ASTRONOMY 161
Introduction to Solar System Astronomy
Seasons & Calendars

Monday, January 8
(1) The cause of the seasons is the tilt of the Earth’s rotation axis relative to its orbit around the Sun.

(2) The **day** is based on the time between one noon and the next.

(3) The **year** is based on the time between one vernal equinox and the next.

(4) The **moon** (month) is based on the time between one new moon and the next.
What causes the Earth’s seasons?

**NOT** the varying distance of the Earth from the Sun.
Earth’s orbit around the Sun:

1) The Earth’s orbit is nearly circular: solar heating is nearly constant.

2) The Earth’s closest approach to the Sun is in JANUARY.

3) Summer in Northern Hemisphere = Winter in Southern Hemisphere (and vice versa).
What causes the Earth’s seasons?

The tilt of the Earth’s rotation axis relative to the Earth’s orbit around the Sun.
Observed properties:

**Summer**
- Warmer temperatures
- Longer daylight
- Sun high in the sky at noon

**Winter**
- Cooler temperatures
- Shorter daylight
- Sun low in the sky at noon
Recall from last Friday:

Seen from earth, Sun drifts west to east along the ecliptic (which is tilted relative to the celestial equator).
Summer solstice: Sun is furthest north of celestial equator (June 21)

Autumnal equinox: Sun crosses celestial equator, southbound (Sep 22)

Winter solstice: Sun is furthest south of celestial equator (Dec 21)

Vernal (spring) equinox: Sun crosses celestial equator, northbound (Mar 21)
The Sun’s apparent motion at different times of year
But what’s this got to do with the tilt of the Earth’s axis?

The ecliptic is tilted by 23.5 degrees relative to the celestial equator

**BECAUSE**

the Earth’s axis of rotation is tilted by 23.5 degrees relative to its orbit around the Sun.
The view from a distance:

(Size of Earth is grossly exaggerated.)
Another view:
Two reasons why **summer** is warmer than **winter**:

1) Sun is above the horizon **longer** during the summer

2) Sun rises **higher in sky** during the summer.
Summer vs. winter in Columbus, Ohio:

Longest day: Jun 21\textsuperscript{st} – 15 hours 1 minute
Sun is $50+23.5=73.5$ degrees above horizon at noon

Shortest day: Dec 21\textsuperscript{st} – 9 hours 19 minutes
Sun is $50-23.5=26.5$ degrees above horizon at noon

About \textbf{4 times} as much solar energy in \textit{summer}!
The day is based on the time between one noon and the next.

The apparent motions of Sun and Moon provided humanity’s first clock.
Defining the day

Meridian = great circle on the celestial sphere, running from north to south, through your zenith.

Local noon = instant when the Sun crosses your upper meridian (above the horizon).

Apparent solar day = time between one local noon and the next.
Complications

Length of apparent solar day varies slightly during the year. Use mean solar day.

Time of local noon varies from place to place. Use time zones.

It is inconvenient to start a new calendar day at noon. Start day at midnight.
(3) The year is based on the time between one vernal equinox and the next.

**Tropical year** = time between one vernal equinox and the next.

Tropical year remains aligned with the seasons; useful for farmers.

**Complication:** Tropical year contains 365.2422 mean solar days (not a whole number).
Julian Calendar

Introduced by Julius Caesar in 46 BC.

Ordinarily, 365 days per year; leap year added every fourth year.

Average length of year in Julian Calendar = \textbf{365.25 days}

True length of tropical year = \textbf{365.2422 days}
Gregorian Calendar

By 16th century AD, Julian calendar was 10 days out of sync with seasons (result: date of Easter was wrong).

Pope Gregory XIII endorsed a new calendar in October 1582:

A century year (ending in two zeros) is not a leap year unless it is divisible by 400.

Average length of year in Gregorian Calendar = \textbf{365.2425 days} (tropical year = 365.2422 days)
The month is based on the time between one new moon and the next. The moon shows phases:

- New
- Last Quarter
- First Quarter
- Full

Time between one new Moon and the next is 29.5306 mean solar days (known as the synodic month).
Other Calendars:

Month always begins at new Moon; months are 29 or 30 days long.

**Chinese:** one year contains 12 or 13 months (354 or 384 days – leap year).

**Islamic:** one year contains 12 months (354 days).

**Jewish:** one year contains 12 or 13 months (354 or 384 days – leap year).