1. Go over the syllabus

2. What is this class about? **physics**
   
do not confuse with astronomy with a lot of fancy pictures

3. Believes vs fact check

   Q: Who believes that Earth rotates and moves around the sun?
   Who does not believe?

4. Address Earth rotation around its axis.

   Surprisingly, solid proof of it came from the Foucault pendulum in 1851.
   
   \[ \omega_{\text{plane motion}} = \frac{360^\circ \sin \phi}{1 \text{ day}} \]

   and later with use of gyroscopes
5. Q: Ok. So what do we see when we look at a star?

A: They move seemingly in sync.

→ Earth, center of rotation and universe. Geocentric system. 

→ Hipparchus (150 BC)

6. What about retrograd motion?

Ptolemy (100 AD) - epicycles

4. Copernicus, with geocentric model, published after his death.

and so on

Note that Magellan's expedition dates are 1519-1522, i.e. we know that we can loop around Earth.

Nice idea. But data does not support it (since perfect circles are no good.)
Tycho Brahe (1546-1601) the best astronomer of that time criticized Copernicus' model on the following base.

No one see parallax while stars appear to have angular size (they did not know about diffraction then). So if we assume that Earth moves, the estimate of star sizes would be huge (larger than Earth orbit) so Sun seems to be a special small star. See 'pdf' link.

Note the Brahe angular precision was about 4'.

1a. Cassini in mid 1650 observe seasonal variation of the Sun, about 3.4% difference in angular size. By itself it is not a proof of Earth motion. May be the Sun just inflates/deflates with seasons.
8. So if one observes a star parallax that would be a nice prove that Earth moves around the sun.

But we need better tools to move beyond a naked eye resolution of 1'

→ telescope by Hans Lippershey in 1608

German-Dutch

Galileo was later (~1609).

Wonderful! Better resolution still no parallax.

But Galileo saw satellites around Jupiter which looks like "miniature" solar system model.

9. Halley (remember the comet?) (1656-1742) in 1718 compared ancient records with current and noticed that stars are moving with respect to each other. So called "proper motion".

Yet no yearly "loops" in their position observation
10. In 1729 James Bradley observed the apparent motion of **α Draconis** (Eltanin) done with attachment of a telescope permanent and fixed to a chimney of his house.

The motion was 20".

Can be explained classically (and was by Bradley) as addition of velocities vectors.

\[
\theta = \frac{v}{c}
\]

This day we know that Earth moves with \( v = 30 \frac{\text{km}}{\text{s}} \) around the Sun and speed of light \( c = 3 \times 10^8 \text{ m/s} \).

\[
\theta = \frac{30 \times 10^3}{3 \times 10^8} = 10^{-4} \text{ rad} = \frac{10^{-4} \times 360^\circ}{2\pi} \times \frac{3600''}{10} = \]

\( \approx 20.6'' \) (as observed by Bradley)

But this explanation was disregarded (did not fit those day theories).
11. So it took Bessel to observe the parallax of 61 Cygni (star with the largest known proper motion at that time).

In 1838, he reported 0.314" parallax (modern value 0.348") on a background of 5.2" of proper motion.

So since 1838 we have a solid prove that Earth is not the center of universe and moves around the Sun.