Solar Astronomy

PTRA 2023

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Resources

Slides

https://bit.ly/PTRASolarSlides

Virtual Handout

https://bit.ly/PTRASolarHandout

Circular Motion - How Fast Are We Going?

Objective

Use the Universal Law of Gravitation and the Centripetal Force formulas, determine the theoretical speed of the Earth going around the Sun.

$$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$$

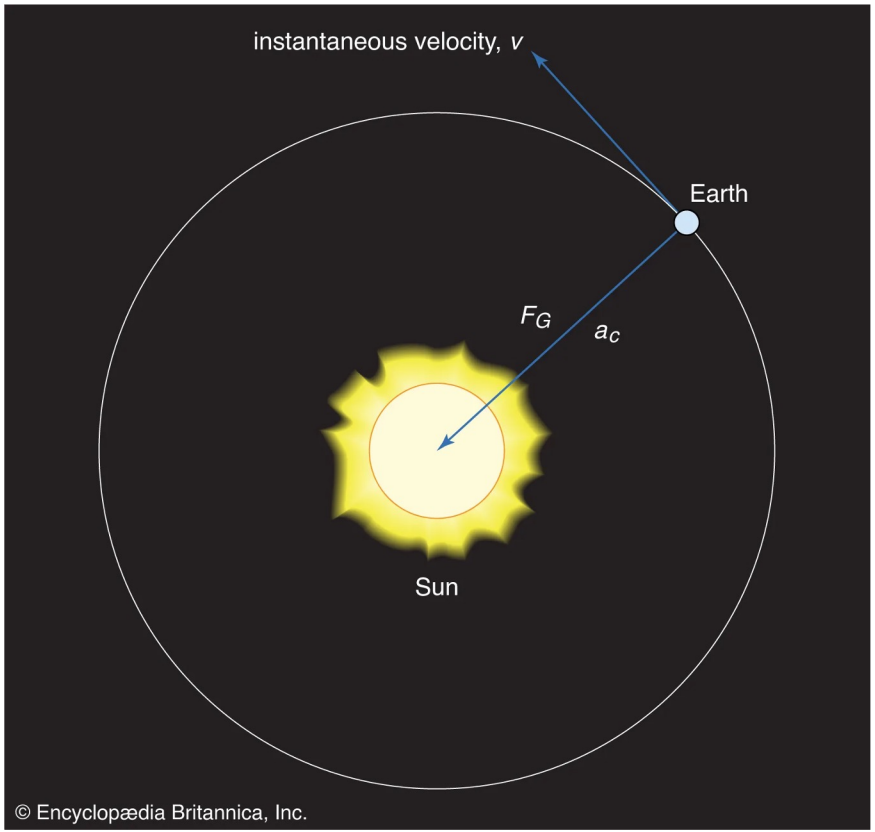
$$m_{sun} = 2.00 \times 10^{30}\ kg$$

$$m_{Earth} = 5.97 \times 10^{24}\ kg$$

$$r_{E-S} = 1.5 \times 10^{11}\ m$$

$$F_g = \frac{G m_{Sun} m_{Earth}}{r_{E-S}^2}$$

$$F_c = m_{Earth} \frac{v^2}{r_{E-S}}$$



$$F_g = F_c$$

$$\frac{Gm_{Sun}m_{Earth}}{r_{E-S}^2} = m_{Earth}\frac{v^2}{r_{E-S}}$$

$$\frac{Gm_{Sun}}{r_{E-S}} = v^2$$

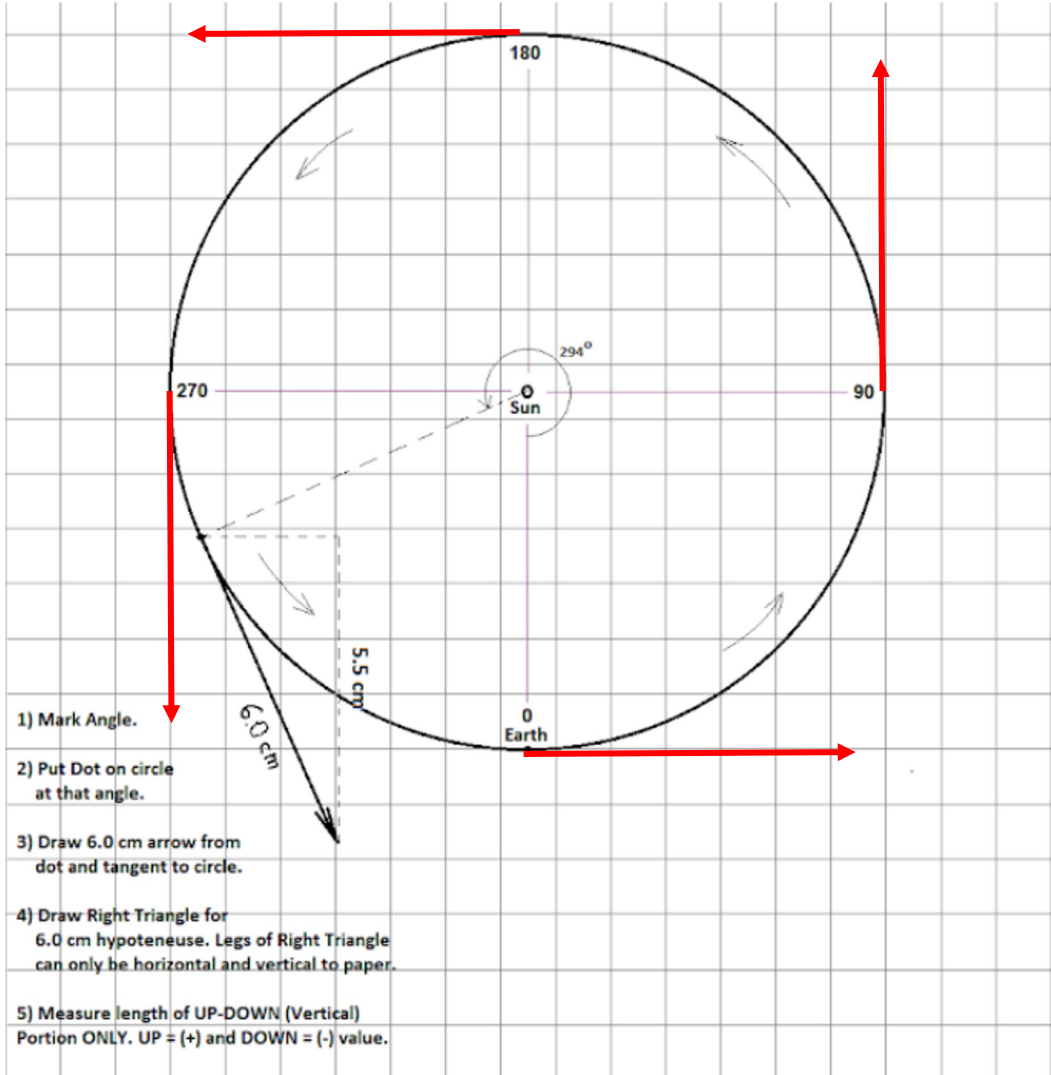
$$v = \sqrt{\frac{Gm_{Sun}}{r_{E-S}}}$$

$$v = \sim 30\ {}^{km}/_{s}$$

Modeling the Earth Around the Sun

On the page, draw in the velocity vector representing the Earth's instantaneous velocity at each of the points 0°, 90° 180°, 270°

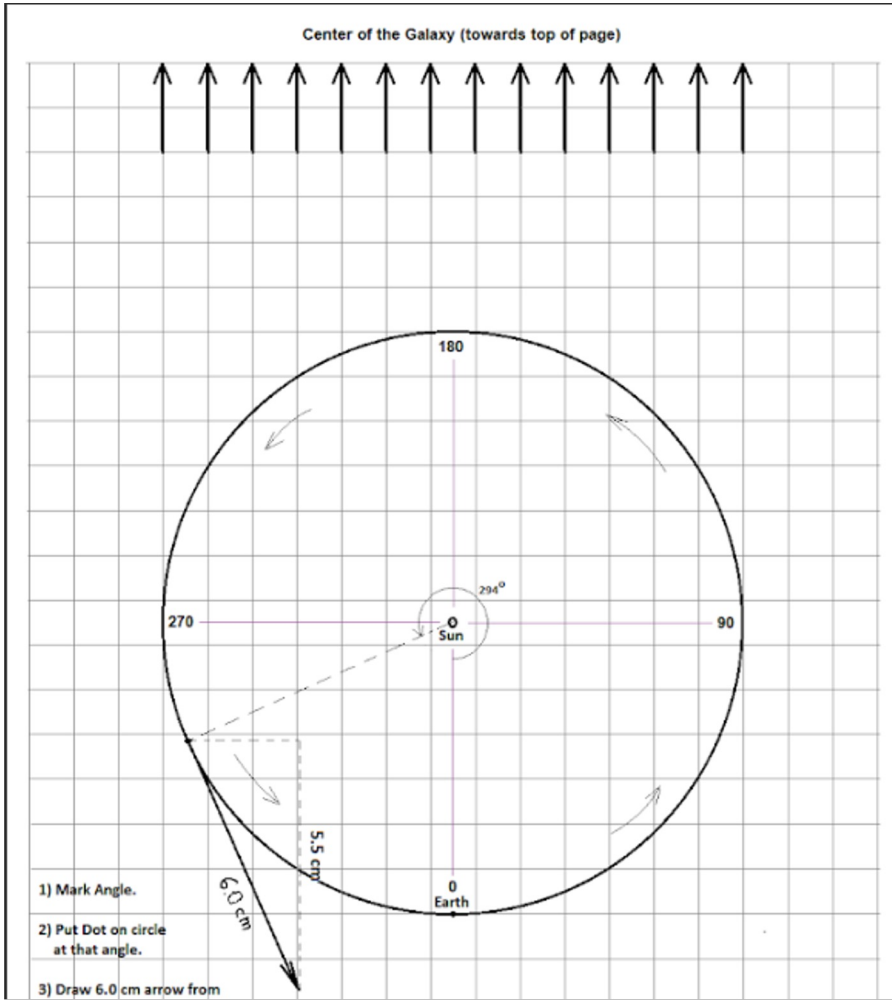
Scale:
1 cm = 5 km/s



Modeling the Earth Around the Sun

How do we MEASURE our speed around the Sun?

At what point on the circle would you “see” the center of the galaxy behind the Sun?

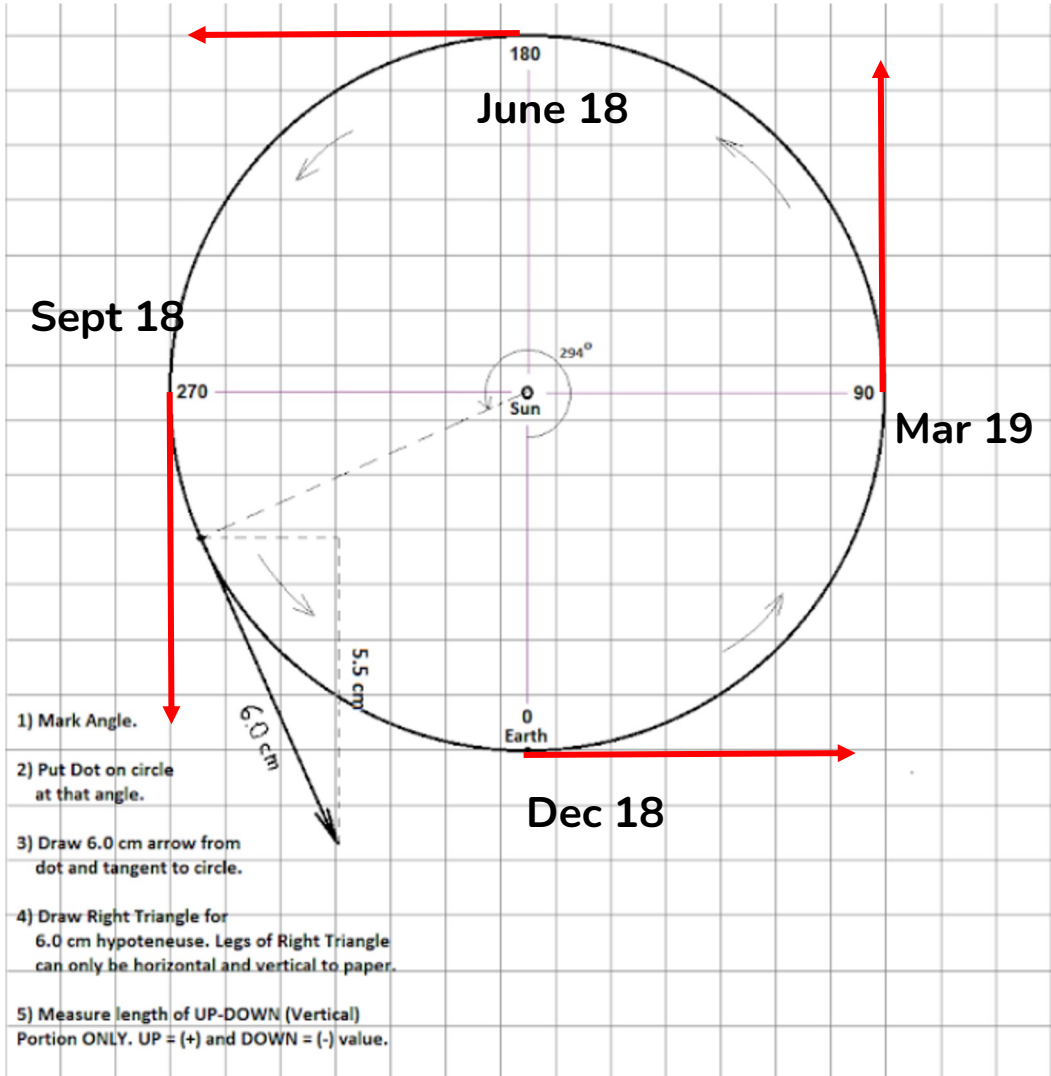



SAGITTARIUS
CORONA AUSTRALIS
SCUTUM
Mercury
Sun
Mars
SCORPIUS
2023-12-18
22:51:09
Moonlight

Modeling the Earth Around the Sun

If 0° is the position of the Earth on Dec 18th, what would be the dates for the other 4 labeled points?

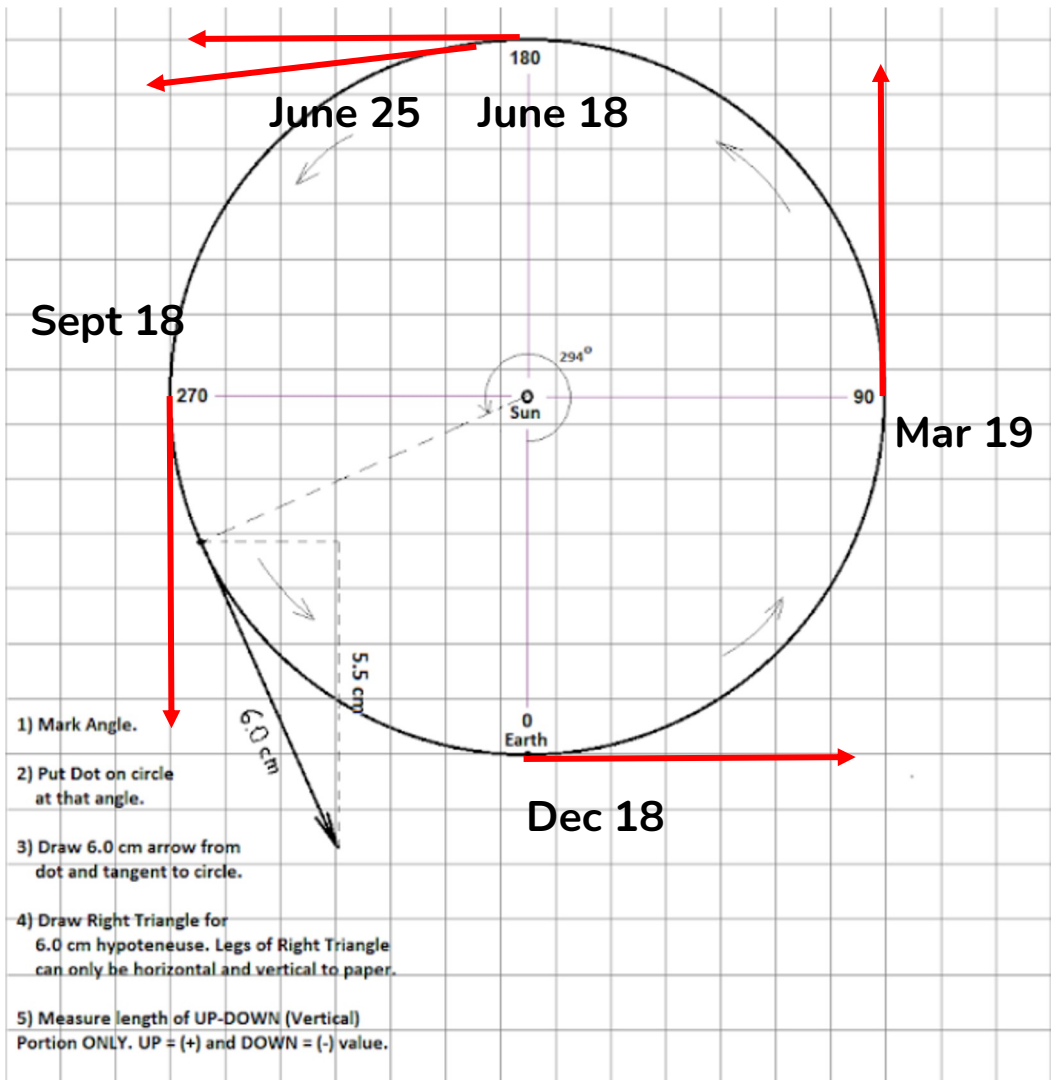
Scale:
1 cm = 5 km/s



Modeling the Earth Around the Sun

Estimate where today's position is and draw in your velocity vector.

Scale:
1 cm = 5 km/s



Modeling the Earth Around the Sun

Estimate where today's position is and draw in your velocity vector.

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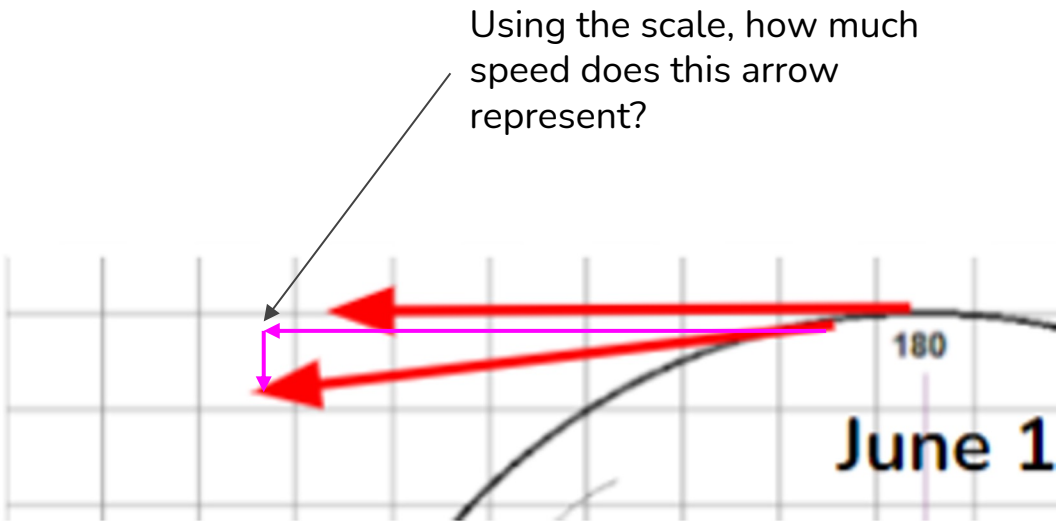
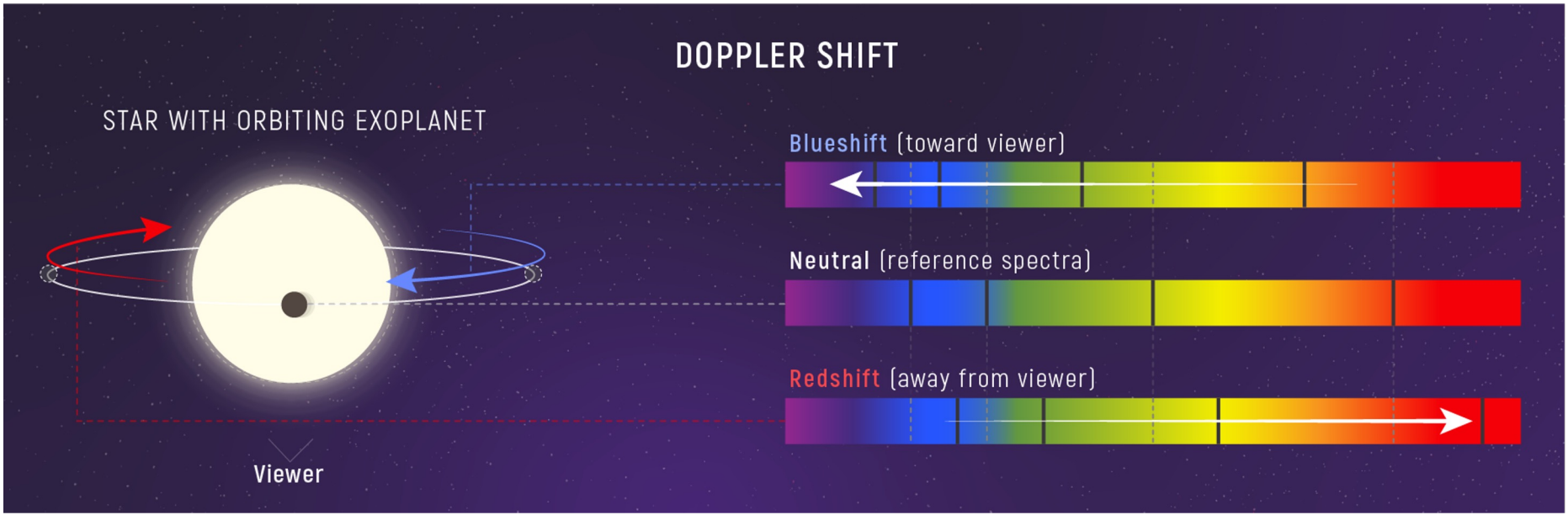


Draw in the horizontal and vertical components of the velocity vector relative to the grid lines.

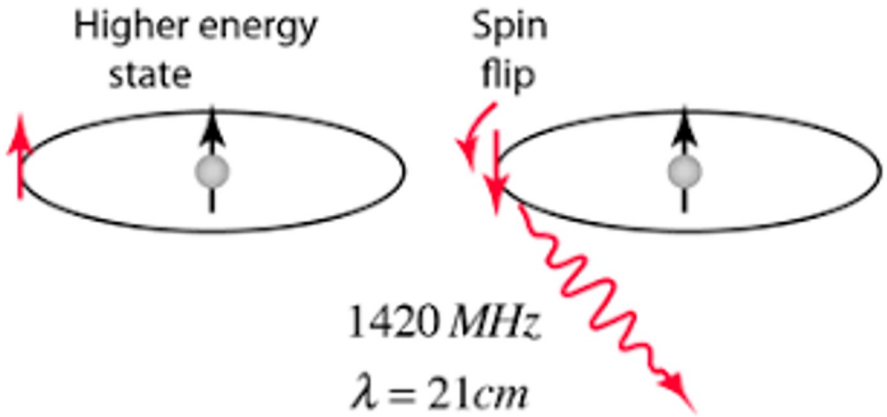
Does the downward facing vertical component mean we are traveling towards or away from the center of the galaxy.

Doppler Effect

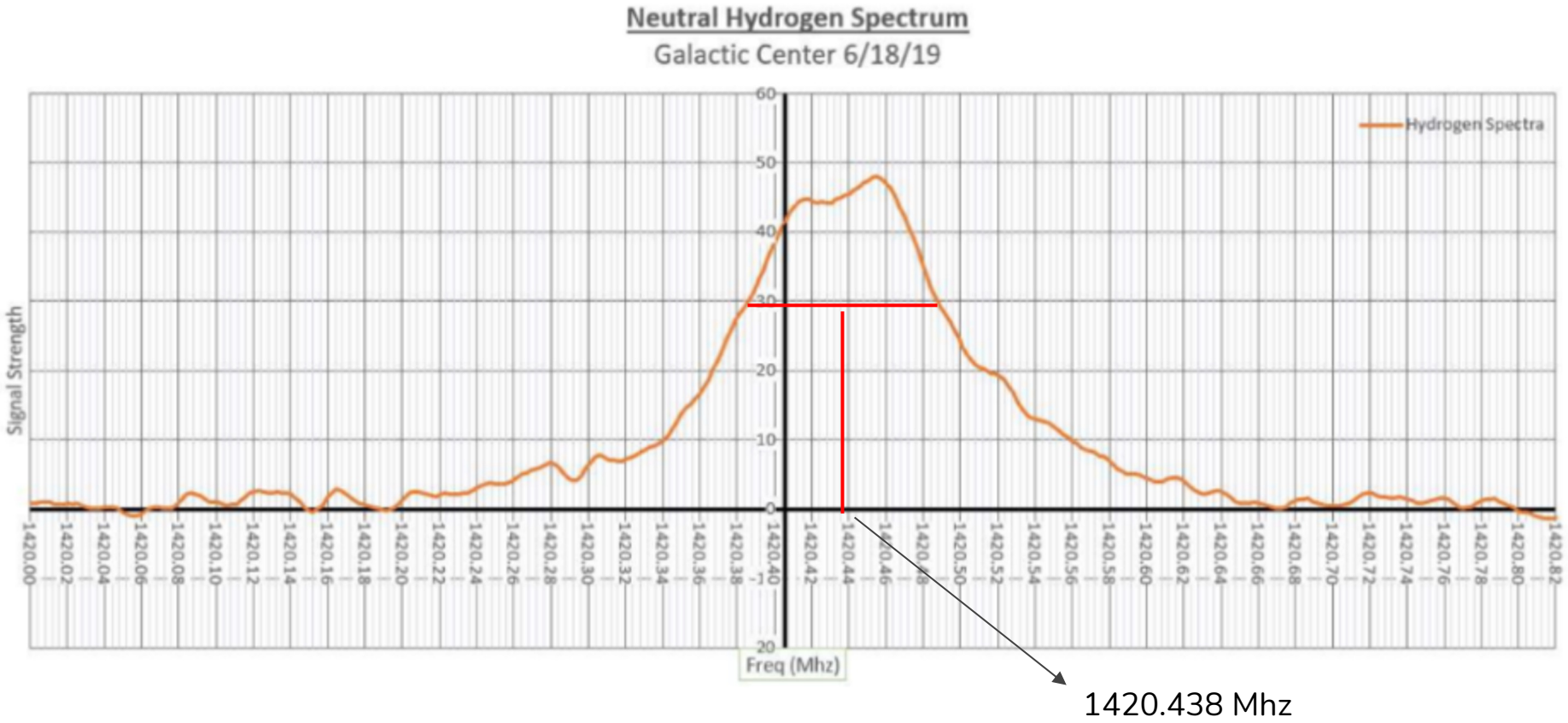


Hydrogen Spin Flip

If left alone for a long time (roughly 10 million years), the electron spin will spontaneously flip which emits a radio wave (21 cm or roughly 1 ft)



Neutral Hydrogen = 1420.406 Mhz



Doppler Effect

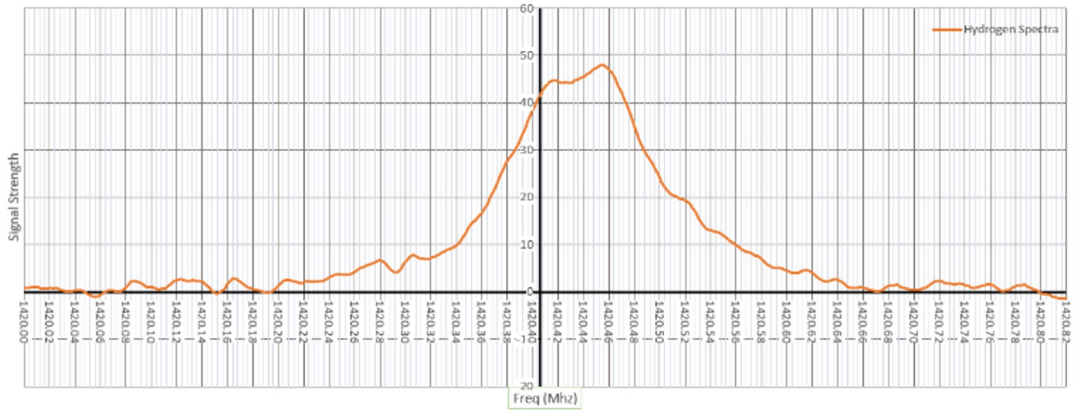
$$v = \left(\frac{\Delta f}{f_0}\right) * c$$

The shift in the frequency of the Hydrogen Radio emissions can tell us how fast the Earth is moving relative to the galactic center.

$$v = \left(\frac{1420.438Mhz - 1420.406\ Mhz}{1420.406\ Mhz}\right) * 300{,}000\ {}^{km}/_{s}$$

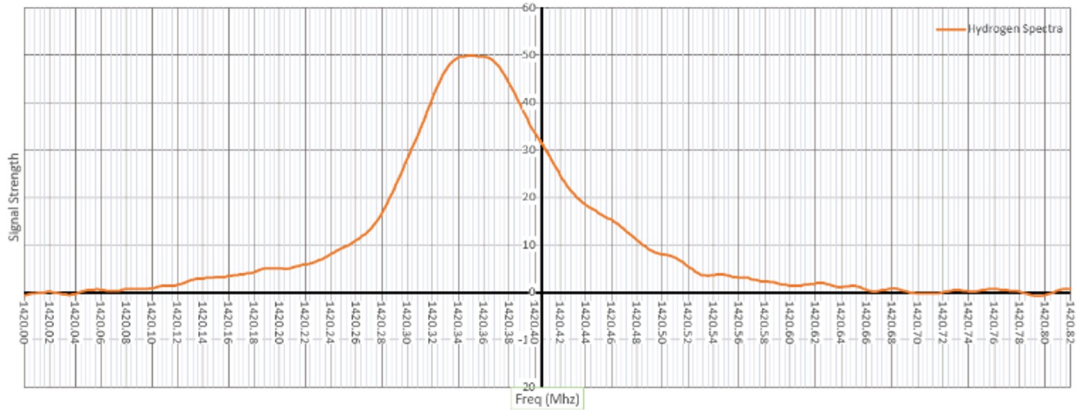
Neutral Hydrogen Spectrum

Galactic Center 6/18/19



Neutral Hydrogen Spectrum

Galactic Center 7/25/19



Radio Horn Telescope

We can measure the hydrogen radio emission with a Horn Radio Telescope.

Other Solar Activities

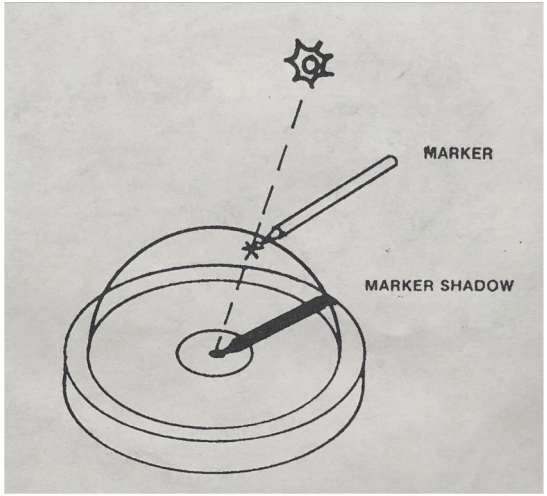
We will be doing multiple activities at the same time to help maximize our content and minimize our time in the heat.

Tracking the Sun's Daily Motion

Plotting the Sun's Position

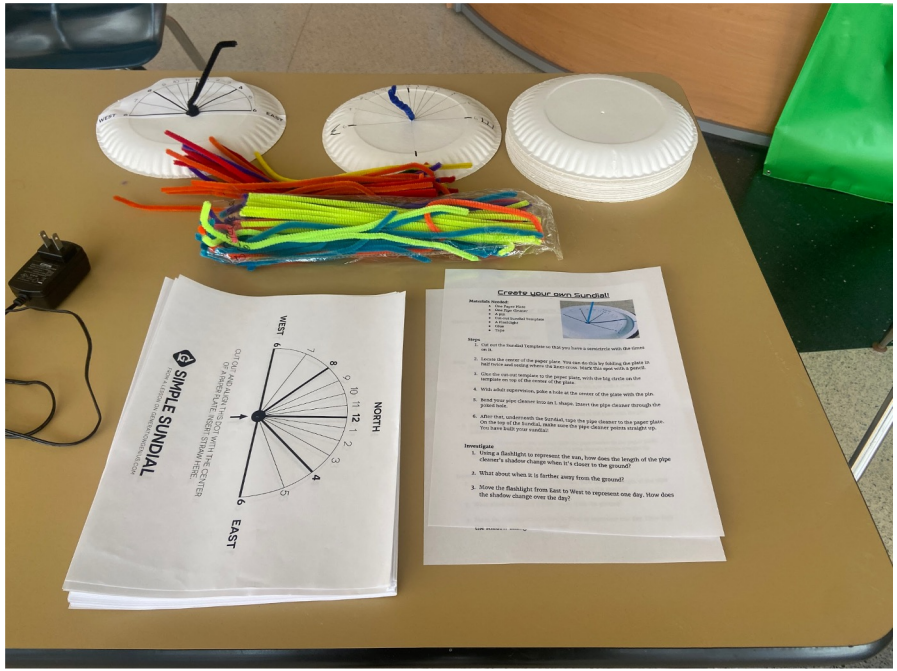
Place the SUNTRACKER in the sun and orient due north and south using the compass. It should be adjusted for the magnetic declination for your location. Once the device is oriented, it may be leveled by using the bubble level.

To plot the sun's position on the tracking dome, place the tip of the marker on the hemisphere until the shadow of the marker tip falls on the white dot at the center of the mirror as shown in Figure 1. Make a mark on the hemisphere and mark the time. Continue to plot the sun's position each hour throughout the day and then connect the dots with a line to indicate the sun's apparent path for that day.



Make Your Own Sundial

Using a plate and pipe cleaner, make a sundial that can tell solar time from your location.



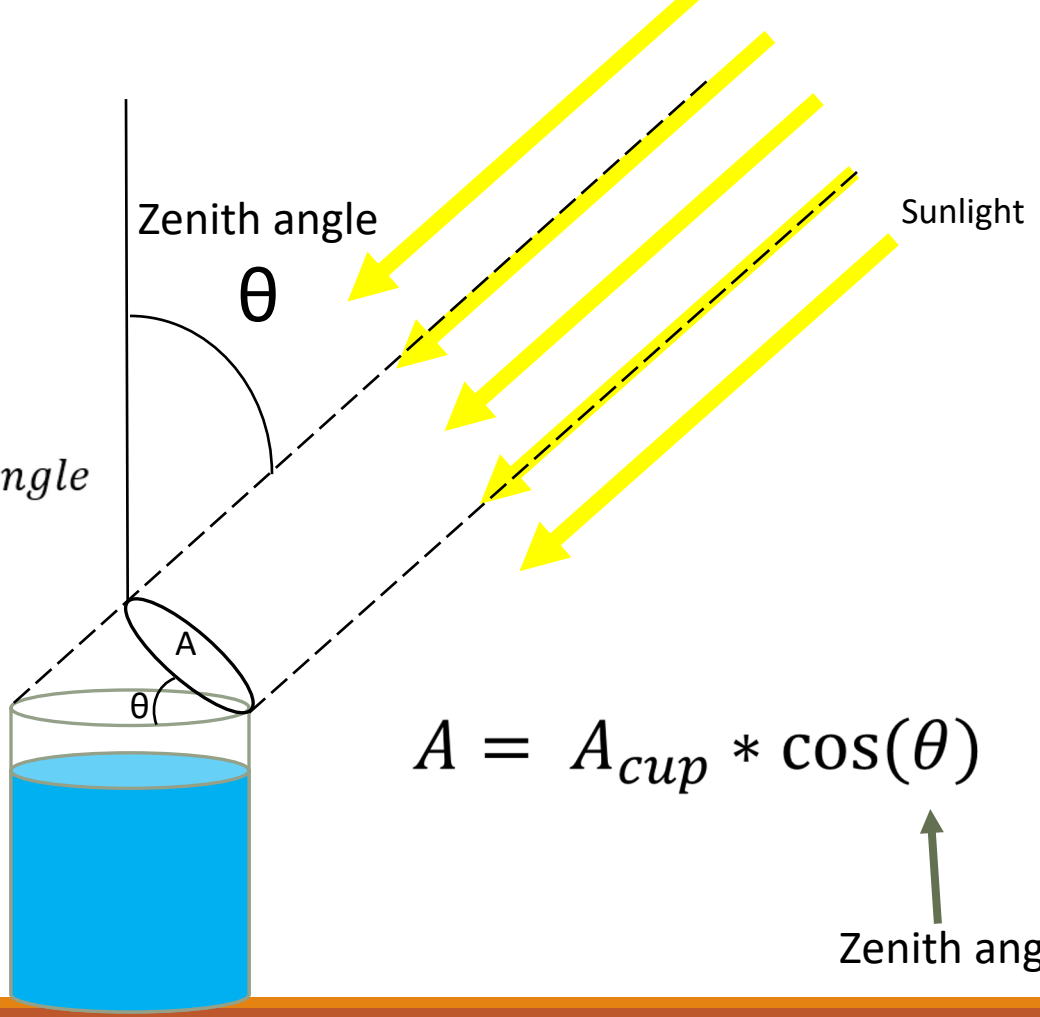
Determining the Surface Temperature of the Sun

The only materials you need are a cup of cold water and a meter stick!

https://bit.ly/SunTempSlides

Use Stellarium to look up the Altitude for the Sun on June 25, 2023 at time of measurement.

$$Zenith\ Angle = 90° - Altitude\ Angle$$



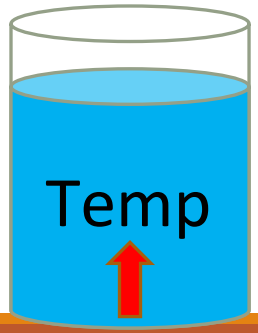
$$A = A_{cup} * \cos(\theta)$$

Zenith angle

$$Energy\ given\ by\ sun = Energy\ absorbed\ by\ water$$

$$Flux\ * A_{cup} * \Delta t = m_{water} * C_{water} * \Delta Temp$$

$$Flux = \frac{m_{water} * C_{water} * \Delta Temp}{A_{cup} * \Delta t}$$

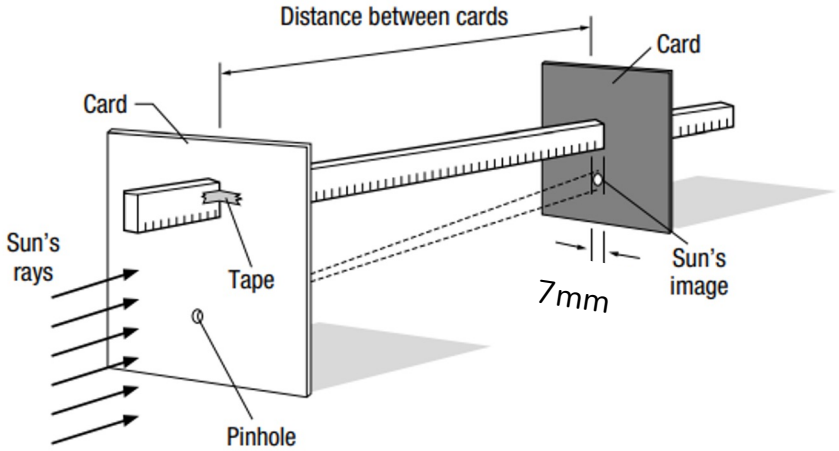


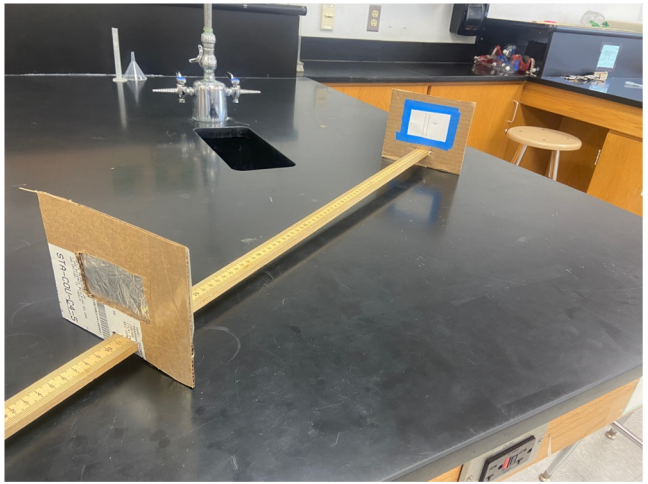
The data was taken on a nice clear day. Use the Atmospheric Transmission Table to find a better

$$Solar\ Flux = \frac{calculated\ Flux}{X}$$

Measuring the Diameter of the Sun

Using a known value for the distance between the Earth and the Sun and the concept of ratios, you will determine the diameter of the Sun.





eclipse
THROUGH THE EYES OF NASA
The 2023 & 2024
Solar Eclipses
through the eyes of
NASA
Lunar topography data from NASA's Lunar Reconnaissance Orbiter and the Japan Aerospace Exploration Agency's SELENE lunar orbiter were used to precisely calculate the location of the Moon's shadow for the 2023 and 2024 solar eclipses. The planetary positions are from NASA's Jet Propulsion Laboratory Development Ephemeris 421. Earth imagery from NASA's Blue Marble: Next Generation series were used to create the terrain and Earth at night imagery from NASA's Black Marble were used under the eclipse paths.
2023 Annular Solar Eclipse
Saturday, October 14, 2023
2024 Total Solar Eclipse
Monday, April 8, 2024
Credit: Michala Garrison and the Scientific Visualization Studio (SVS), in collaboration with the NASA Heliophysics Activation Team (NASA HEAT), part of NASA's Science Activation portfolio
Eclipse calculations by Ernie Wright, NASA Goddard Space Flight Center
2023 Annular Solar Eclipse
2024 Total Solar Eclipse
2023 Maximum Partial Obscuration (%)
2024 Maximum Partial Obscuration (%)
9:15 AM PDT
9:20 PDT
9:25 PDT
10:30 MDT
10:35 MDT
10:40 MDT
11:45 CDT
11:50 CDT
11:55 CDT
12:00 CDT
12:05 PM CDT
12:20 PM CST
12:25 CST
12:30 CST
1:30 CDT
1:35 CDT
1:40 CDT
1:45 CDT
1:50 CDT
1:55 CDT
2:00 CDT
2:05 CDT
3:05 EDT
3:10 EDT
3:15 EDT
3:20 EDT
3:25 EDT
3:30 EDT
4:35 PM ADT
CANADA
UNITED STATES
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
2023 Path of Annularity October 14, 2023
Along a path about 125 miles wide, the Sun will appear as a "ring of fire" in the sky. Annularity lasts up to 5 minutes depending on the viewer's location within this path.
2024 Path of Totality April 8, 2024
Along a path about 115 miles wide, the Moon will completely block the Sun in the sky. Totality lasts up to about 4 minutes and 28 seconds depending on the viewer's location within this path.
Outside of these paths, viewers within the 48 contiguous U.S. states and many other areas will see a partial solar eclipse (in the shaded areas below).
Find More: solarsystem.nasa.gov/eclipses
NP-2022-11-909-GSFC

Eclipse Modeling

Using scale models of the Earth and Moon, we will investigate what orientation of objects creates the two types of eclipses.

Safe Solar Viewing Methods

Available outside will be several methods to safely observe the Sun that could be used during the upcoming eclipses.