Peer-reviewed Astronomy Education Activities

The sky at your fingertips

Build a simple cross-staff and measure the stars!

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KEYWORDS

star-chart, angular distance, cross-staff, star-gazing, coordinate, observation

CATEGORY

<QuerySet [<SciCategory: Observational astronomy>, <SciCategory: Other>, <SciCategory: Scientific instrumentation>]>

LOCATION

Does not matter

AGE

10 - 14

LEVEL

<QuerySet [<Level: Middle School>, <Level: Primary>]>

TIME

2h

COST

Low Cost

SKILLS

<QuerySet [<Skills: Analysing and interpreting data>, <Skills: Developing and using models>]>

TYPE OF LEARNING

<QuerySet [<Learning: Informal/Field Trip Related>, <Learning: Observation based>, <Learning: Project-based learning>]>

MATERIALS

Material needed to build the cross-staff (See Image below).

- a sheet of stiffer paper (A4 at least 200 g/m2)
- 40 cm ruler
- pen
- scalpel
- scissors
- adhesive tape
- Cardboard
- Cross-staff mask (in attachement)
- Ruler mask (in attachement)

GOALS

Show how angular distances can be measured using one's own body and a simple self-made aid in order to determine the position of a celestial object on the celestial sphere.

LEARNING OBJECTIVES

- Orientation in the sky.
- Learning about constellations and bright stars.
- Measuring with angles applicable between celestial bodies.
- Using sky charts.
- Measurements on the sky charts.

BACKGROUND

Measuring angles in astronomy is of great importance. By knowing the positions of celestial objects and their apparent movements, we can find out where we are among them, in which direction we are moving, predict eclipses, transits, occultations or even if we are in danger of colliding with one of the newly discovered asteroids. We can also find out the characteristics of other star and planetary systems or go back in time and analyze historical events. The positions of distant objects such as stars, star clusters, nebulae, galaxies, etc. are plotted in star maps where stars are represented by circles of different diameters depending on their apparent brightness (a brighter star is represented by a larger circle)., In order to plot objects in star charts and determine their coordinates, it is necessary to define appropriate coordinate systems.

Coordinate Systems

The most frequently used celestial coordinate system is the **equatorial one**, whose main advantage is that it coincides with the Earth's orientation in space. The reference plane is the celestial equator which coincides with the Earth's, only the vernal equinox was chosen as the origin. Coordinates are right ascension and declination.
The **ecliptic coordinate system**, in which the reference plane is the ecliptic plane measured with ecliptic longitude and latitude, is more suitable for describing motion in the solar system.

For more information:

https://en.wikipedia.org/wiki/Equatorial_coordinate_system

https://en.wikipedia.org/wiki/Ecliptic_coordinate_system

FULL DESCRIPTION

Students should be introduced to star charts and the starry sky to identify where the Moon is among the stars. Angles can be determined by the ratio of the distance and the size of the object. Using the method of similarity of triangles, it can be shown that it is possible to measure the mutual angular distances of distant objects.
By simply measuring the angular distances between the Moon and nearby stars at night time without the use of instruments, it is possible to approximately determine its position on the star chart.

A simple instrument such as cross-staff can be used for better accuracy, and the camera can be used to achieve even greater accuracy (comparing the position in the shot using the star chart).

Step 1- Build your own cross-staff

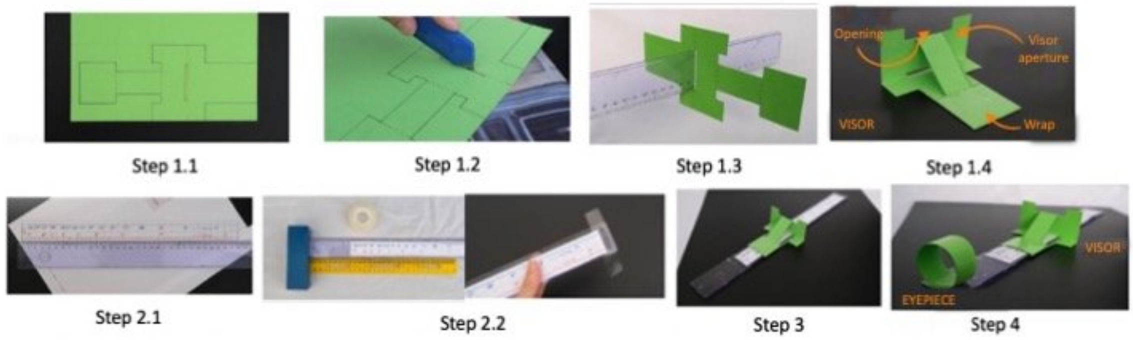


Image: steps of the building procedure of the cross-staff

- Download and print the Cross-Chart
- Redraw the outline from the sketch onto a harder paper. (Step 1.1 image above)
- According to the sketch, cut the model. Use a scalpel to cut an opening that corresponds to the dimensions of the ruler that will be passed through it. (Step 1.2). The opening on the sketch is drawn to fit a ruler 4 cm wide and 3 mm thick. (Step 1.3)
- Fold the model along the marked dashed lines. Align the corresponding points A, B, C and D to overlap. With adhesive tape, stick the edges between points A and D, as well as between points B and C. What we have made is called aimer. The aimer has a slot and sleeve for a ruler and a visor with an opening.(Step 1.4)
- Download and print the Ruler.pdf: this page shows a measuring tape that must be exactly 32.0 cm long and a double scale for measuring an angle in a scale of 1:1. (Step 2.1)
- Stick the measuring tape on the ruler. Place the edge of the tape where it says 8 cm exactly 8 cm from the edge of the ruler (not from the 0 cm mark on the ruler).
- Slide the ruler through the opening (between points C and D) of the aimer and through the pre-cut hole. The aimer can now be moved along the ruler. The blue scale on the measuring tape corresponds to the width of the measuring screen of 4.5 cm, and the red scale to the width of the measuring screen of 2 cm. (Step 3)
- Cut a strip of width *a* = 2 cm along the shorter side of the harder A4 paper. Fold the rectangle into a roll and glue it so that it does not fall apart. Stick the roller to the edge of the ruler on the side where the 8 cm mark is on the measuring tape. From now on we call the roller the eyepiece. (Step 4)

The cross-staff is now ready (see Image below).

Image: Cross staff measurements. (photo: A. Guštin)

Step 2- Learning to use the cross-staff

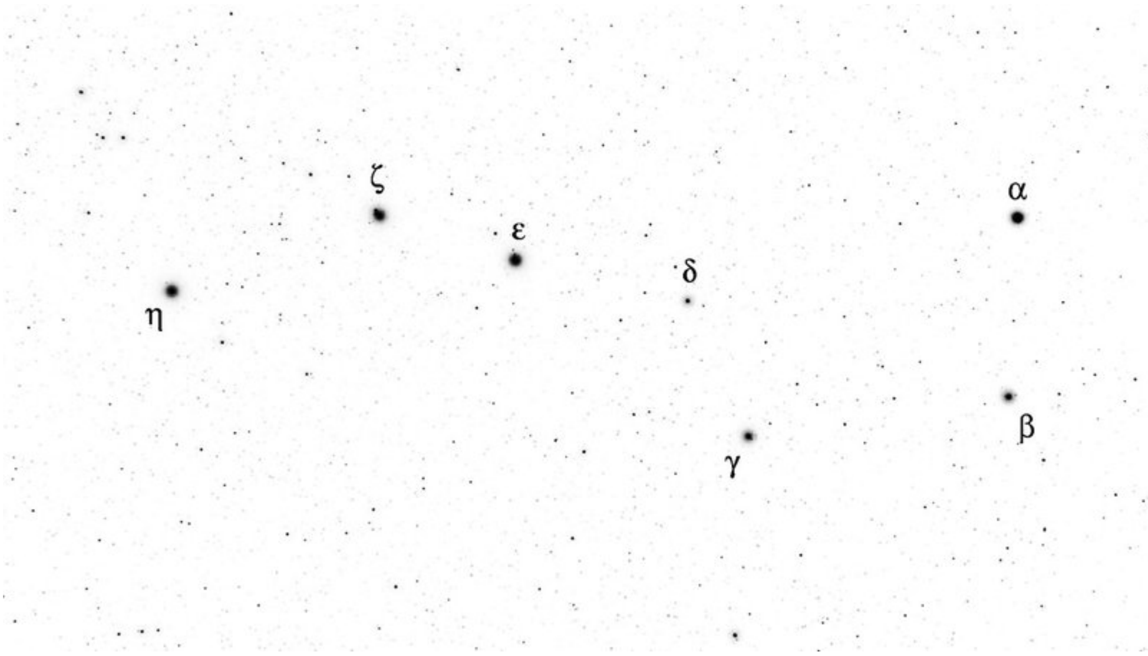
Image: learning to use the cross-staff

- Place the cross-staff against your face so that you look through the eyepiece with one eye. Choose two distant objects that are slightly apart (e.g. two light bulbs on the road, a chimney and a lightning rod, etc.) and measure the angle between them. The angle is measured by moving the aimer along the ruler to the position when the objects are on the edges of the measuring screen.
- Angular distance can be read from the measuring tape in the place where the aimer screen is.
- If the cross-staff is rotated by 90 degrees, then with it we can measure angular distances in the vertical plane. With a cross-staff, measure the apparent angle at which you see the tree from the ground to the top of the crown.

Note: Angular distances can also be measured with a cross-staff in a plane inclined at any angle.

Step 3- Let's measure the sky!

Look for the Big Dipper asterism in the clear night sky. Measure the distances between its stars with the cross-staff. In order to easily read the angular distance, illuminate the measuring scale with a dimmed red light. Verify if you have measured the distances correctly comparing your measurements with the calibration table below.



The big dipper.

Star pairs	Angular distance in degrees
$\alpha - \beta$	5.4
$\alpha - \varepsilon$	15.3
$\alpha - \eta$	25.7

Calibration table for angular distances between some stars in the Big Dipper asterism.

NOTE: In the southern hemisphere you should use stars in some bright constellation, Crux for example.

EVALUATION

Evaluation of both the build-up of the physical object (cross-staff) and the knowledge acquired by the students could be considered.

To evaluate the physical object, teachers could consider the correctness, accurateness, and functioning of the cross-staff.

To evaluate the knowledge of the students , both a quiz or a guided class discussion could be used. Some of the questions that could be asked concern the angular distance of different objects both nearby and in the sky; the ability to identify specific celestial objects (e.g., Big Dipper); the understanding of sky charts.

CURRICULUM

This activity can be employed in several curricular subjects, such as: Science, Physics, Technology, and Mathematics.

ADDITIONAL INFORMATION

For more information about the STEAM-Med co-design project : Read this Link

This activity is available in other languages: Link (to be provided soon).

FURTHER READING

In the second part of this activity, “Chasing the Moon”, students are guided in one of the practical applications of these measurement methods. Students can draw the phase and position of the Moon on a prepared celestial map and determine its coordinates in the ecliptic and/or equatorial celestial coordinate systems. Students will learn the basics of astrometry, that is, how they can determine the position of a celestial body (in this case the Moon) on the celestial sphere, and also that the Moon has a noticeable apparent motion between the stars.

CITATION

Andrej Guštin; Damir Hržina; Barbara Rovšek, 2024, *The sky at your fingertips*, astroEDU, 2401