# Motions in the Sky (Part II)

Sept 4, 2002

1) Review
2) The Moon Revolves Around the Earth
3) Eclipses
4) Summary

# Announcements

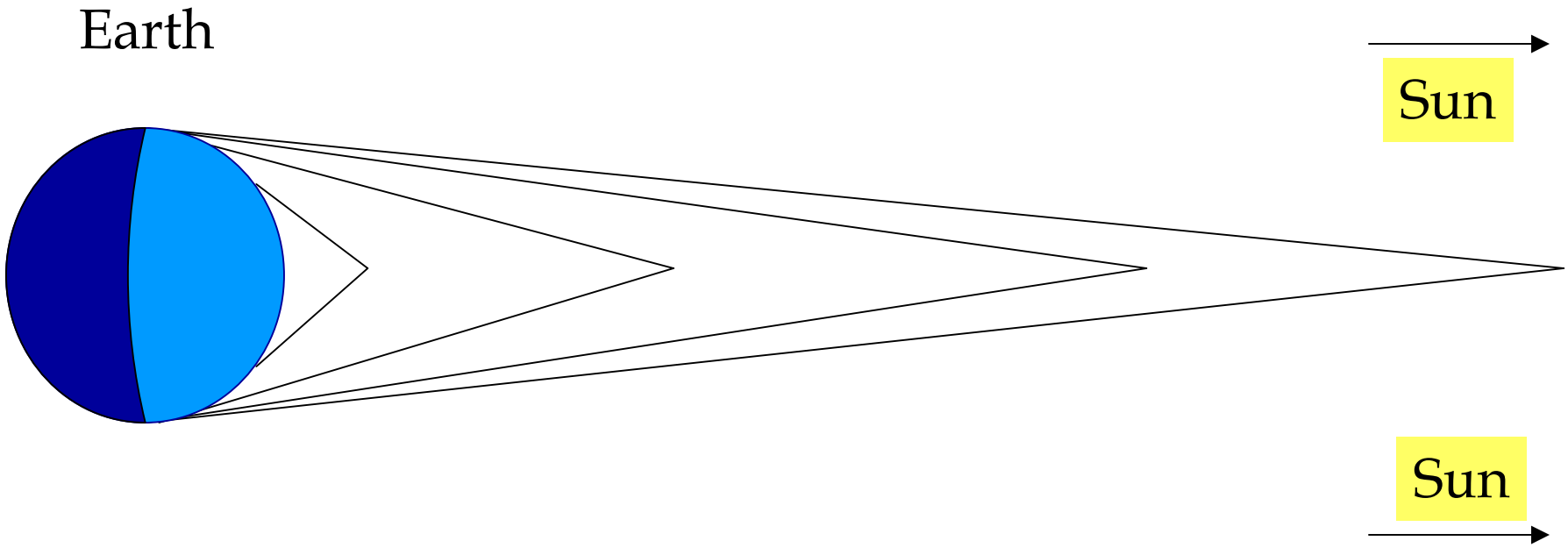
- PRS numbers have been assigned
  - Check the web page
    - http://www.hep.fsu.edu/~tadams/courses/fall02/ast1002/PRS.html
  - Check the PRS screen
  - Remember your number and pick up your zapper before class
  - Return your zapper at the end of class
- This section has been added to Blackboard
  - http://campus.fsu.edu/
- I have added homework assignments to the course website
  - This is non-credit homework to help test your understanding of the material
- There are extra credit problems available which are due by 5pm on Friday

# Review

- There is lots of motion in the Universe
- The Earth spins around its axis once per day
  - north & south celestial poles, horizon
- The Earth revolves around the Sun once per year
- The Earth is tilted 23.5° on its axis
- Seasons are caused by the Earth's tilt and revolving around the Sun

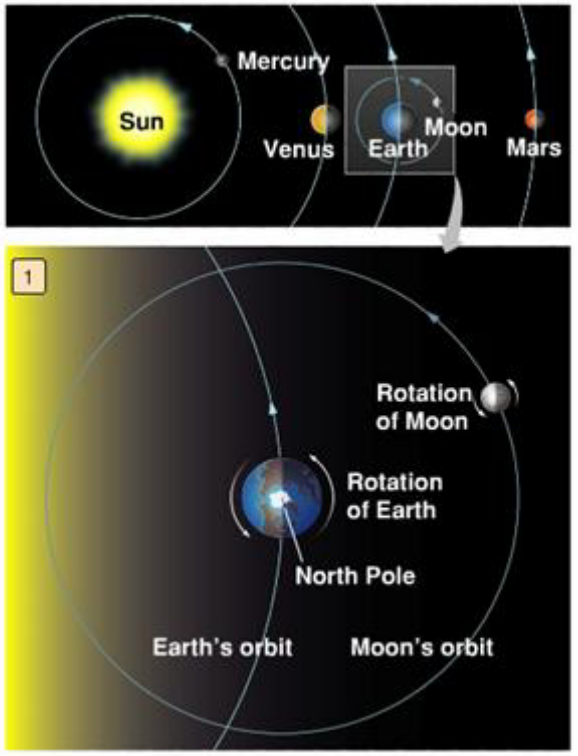
# Light Rays from Afar

- The farther away a light source is, the more parallel the rays are
  - The Sun is so far away, the light rays hitting opposite sides of the Earth are almost parallel (about $10^{-6}$ degrees)
  - Stars are even farther away



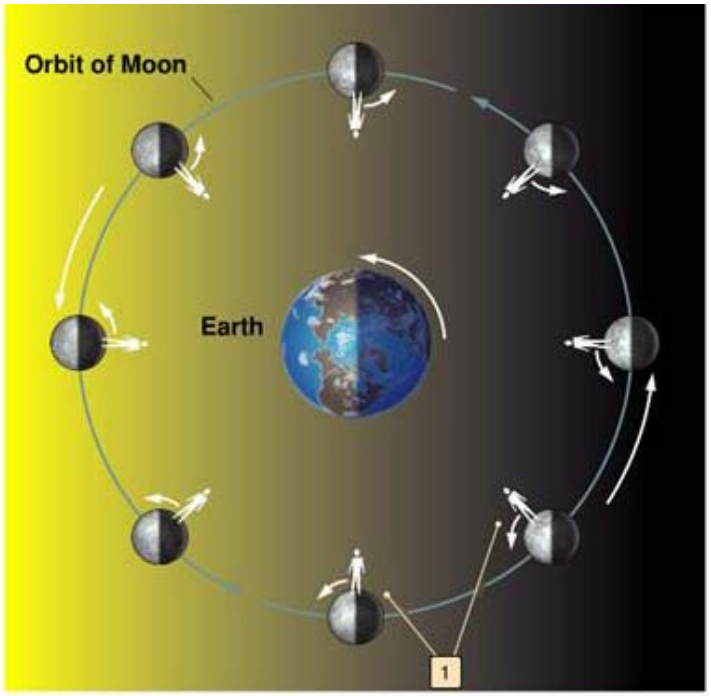
# Moon Revolves Around the Earth

- The Moon revolves around the Earth every 29½ days
  - Since the Moon revolves around the Earth, it rises later and later as the month goes on
- The Moon "pulls" on the Earth (gravity)
- This pull is responsible for tides



# Moon Rotates

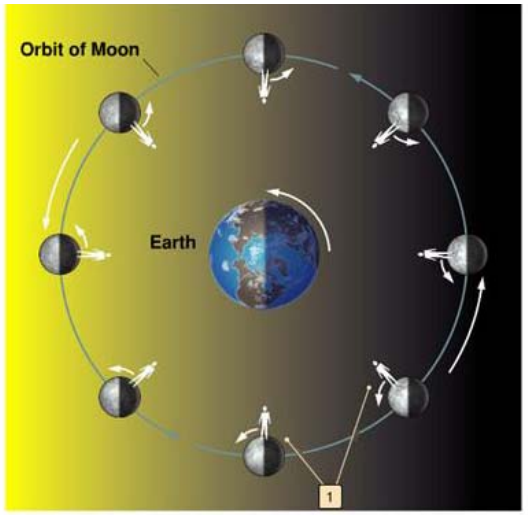
- The Moon spins with the same period that it revolves around the Earth (once every 29½ days)
- This means the same side of the Moon always faces the Earth




- A day on the Moon (sunrise to sunrise) is 29½ days long

# Lunar Phases

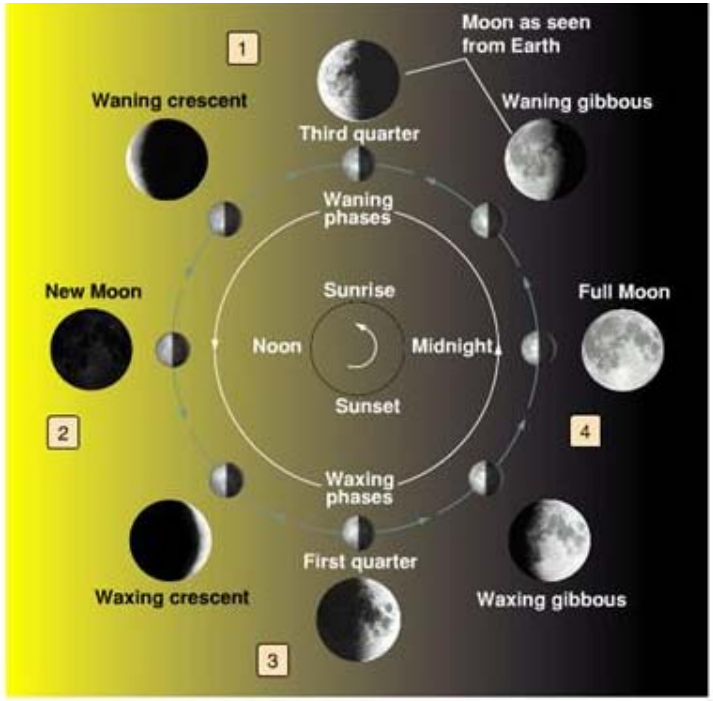
- Sunlight illuminates half of the Moon
  - it's a ball and the Sun is shining on it from one direction
  - the side facing the Sun is the one illuminated, but that side is not always facing the Earth




- This causes the "phases" of the Moon
  - Waxing Moon – amount of visible, illuminated Moon is growing from day to day
  - Waning Moon – amount of visible, illuminated Moon is decreases from day to day

# Lunar Phases (cont)

- Phases
  - New Moon
  - Waxing Crescent Moon
  - Waxing Half Moon
  - Waxing Gibbous Moon
  - Full Moon
  - Waning Gibbous Moon
  - Waning Half Moon
  - Waning Crescent Moon
  - New Moon
  - …




- New Moon
  - The Sun is on the same part of the sky as the sun and rises and sets with the Sun
- Full Moon
  - The Sun is in the opposite side of the sky as the Sun and rises when the Sun sets and sets when the Sun rises

# Moonrise/Moonset

The time the Moon rises and sets is correlated to its phase

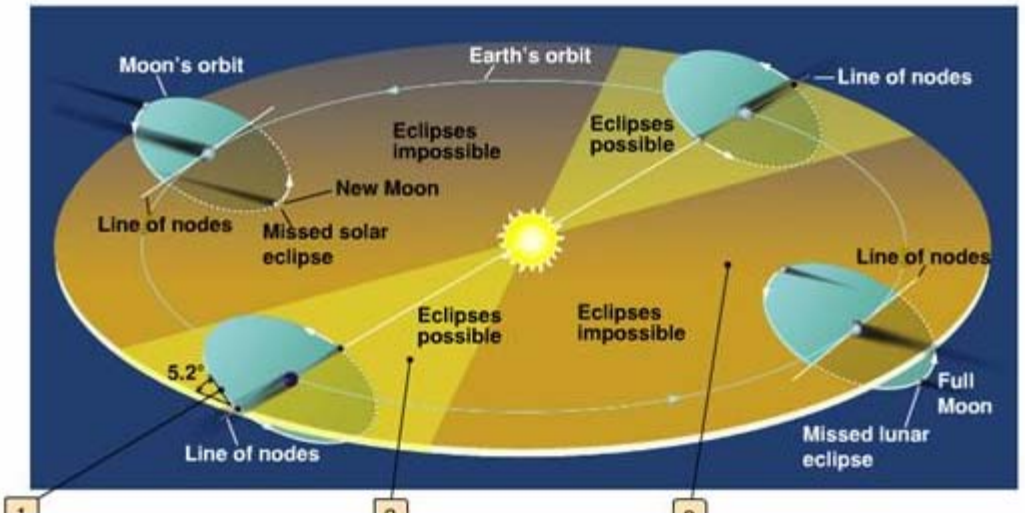
| Phase of the Moon | Rise | Zenith | Set |
|---|---|---|---|
| New Moon | 6 am | Noon | 6 pm |
| Waxing Half Moon | Noon | 6 pm | Midnight |
| Full Moon | 6 pm | Midnight | 6 am |
| Waning Half Moon | Midnight | 6 am | Noon |
| New Moon | 6 am | Noon | 6 pm |

# "Dark Side" of the Moon

- The Moon doesn't have a "dark side"
  - Everywhere on the Moon, the Sun rises and sets once per month
- It has a side which faces away from us
  - During a New Moon, the far side is completely illuminated

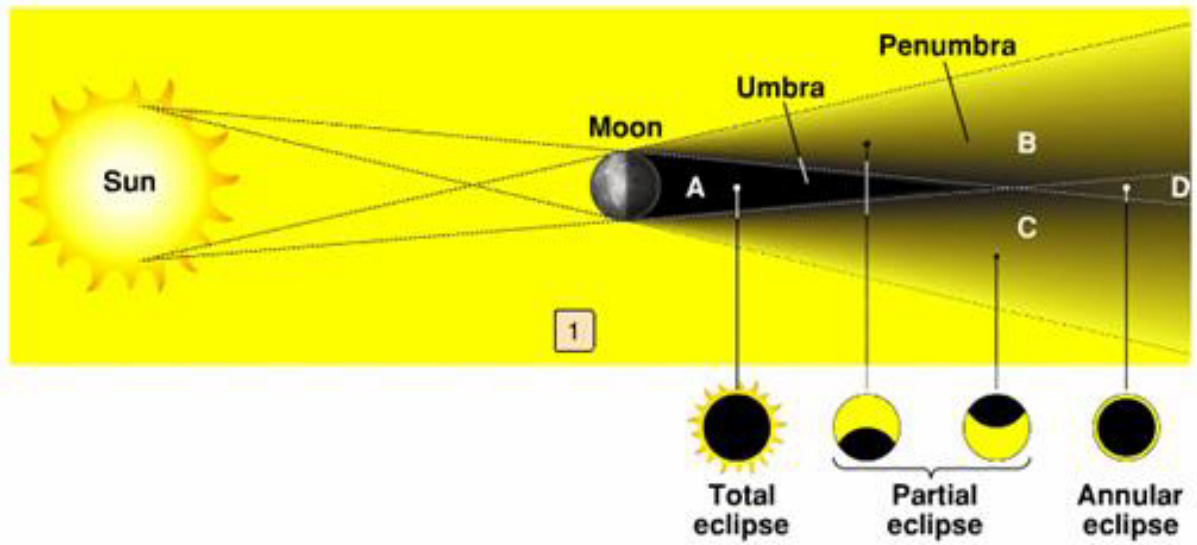
# Eclipses

- Eclipses occur when the Sun, the Earth and the Moon all lie along a straight line
  - They must line up in all 3 dimensions + time
  - If the Moon and Sun followed the same path around the Earth (the ecliptic), we would see an eclipse every month, but the Moon's orbit is tilted 5o with respect to the ecliptic, so there are only two times a year when the paths overlap



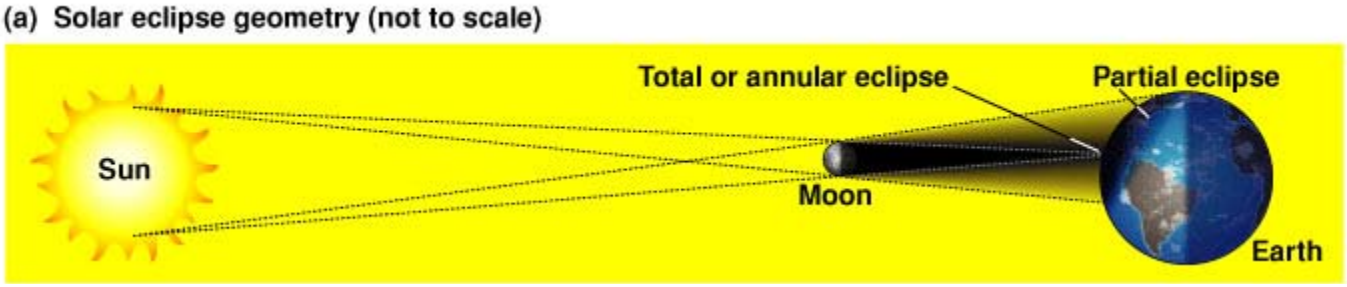
# Shadows

- Umbra
  - dark cone of complete shadow
- Penumbra
  - lighter area of partial shadow



# Solar Eclipse

- The Moon is between the Sun and the Earth
  - as seen from the Earth, the Moon blocks the Sun either partially or fully




- A truly amazing sight

# Solar Eclipse (cont)

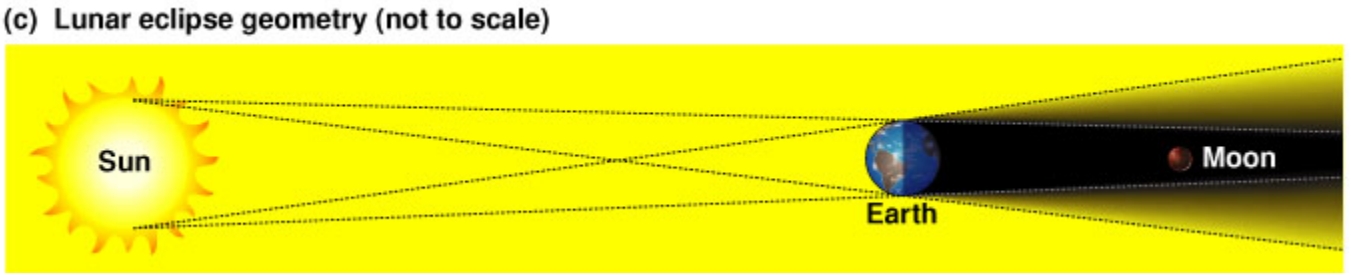
- The Sun and the Moon have the same apparent size in the sky ($\frac{1}{2}^{\circ}$ wide)
  - Sun is 400 times larger than the Moon, but 400 times farther away
  - Earth to Moon distance varies (elliptical orbit) so sometimes the Moon won't totally block the Sun
  - area of total eclipse is small
    - 0 to 175 km wide
  - time of total eclipse is small
    - 0 to 7 minutes
    - shadow moves across Earth at 1500 km/hr
  - partial eclipse is visible 3000 km on either side
- Earth is the only place in the Solar System where solar eclipses occur

# Upcoming Solar Eclipses

| Date | Duration of Totality (minutes) | Where Visible |
|---|---|---|
| Dec. 4, 2002 | 2.1 | South Africa, Australia |
| Nov. 23, 2003 | 2.0 | Antarctica |
| April 8, 2005 | 0.7 | South Pacific Ocean |
| Mar. 29, 2006 | 4.1 | Africa, Asia Minor, Russia |
| Aug. 1, 2008 | 2.4 | Arctic Ocean, Siberia, China |
| July 22, 2009 | 6.6 | India, China, South Pacific |
| July11, 2010 | 5.3 | South Pacific Ocean |
| … | | |
| Aug. 21, 2017 | 2.7 | Pacific Ocean, USA, Atlantic Ocean |
| … | | |
| April 8, 2024 | 4.5 | South Pacific, Mexico, Eastern USA |

# Lunar Eclipse

- The Earth is between the Sun and the Moon




- The Earth's shadow is much larger and lunar eclipses are visible from anywhere on the night side of Earth
- So, lunar eclipses are much more common
  - Every 2-3 years
  - Totality lasts up to 1 hour 40 minutes

# Nicholas Copernicus

- Early people believed the Earth was the center of the Universe and that the Sun, Moon, stars and other celestial bodies revolved around the Earth
- Nicholas Copernicus (1473-1543) was the first recorded person to suggest the Earth revolved around the Sun
  - He suggested the planets went around in circles
  - didn't publish this until the year he died
- Not readily accepted

# Brahe and Kepler

- Tycho Brahe (1546-1601)
  - Brahe spent decades observing and recording the positions of the planets in the sky
- Johannes Kepler (1571-1630)
  - Compared the data from Brahe to Copernicus' theory of planets revolving around the Sun in circular orbits
  - The data did NOT support this theory
    - What does the scientific method say we should do?