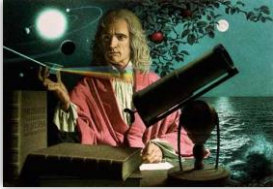


## Today's Class: Newton's Laws of Motion

See class syllabus at:

<http://lunar.colorado.edu/~jaburns/astr2020/>

- Read: *Cosmic Perspective*, Chapter 4, Section 4.3.
- Complete Daily Health Form



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## Class Exercise: Space Station astronauts are weightless because

- no force is acting on them.
- their acceleration is zero.
- their acceleration is equal to the acceleration due to gravity.
- they are in space.
- A and B

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## Class Exercise: Space Station astronauts are weightless because

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## Today's Class

- How did Newton change our view of the universe?
- What are Newton's three laws of motion?



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## How did Newton change our view of the Universe?

- Realized the same physical laws that operate on Earth also operate in the heavens
  - one *universe*
- Discovered laws of motion and gravity



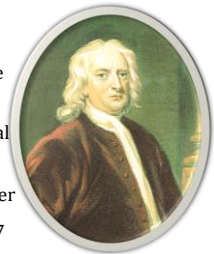
Sir Isaac Newton  
(1642–1727)

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## A Brief History of Isaac Newton

- Lived from 1642-1726.
- His book *Mathematical Principles of Natural Philosophy (Principia)* laid the mathematical foundation for classical mechanics.
- Built first reflecting telescope, physical laws of optics, principles of fluid dynamics.
- Difficult early childhood: left by mother to be cared for by grandmother. Poor. Forced to leave Cambridge in 1665-67 because of the Great Plague (invented calculus, law of gravity, optics).



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## What are Newton's three laws of motion?



- **Newton's first law of motion:** An object moves at constant velocity unless a net force acts to change its speed or direction (inertia).
  - After engine shutdown on spacecraft, it continues at a constant speed in a straight line.
  - You feel no different in airplane cabin than on the ground when traveling at constant speed.

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## Class Exercise

Using Newton's First Law of Motion, discuss how Isaac Newton inferred that the same force of gravity which causes an apple's motion toward the ground must also hold the Moon in orbit about the Earth?



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## Newton's Second Law of Motion

- There are two equivalent ways to express **Newton's Second Law of Motion**

– Force = mass × acceleration

$$F = ma$$

– Force = rate of change in momentum

$$F = \frac{\Delta p}{\Delta t}$$



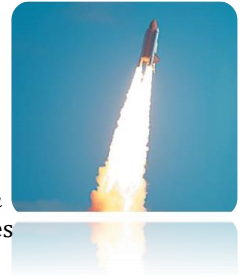
=>You can throw a baseball further than a cannon ball with same force.

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## Newton's third law of motion

- For every force, there is always an *equal and opposite* reaction force.
- Explains how a rocket works! Rocket engine generates force that drives hot gas out of exhaust creating equal & opposite force that moves rocket forward.



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## Class Exercise

A compact car and a Mack truck have a head-on collision. Are the following **true** or **false**?

1. The *force* of the car on the truck is equal and opposite to the force of the truck on the car.
2. The *momentum* transferred from the truck to the car is equal and opposite to the momentum transferred from the car to the truck.
3. The *change of velocity* of the car is the same as the change of velocity of the truck.

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## Class Exercise

A compact car and a Mack truck have a head-on collision. Are the following **true** or **false**?

1. The *force* of the car on the truck is equal and opposite to the force of the truck on the car. **T**
2. The *momentum* transferred from the truck to the car is equal and opposite to the momentum transferred from the car to the truck. **T**
3. The *change of velocity* of the car is the same as the change of velocity of the truck. **F**

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## What have we learned?

- **How did Newton change our view of the universe?**
  - He discovered laws of motion and gravitation.
  - He realized these same laws of physics were identical in the universe and on Earth.
- **What are Newton's three laws of motion?**
  1. Object moves at constant velocity if no net force is acting.
  2. Force = mass  $\times$  acceleration
  3. For every force there is an equal and opposite reaction force.

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