# International Astronomy and Astrophysics Competition
Qualification Round 2021

## Problem A : Observing the Night Sky (5 Points)

Fill in the blank spaces with the correct answers:

*Approximately how many stars are visible with the naked eye in the night sky?*

(1) _____

*Where in the night sky can you observe the famous double star system Mizar and Alcor?*

(2) _____

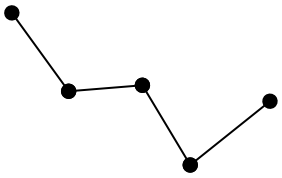
*What kind of celestial object is Neowise C/2020 F3 and what makes it special?*

(3) _____

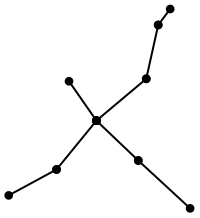
*Which very intense meteor shower is taking place annually in December?*

(4) _____

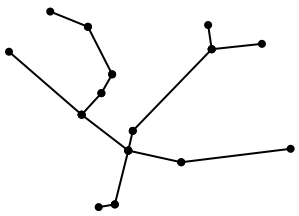
*What are the names of the following three well-known constellations?*



(5) _____



(6) _____



(7) _____

## Problem B : Shock Wave Escape (5 Points)

The star of a distant solar system explodes as a supernova. At the moment of the explosion, an resting exploration spaceship is 15 AU away from the shock wave. The shock wave of the explosion travels with 25000 km/s towards the spaceship. To save the crew, the spacecraft makes use of a special booster that uniformly accelerates at 150 m/s$^2$ in the opposite direction.

Determine if the crew manages to escape from the shock wave. (Neglect relativistic effects.)

## Problem C : Mysterious Planet (5 Points)

A research team has discovered that a moon is circling a planet of our solar system: The moon orbits the planet once every 7 hours on a nearly circular orbit in a distance $R$ of 48000 km from the centre of the planet. Unfortunately, the mass $m$ of the moon is not known. Use Newton's law of gravitation with $G = 6.67 \cdot 10^{-11}$ m$^3$/(kg·s$^2$) to approach the following questions:

$$F = G \cdot \frac{mM}{R^2} \tag{1}$$

(a) Based on the observations, determine the total mass $M$ of the planet.
(b) Which moon and planet of our solar system is the team observing? (Use literature.)

## Problem D : Gravitational Constant (5 Points)

An astronaut working on the Moon tries to determine the gravitational constant $G$ by throwing a Moon rock of mass $m$ with a velocity of $v$ vertically into the sky. The astronaut knows that the Moon has a density $\rho$ of 3340 kg/m$^3$ and a radius $R$ of 1740 km.

(a) Show with (1) that the potential energy of the rock at height $h$ above the surface is given by:

$$E = -\frac{4\pi G}{3} m\rho \cdot \frac{R^3}{R+h} \tag{2}$$

(b) Next, show that the gravitational constant can be determined by:

$$G = \frac{3}{8\pi} \frac{v^2}{\rho R^2} \left(1 - \frac{R}{R+h}\right)^{-1} \tag{3}$$

(c) What is the resulting $G$ if the rock is thrown with 30 km/h and reaches 21.5 m?

# Problem E : Pulsars (5 Points)

Radio telescopes are an essential tool for modern astrophysics. They played a crucial role in discovering a fascinating astronomical object: Pulsars - highly compact objects that periodically emit radiation. Pulsars are still an active part of astrophysical research.

Explain how pulsars are formed and the causes for their pulsating behaviour.

**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 30. April 2021 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!