Discovering the Universe for Yourself
By next class time

- Read Ch. 3 & DO Online Exercise 03 ("Seasons" tutorial)
- Optional:
  - Do “Eclipse” tutorial
Axis tilt changes directness of sunlight during the year.
Manly Beach, Sydney, Australia
Dec. 23, 2009
Seasonal Change in Sun’s Altitude

“Figure 8” shows Sun at same time each day over a year.
Seasonal changes are more extreme at high latitudes

Path of Sun on summer solstice at Arctic Circle
2.3 The Moon, Our Constant Companion

Our goals for learning:

- Why do we see phases of the Moon?
- What causes eclipses?
Thought Question
If the moon is rising at the same time the sun is setting, what is the moon’s phase?

A. first quarter
B. waxing gibbous
C. full
D. waning crescent
Thought Question

If the moon is rising at the same time the sun is setting, what is the moon’s phase?

A. first quarter
B. waxing gibbous
C. full
D. waning crescent
Why do we see phases of the Moon?

- Lunar phases are a consequence of the Moon’s 27.3-day orbit around Earth.
Phases of the Moon

- Half of the Moon is illuminated by the Sun and half is dark.
- We see a changing combination of the bright and dark faces as the Moon orbits Earth.
Phases of the Moon

http://www.moonconnection.com/moon_phases_calendar.phtml
Lunar Motion

Phases of the Moon’s 29.5 day cycle

- new
- crescent
- first quarter
- gibbous
- full
- gibbous
- last quarter
- crescent

waxing
waning
Phases of the Moon
Moon Rise/Set by Phase

Time the Moon Rises and Sets for Different Phases
Questions

1. About what is the phase of the moon right now?
   a. First quarter
   b. Third quarter
   c. New moon
   d. Full moon
Questions

1. About what is the phase of the moon right now?
   a. First quarter
   b. Third quarter
   c. New moon
   d. Full moon
Thought Question

Suppose the full moon is rising in the east. About what time is it?

A. 6 a.m.
B. 12 midnight
C. 6 p.m.
D. 12 noon
Thought Question

Suppose the full moon is rising in the east. About what time is it?

A. 6 a.m.
B. 12 midnight
C. 6 p.m.
D. 12 noon
Thought Question

It’s 9 A.M. You look up in the sky and see a moon with half its face bright and half dark. What phase is it?

A. first quarter
B. waxing gibbous
C. third quarter
D. half moon
Thought Question

It’s 9 A.M. You look up in the sky and see a moon with half its face bright and half dark. What phase is it?

A. first quarter
B. waxing gibbous
C. third quarter
D. half moon
We see only one side of the Moon.

Synchronous rotation: The Moon rotates exactly once with each orbit.

This is why only one side is visible from Earth.
What causes eclipses?

- The Earth and Moon cast shadows.
- When either passes through the other’s shadow, we have an eclipse.
Lunar Eclipse
When can eclipses occur?

- Lunar eclipses can occur only at full moon.
- Lunar eclipses can be penumbral, partial, or total.
Solar Eclipse

Evolution of a Total Solar Eclipse
When can eclipses occur?

- Solar eclipses can occur only at *new moon*.
- Solar eclipses can be partial, total, or annular.
Why don’t we have an eclipse at every new and full moon?

— The Moon’s orbit is tilted 5° to the ecliptic plane.
— So we have about two **eclipse seasons** each year, with a lunar eclipse at new moon and solar eclipse at full moon.
Summary: Two conditions must be met to have an eclipse

1. It must be a full moon (for a lunar eclipse) or a new moon (for a solar eclipse).

   AND

2. The Moon must be at or near one of the two points in its orbit where it crosses the ecliptic plane (its nodes).
Predicting Eclipses

- Eclipses recur with the 18-year, 11 1/3-day *saros cycle*, but type (e.g., partial, total) and location may vary.
Solar Corona during an Eclipse
Monitoring Solar Corona & Wind with artificial eclipse
What have we learned?

• Why do we see phases of the Moon?
  — Half the Moon is lit by the Sun, half is in shadow, and its appearance to us is determined by the relative positions of the Sun, Moon, and Earth.

• What causes eclipses?
  — Lunar eclipse: Earth’s shadow on the Moon
  — Solar eclipse: Moon’s shadow on Earth
  — Tilt of Moon’s orbit means eclipses occur during two periods each year.
2.4 The Ancient Mystery of the Planets

Our goals for learning:

- Why was planetary motion so hard to explain?
- Why did the ancient Greeks reject the real explanation for planetary motion?
Planets Known in Ancient Times

- **Mercury (bottom)**
  - Difficult to see; always close to Sun in sky
- **Venus (above Mercury)**
  - Very bright when visible; morning or evening “star”
- **Mars (middle)**
  - Noticeably red
- **Jupiter (top)**
  - Very bright
- **Saturn (above Mars)**
  - Moderately bright
Why was planetary motion so hard to explain?

- Planets usually move slightly *eastward* from night to night relative to the stars.
- But sometimes they go *westward* relative to the stars for a few weeks: *apparent retrograde motion.*
We see apparent retrograde motion when we pass by a planet in its orbit.

Apparent retrograde motion occurs between positions 3 and 5, as the inner person (planet) passes the outer person (planet).

Follow the lines of sight from inner person (planet) to outer person (planet) to see where the outer one appears against the background.
Explaining Apparent Retrograde Motion

• Easy *for us* to explain: this occurs when we “lap” another planet (or when Mercury or Venus laps us).

• But it is very difficult to explain if you think that Earth is the center of the universe!

• *In fact, ancients considered but rejected the correct explanation.*
Why did the ancient Greeks reject the real explanation for planetary motion?

- Their inability to observe stellar parallax was a major factor.
The Greeks knew that the lack of observable parallax could mean one of two things:

1. Stars are so far away that stellar parallax is too small to notice with the naked eye.
2. Earth does not orbit the Sun; it is the center of the universe.

With rare exceptions, such as Aristarchus, the Greeks rejected the correct explanation (1) because they did not think the stars could be *that* far away.

*Thus the stage was set for the long, historical showdown between Earth-centered and Sun-centered systems.*
What have we learned?

• Why was planetary motion so hard to explain?
  —Like the Sun and Moon, planets usually drift eastward relative to the stars from night to night; but sometimes, for a few weeks or few months, a planet turns westward in its apparent retrograde motion.

• Why did the ancient Greeks reject the real explanation for planetary motion?
  —Most Greeks concluded that Earth must be stationary, because they thought the stars could not be so far away as to make parallax undetectable.
By next class time

- Read Ch. 3
- Do practice online quiz 01