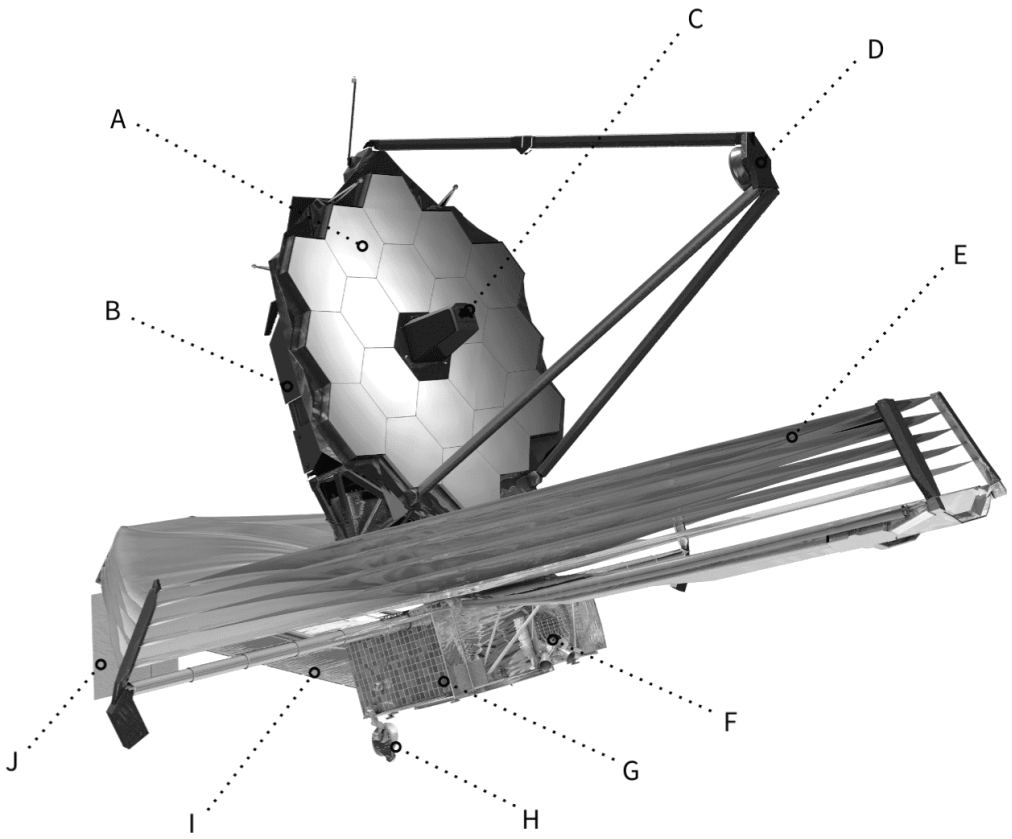
International Astronomy and Astrophysics Competition

Qualification Round 2022

Problem A : The James Webb Space Telescope (5 Points)

The James Webb Space Telescope (JWSP) was finally launched into space on December 25, 2021, and is about to become one of the most important scientific instruments of our time. Name the major components of the JWSP shown in the figure below:



(A) _____ (B) _____ (C) _____

(D) _____ (E) _____ (F) _____

(G) _____ (H) _____ (I) _____

(J) _____

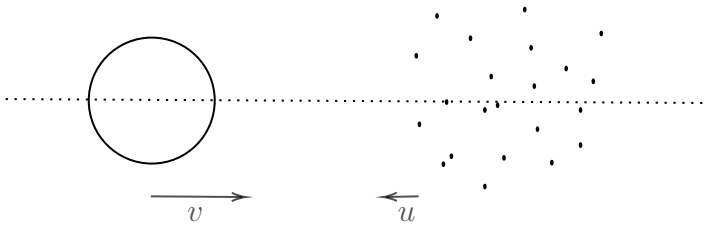
Problem B : Very Dense Earth (5 Points)

Neutron stars are some of the densest objects in the universe. They form during supernova explosions and are very small compared to other astronomical objects. You can assume 5 x 10^{17} kg/m^3 as the average density of a neutron star. The Earth has a total mass of about 5.97 x 10^{24} kg.

What would be the diameter of the Earth if it had the density of a neutron star?

Problem C : Asteroid Field (5 Points)

Assume that a gravitational anomaly in the solar system has shifted a field of asteroids into Earth's orbit, and the field is now moving directly towards Earth. The asteroid field has a density of ρ (asteroids/volume), and each asteroid has an average mass of m. The asteroid field stretches over a distance d in Earth's path. Assume that the Earth moves with a velocity of v, the asteroids with u, and that $v \gg u$. Let R be the radius and M the mass of the Earth. The Earth collides with the asteroid field:



Show that the slow-down Δv of the Earth due to the asteroid collisions is given by:

$$\Delta v = v\left(1 - \frac{1}{1 + \pi R^2 d\rho\frac{m}{M}}\right)$$

Problem D : Position of the JWST (5 Points)

The James Webb Space Telescope is positioned around 1.5 million kilometres from the Earth on the side facing away from the Sun. The telescope remains at this distance and orbits around the Sun with the Earth's orbital velocity.

(a) Why is it important to position the JWST behind the Earth?
(b) Determine the angular velocity ω of the telescope as it orbits around the Sun.

The centrifugal F_ω and gravitational force F_G are acting on objects orbiting the Sun: $F = F_\omega - F_G$

(c) Based on this, how much should the telescope accelerate towards or away from the Sun?
(d) Why is the orbit of the telescope stable nonetheless? What other forces need to be considered?

Problem E : Infrared Radiation (5 Points)

The electromagnetic spectrum contains various types of radiation with different properties. The James Webb Space Telescope is not like an optical telescope at home and does not capture visible light; instead, it observes the sky in the infrared spectrum.

Explain what infrared radiation is and answer the following questions: How is infrared radiation different from visible light? Why does the JWST observe infrared light, and what are the scientific advantages for astronomers?

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 20. May 2022 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!