Astronomy 122

<u>This Class (Lecture 8):</u>

How to make a jump shot?

<u>Next Class:</u>

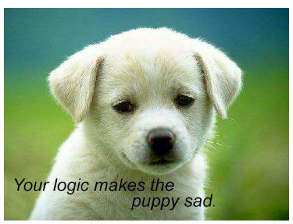
What is a star?

Homework #3 due Sun at 11:59pm!

Music: *Earthbound* – Darrin Drda

iClicker

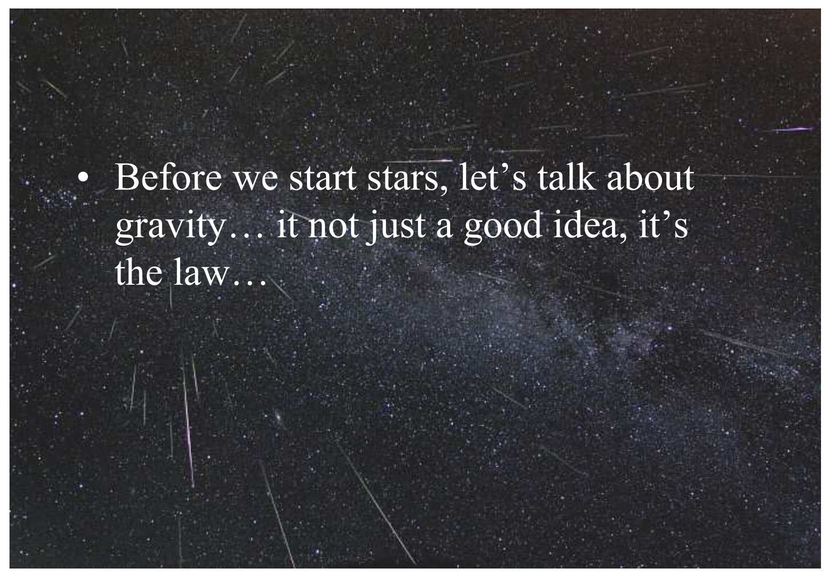
- There are about 5 people without iClicker registration.
- Register now!
- After Friday, only registered grades will count.
- If you see zeros for lecture participation (e.g. 24-Jan), see me or email me ASAP.



HW

- As I can tell when you look at the HW, I have noticed that on Wednesday, the discussion section day, less than 5% of you have even looked at the HW-short.
- This makes me sad!
- So, I will check this again next week, if it is the same percentage, I will move the HW due to Friday evening.
- If it still does not improve, I will move it to Thursday morning.
- Don't make me sad….

Outline



- Before we start stars, let's talk about gravity… it not just a good idea, it's the law…

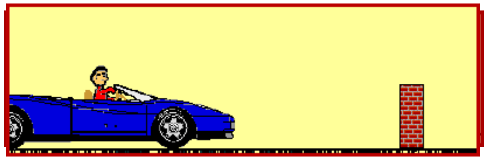
The Laws of Motion

- Until the mid-17th century, scientists worked *empirically*
  - Building a mathematical formula that fit the data
  - No reason *why* the Universe worked

Isaac Newton (1642-1727)

- Developed fundamental laws of nature
- Gave us a reason why the Sun-centered system works
  - **GRAVITY**
- Designed the reflecting telescope
- Discovered that white light is a mix of all colors
- Also invented calculus

Newton's 1st Law of Motion



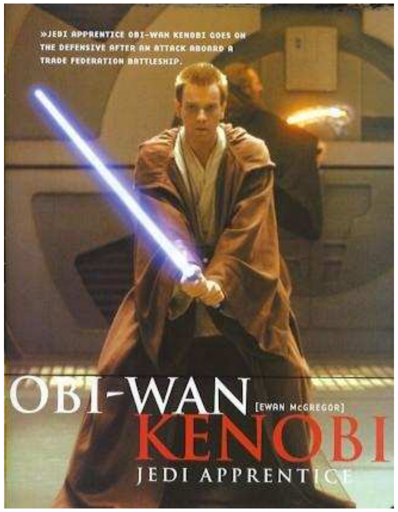
Law of Inertia

"An object at rest will remain at rest and an object in motion will remain in motion ***in a straight line*** *at constant speed, unless acted upon by an unbalanced force."*

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
- Measured in Newtons

You must learn the ways of the force.



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?

A Feather and a Hammer

http://www.hq.nasa.gov/office/pao/History/alsj/a15/a15v_1672206.mpg

Newton's 2nd Law of Motion

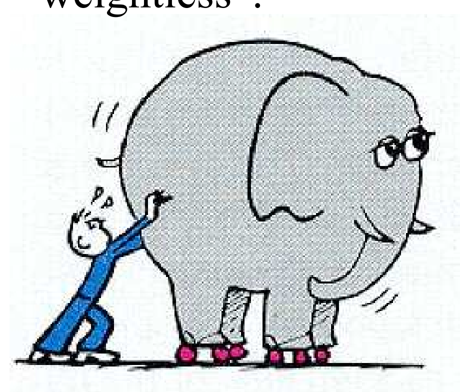
- Law of Acceleration
  - The net force acting on an object is proportional to the object’s mass and its resulting acceleration.

F = m a

- *Acceleration* is a change in velocity (in speed and/or direction, think of the 1st law)
  - Measured in meters per second per second
  - To accelerate something you have to apply a force
- *Mass* is amount of matter in an object
  - Measured in grams or kilograms, *not pounds!*

Elephant at rest stays at rest

Takes a big force, or the Elephant stays at rest. Or an anvil in space– even if it is “weightless”.



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

Newton's 3rd Law of Motion

- Law of Action-Reaction
  - "Every action has an equal and opposite reaction"
  - Action: Guy jumps forward out of the boat
  - Reaction: Boat moves away from the pier

Newton's 3rd Law of Motion

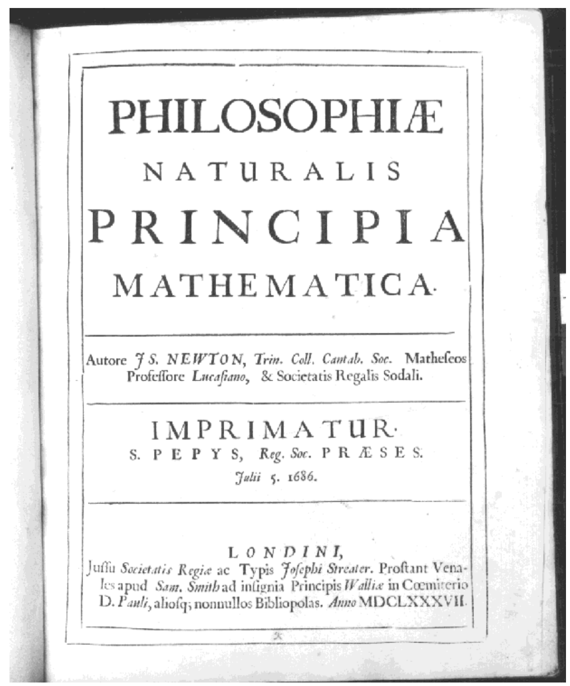
- Law of Action-Reaction
  - "Every action has an equal and opposite reaction"
  - Action: Player makes a shot.
  - Reaction: He moves backwards slightly.

Question

You are an astronaut taking a space walk to fix your spacecraft with a hammer. Your lifeline breaks and you are left floating in space. To return safely to your spacecraft, you should

a) Throw the hammer at the spacecraft to get someone's attention.
b) Throw the hammer away from the spacecraft.
c) Use a swimming motion with your arms & legs.
d) Reach down and kiss your ship goodbye.
e) Cry, because you should have brought a radio with you.

Newton



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore J S. NEWTON, *Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

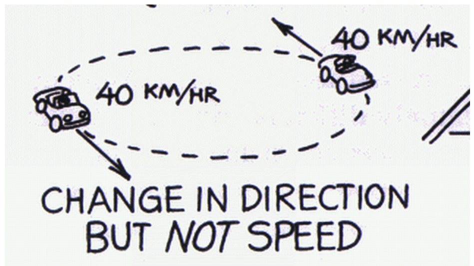
LONDINI,
Jussu *Societatis Regiæ* ac Typis *Josephi Streater*. Prostant Venales apud *Sam. Smith* ad insignia Principis *Walliæ* in Cœmiterio D. *Pauli*, aliosq; nonnullos Bibliopolas. *Anno* MDCLXXXVII.

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

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.

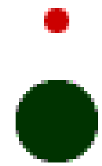
Going in a Circle

- Circle (or orbit) not equal to a straight line.
- The object is constantly changing direction.



Newton and the Planets

Newton's ideas can/should be applied to the heavens as well as the Earth. Right?

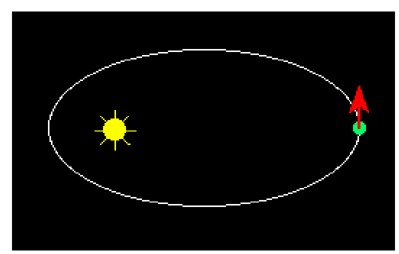


Planetary Motion… By Newton

- A planet going around the Sun (or a moon going around a planet) is always accelerating
  - The direction of motion is changing
- There must be a force acting on the planet! (F = ma)
  - Imagine it as a string
- If we "cut the string", what happens?
  - According to Newton's 1st Law, the ball moves in a straight line

Nature of Gravity

- Newton's Law of Acceleration then tells us that the Sun MUST be applying a **force**

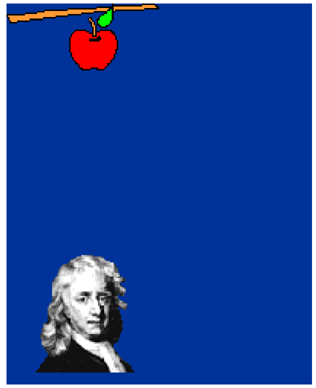


- Ah GRAVITY!

Newton's Law of Gravity

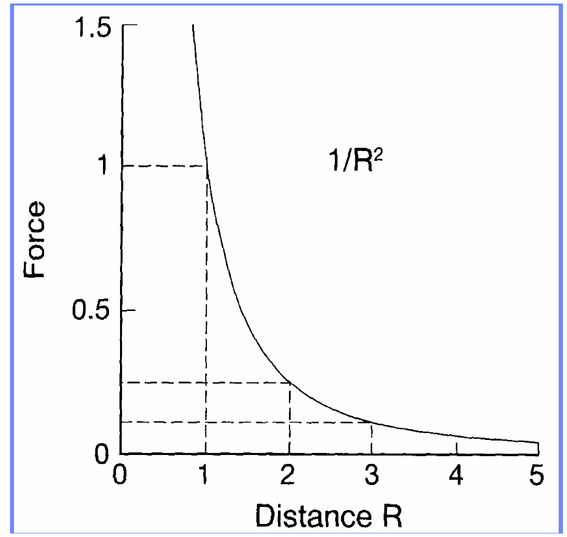
- Any two masses have a gravitational force between them:

$$F = G\frac{m_1 m_2}{r^2}$$



- m_1 and m_2 are the masses
- r is the distance between the two masses
- G is the "gravitational constant"
  (G = 6.67 x 10^{-11} when kg and meters are used)

Inverse Square Law

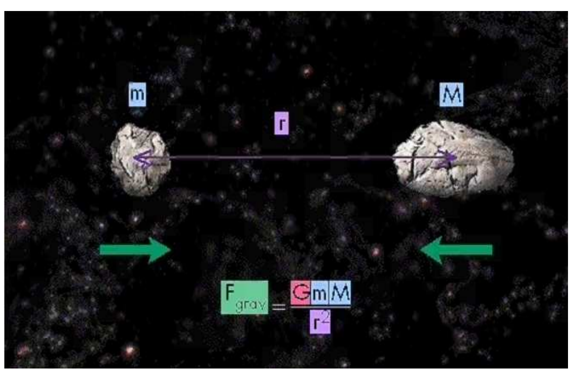


Strong function of separating distance!

Half the distance makes four times the force!

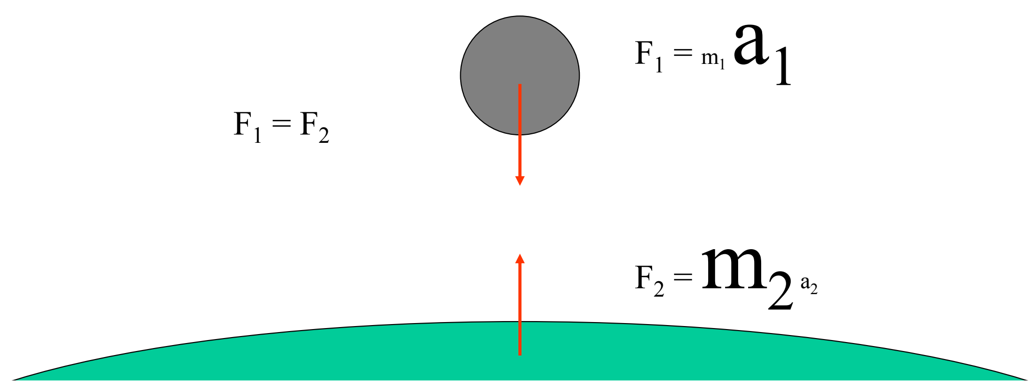
Newton's Law of Gravity

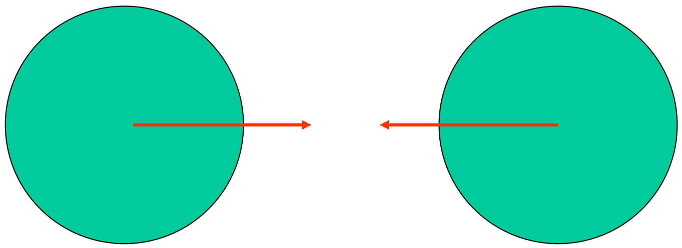
Two bodies attract each other with a force that is directly proportional to the product of the their masses and inversely proportional to the square of the distance between them.



Newton's Universal Law of Gravity

The Earth pulls you and you pull it. But the Earth wins, inertial-wise.





F = m a F = m a

What is Weight?

- What we feel as weight is actually the force we feel from Newton's Law of Gravity.

$$Weight = \frac{GM_{Earth}M_{you}}{R_{Earth}^{2}}$$

- It is confusing since social convention has made weight and mass the same at the earth's surface, but what happens to your weight elsewhere?

Question

When you fly in an airplane, does your weight

a) Increase.
b) Decrease.
c) Stay the same.

Question

When you fly in an airplane, does your mass

a) Increase.
b) Decrease.
c) Stay the same.

Weight in an Airplane?

When you fly in an airplane, you increase your distance from the center of the Earth.

If the distance increases, your weight is reduced.

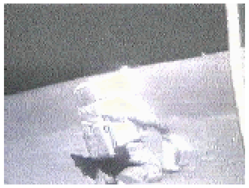
$$Weight \propto \frac{1}{(R_{Earth} + d)^2}$$

Gravity on the Moon

- Is there gravity on the moon?
- **Yes!**
- But your weight is 1/6th of your Earth weight

Moon Gravity

- See you next fall..



http://btc.montana.edu/ceres/html/Weight/weightstudentactivity.htm

Moon weight

- The Moon is around 3.7 times smaller and 81 times lighter than the Earth

$$Weight = \frac{GM_{Moon}M_{you}}{R_{Moon}^{2}}$$

- Your mass would be exactly the same, but your weight would be around 1/6th of your weight on Earth.

Moon weight

$$Weight = \frac{GM_{Moon}M_{you}}{R_{Moon}^{2}} = \frac{G\left(\frac{M_{Earth}}{81}\right)M_{you}}{\left(\frac{R_{Earth}}{3.7}\right)^{2}}$$

Moon weight

$$Weight = \frac{GM_{Moon}M_{you}}{R_{Moon}^{2}} = \frac{G\left(\frac{M_{Earth}}{81}\right)M_{you}}{\left(\frac{R_{Earth}}{3.7}\right)^{2}}$$

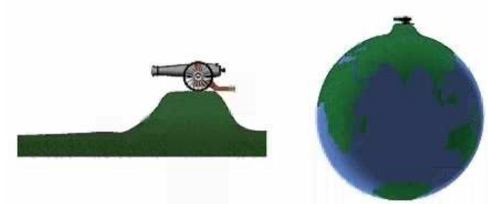
$$or\ldots = \frac{1}{81}(3.7)^2 \frac{GM_{Earth}M_{you}}{R_{Earth}^{2}} \approx \frac{1}{6}Weight_{Earth}$$

Moon Olympics?

http://www.astronomy.org/programs/moon/moon.html

Newton's Great Insight

- The same force makes things fall down on Earth **and** keeps the planets in their orbits



Orbiting bodies are falling bodies!

Or http://spaceplace.jpl.nasa.gov/orbits1.htm

Why was this important?

- Remember, the ancients believed that there were two sets of rules
  - One for Earth
  - One for the Heavens
- Newton showed that the same laws of nature applied everywhere!
- Earth is not a "special place"
- We are a part of the **Universe**

"Zero-G"

- Why are astronauts "weightless" when in orbit? Are they out of the Earth's gravity?
  - No! Gravity is what keeps them in orbit
  - Astronauts feel weightless because they are falling at the same speed as the spacecraft
  - There is no force pressing them against the floor

Free Falling Objects

"weightless" : not beyond influence of gravity

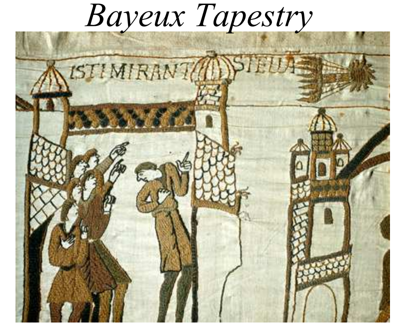
- Astronaut is just another orbiting body
- Earth's pull is what keeps astronaut in orbit
- Astronaut feels "weightless" because she and spacecraft are experiencing gravity together

Testing: Halley's Comet

Halley's Comet was known to often reappear. Edmund Halley used Newton's formulism to find next arrival.

http://seds.lpl.arizona.edu/nineplanets/nineplanets/halley.html

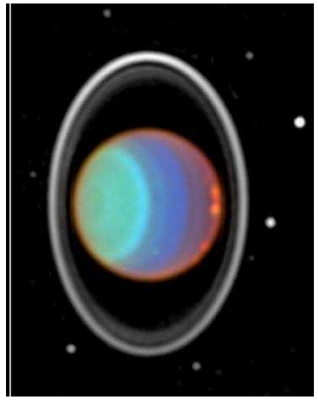
Bayeux Tapestry



http://www.getty.edu/artsednet/resources/Space/Stories/halleys.html

Problem with Gravity?

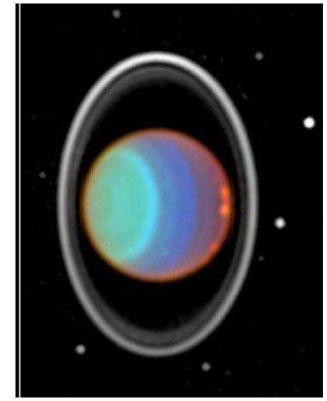
- 1830's: Uranus observed orbit did not follow predictions of Newtonian solar system model.
- Was this the death of Newton's gravity?
- Not good. Theory has to agree with all data, not just some.
- So despite great job with planets, moons, other stars, even one clear failure is enough.

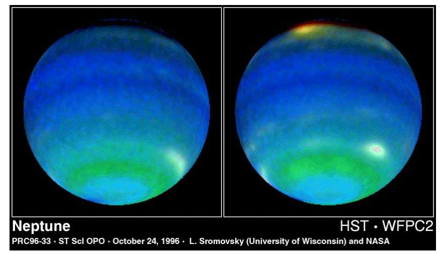


http://lyra.colorado.edu/sbo/hubble/ss/ss.html

Problem with Gravity?

- What's going on?
- What do you think?
- Throw out Newton?





Unknown mass, right at predicted location in 1846.

Victory snatched from jaws of defeat!!!!

http://lyra.colorado.edu/sbo/hubble/ss/ss.html

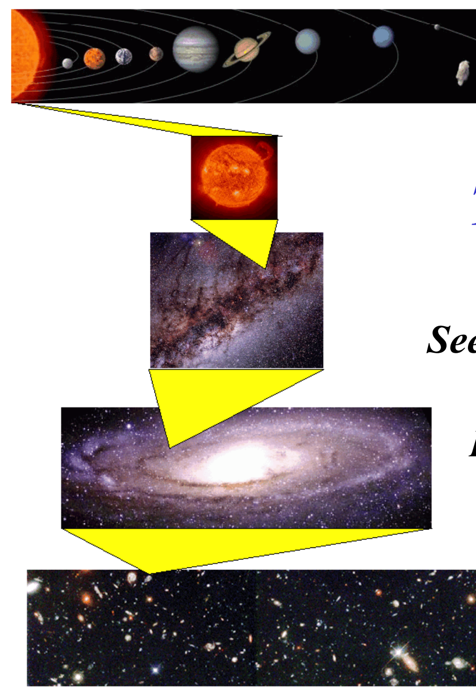
Escape Velocity

We talked about the horizontally aimed cannon, but if we fired it vertically, what velocity do we have to fire it so that it doesn't fall back down?

At some velocity the cannonball outruns gravity's pull. That number is 11.2 km/s or 25,000 m/hr.

Jules Verne: Moon Ship

http://vesuvius.jsc.nasa.gov/er/seh/earlysf.html



Astronomy: The Big Picture

Seeing how all these pieces fit together into a coherent picture of our Universe!

The Big Picture

- Today, we can observe in almost every part of the electromagnetic spectrum
- Only 100 years ago, we were blind to the big picture of the Universe
- As we begin to piece together the big picture, our understanding of the cosmos grows

Star's Physical

- Please step on scale. Turn head. Cough.
- No, really. How to measure the properties of objects that are very, very far away?
- What properties would we like to know about the stars.

Star's Physical

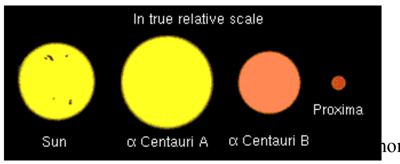
- Are all stars the same? Are they all just like our Sun?
- Do they have different brightnesses?
- Do they have different temperatures? Colors?
- Do they have different masses?
- Do they have different sizes?
- What happens to them? Just grow old and get retirement?

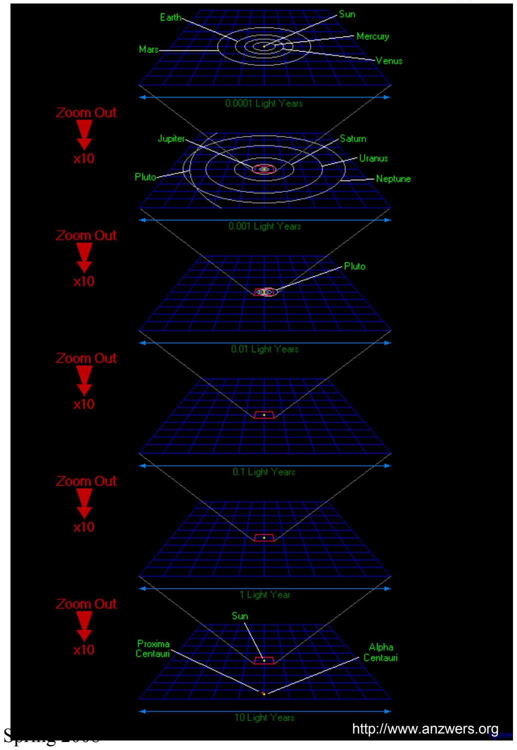
Distance

- We know that the stars must be very far away.
  - They don't move much.
- Measuring the distance is a <u>hard</u> problem.
- We've only had the technology to do it for the last 200 yrs or so.

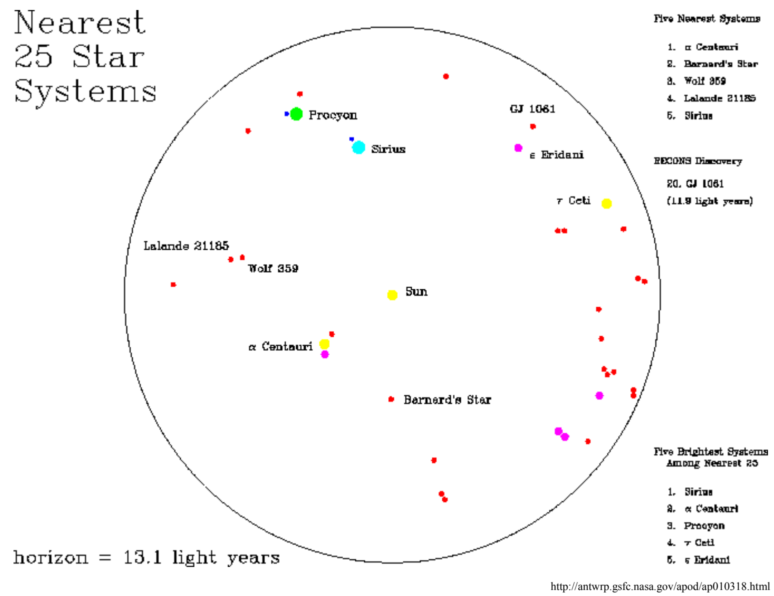
Leaving Home

- Nearest star is 4 x 10^{13} km away
  - Called Proxima Centauri
- Around 4 light years
- More than 5000 times the distance to Pluto
- Walking time: 1 billion years
- Fastest space probes: Voyagers 1 & 2, Pioneers 10 & 11) – 60,000 years at about 3.6 AU/year (38000 mi/hr)





Our Nearest Neighbors



http://antwrp.gsfc.nasa.gov/apod/ap010318.html

Parallax

- How do astronomers measures distances to nearby stars?

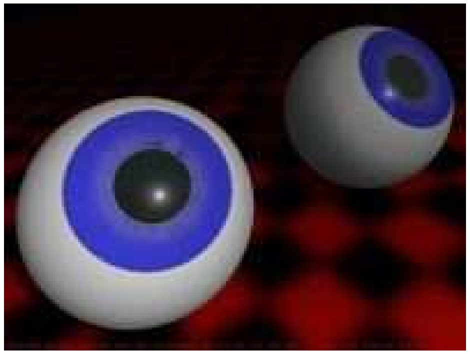
Stupid Demo #?

1. Close one eye
2. Hold out arm at full length
3. Place my face under your thumb
4. Now, switch eyes. Blink back and forth a few times.
5. Hold out arm at half-length
6. Repeat

http://www.ibiblio.org/john/photos/thumb.jpg

Parallax– Is Triangulation

If one loses the use of an eye, then it becomes very difficult to judge distances. Usually, each of your eyes observe objects with slight shifts in position. When objects are closer, the effect is larger. Stereo-vision!



http://www.kidsdomain.com/holiday/halloween/clipart/eyes.jpg