**Ages:** 10 – 12 years old

# SCIENTIFIC CASE: Night sky constellations

## Team members

Writer: ____________________________________________

Equipment manager: ____________________________________

Reader: ___________________________________________

Spokeperson:_________________________________________

Artist: ____________________________________________

## Context

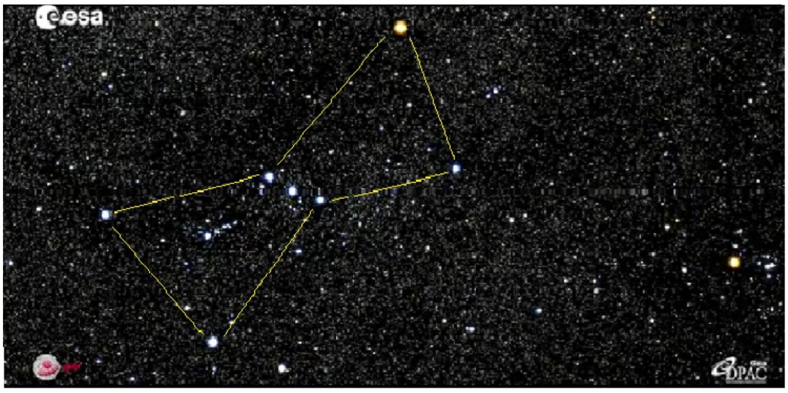
For a long time, we thought the stars high above were fixed on a motionless dome. We know now that they are turning around the center of the galaxy, like us, at huge distances one from the others.

Understanding those distances is not an easy task. Imagine our Sun reduced to the size of a grain of sand. The farthest planet, Neptune, would be roughly four meters away. The first star we can find, Proxima Centauri, would be around 30 km away, like the distance between Madrid and Alcalá de Henares. Sirius, the brightest star in our night sky, would by twice as far, using this scale, this would get us the mountain region in Madrid! Wrapping our head around this concept of distances is complicated, instead, we can create very precise maps for these and many other stars.

*Gaia* is the name of a spacecraft from the European Space Agency. It was launched in December, 19th of 2013 from Kourou, the European space port in the French Guiana.

The *Gaia* satellite is trying to map in 3D the stars from our galaxy, the Milky Way. The used technique is called astrometry, in which the following characteristics are measured for the stars: their positions, their distances and their proper motion (stars change their position on the sky because they are moving with respect to the Sun).

Let's go out to look at the stars during any particular night. For sure you have imagined up there pictures of animals, people, objects… by joining the sparkly dots. Those are called **constellations**. Do you know what they really are?




*http://www.esa.int/Our_Activities/Space_Science/Gaia/The_future_of_the_Orion_constellation*

More educational resources:

http://www.cosmos.esa.int/web/cesar
http://www.esa.int/Our_Activities/Space_Science/Gaia/The_future_of_the_Orion_constellation

# Mission 1: Study of the stars in a constellation

## Hipothesis

Are the stars of a constellation the same size?

## Equipment

- Pencil.
- Rubber.
- 5 balls.
- 5 sticks of different lengths, plus a support.

## Procedure

In a solar eclipse, the Moon hides the disk of our star for a few minutes. But our natural satellite is much smaller than the Sun. How can this be? Draw it.

Now you will study the different sizes of stars in a constellation.

1. Every member of the team picks up one of the balls and puts a stick through it. Each "star" can have a different size.
2. Put them all together on the table.
3. Decide as a team how you want to the "stars", while trying to eclipse the bigger ones with the smaller ones.

Draw the results. What do you have to do?

4. Now, **without touching the "stars"**, turn around the table and look at the shape they form. Can you imagine different pictures from different points of view? Draw them.

## Result and conclusions

Can you move the “stars” around until you see them having the same size? How?

# Mission 2: The distance between the stars

## Hypothesis

Do the pictures on the stars always remain the same?

## Equipment

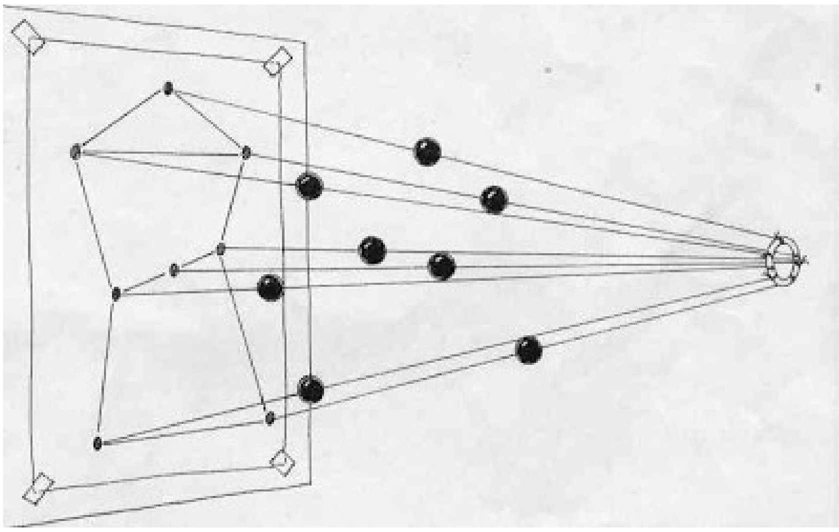
- Thick cardboard.
- Adhesive tape and glue.
- Graver.
- Soft mat.
- Picture of a constellation.
- Thread.
- Wooden beads.
- Table of data.
- Milimetered paper.

## Procedure

You are going to build a constellation in three dimensions (3D):

1. Glue the picture of the constellation to the thick cardboard. Put the cardboard on top of the soft mat and puncture a tiny hole for every star.
2. Pass a portion of the thread through each tiny hole, let it hang on both sides. Turn around the cardboard and tie a knot for each thread. Then, put some adhesive tape to prevent the thread from sliding out.
3. Prepare the cardboard face up and string one wooden bead per thread. String again, on the same direction away from the cardboard. When the thread is tighten up, each bead stays fixed. When the thread is hanging a bit loose, the bead may slide to the point of your choosing.
4. Now every team member has an extra role to play:
    - two of you shall hold the cardboard on each side,
    - two of you shall hold the threads as tighten as possible,
    - the last one reads the table of data and supervises.

5. The table of data shows the distances between the stars of a constellation proportionally. You will have to order the stars from the closest to the farthest (touching the cardboard). You can use the milimetered paper to better mark the distances.
6. Slide the beads closer or farther apart from you. Be careful: The stars of a constellation are named with Greek letters (alpha, beta, gamma…) Sometimes they also have a proper noun.
7. Whenever you finish, you have a toy model for a constellation in 3D. If you have any doubts, ask  for help to the educators.



8. Check the results from the rest of the teams.

## Result and conclusions

Do the picture of the stars look the same to you from every perspective?

Can you see the same constellations on Earth and on every other planet from the solar system? What about on a planet that orbits a different star?

Why do we see some brighter or bigger stars than others?

Inside the galaxy, stars turn around the center. Will the constellations change as time passes by?

Look at the video about "The future of the Orion constellation" [link in *Context* seciont]. Why do you think that happens?

# To study more

## Hypothesis

Why do we see some stars as brighter or bigger than others?

| |
|---|
| |

## Equipment

- Computer program, *Stellarium*.

## Procedure

- Two by two, sit in front of a computer to work with a program that simulates the night sky (*Stellarium*).
- Choose a constellation among those previously built and decide which stars will be bigger or smaller than our Sun. Clue: pay attention to the size of the star and the distance from the observer in your toy model.
- Fill up the two first columns from the table with your guesses: name of the star and estimated size (bigger/smaller than the Sun, or even by how much).
- Using the program, check these hypothesis and complete the last column with the real size of the star.

## Result

| Name of the star | Estimated size* | Real size* |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

(*) For the most part, knowing the radius of a star is really difficult, so you will have to check the mass of the stars. Solar mass is a standard unit in Astrophysics and it is usually written as $\mathbf{M}_{\odot}$. This quantity is more than 300 000 times the mass of the Earth.

## Conclusions

What criteria have you used to determine the size of the stars?

Do you think the distance to the stars affects what we see?

Do you think the brightness we can perceive is an important factor?

What do you think is the most important factor to take into account? Why?

## Research equipment

CONSTELLATION 1: *The Big Dipper* (Ursa Major)

| Megrez | Alioh | Merak | Pecda | Mizar/Alcor | Dubhe | Akaid |
|---|---|---|---|---|---|---|
| 1 | 1,1 | 1,2 | 1,4 | 1,4/1,6 | 1,7 | 3,3 |

CONSTELLATION 2: Ursa Minor

| α | β | γ | δ | ε | η | ζ |
|---|---|---|---|---|---|---|
| 6,2 | 1,1 | 14,5 | 10,9 | 4,3 | 1 | 2,7 |

CONSTELLATION 3: Cassiopeia

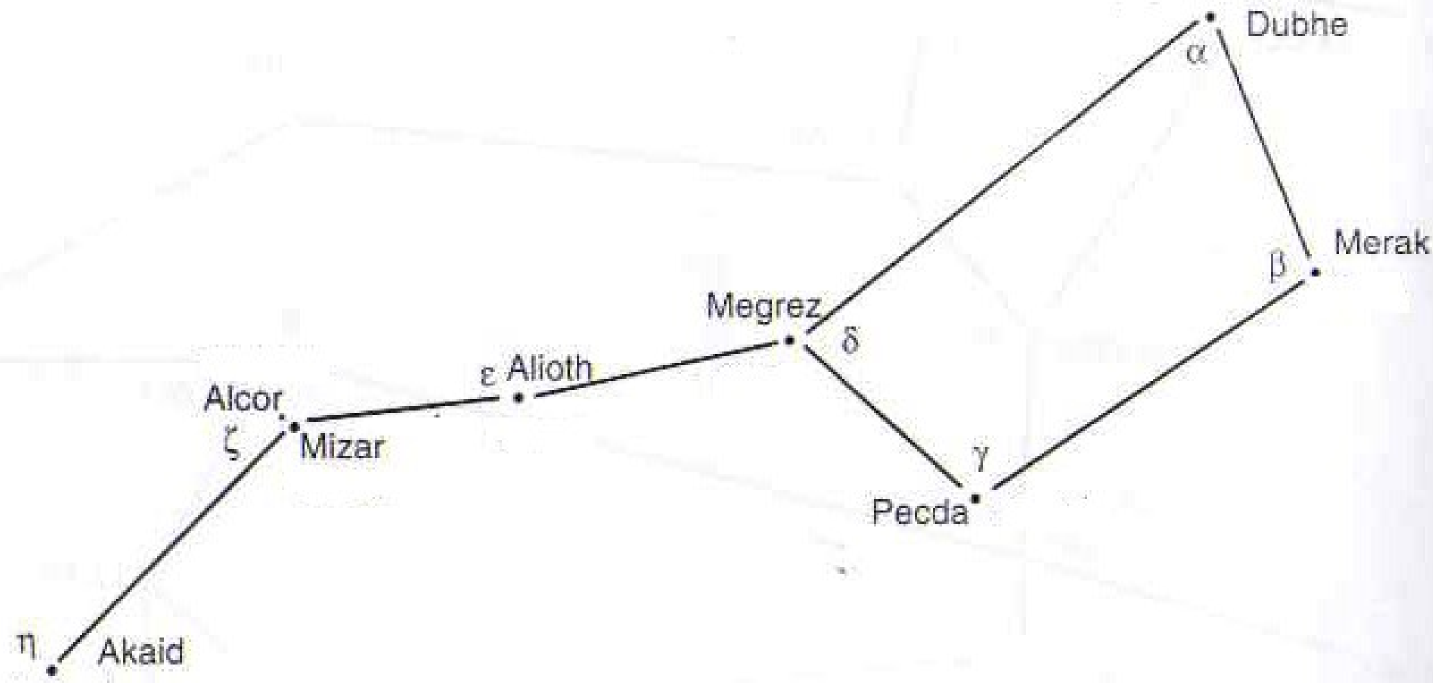
| α | β | γ | δ | ε |
|---|---|---|---|---|
| 4,4 | 1 | 4,4 | 2 | 7,3 |

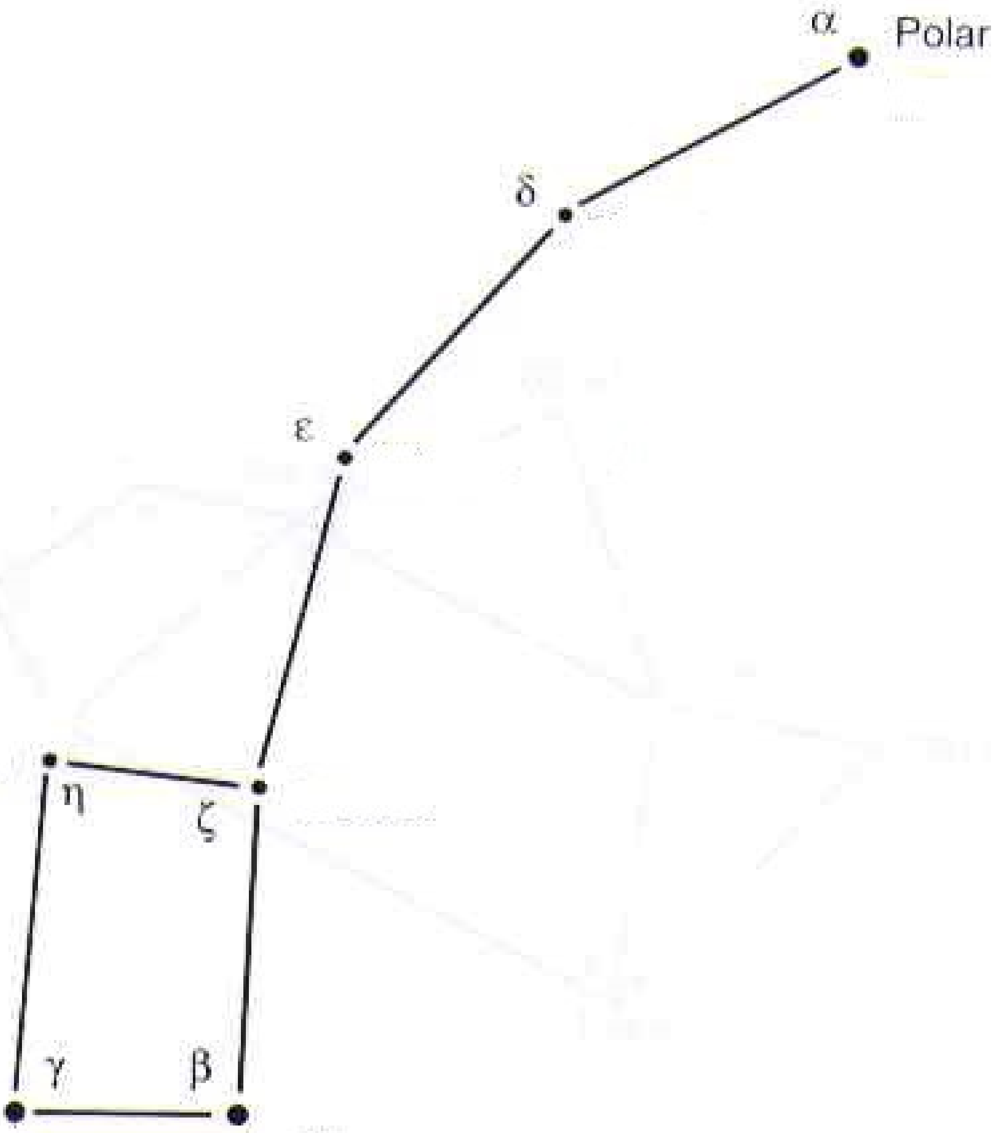
CONSTELLATION 4: Orion

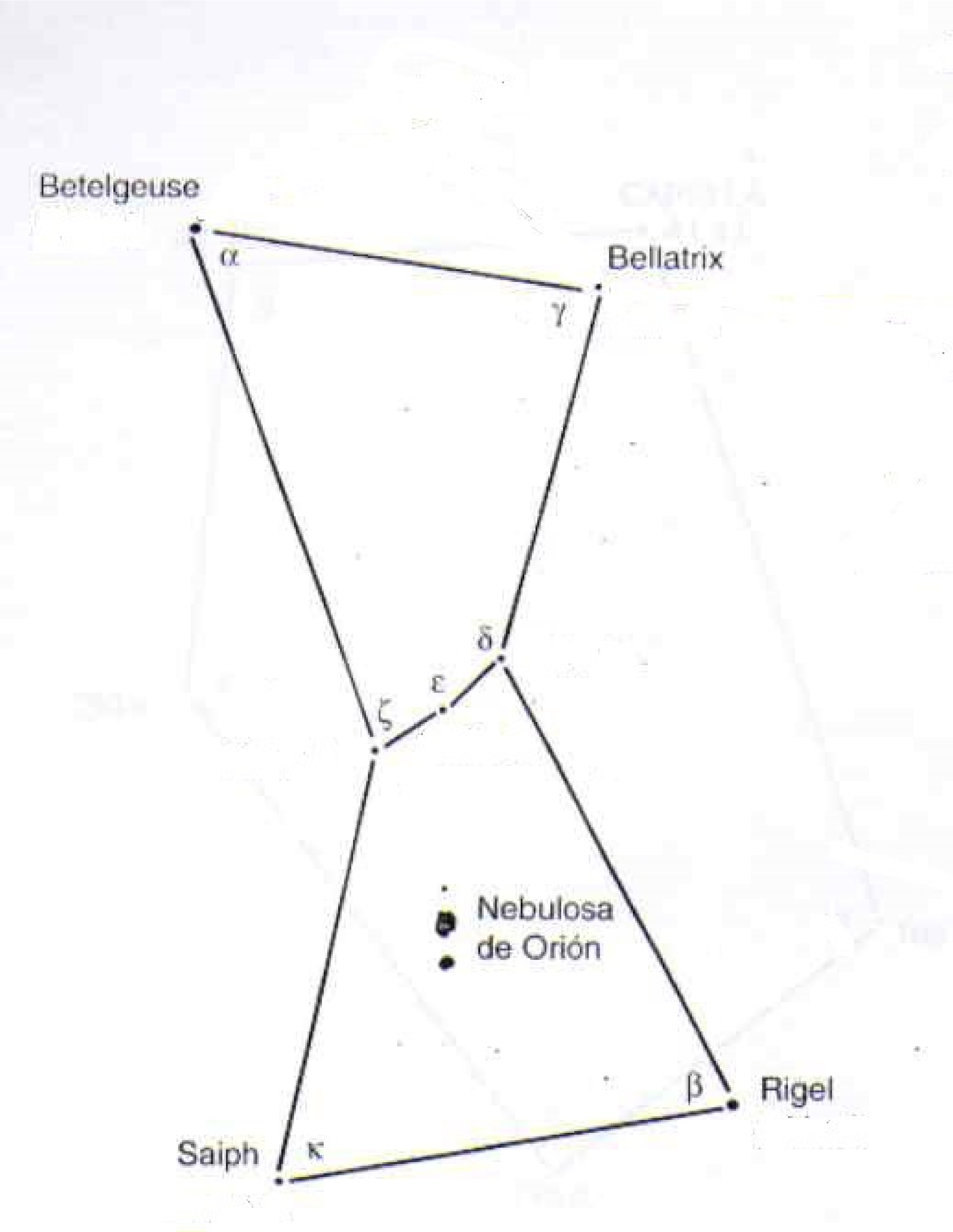
| α | β | γ | δ | ε | ζ | κ |
|---|---|---|---|---|---|---|
| 5,8 | 2,2 | 1 | 2,1 | 14,5 | 2,7 | 1,6 |

CONSTELLATION 5: *The Teapot* (Sagittarius)

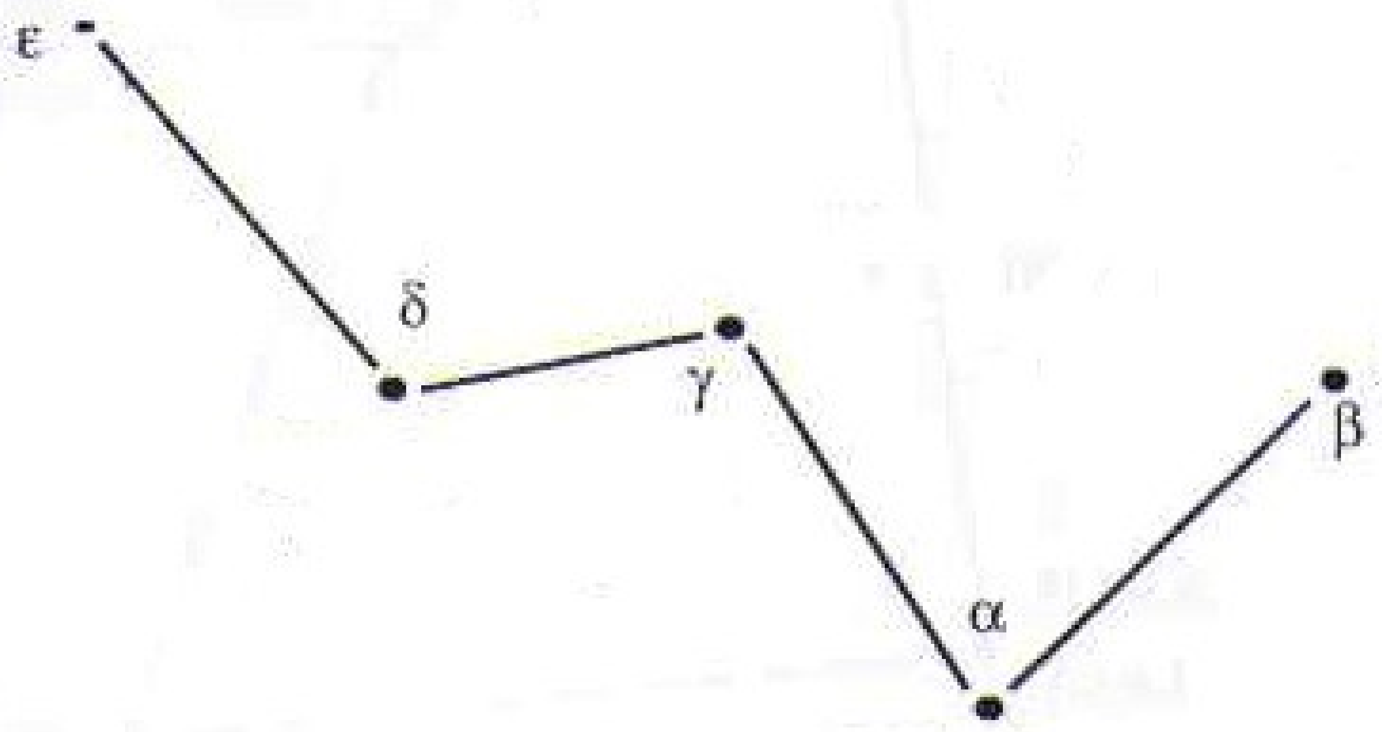
| γ | δ | ε | ζ | σ | λ | φ | τ |
|---|---|---|---|---|---|---|---|
| 2,1 | 1,1 | 2,4 | 2,1 | 1,1 | 1 | 4,0 | 1,2 |

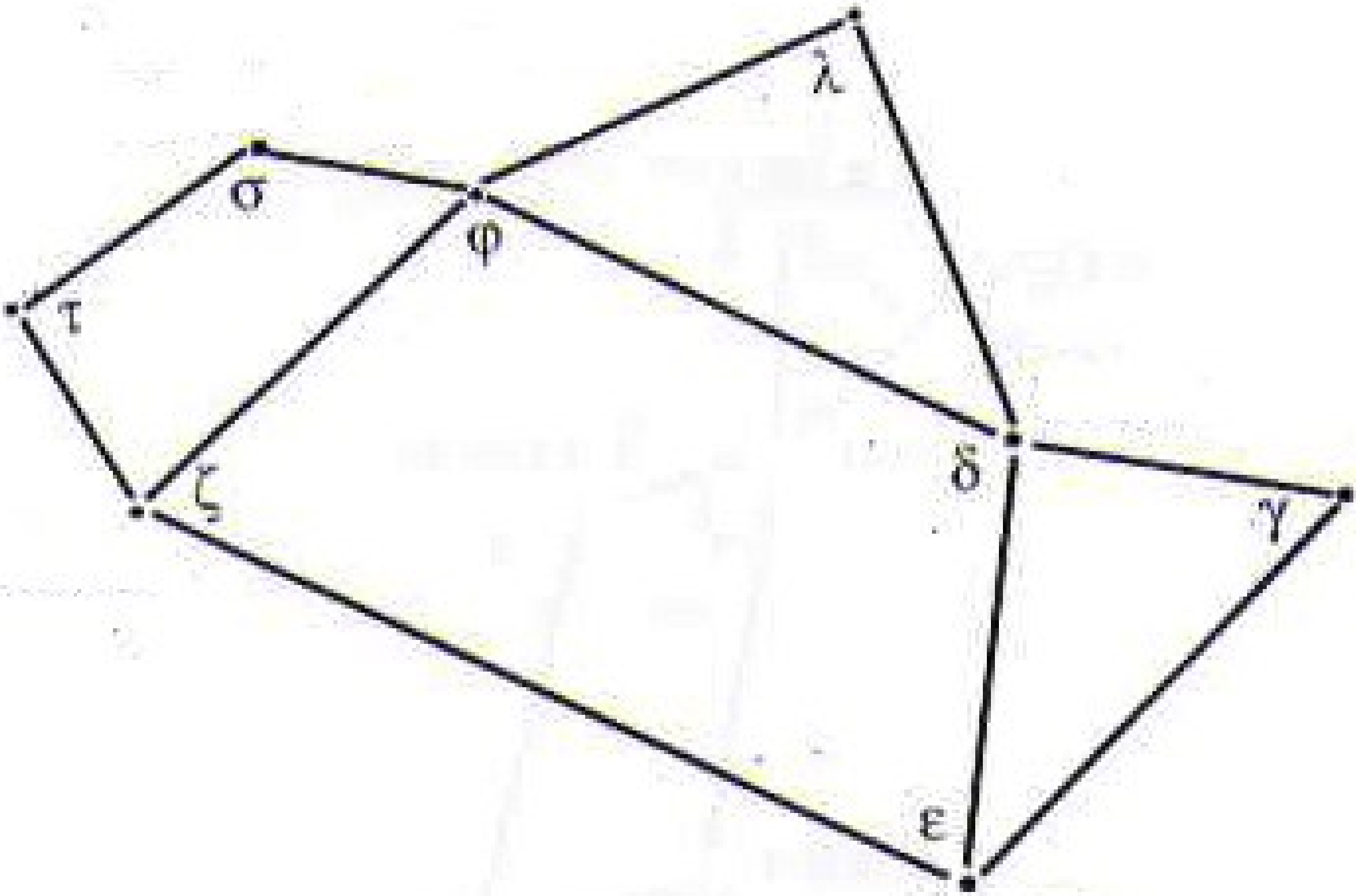

Dubhe
α
Merak
β
Megrez
δ
ε Alioth
Alcor
ζ
Mizar
γ
Pecda
η
Akaid


α
Polar
δ
ε
η
ζ
γ
β



Betelgeuse
α
Bellatrix
γ
δ
ε
ζ
Nebulosa
de Orión
β
Rigel
Saiph
κ


ε
δ
γ
α
β



λ
σ
φ
τ
δ
ζ
γ
ε