International Astronomy and Astrophysics Competition
Qualification Round 2019

Problem A : Planets and Stars (5 Points)

Fill in the blank spaces with the correct information:

The earth has a distance of (1) light minutes to our sun. When the moon covers the sun we call this event a (2). There are eight planets in the solar system and (3) is the heaviest of them all. The smallest planet is (4) and it circles the sun in just (5) days. Besides the planets, there are thousands of stars visible in the night sky. The brightest star is called (6) and it is just one of about (7) billion stars in our Milky Way. The (8) galaxy is the closest spiral galaxy to our Mily Way.

(1) _____ (2) _____ (3) _____ (4) _____
(5) _____ (6) _____ (7) _____ (8) _____

Problem B : The Size of Jupiter (5 Points)

The Earth has a radius of $R_E \approx 6371\ km$ and an average density of $\rho_E \approx 5.514\ \frac{g}{cm^3}$. Jupiter is much bigger and heavier with a radius of $R_J \approx 70000\ km$ and an average density of $\rho_J \approx 1326\ \frac{kg}{m^3}$. Use these values to answer following questions (write down your steps):

(a). Approximately how many Earths fit into Jupiter (by volume)?
(b). How many times heavier is Jupiter compared to Earth?

Problem C : Space Race to the Moon (5 Points)

Alice and Bob are doing a space race from Earth to the Moon which is $d \approx 384000\ km$ far away. Alice's spaceship flies with a constant speed of $v = 500\ \frac{km}{h}$. Bob's spaceship starts slowly but accelerates constantly with $a = 1.4\ \frac{km}{h^2}$.

Who wins this space race? (Write down your steps.)

Problem D : Forces between Earth and Moon (5 Points)

Alice and Bob will encounter on their space race the so called *Lagrange point* L_1 at which the forces from Earth and Moon cancel out. The gravitational force on the spaceships is given by

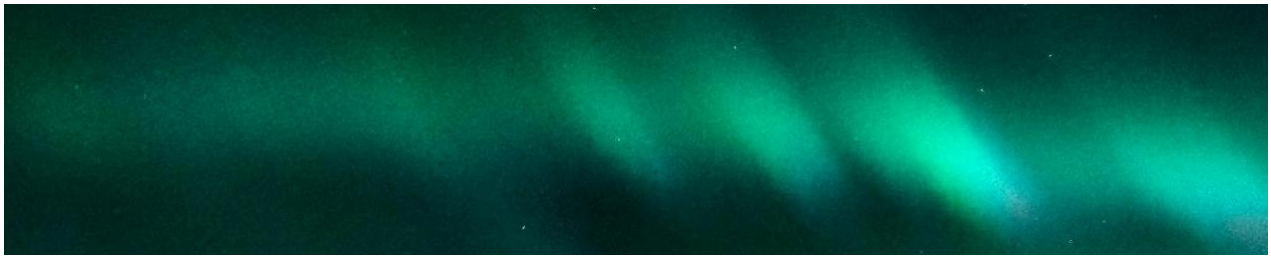
$$F(r) = mG\left(\frac{M_E}{r^2} - \frac{M_M}{(d-r)^2}\right)$$

with the constant G, the mass of the spaceship m, the masses M_E, M of Earth and Moon, the distance d between Earth and Moon, and the distance r of the spacecraft to the center of the earth. For this problem we assume that the Earth-Moon system is at rest.

(a). Use $F(r)$ to find a formula that calculates the distance to the *Lagrange point* L_1.
(b). Explain missing aspects in this calculation due to the assumption that the 'Earth-Moon system is at rest'.

Problem E : Polar Lights (5 Points)

Since the existence of humans we were fascinated by the natural phenomena of polar lights (aurora). The various colors in the skies have inspired many stories and are a symbol for the beauty of nature. Today, we understand the underlying scientific reasons for this phenomena.



Explain the causes and scientific reasons that explain polar lights.

General Information and Submission

You can write the solution by hand on this paper 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 until *14. April 2019 23:59 UTC+0* online at www.iaac.space/submission. In case of questions or comments you can contact the team of IAAC at info@iaac.space. Good luck!