The Sun and the Celestial Sphere

- As the Earth orbits the Sun we seen the Sun in different locations against the backdrop of stars.

- The Earth reaches the same location in its orbit on the same calendar date each year.
The Sun and the Celestial Sphere

- As the Earth orbits the Sun we see the Sun in different locations against the backdrop of stars.

- The path the Sun follows amongst the background of stars is nearly identical from year to year and is called the **Ecliptic**.
The Sun and the Celestial Sphere

- As the Earth orbits the Sun we seen the Sun in different locations against the backdrop of stars.

- The set of constellations through which the Sun passes is called the Zodiac.
  - The Sun lies in front of your “birthsign” constellation on your birthday.
Solstices and Equinoxes

Because the Earth is a spinning top, the direction of its pole in the sky is fixed (at least from the perspective of a human lifetime).

- The pole is tilted $23 \frac{1}{2}$ degrees to Earth's orbital plane.
- The Sun traces out an identical path year after year.
- That path is tipped $23 \frac{1}{2}$ degrees to the Celestial Equator.
Solstices and Equinoxes

- Because the Earth is a spinning top, the direction of its pole in the sky is fixed (at least from the perspective of a human lifetime).
  - The Sun does not lie on the celestial equator but follows a path inclined by 23½ degrees.
  - The path crosses the celestial equator at 2 points (the vernal and autumnal equinox) marking the instant of the beginning of Spring and Fall.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date*</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vernal equinox</td>
<td>March 20</td>
<td>Spring begins</td>
</tr>
<tr>
<td>Summer solstice</td>
<td>June 22</td>
<td>Summer begins</td>
</tr>
<tr>
<td>Autumnal equinox</td>
<td>September 22</td>
<td>Autumn begins</td>
</tr>
<tr>
<td>Winter solstice</td>
<td>December 22</td>
<td>Winter begins</td>
</tr>
</tbody>
</table>

* Give or take a day due to leap year and other factors.
How You See the Sun's Motion Through a Year

- Since the Sun is sometimes 23 ½ degrees above the Celestial Equator, sometimes 23 ½ degrees below and sometimes right on the Equator the Sun's behavior is different as the Celestial Sphere turns.

  ➔ Remember that day by day the Sun occupies a slightly different location on the celestial sphere, but it is the turning of the celestial sphere that dictates its daily motion.
How You See the Celestial Equator on the Sky

- The Celestial Equator is a fixed line on the sky running from due-East on the horizon, high up in the South, and then down to due-West on the opposite horizon.
  - Since it is 90 degrees away from the pole the angular altitude at its peak is 90-latitude.
How You See the Celestial Equator on the Sky

- The Celestial Equator is a fixed line on the sky running from due-East on the horizon, high up in the South, and then down to due-West on the opposite horizon.
  - Since it is 90 degrees away from the pole the angular altitude at its peak is 90-latITUDE.
How You See the Celestial Equator on the Sky

- The Celestial Equator is a fixed line on the sky running from due-East on the horizon, high up in the South, and then down to due-West on the opposite horizon.
  - Since it is 90 degrees away from the pole the angular altitude at its peak is 90-latITUDE.
How You See the Sun's Motion Through a Year

- Since the Sun is sometimes 23 ½ degrees above the Celestial Equator, sometimes 23 ½ degrees below and sometimes right on the Equator the Sun's behavior is different as the Celestial Sphere turns.
Consequences for the Seasons

- The altitude of the Sun in the sky at Noon determines how directly sunlight reaches the ground and warms the Earth.
- The length of the day is an important factor.
- In Winter the Sun never gets high in the sky and the day is short.
How You See the Sun's Motion Through a Year

- In the Summer, the Sun is well north of the celestial equator and behaves more like a star near the north celestial pole (more like a circumpolar star) – so it is above the horizon much more than 12 hours.
  - At very northerly latitudes the Sun actually can be circumpolar.
- In the Winter, the Sun is well south of the celestial equator. It behaves more like one of those southern stars that barely makes it above the horizon – short days.
Consequences for the Seasons

- The altitude of the Sun in the sky at Noon determines how directly sunlight reaches the ground and warms the Earth.
- The length of the day is an important factor.
- In Winter the Sun never gets high in the sky and the day is short.

Views from the Sun at the Winter (left) and Summer (right) solstice
Consequences for the Seasons

- Note that the Seasons are reversed between the Northern and Southern hemispheres. It is Summer in January in Brazil.
A Big Misconception

- Although it makes sense that the Earth should be warmer when it is closest to the Sun, perihelion (closest approach) is in January.
  - The Earth's orbit is not a perfect circle and sometimes it is closer to the Sun than at other times, but this difference is SMALL and the effect on seasons minuscule.

Views from the Sun at the Winter (left) and Summer (right) solstice
On the day of the summer solstice in late June, Earth’s northern hemisphere is inclined toward the sun, and sunlight shines almost straight down at northern latitudes. At southern latitudes, sunlight strikes the ground at an angle and spreads out. North America has warm weather, and South America has cool weather.

Earth’s axis of rotation points toward Polaris, and, like a top, the spinning Earth holds its axis fixed as it orbits the sun. On one side of the sun, Earth’s northern hemisphere leans toward the sun; on the other side of its orbit, it leans away. However, the direction of the axis of rotation does not change.
On the day of the winter solstice in late December, Earth's northern hemisphere is inclined away from the sun, and sunlight strikes the ground at an angle and spreads out. At southern latitudes, sunlight shines almost straight down and does not spread out. North America has cool weather and South America has warm weather.

Earth's orbit is only very slightly elliptical. About January 4th, Earth is at **perihelion**, its closest point to the sun, when it is only 1.7 percent closer than average. About July 4th, Earth is at **aphelion**, its most distant point from the sun, when it is only 1.7 percent farther than average. This small variation does not significantly affect the seasons.