



- Homework #1 was due at 11:50am! Now it's too late!
- Homework #2 is online and is due next Friday!
- New format for lectures– 4 sheets per page PDF.
- Planetarium shows are getting full.
- Solar Observing starts Monday!
- Nighttime observing starts in < 2 weeks.

Sept 12, 2003

Astronomy 100 Fall 2003

Outline



- Galileo's Observations using the telescope.
- Explanation of speed, velocity, acceleration, and force.
- Newton's Laws of Motion
 - A body remains in motion unless acted upon by a force
 - The Acceleration of an object is equal to the Force applied, divided by its Mass
 - Every action has an equal and opposite reaction

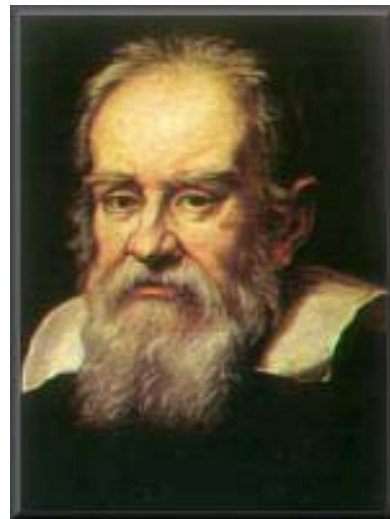
Sept 12, 2003

Astronomy 100 Fall 2003

Galileo Galilei (1564-1642)



- As we learned, he used the telescope to make ground breaking discoveries about the Solar System
- Worked on the concept of Velocity, Speed, Acceleration, and Gravity



<http://www.unet.univie.ac.at/~a9503672/astro/history/galilei.htm>

Sept 12, 2003

Astronomy 100 Fall 2003

Galileo (1610)



First to systematically use the telescope (but did not invent it).

- Moon has mountains and valleys
- Milky Way consists of faint stars
- Saturn is elongated
- Venus shows phases
- Jupiter has moons (now called Galilean moons)

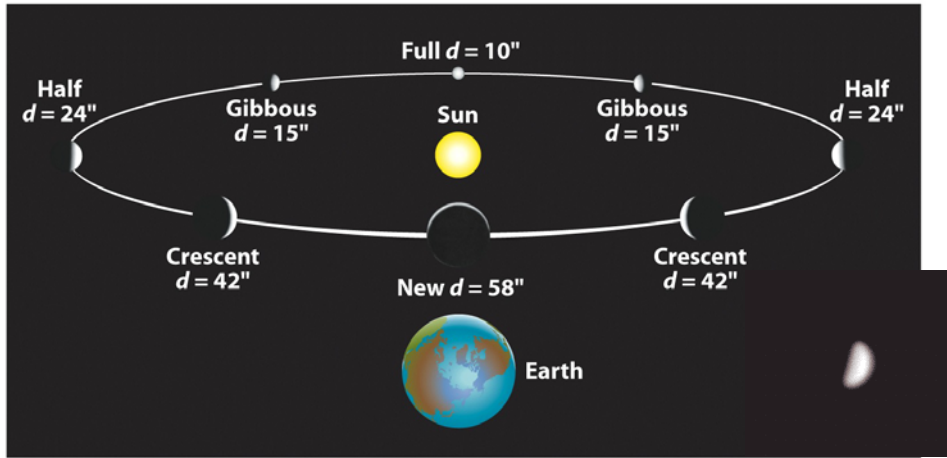
Wow! Big stuff. The moons of Jupiter did not orbit the Earth!



Sept 12, 2003

Astronomy 100 Fall 2003

The Phases of Venus



Could not be explained with the Geocentric model

<http://www.calvin.edu/academic/phys/observatory/images/venus/venusb.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Phases of Venus



Compare the Heliocentric to Geocentric models to explain the phases of Venus.

<http://www.astro.ubc.ca/~scharein/a310/SolSysEx/phases/Phases.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Galileo (1610)



- Disproved Ptolemaic system
- Rome bullied him into recanting (cleared in 1992)
- Now we understand the motions and the fact that the solar system **MUST** be Heliocentric?

Sept 12, 2003

Astronomy 100 Fall 2003

Kepler's Laws



Kepler discovered these patterns in nature by using the data that Tycho collected, **BUT** the world had to wait until someone could understand the Natural Law that predicts Kepler's Laws.

The real problem: On Earth we're used to things that move but always come quickly to a rest. Why didn't the planets stop?

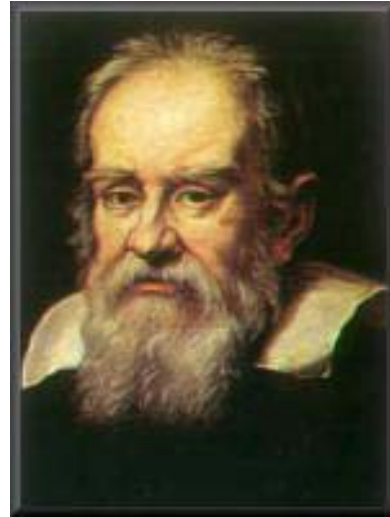
Sept 12, 2003

Astronomy 100 Fall 2003

Galileo Galilei



- For Aristotle, the distance of an object was a fundamental attribute.
- Galileo broke with the traditional concept and realized that time was important— distance and time being the key.



<http://www.unet.univie.ac.at/~a9503672/astro/history/galilei.htm>

Sept 12, 2003

Astronomy 100 Fall 2003

Speed or Velocity



What's the difference between speed and velocity?

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Measured in km/h, miles/hr, cm/s, AU/century, etc...



Sept 12, 2003

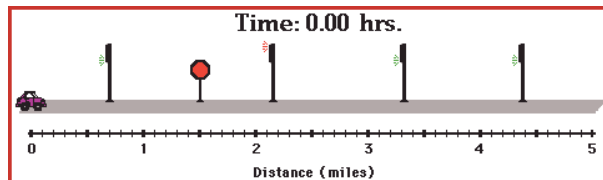
Astronomy 100 Fall 2003

<http://www.physicslessons.com/speed.jpg>

Average Speed



You notice when you drive you can never keep a constant speed due to stop signs, traffic, whatever... Your instantaneous speed is what your speedometer reads.



$$\text{Ave. Speed} = \frac{5 \text{ miles}}{0.2 \text{ hours}} = 25 \text{ miles/hour}$$

Sept 12, 2003

Astronomy 100 Fall 2003

<http://www.physicsclassroom.com/mmedia/kinema/trip.html>

Speed or Velocity



We use the terms loosely today, but there is a distinction.

Velocity is a speed AND direction. See the arrow?



Sept 12, 2003

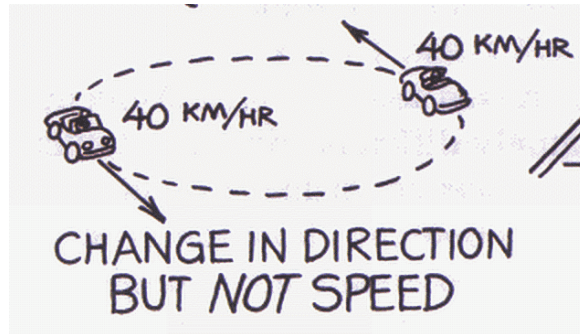
Astronomy 100 Fall 2003

<http://www.sdsc.edu/~sallen/Cars.html>

Speed and Velocity



Take as an example, a car driving in a circle. The car is always going the same speed, but it's direction, or velocity, is constantly changing.



From *Conceptual Physics*

Sept 12, 2003

Astronomy 100 Fall 2003

Acceleration

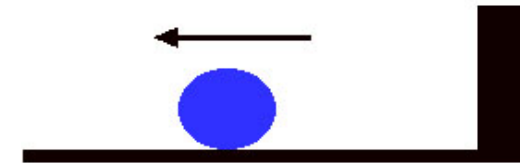


Acceleration is a change to velocity, either in the speed of the object or in the direction

Velocity is to the right.



Velocity is to the left.



<http://www.physics.montana.edu/physed/misconceptions/acceleration/zerovzeroa/discover.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Acceleration

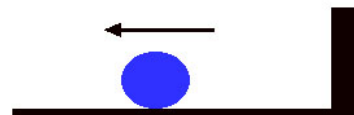


As velocity is the change of distance with time, acceleration is the change of velocity with time. The units for acceleration are meters per second per second (or m/s^2), miles/hr², etc.

Velocity is to the right.



Velocity is to the left.



<http://www.physics.montana.edu/physed/misconceptions/acceleration/zerovzeroa/discover.html>

Sept 12, 2003

Astronomy 100 Fall 2003

A Feather and a Hammer



<http://www.solarviews.com/cap/apo/apo15g.htm>

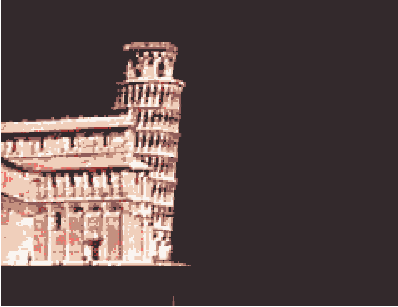
Sept 12, 2003

Astronomy 100 Fall 2003

Nature of Gravity



- Gravity is a force, producing acceleration
- On the surface of the Earth, the acceleration due to gravity is 9.8 meters per second per second
- Drop a ball off the leaning tower of Pisa:



Sept 12, 2003

Astronomy 100 Fall 2003

Time (seconds)	Velocity (m/s)	Accel. (m/s ²)
0	0	9.8
1	9.8	9.8
2	19.6	9.8
3	29.4	9.8

Isaac Newton (1642-1727)



- Arguably the most famous scientist of all time
- Born in England in 1642 (the year of Galileo's death)
- Studied at Cambridge where he also became a professor of mathematics in 1669



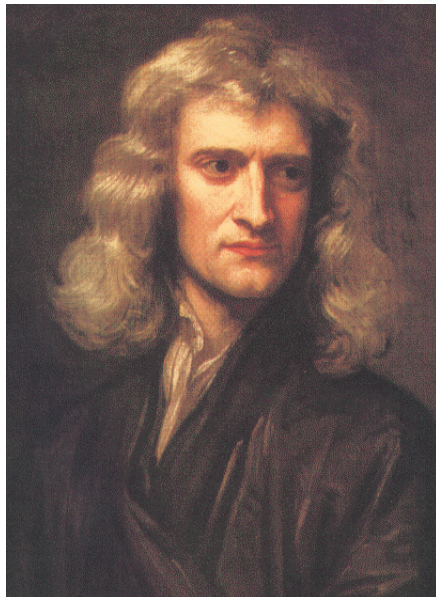
Sept 12, 2003

Astronomy 100 Fall 2003

Isaac Newton



- At Cambridge he studied physics, optics, astronomy, thermodynamics, +
- His greatest work described how things moved (Laws of Motion) and presented a law of gravity
- To do this, he developed calculus (with Leibniz)



<http://www.hao.ucar.edu/public/education/sp/images/newton.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Isaac Newton



- Gave us a reason why– GRAVITY and its description mathematically
- Kepler's 3rd law now became a way to probe the structure of the Universe!



<http://www.windows.ucar.edu/tour/link=/people/enlightenment/newton.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Newton's 1st Law of Motion



An object in motion will stay in motion and an object at rest will stay at rest unless acted on by a net outside force

- Objects keep on doing what they're doing (e.g. kids and TV and the force is mom or dad)
- Similar to what Galileo said– also called inertia

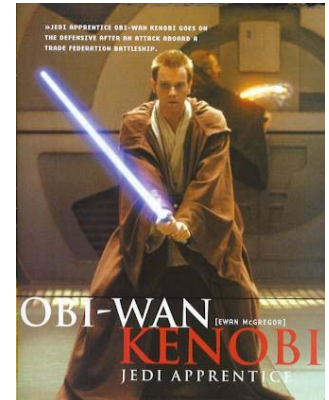
Sept 12, 2003

Astronomy 100 Fall 2003

What is a Force?



- NO not THE Force
- Force in the simplest sense is a push or pull. It may be from gravity, electrical, magnetic, or muscle efforts.
- In metric units, Force is measured in Newtons (N)



<http://members.aol.com/PrinceG0R0/jedi.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Newton's 1st Law of Motion



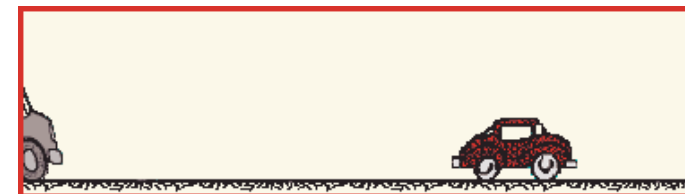
The brick wall acts (applies force) against the car. Since the driver did not wear a seatbelt, he had no other force acting on him, and he kept going.

<http://www.glenbrook.k12.il.us/gbssci/phys/mmedia/newtlaws/cci.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Newton's 1st Law of Motion



The small car acts (applies force) against the truck. Since the ladder was not latched, it had no other force acting on it, and it kept going

<http://www.geocities.com/Athens/Academy/9208/i1.html>

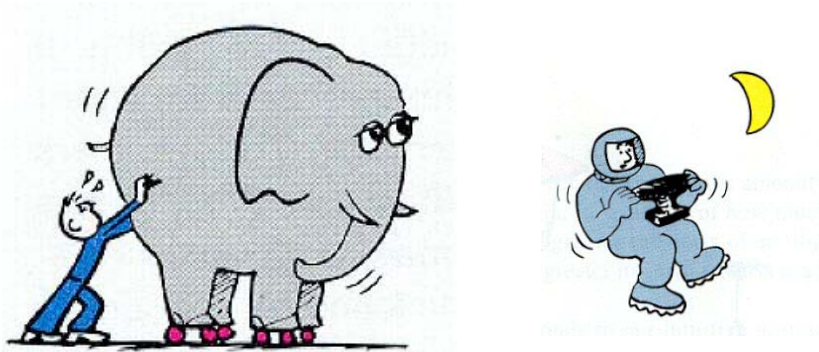
Sept 12, 2003

Astronomy 100 Fall 2003

Elephant at rest



Takes a big force, or the Elephant stays at rest. Or an anvil in space– weightless.



<http://sol.sci.uop.edu/~jfalward/physics17/chapter2/chapter2.html>

Sept 12, 2003

Astronomy 100 Fall 2003

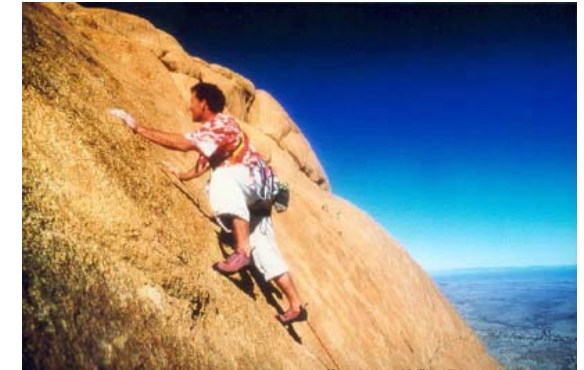
Why was it so hard to see this?



Usually we have Friction! Friction is a possible net outside force that Newton was talking about. Remember the feather/hammer experiment? Air Friction dominates the feather causing this to fail in the classroom.



<http://www.abc.net.au/juniors/pages/2000/transport/land/img/friction.jpg>
Sept 12, 2003



Astronomy 100 Fall 2003

<http://www.vimlf.org/images02/films/Desert%20friction%20-%20image%202.jpg>

Effects of Friction



<http://library.thinkquest.org/CR0215468/friction.htm>

Sept 12, 2003

Astronomy 100 Fall 2003

What is Mass?



- The total amount of material in an object.
- Measured in kg for example
 - Mass of Sun is 2×10^{30} kg
 - Mass of Hydrogen atom is 1.7×10^{-27} kg
 - Mass of me is 90 kg
- Do not confuse mass with weight. Weight will actually depend on where you are on the Earth's surface.

Sept 12, 2003

Astronomy 100 Fall 2003

What is Weight?



- Your weight is the Force you feel from your mass in the presence of the Earth's Gravity.
- I would weigh nothing in the space shuttle, but my mass would still be 90 kg. It's the force with which the Earth pulls on me.
- If I was in a fighter jet, pulling some g's, my weight would be heavier, but I would still have the same mass.



Sept 12, 2003

Astronomy 100 Fall 2003

<http://www.incredible-adventures.com/capetown.html>

Newton's 2nd Law of Motion



The Acceleration of an object is equal to the Force applied, divided by its Mass

$$a = F / m \quad \text{or} \quad F = m \times a$$

- Acceleration is a change in velocity (speed and/or direction, think of the 1st law) in meters per second per second
- To Accelerate something you have to apply a Force
- Mass is a fundamental property of any object, measured in grams or kilograms. Your weight is the Force.

Sept 12, 2003

Astronomy 100 Fall 2003

Newton's 2nd Law of Motion



$$a = F / m \quad \text{or} \quad F = m \times a$$

- It accelerates in the direction you push it.
- If you push twice as hard, it will accelerate twice as much.
- If it has twice the mass, it will accelerate only half as much.

Sept 12, 2003

Astronomy 100 Fall 2003

Simple Proof



http://library.thinkquest.org/CR0215468/newtons_second_law.htm

Sept 12, 2003

Astronomy 100 Fall 2003

Newton's 3rd Law



Every action has an equal and opposite reaction—action-reaction.

That's how rockets or guns work. As the black powder expands, the gun pushes the bullet and the bullet pushes the gun. Which has the higher acceleration?



<http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u214a.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Newton's 3rd Law



<http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u214a.html>

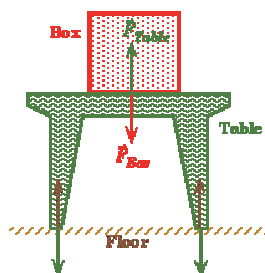
Sept 12, 2003

Astronomy 100 Fall 2003

Equal Forces— and no acceleration



Applied forces	Net force

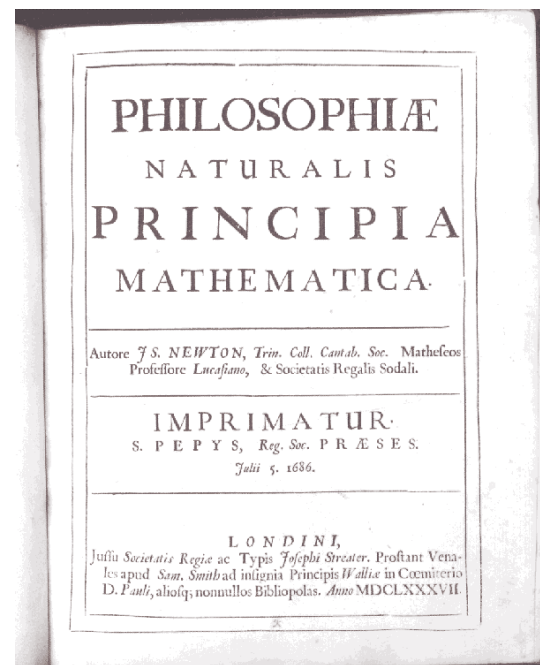


<http://sol.sci.uop.edu/~jfalward/physics17/chapter2/chapter2.html>

<http://www.ac.wvu.edu/~vawter/PhysicsNet/Topics/Dynamics/ThirdLaw.html>

Sept 12, 2003

Astronomy 100 Fall 2003



<http://www.lib.udel.edu/ud/spec/exhibits/treasures/science/newton.html>

Sept 12, 2003

Astronomy 100 Fall 2003

Newton



Principia is one of great science works. By demonstrating that the motion of all bodies was controlled by the same universal laws, Isaac Newton brought to the scientific community a vision of an orderly, harmonious universe.