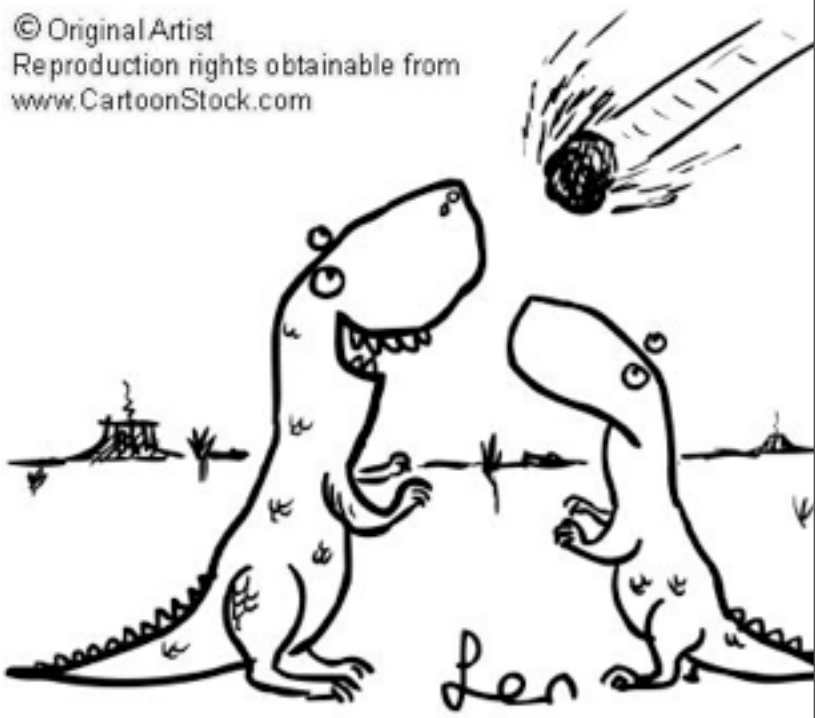
ASTR 150
Jan 25, 2012

- **Homework 1** due Monday
  - all other HW due on Fridays
  - Office Hours after class today
- **Planetarium** Shows begin next week
  - need to **register** to reserve a spot
  - registration, schedule, and report info on course website
- **Register** your iClicker!
- Last time: Planetary Motion
- Today:
  - Gravity
  - begin Astro Threat I: Impacts



"Ooh, look! A shooting star. Make a wish."

Space is Big!

"Space is big. Really big. You just won't believe how vastly hugely mind- bogglingly big it is. I mean, you may think it's a long way down the road to the chemist [drugstore], but that's just peanuts to space..."

"To be fair though, when confronted by the sheer enormity of the distances between the stars, better minds than the one responsible for the Guide's introduction have faltered. "

"The simple truth is that interstellar distances will not fit into the human imagination."

- Douglas Adams
- The Hitchhiker's Guide to the Galaxy

Space is Big! Part I

Size scale of solar system

- enormous! impossible to really get a gut feel!
- but can measure anyway, and get a feel for relative scales--how different orbits compare

Useful standard of comparison:

- Earth-Sun average distance = Earth semimajor axis

Overwhelming! But can improve:

- Better:
- Better still:
- Best: define Astronomical Unit

Now much easier to envision Solar System arrangement

- for example:

Also ideal for Kepler III:

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Also ideal for Kepler III: $\left(P_{\text{in years}}\right)^2 = \left(a_{\text{in AU}}\right)^3$

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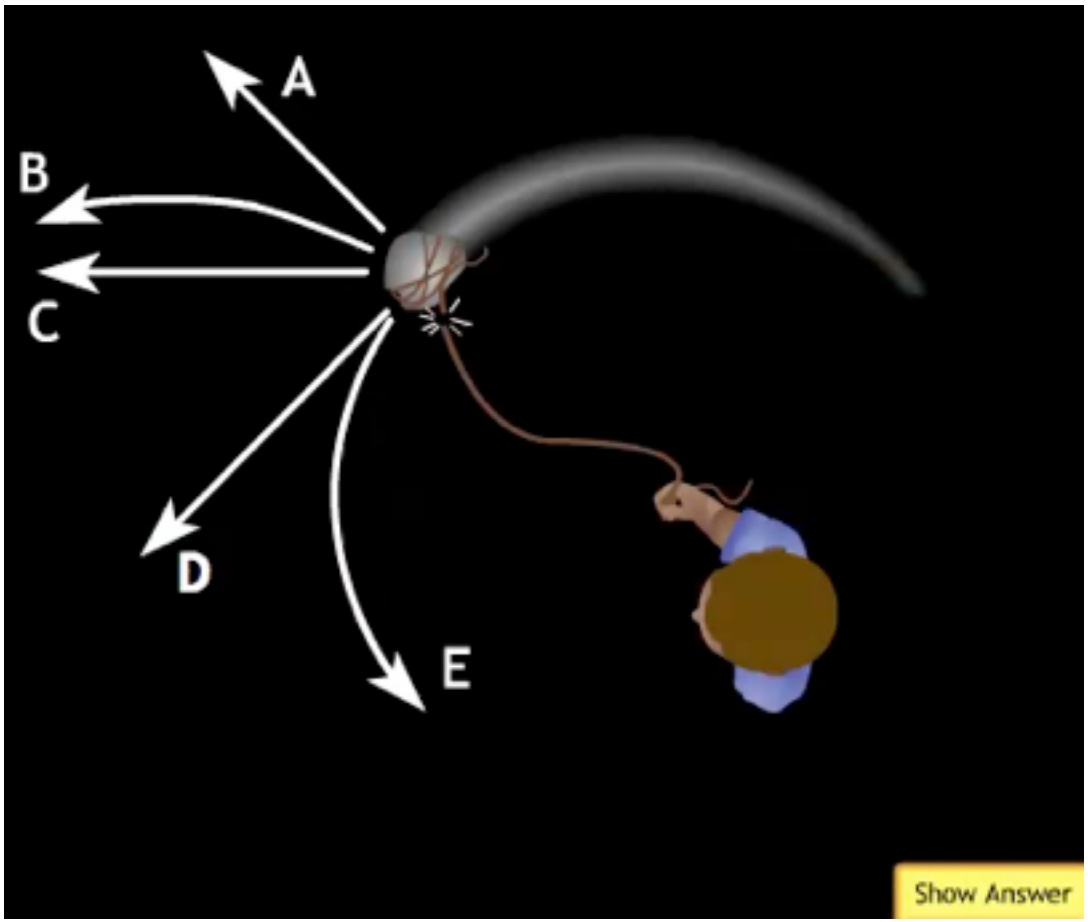

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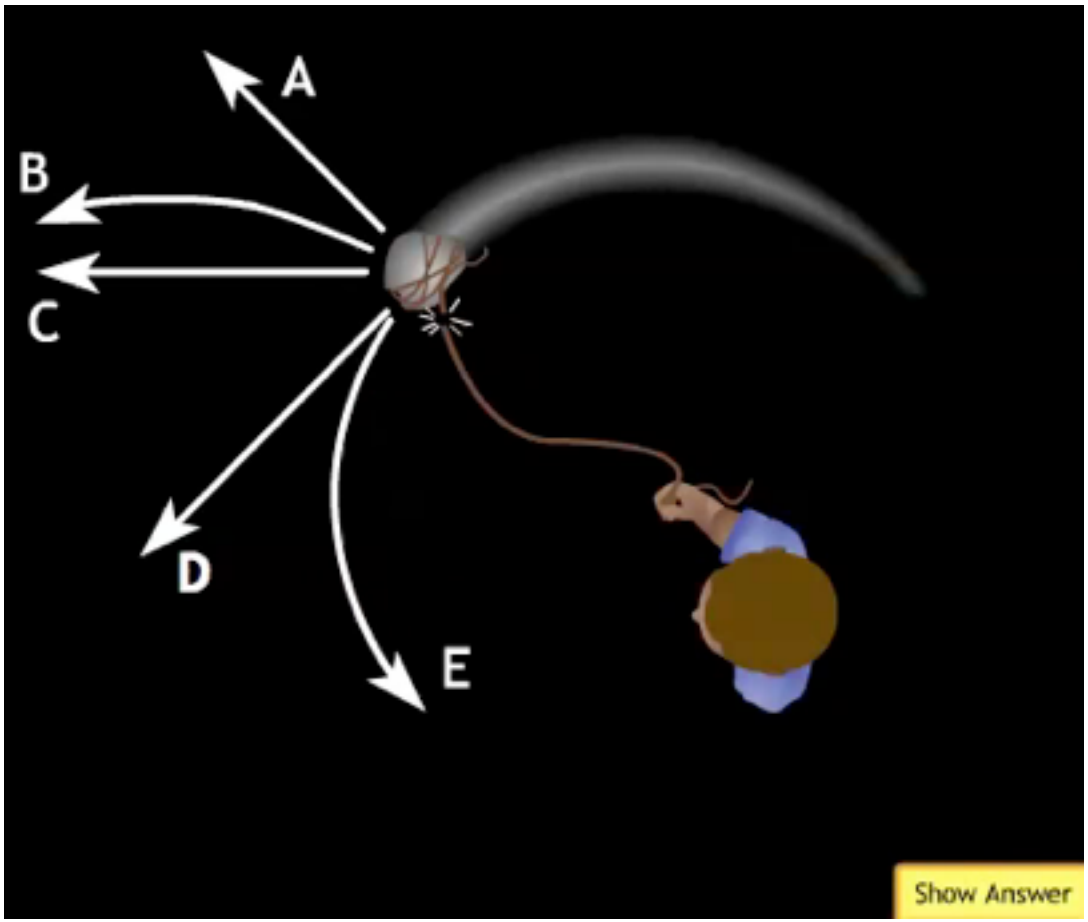
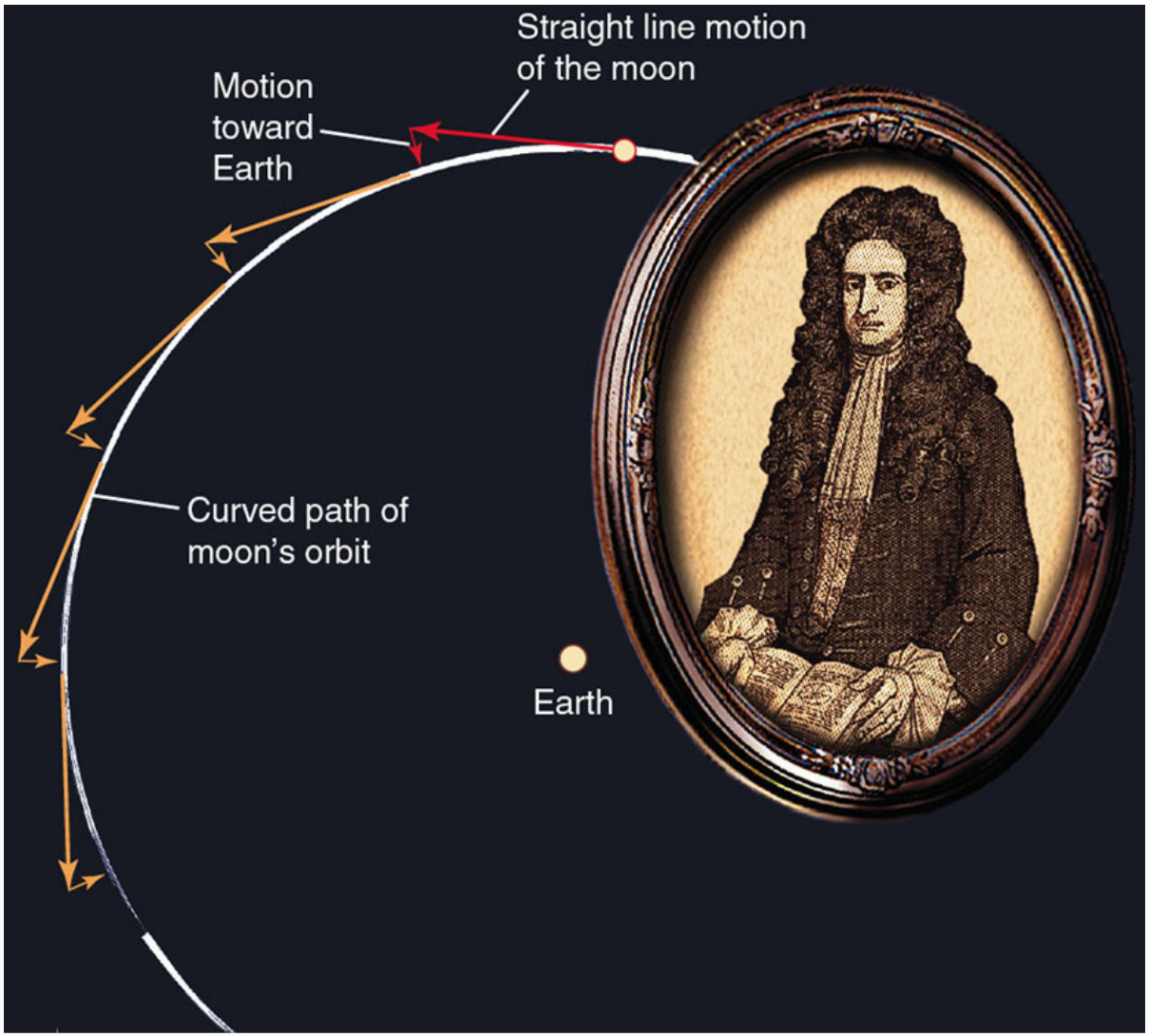


Curved path: changing direction = changing velocity = acceleration

But $F=ma$: acceleration requires force!

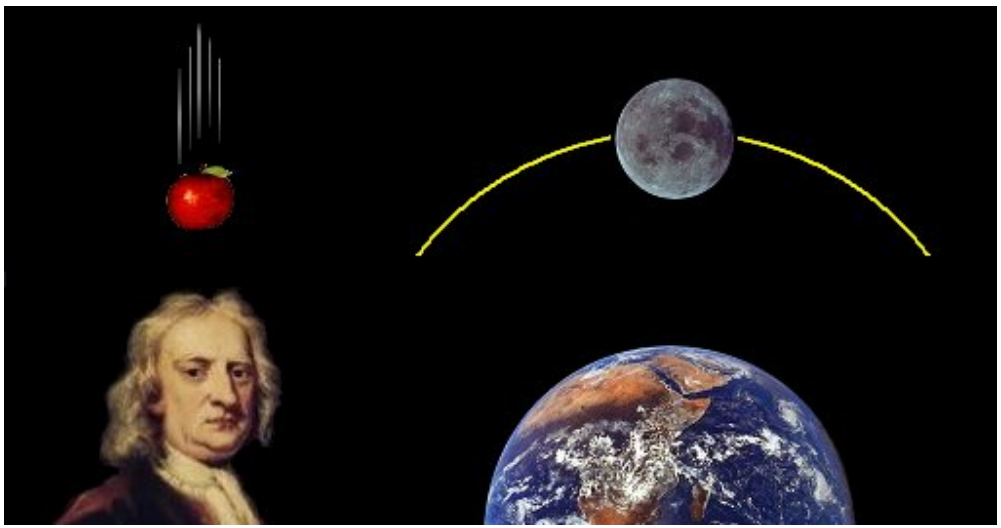
A force must pull the Moon toward Earth's center

If there were no force acting on the Moon, it should follow a straight line and leave Earth



Newton's Great Insight

- The same force makes things fall down on Earth and keeps the planets in their orbits
- gravity!
- Newtonian gravitation is sometimes called universal gravitation



Gravity makes apples fall from trees and keeps the Moon orbiting the Earth

Universal Gravitation

Newton's law of gravity combines these ideas:

- gravity is attractive: gravity force between two objects pulls each towards the other
- the force of gravity acts beyond the Earth

  "reaches out" into space
- gravity force directed on line connecting centers of bodies
- gravity strength decreases with distance
- the source of gravity is mass

  all objects with mass are sources of gravity

  everything attracts everything else in the universe!

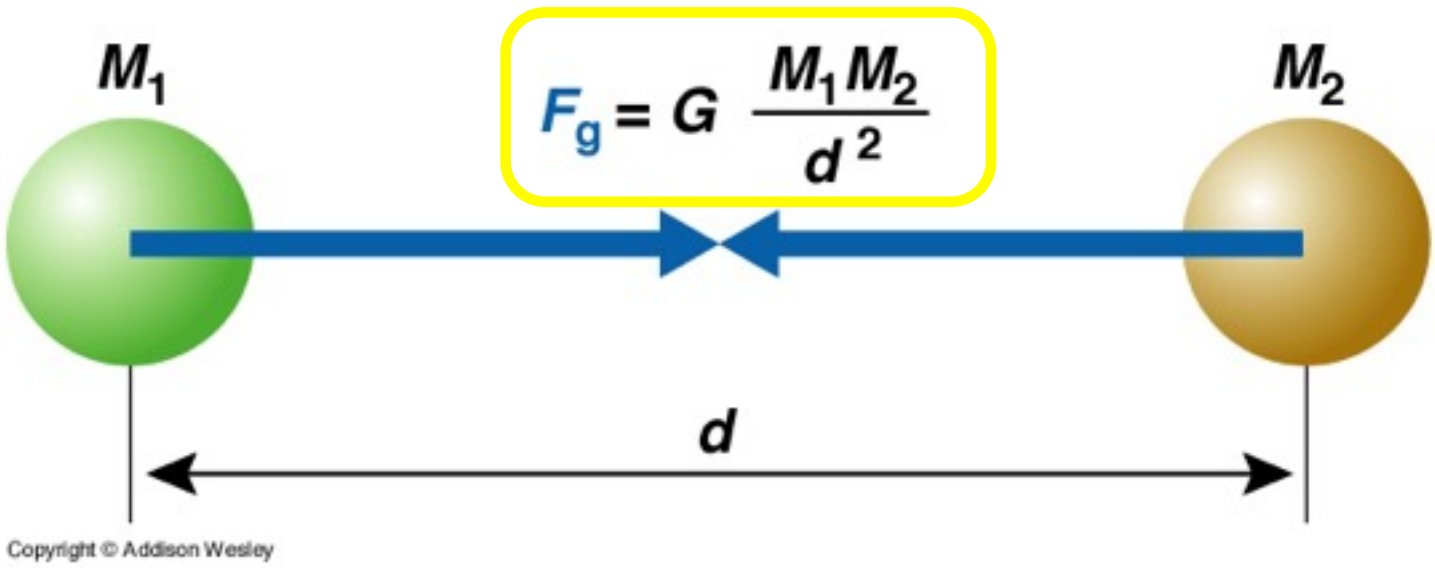
Universal Gravitation Law

Summarize gravity properties in compact way

for two masses M_1 and M_2 separated by distance d

gravity force is:

- **proportional to product of the masses**
- **inversely proportional to the square of the distance between their centers**
  - **"inverse square law"**
  - **in equation, G is just a fixed number (grav. constant)**



iClicker Poll: Inverse Square Law

The force of gravity on you is your weight.

If you go into space and double your distance from the center of the earth, your weight will be

A. 2 times stronger
B. 4 times stronger
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Guaranteed weight loss: go to space!

Gravity and Planet Motion

$F=ma$: for planets, force is gravity only: free fall

So: find acceleration when

$$F = F_{\text{grav}} = G\frac{m_{\text{planet}}m_{\text{sun}}}{d^2}$$

acceleration gives change in velocity

- ...which tells where move to next
- ...where there is a new acceleration
- and so forth: $F_{\text{gravity}}=ma$ predicts orbit

What is prediction?

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- orbits are ellipses, with Sun at one focus
- equal areas in equal times

$$P^2_{\text{in years}} = a^3_{\text{in AU}}$$

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So: Newton's laws + gravity gives Kepler's laws

theory agrees with observation! Woo hoo!

Testing Newton's Gravity

Moons of Jupiter: orbits obey Kepler's laws

- Jupiter gravity works like Sun's, Earth's: check!

1830's: Uranus observed orbit did not follow predictions of Newtonian solar system model

- the death of Newton's gravity?

First rule of Science: theory must agree with all data, not just some

- even one clear failure enough to kill theory

maybe...but also: maybe have not included all sources of gravity

- maybe unknown objects causes Uranus devitaions
- a new planet?

iClicker Poll: Uranus Discrepancy

It's 1830. You are a famous Astronomer.

Measured Uranus orbit doesn't match predictions of Newtonian Gravity theory.

Vote your conscience!

Which seems more likely to you?

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Q: What experiment/observation would tell which is right?

Mystery of the Crazy Orbit Solved by Observations

- Astronomers noted discrepancies between Uranus' orbit and calculations
- Predicted the position of an unknown planet based on its gravity perturbations
- the race was on to scan this region of sky, and....

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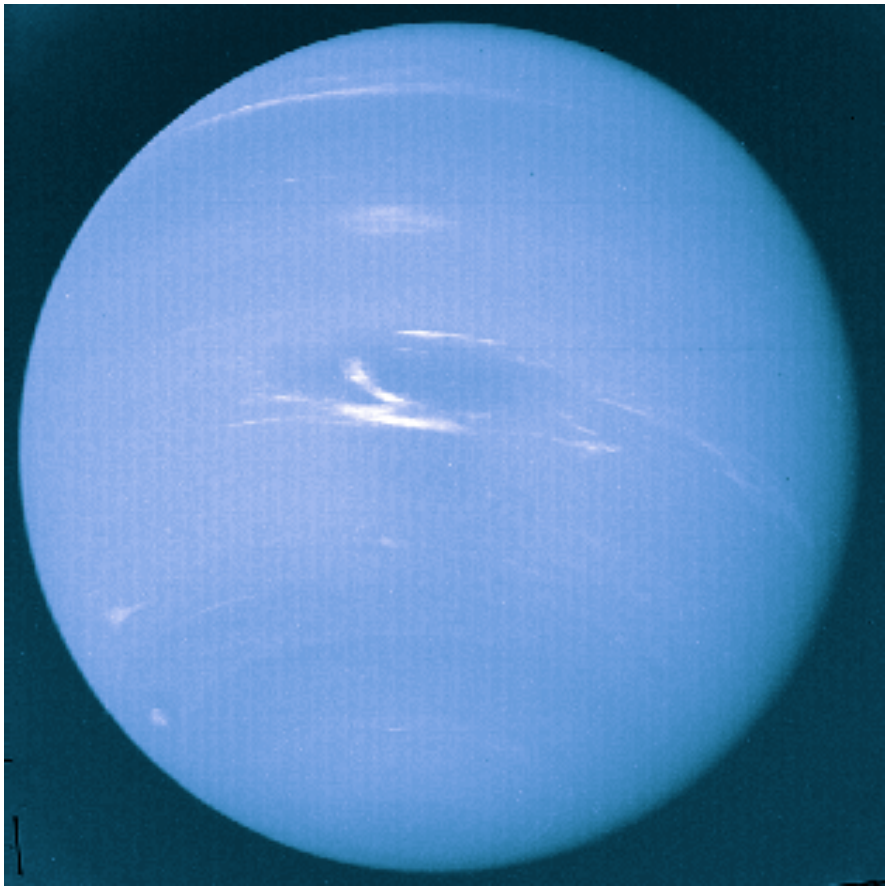

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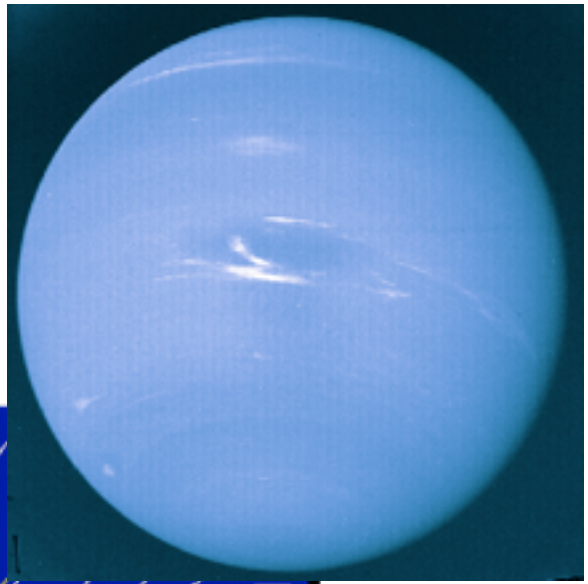

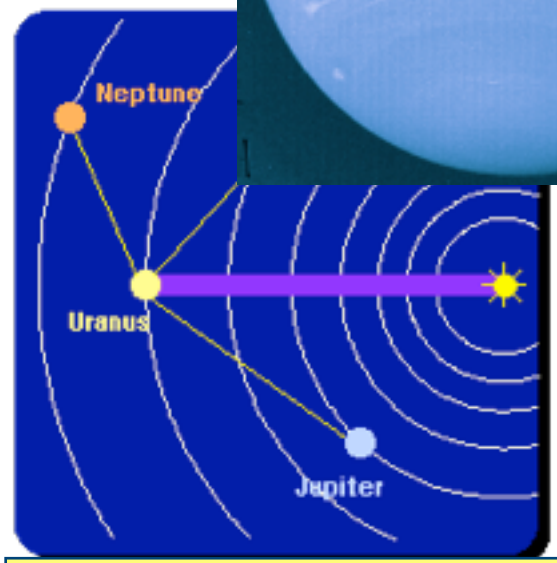

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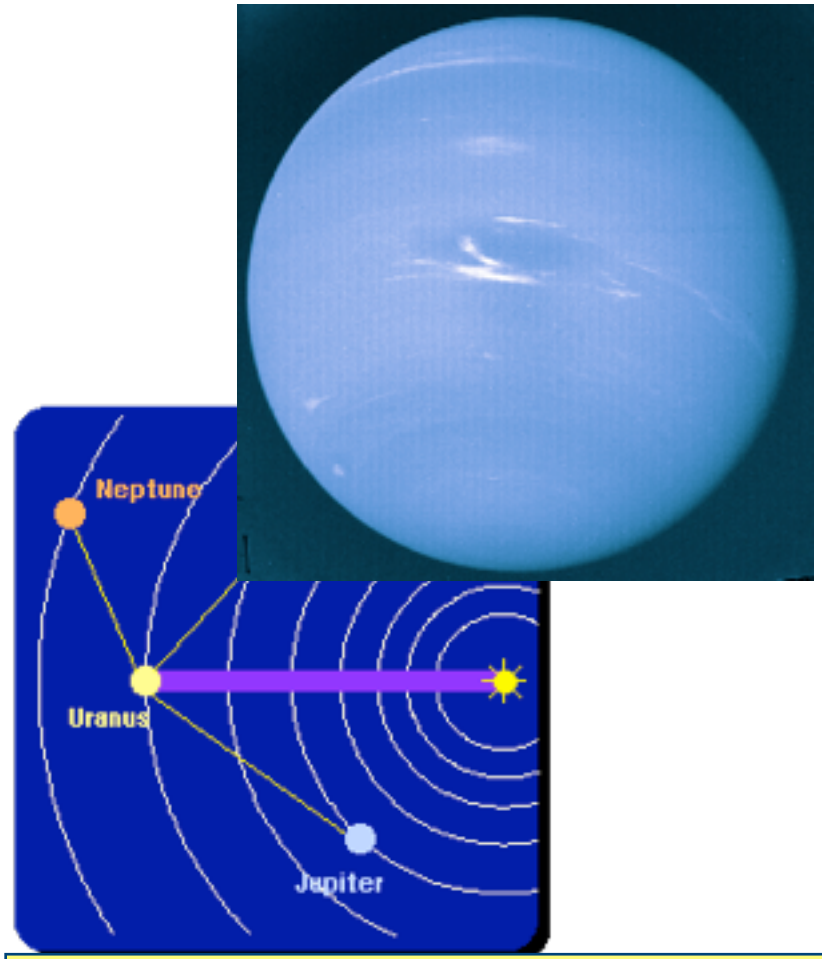

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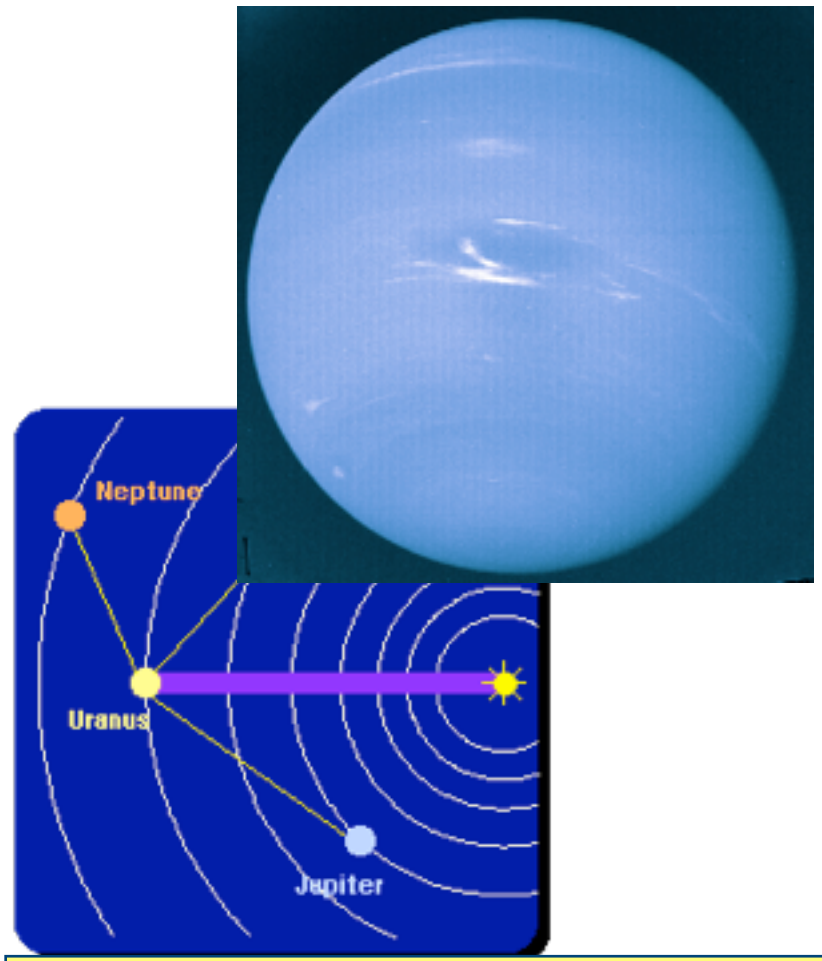
Questions?



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Astro Threat 1:
Impacts

Imagine

Imagine

- *Walking to class next week, you notice that you suddenly have two shadows.*
- *You turn quickly, and it looks like there are two Suns, but one of them is moving toward the horizon!*
- *Very Fast!*
- *As it meets the horizon, there is a incredible bright flash, and you can feel the heat!*

Imagine

Imagine

- *An earthquake throws you to the ground, and you get a little worried as you notice that the trees in the distance have burst into flames.*
- *A sound wave bears down on you at 700 mph!*
- *Like a mighty thunderclap, it sweeps over you, pulverizing all the nearby buildings…*
- *As your body disintegrates, you wonder what Brian was going to lecture on today.*

Top 10 Ways Astronomy Can Kill you or your Descendants

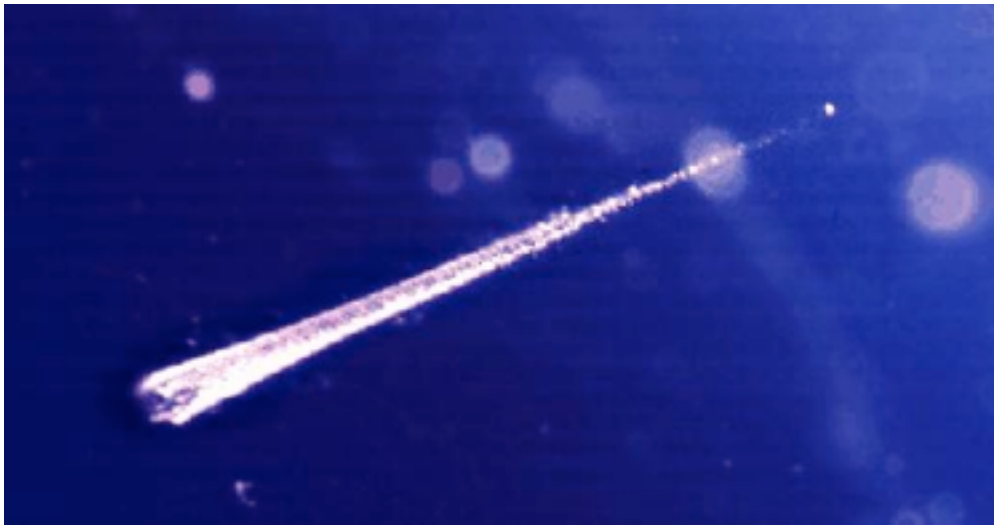
1. Impacts!

Meteors
Meteoroids
Asteroids
Comets
Pieces of freakin' debris

Whatever…. http://www.youtube.com/watch?v=flJeK8AK7y8

Or http://www.youtube.com/watch?v=-zvCUmeoHpw

What am I talking about?



Space debris.

Space rocks.

The leftovers from building the Sun and planets.

Can it happen? Has it happened before?
Should I place my head between my knees?

What are the terms I should know?

http://www.faculty.uaf.edu/ffdjw/211/2007/meteors/Facts%20about%20Meteors%20entering%20Earth%20(page%202).htm

Meteors

Meteor:

- fiery passage of space debris through the atmosphere, in the act of falling to Earth

What you see:

- a flash or streak of light

Sometimes called "a shooting star"

Usually occurs ~50 miles up

http://www.youtube.com/

http://antwrp.gsfc.nasa.gov/apod/ap090501.html

Meteors

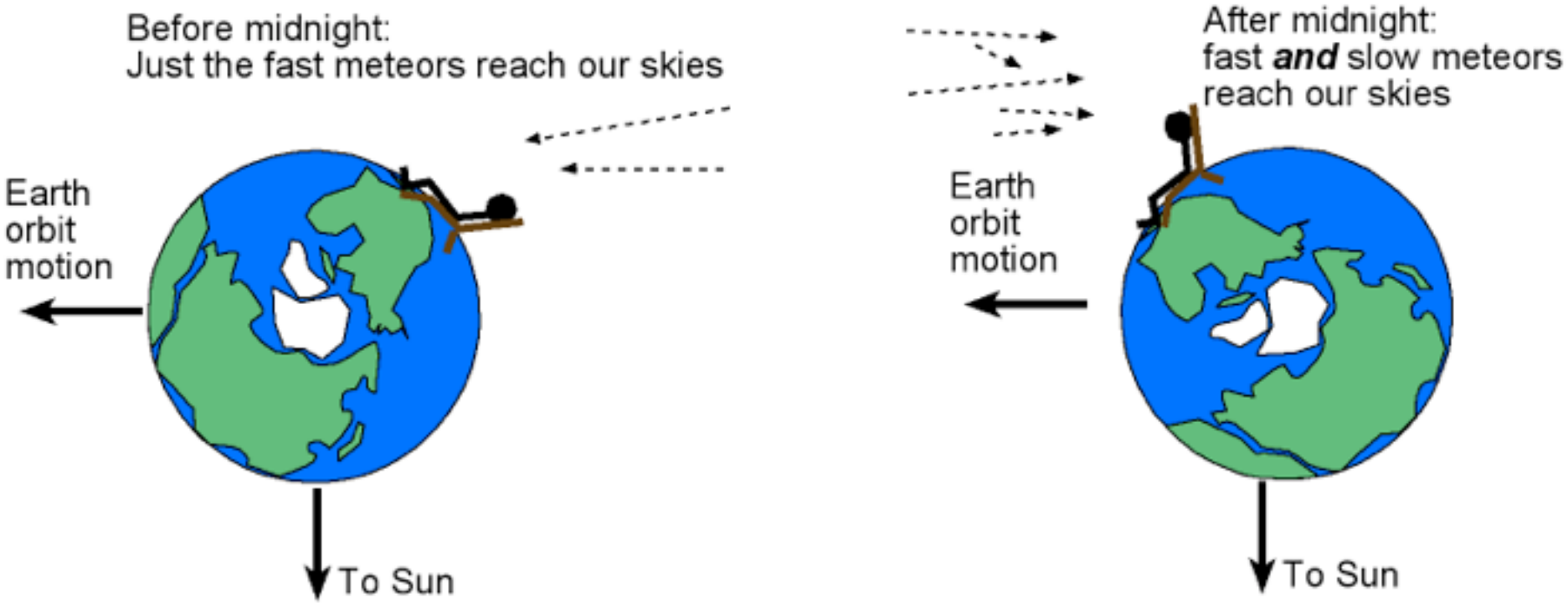
Typically from sand-grain sized particles falling into the atmosphere

When they fall into the atmosphere, they heat up due to the atmosphere interaction.

Creates a bright tail of hot gases and melted stuff

http://antwrp.gsfc.nasa.gov/apod/ap080814.html

Meteors: Best Viewed After Midnight



Meteor Showers

Meteors can be seen all the time

In the early morning, you can typically see about 3 per hour

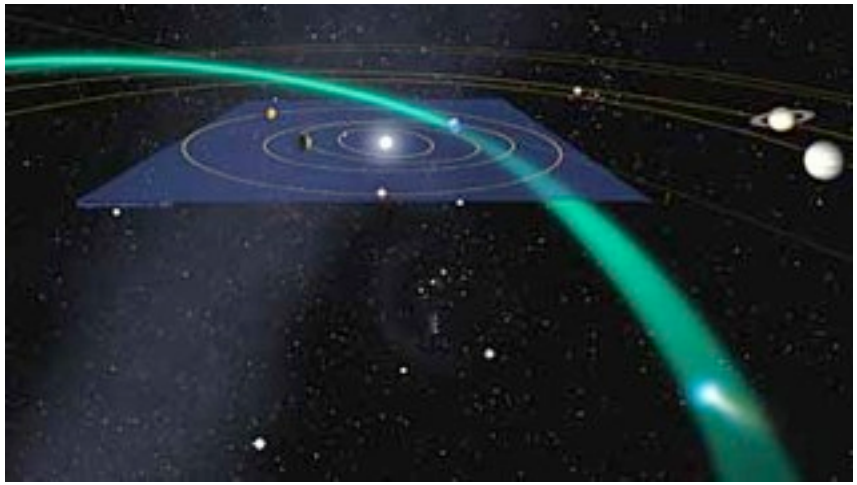
Several times a year, the rate increases

- Maybe more than a meteor per minute
- Called meteor showers

Seem to originate from a single point in the sky

Meteor Showers

- When a comet enters the inner Solar System, it leaves a trail of dust
- When Earth passes through this dust, we get a meteor shower

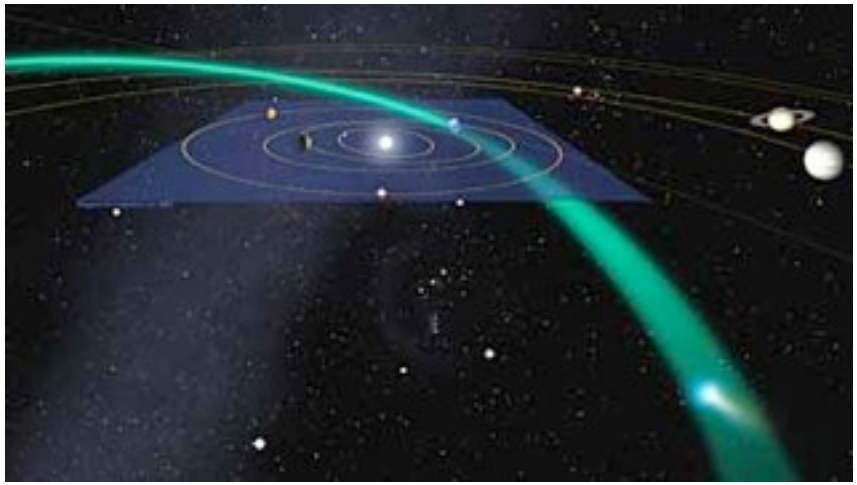


Prominent Yearly Meteor Showers

Shower	Date of maximum intensity	Typical hourly rate	Constellation
Quadrantids	January 3	40	Boötes
Lyrids	April 22	15	Lyra
Eta Aquarids	May 4	20	Aquarius
Delta Aquarids	July 30	20	Aquarius
Perseids	August 12	80	Perseus
Orionids	October 21	20	Orion
Taurids	November 4	15	Taurus
Leonids	November 16	15	Leo Major
Geminids	December 13	50	Gemini
Ursids	December 22	15	Ursa Minor

Meteor Showers

- Meteor showers don't typically produce meteorites
  - It's all dust, not rocks
- http://vimeo.com/14173983



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Fireballs

- A brighter than usual meteor.
- Sometimes called bolides by geologist.
- Sometimes explodes, larger than grains of sand.. about millimeter-size pieces of debris.
- http://www.youtube.com/watch?v=jUh7pYDmK08&NR=1

http://antwrp.gsfc.nasa.gov/apod/ap050812.html

Fireballs

- Since most meteors are from small objects, they burn up before they hit the ground.
- But some are from larger objects, which survive all the way to the ground.
- These leftover objects are then called **meteorites**

http://antwrp.gsfc.nasa.gov/apod/ap081011.html

Peekskill Fireball (October 9, 1992)

Objects in space <50 meters in size are called meteoroids

Closer to Home

March 26th, 2003

Park Forest, IL

Through the roof, hit the printer, hit the wall

i>clicker question

You and your friends watch a meteor shower together. Your friends want to go look for the meteorites. What do you say?

a) Cool, let's go!
b) Yes, all we need to do is look for the smoke.
c) No, it's too dangerous. We could be hit by one while looking.
d) No, they burned up in the atmosphere, nothing left.
e) Yes, I like cake.