Total Marks: 45   **Time: 1 Hour 30 Minutes**

BDOAA 2019

BANGLADESH OLYMPIAD ON ASTRONOMY AND ASTROPHYSICS

Name:
Class:
Registration no:

For Spot Registration
Institution:
Email:
Phone Number:
Alternate Phone Number:

Instruction for the Candidate:

- The candidate must write his/her personal information and registration number on the answer script.
- You will write your answer in the space provided. If you need more space, use asterisk (*) and Question No. in extra paper from the exam invigilator.
- The Star map part has 4 questions. Draw any letter and line in the Map provided for necessary answers.
- For all questions, the process involved in arriving at the solution is more important than the answer itself. Valid assumptions / approximations are perfectly acceptable. Please write your method clearly, explicitly stating all reasoning.
- Non-programmable scientific calculators are allowed.
- The mark distribution is shown in the [ ] at the right corner for every question.

Table of Constants:

- *Luminosity of Sun, $L_\odot \approx 3.826 \times 10^{26}$ W*
- *Radius of the Earth, $R_\oplus \approx 6.371 \times 10^6$ m*
- *Gravitational Constant, $G \approx 6.674 \times 10^{-11}$ Nm^2/kg^{-2}*
- *Stefan-Boltzmann Constant, $\sigma = 5.67 \times 10^{-8}$ W/m^2*

- Angular resolution, $\theta > \dfrac{1.22\lambda}{D}$
- *$1pc = 3.086 \times 10^{16}$ m $= 206265 AU$*
- *Pogson's law of magnitude and brightness, $m_1 - m_2 = -2.5 \log (F_1/F_2)$*
- *Astronomical Unit, $AU = 1.496 \times 10^{11}$ m*

# Part A: Theory

1. Wibbly-wobbly
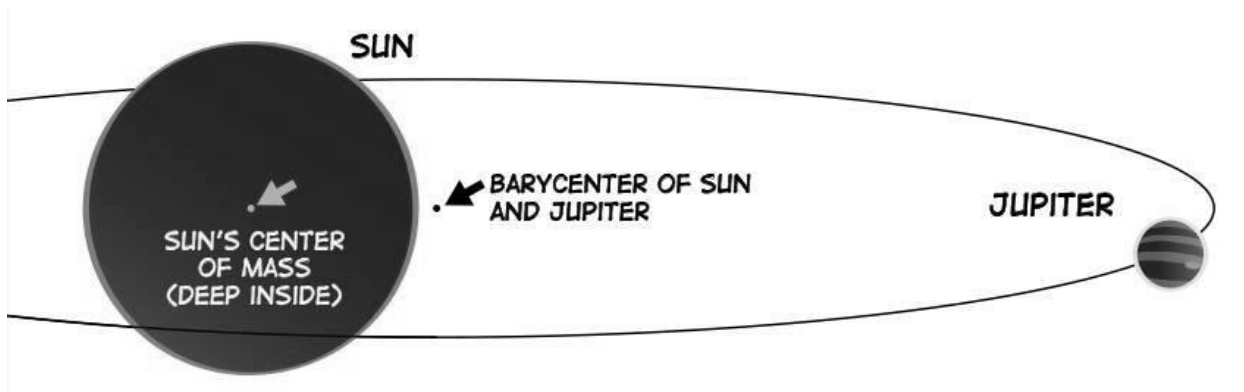
The sun and Jupiter can be assumed as a binary system. They rotate each other around their barycenter (center of mass). The mass of Jupiter is, $M_J = 1.898 \times 10^{27}$ kg and its' semi major axis, $a_J = 5.2$ AU. The mass of Sun is, $M_\odot = 2 \times 10^{30}$ kg.

a) How far is the Sun-Jupiter systems' barycenter from the center of the Sun [2]

b) Find the orbital speed, $v_\odot$ of the Sun around the barycenter of the binary system Sun-Jupiter. [3]

c) What is the angular amplitude of the oscillatory motion of the Sun, due to the existence of Jupiter, as measured by an observer located **2pc** away from us? What is the period of this oscillation? [3]

2. Magnitude System

In 200 BC, a German mathematician and astronomer **Hippocrates**, first categorized the stars according to their brightness. According to his classification the term used for this cause is named **magnitude**. But the relation between magnitude and stellar brightness is a little different. As the brightness grows the magnitude value decreases. For example, Suns' apparent magnitude is -26.7. Again for Full moon it is -12.6 where Full moons brightness is very less than that of the Sun. The relation of brightness and magnitude of two star is given -
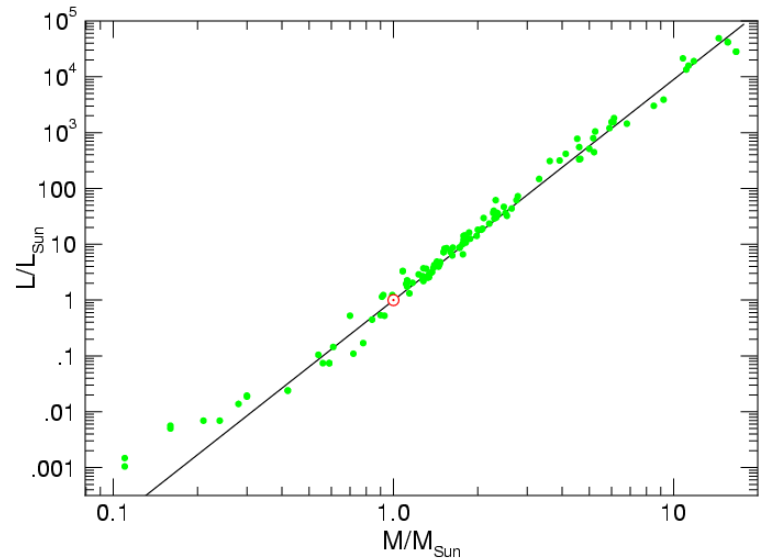
Mass-Luminosity relation of a Star

$$\frac{B_1}{B_2} = 2.512^{m_1 - m_2} \qquad B = \frac{L}{4\pi R^2}$$

a) If the luminosity of the Sun and mass is respectively 1 L$_\odot$ = 3.828×10^{26} W and 2×10^{30} kg what is the **Luminosity** of a star with 2 M$_\odot$? [2]

b) Assuming that we receive same amount of flux from the star, what is the distance of star from question **a**? [3]

c) The magnitude system of a star never follows a linear relation. Actually they have a logarithmic relation. That's why the combined magnitude of two star m_1 and m_2 will not be m_1+m_2. What is the **combined magnitude** of a triple star system with magnitude of 1, 2 and 3 respectively? [4]

3. Large Telescope!

Ishraque decided that we will place a large telescope outside our atmosphere so that he can observe the distant galaxies and exoplanets with more accuracy. He wants to examine an exoplanet which is 19.44 pc away from us and orbiting its' host star from **9.2 AU** away. The telescope works best in infrared (λ = **1650 nm**) wavelength. On the other side, Fahim has an ambitious plan to place a telescope lens so that it can block (minimize) the stellar flux from reaching the earth.

    a) What type of lens should be used for Fahims' purpose? [2]
    b) Where should we put the lens between earth and the Sun so that this reduction in intensity is permanent? [2]
    c) What should be the **minimum** diameter of Fahims' telescope lens? [3]
    d) What is the minimum telescope diameter (for Ishraque) of that is able to resolve the exoplanet and its' host star? [4]

Part B - Practical

Sky Map

Yesterday Arnab and Pallab was observing their local sky in a field. Pallab made a sky map using Your Sky website according to their observations. Now you've to find few things according to their map-
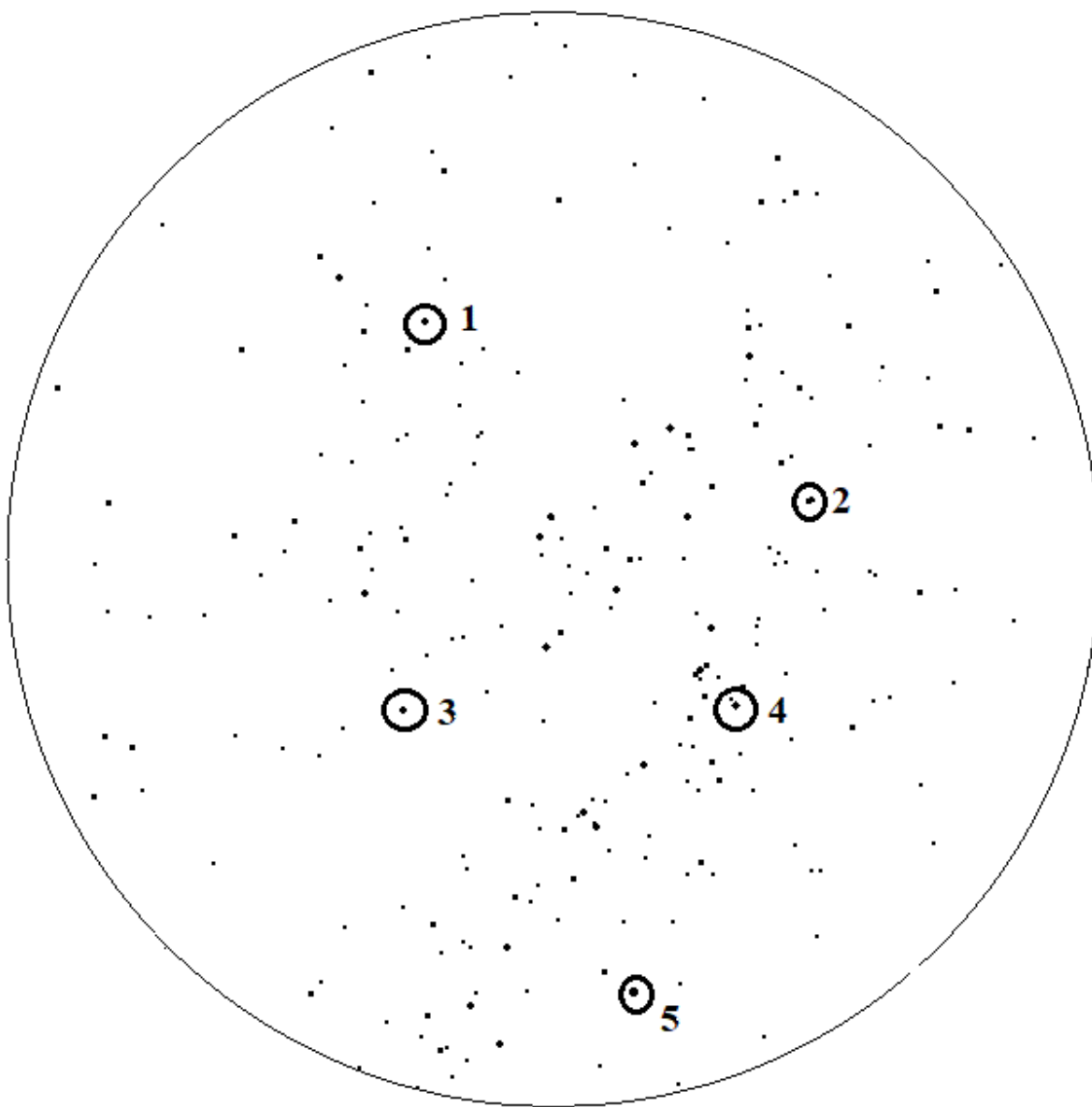
1. An easy way to remember a constellation is by remembering their bright stars. In the map provided 5 stars are marked. What is the name of the stars and the constellations they belong to?
2. Because of faulty printer, 5 stars are missing in the map provided. Mark at least 3 missing stars in the map and also mark out the cardinal points with **N,S,E,W** of the map. [5]

3. Find the **Latitude (φ)** of the field .The center of the map indicates zenith point of the observer [2]

4. Find the minimum **zenith distance, z** of a star in the ecliptic on 21st March with help of the value from question no. 3. (If you can't find the value from question no. 3 you can assume a value and use in this question. In this case a certain mark will be penalize. Draw a Celestial Sphere if necessary) [5]

Stars	Constellation