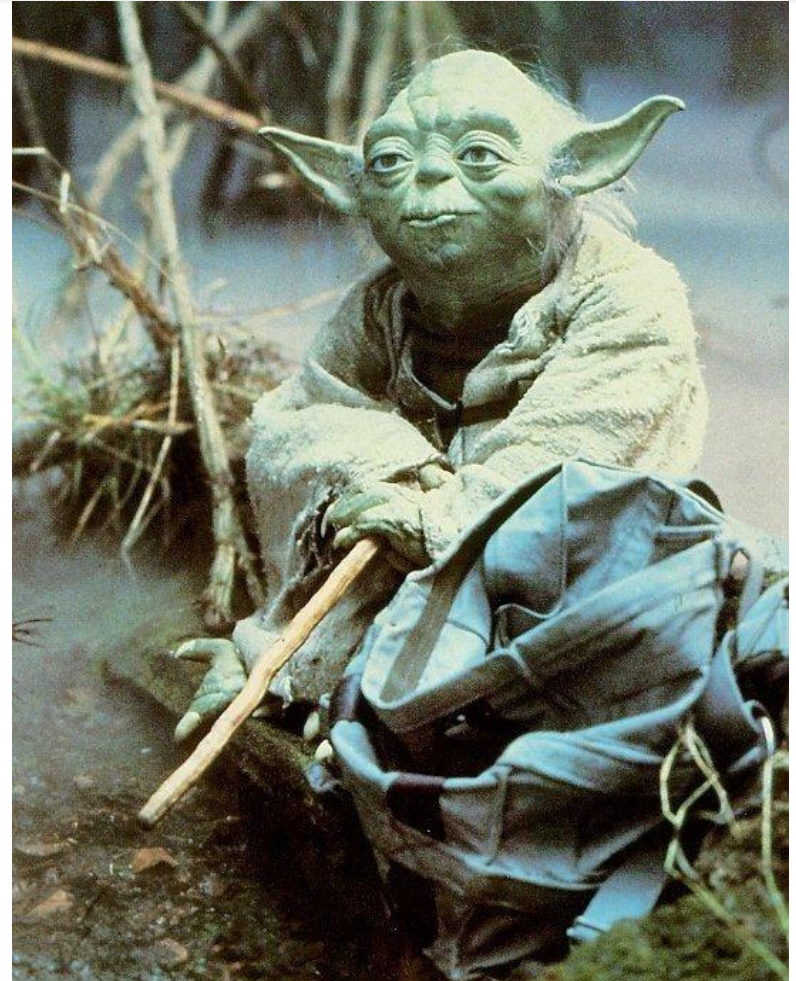


# Forces and Motion

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# 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?

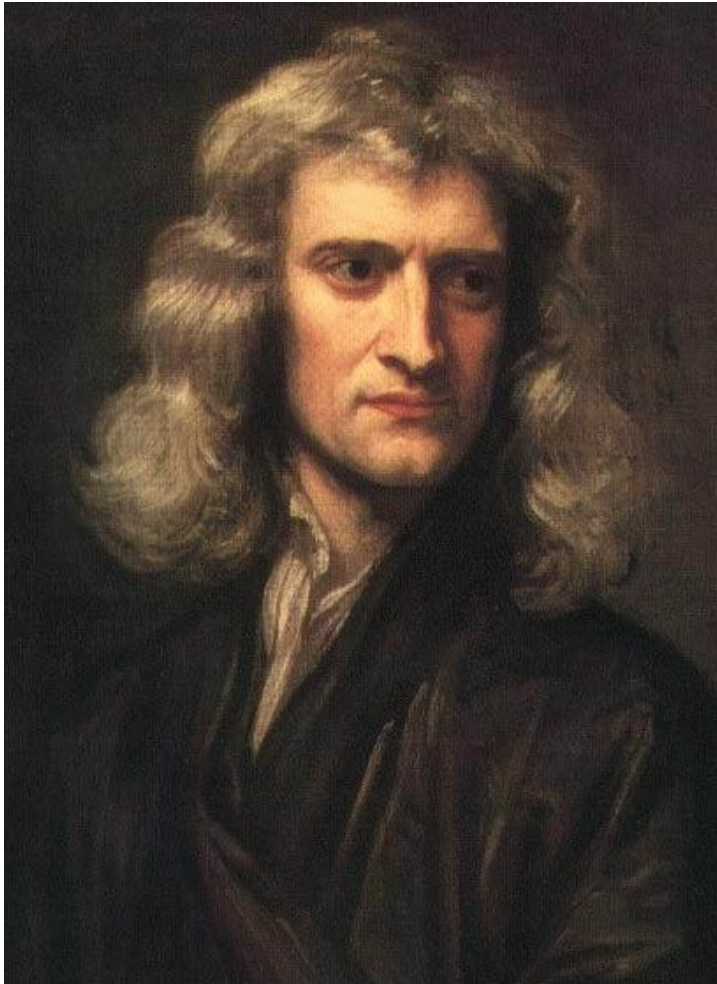


# Newton's 2<sup>nd</sup> Law

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

**MAY THE  
MASS TIMES  
ACCELERATION  
BE WITH  
YOU**

# 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<sup>2</sup>
  - **1kg \* 1 m/s<sup>2</sup>**

# Newton's 2<sup>nd</sup> 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 2<sup>nd</sup> Law

## PRACTICE PROBLEM:

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

# Newton's 2<sup>nd</sup> 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 second law says, the more mass an object has the more force is needed to move it. These penguins will help me demonstrate this.

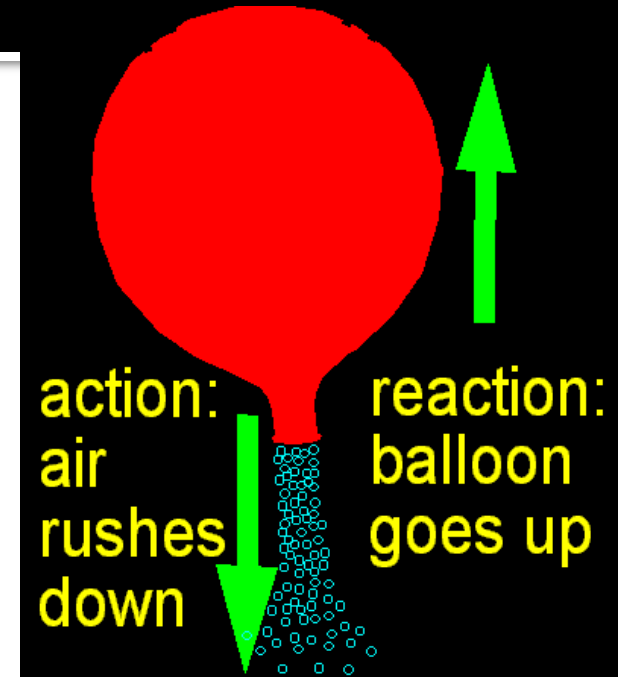
I'm very heavy, so it takes a lot of force to move me.

I don't weigh much, so he could lift me with ease.

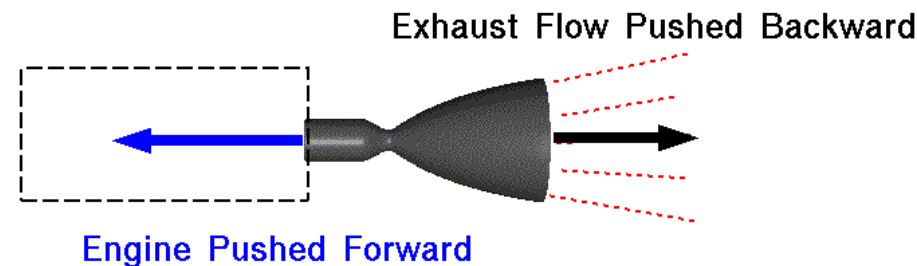


# Newton's 3<sup>rd</sup> Law

- For every action, there is an equal and opposite reaction.
  - Forces always act in pairs
  - Forces are equal and opposite
- Newton's 3<sup>rd</sup> 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?



Rocket Engine Thrust



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

# Newton's 3<sup>rd</sup> Law

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





# Newton's 3<sup>rd</sup> Law: Examples

- Dog walking on a float in the pool (2 min)
  - [http://www.youtube.com/watch?v=HFDPwFrn\\_KU](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](http://www.youtube.com/watch?v=4-vF_Vby-nQ)
- Newton's 3<sup>rd</sup> Law: USC Lecture (4 min)
  - <http://www.youtube.com/watch?v=XxgkiFoorts>
- **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 2<sup>nd</sup> 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 1<sup>st</sup> Law**
- Cannon fires a cannonball. The cannon moves backward as it is fired, while the cannonball shoots forward.
  - **Newton's 3<sup>rd</sup> Law**

# Quick Recap:

## How can you explain each law?

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



# Quick Recap:

## How can you explain each law?

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

