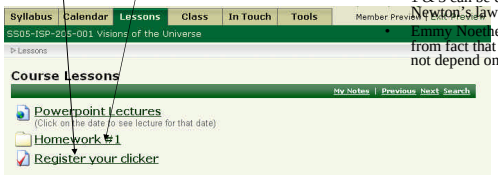
Newton's Laws of Motion–January 21

- First homework
  - http://angel.oregonstate.edu
    - Open "lessons" folder.
  - Must finish by 3:00 am, Wed, 26th, (Tues night).
- Register your clicker number.
- Forget your clicker or your clicker doesn't work?
  - You may turn in clicker answers on paper after class.
  - You may do this at most two times during the entire term.



- **Outline**
- What is the reason for Kepler's three descriptive laws?
  1. Orbit of planet is an ellipse with sun at one focus
  2. Line joining planet & sun sweeps out equal areas in equal amounts of time
  3. $P^2 = a^3$
- Newton's & Aristotle's contrasting ideas of "natural" motion
- Newton's Law of Gravity
- Modern view of Kepler's Laws
  - 1 & 3 can be derived from Newton's laws of motion
  - Emmy Noether: 2 can be derived from fact that laws of physics do not depend on direction.

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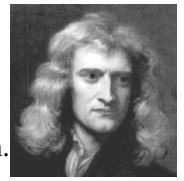
Isaac Newton (1643-1727)



- One of the great geniuses of the millennium.
  - Invented *calculus* (mathematics of change)
  - Invented *mechanics* (the description of how things move). *Principia*, 1687.
  - Discovered *Law of Gravity*
- Kepler's laws can be derived from Newton's laws
- But Newton's laws are a general descriptions of a far wider range of phenomena
  - universally valid
    - except on the smallest or largest scales, or in extreme situations (strong gravity, high velocities).

"Natural" motion for Newton & Aristotle

- Natural motion is motion that needs no explanation: the object naturally moves that way.
- Aristotle: For heavenly objects, natural motion is motion in a circle with the same speed. For base objects, natural motion is rest.
  - A book falls off the table and comes to rest on the floor. This needs no explanation because rest is the natural state.
- Newton: Natural motion is moving at the same speed in the same direction.
  - Newton's First Law: In the absence of a force, an object moves at the same speed in the same direction.
- Q1: A book falls off the table and lands on the floor. For Newton, what is natural?
  a. The book is on the floor.
  b. The book is halfway to the floor.
  c. The book is just starting to fall.
  d. I push the book off the table.
- Q2: Same after discussion with partner

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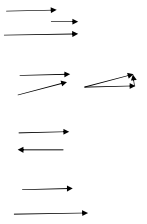
- Q3: Venus moves around the sun in a circle at the same speed. Does Newton consider this motion natural?
  a. Yes, Venus is a heavenly object.
  b. Yes, the speed is the same.
  c. No, the direction is not always the same.
  d. No, Venus is not at rest.

Newton's Second Law

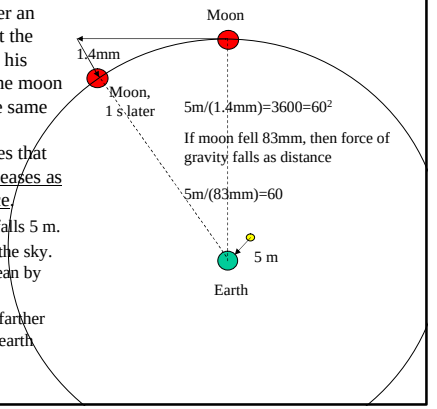
- Newton's First Law: In the absence of a force, an object moves at the same speed in the same direction.
- Newton's Second Law tells how to find the motion if there is a force.
  - *Force = mass x acceleration*
    F = m x a
  - Acceleration is change in velocity divided by amount of time
- Q4 The velocity changed in
  a. Case A only
  b. Case B only
  c. Neither cases A nor B
  d. Both cases A and B
- Q5 The acceleration is greatest for case
  a. A
  b. B
  c. C
  d. D

- Case A
  - Velocity at start
  - Velocity after 1 s
- Case B
  - Velocity at start
  - Velocity after 1 s
- Case C
  - Velocity at start
  - Velocity after 1 s
- Case D
  - Velocity at start
  - Velocity after 2 s



Newton discovers the law of gravity

- Newton was sitting under an apple tree and looking at the moon. An apple falls on his head. Newton realizes the moon and the apple fall for the same reason. He does a quick calculation and concludes that the force of gravity decreases as the square of the distance.
  - In a second, an apple falls 5 m.
  - The moon stays up in the sky. What does Newton mean by "the moon falls?"
  - The moon is 60 times farther from the center of the earth than the apple.



Newton's Law of Gravity

- Force between sun and earth
  - Force = G $mass_{Sun}$ $mass_{Earth}$/$Distance^2$
- How to calculate the path of the planets using a computer
  - Start with present location, speed, & direction of a planet
  - Find the force due to sun and other planets (using law of gravity) Use F=mass×acceleration to find new speed & direction
  - Use speed & direction to find new location Orbits with mass of planets 45 times heavier