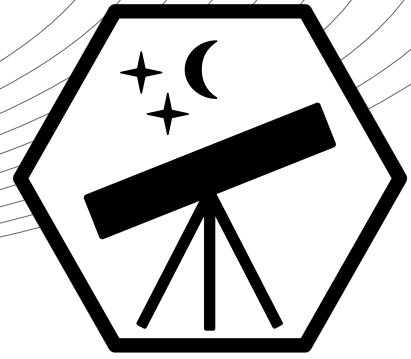


International Astronomy and Astrophysics Competition

Qualification Round 2023



Problem A : The Classification of Galaxies (5 Points)

Galaxies are some of the most beautiful objects in the universe and are observable in many different shapes, colours and sizes. Astronomers have classified galaxies into different groups: spiral (SA), intermediate spiral (SAB), barred spiral (SB), lenticular (S0), elliptical (E), and irregular (Irr).

Which galaxy classes are illustrated by the shapes below (A1-A4)? Find the correct class (B1-B4) and name (C1-C4) of each galaxy shown in the images: NGC 2337, NGC 300, NGC 1365, Messier 110



(A1) _____ (A2) _____ (A3) _____ (A4) _____



(B1) _____ (B2) _____ (B3) _____ (B4) _____

(C1) _____ (C2) _____ (C3) _____ (C4) _____

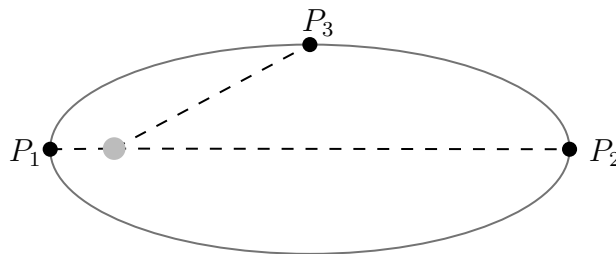
Problem B : The Speed of Light (5 Points)

Light travels extremely fast through the universe. However, the speed of light is limited to about 300,000 km/s. Because of that, it takes sunlight 8.3 minutes to reach the Earth.

How long does it take light from the Sun's surface to reach Mars (223 million km distance to the Sun), Jupiter (777 million km) and Pluto (5,906 million km), respectively?

Problem C : Elliptical Orbit (5 Points)

Objects go around the Sun in elliptical orbits. Especially comets can have orbits with a high eccentricity. The newly found comet P/2023 IAAC has a semi-major axis of 16.5 AU and a semi-minor axis of 8.3 AU. The comet's mass is negligible compared to the Sun (1.9×10^{30} kg).



The *vis-viva equation* gives the orbital speed of an object travelling along the ellipse:

$$v(x) = \sqrt{\mu \left(\frac{2}{x} - \frac{1}{a} \right)}, \quad \mu = G(m_1 + m_2)$$

Here, a is the semi-major axis, m_1 and m_2 are the masses of the orbiting bodies, x is the distance between the comet and the centre of mass, and G is the gravitational constant.

- Calculate the eccentricity of P/2023 IAAC's orbit around the Sun.
- Which one of the points P_1 , P_2 , P_3 is the aphelion and which one the perihelion?
- Determine the comet's speed at the three points P_1 , P_2 , P_3 .

Problem D : Distance between Stars (5 Points)

Determining the distance to stars can be challenging. The parallax method is one way of finding the distance to many stars around us. Your research team measures the parallax of two stars that have a distance of 5 degrees from each other in the night sky: The first star has a parallax of 0.11 arcsec, and the second has a parallax of 0.13 arcsec.

How far apart are the two stars from each other? Express your answer in light-years.

Problem E : Dark Energy (5 Points)

Cosmology studies the dynamics of the universe on its largest scales. Its research reveals how the universe evolves over time and, in particular, how it expands. The term *dark energy* frequently appears in cosmology.

What does the term *dark energy* describe? What are evidences for the existence of dark energy?

General Information and Submission

You can write the solution by hand or type it on a computer. To qualify for the pre-final round, you have to get at least 15 points (Junior, under 18 years) or 20 points (Youth, over 18 years). Make sure to submit your solution by *Friday 21. April 2023 23:59 UTC+0* online at www.iaac.space/submission. In case of questions or comments, please feel free to contact us via email: info@iaac.space. Good luck!