Below are questions of the Practical Round of IRAO2021 held online on 9 November 2021. At that time the Malaysian Team was at the AC Marriot Hotel in Penang.

PRACTICAL ROUND

(1 HOUR)

Students in the Beta and Gamma Groups have to answer Problems 12, 13 and 14

АСТРОНОМИЧЕСКОЕ ОБЩЕСТВО
EURO-ASIAN ASTRONOMICAL SOCIETY
Round M & I
Group α β γ
Международная дистанционная астрономическая олимпиада
International Remote Astronomy Olympiad
IRAO 2021
Италия, Милан 5-13. XI. 2021 Milan, Italy
язык language English

Practical round. Problems to solve

12. Mars motion as seen from the Earth

Assuming that the orbits of Earth and Mars are circular, picture 12.a shows such orbits to scale; positions of the Sun and of the Earth and Mars when Mars is at opposition are also represented.

In table 12.b you will report distance from Earth and angular data for Mars:

- Column 1: day of observation (in the interval ±105 days from time of opposition t_0).
- Column 2: distance to Mars from Earth, to be given in km.
- Column 3: position angle α of Mars, to be given in degrees.
- Column 4: day/days in which Mars is in quadrature with the Sun as seen from Earth (to be indicated by the symbol **Q**) or it appears "stationing" (to be indicated by the symbol **S**).

12.1. Taking into account the sidereal periods of the Earth and Mars with a good approximation and starting from the initial configuration where Mars is in opposition (i.e. along the up-down direction the orbit representation), compute the positions of the two planets every 15 days for a time interval of ±105 days and draw them on picture 12.a.

In picture 12.a draw the lines connecting the positions of Earth and Mars at the same epoch and, for each epoch, measure:

12.2. the Earth-Mars distance **D** and report it, in km, in column 2 of table 12.b,

12.3. the position angle α of Mars as seen from the Earth with reference to the up-down direction (i.e. line connection Earth and Mars when the Mars is at opposition) and report it, in degrees, in column 3 of table 12.b.

12.4. Infer in which of the positions of Earth and Mars at the same epoch you have drawn Mars would be in quadrature with the Sun and mark them (one, two or more) with the symbol **Q** in column 4 of table 12.b.

In picture 12.c report the distance (in au, **Y** axis) Mars-Earth **D** as a function of the position angle α (in degrees, **X** axis).

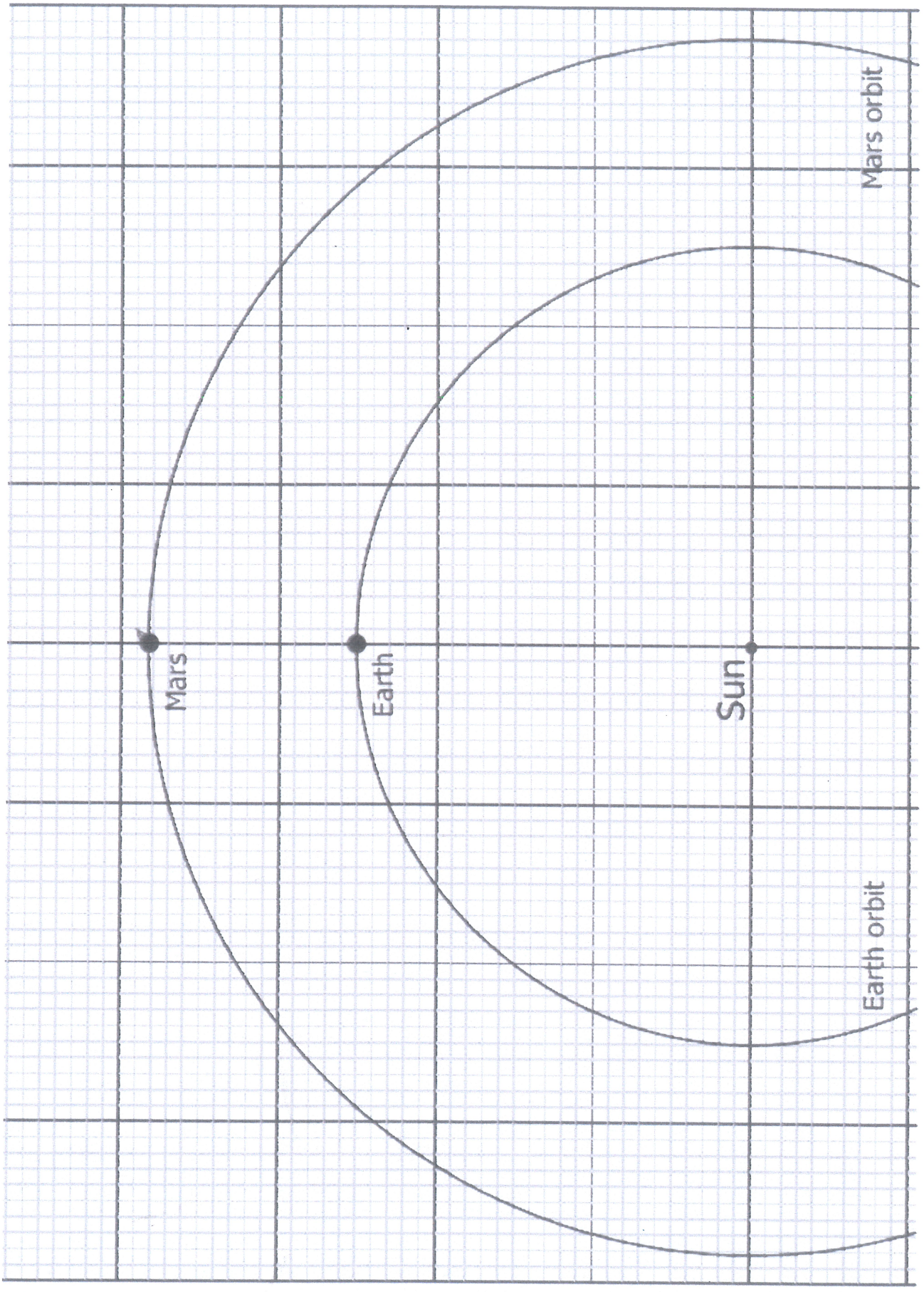
12.5. Infer the days (one, two or more with the precision allowed by the data) when Mars appears stationing in the sky during the considered time interval (±105 days) and mark them with the symbol **S** in column 4 of table 12.b.

12.6. Provide an estimation of the duration of the apparent retrograde motion of Mars **T(retrograde)** and write it, in days, in the box at the bottom of picture 12.c.

Code of participant код участника

МУ-В-1

12.a.

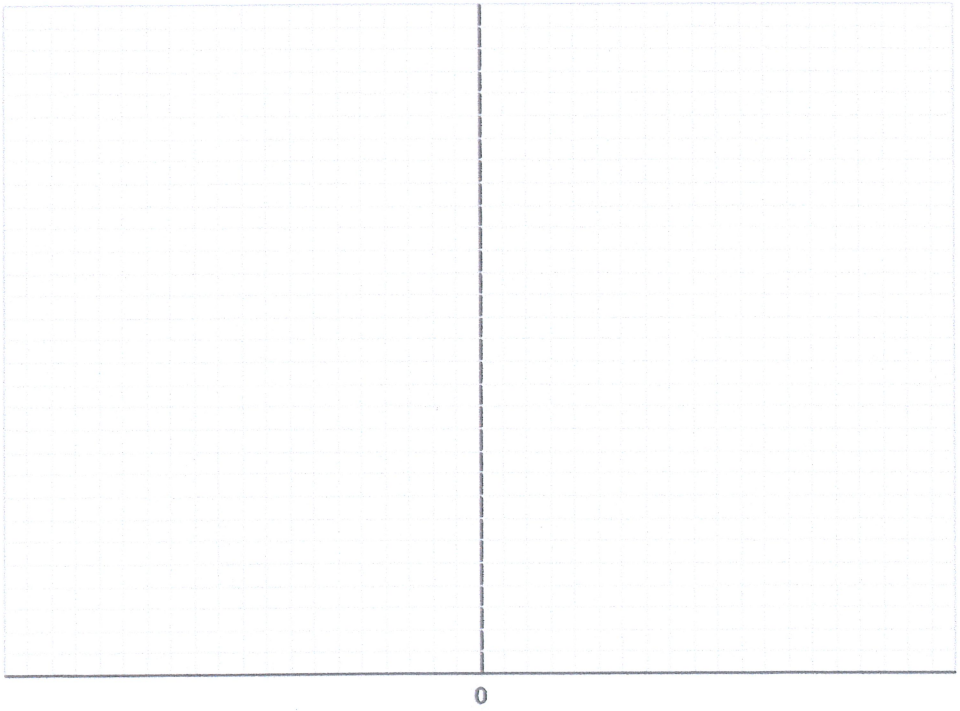


Code of participant	код участника
MY-B-1	

12.b.

1	2	3	4
Day	D (km)	α (°)	Quadrature / Stationing
t_0 - 105^d			
t_0 - 90^d			
t_0 - 75^d			
t_0 - 60^d			
t_0 - 45^d			
t_0 - 30^d			
t_0 - 15^d			
t_0 (opposition)			
t_0 + 15^d			
t_0 + 30^d			
t_0 + 45^d			
t_0 + 60^d			
t_0 + 75^d			
t_0 + 90^d			
t_0 + 105^d			

12.c.



T(retrograde) =

Practical round. Problems to solve

13. Observations at the INAF – Abruzzo Astronomical Observatory (OAAB)

The observation nights of December 23, 2021, January 24, 2022 and November 25, 2022 are made available at the "TNT" telescope (on photo 13.1.) of the OAAb (geographical coordinates: $\lambda = 13°44'$, $\varphi = 42°39'$).

The TNT has a Ritchey-Chretien optical design (two mirrors with hyperbolic curvature), with a primary diameter of 720 mm and a secondary of 185 mm. The overall focal length is 9800 mm.

At the focal plane is mounted a back-illuminated E2V CCD47 with 2048x2048 square pixels of 20x20 micron size each.

You are the scientific manager of a project that aims to study the optical bands of open stellar clusters of our galaxy listed in Table 13.a. In such table you find:

- Column 1: cluster name.
- Columns 2 & 3: right ascension and declination of the cluster.
- Column 4: angular diameter of the cluster.
- Column 5: distance of the cluster in parsecs.

Write in Table 13.b the answers to the following questions:

13.1. Choose for each of the three available dates listed in column 1 the globular cluster that at 00:00 Local Time is the nearest at culmination and write its name in column 2.

13.2. For each of the three selected clusters infer if it can fit entirely into the field of view of the CCD (i.e. if you can get an image of it with one single acquisition) and write the answer as YES or NO in column 3.

13.3. Calculate the radius in light years of the three selected clusters and write them in column 4.

Code of participant	код участника
MY-B-1	

13.1.

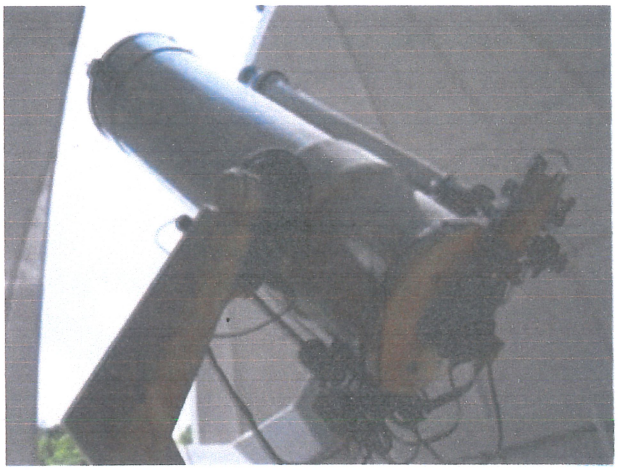


Table 13.a.

1	2	3	4	5
Cluster	**RA (2021)**	**DEC (2021)**	**Diameter**	**Distance (pc)**
NGC1039	02h 42m	42° 45'	25.2'	470
NGC1342	03h 31m	37° 22'	15.0'	665
NGC1444	03h 49m	52° 38'	4.1'	1000
NGC1502	04h 08m	62° 20'	7.1'	821
NGC1746	05h 04m	23° 46'	45.2'	760
NGC2129	06h 01m	23° 19'	6.1'	2036
NGC2323	07h 03m	-08° 20'	15.3'	998
NGC2548	08h 14m	-05° 45'	30.2'	775

Table 13.b.

1	2	3	4
Date	Cluster	Image with a single acquisition (Yes/Not)	Radius (ly)
23 December 2021	NGC 2129	Yes	2494.9575
24 January 2022	NGC 2323	Yes	709.3292
25 November 2022	NGC 1746	No	890.0514

Practical round. Problems to solve

14. Galilean Moons

Let's assume Jupiter equator and the orbits of its four Galilean Moons be coincident with the ecliptic. The position of Galilean Moons on 1st of November 2021, as observed from Earth, is shown in Figure 14.1. The in-scale corresponding orbital configuration, as could be observed from a distant point located on the extension Jupiter rotation axis, is shown in Figure 14.2, where the direction to Earth is represented as a dot-and-dash line.

The basic data for the four Galilean Moons of Jupiter are given in Table 14.a:
Column 1: Moon name.
Column 2: Semi-major axis in km.
Column 3: Sidereal period (day, hours, minutes).
Column 4: Azimuth on 1st November 2021 in degrees as measured anticlockwise with respect to Earth direction.

All moons orbits have a very low eccentricity and then they can be considered circular. The Jupiter average radius is assumed to be 69173 km.

14.1. Draw in Figure 14.3 what will be the observed orbital configurations for observations made at the same hour in the following dates:

- 3rd of November, 2021.
- 4th of November, 2021.
- 5th of November, 2021.
- 8th of November, 2021.
- 9th of November, 2021.
- 10th of November, 2021.
- 12th of November, 2021.

Taking into account the poor spatial resolution of Galileo's telescope, one of the computed 2021 configurations appears quite similar (although not identical) to one of the 1610 configurations observed by Galileo that are shown in Figure 14.4.

14.2. Which one of the 2021 configurations is similar to one of the 1610 configurations? Write in English the two dates in the box below Figure 14.4.

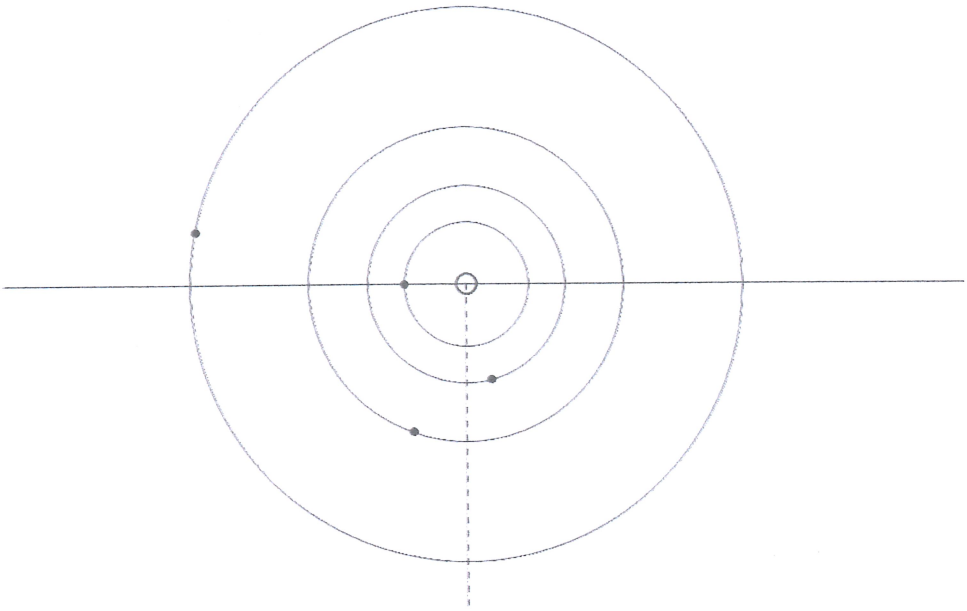
Code of participant код участника

MY-B-1

14.1.

1st Nov, 2021

14.2.



14.a.

1	2	3	4
Moon	**Semi-major axis**	**Sidereal period**	**Azimuth on 01.11.2021.**
Io	421700 km	1d 18h 27m	-90.0°
Europa	671034 km	3d 13h 14m	+14.6°
Ganymede	1070400 km	7d 03h 42m	-20.4°
Callisto	1882700 km	16d 16h 32m	-100.6°

Code of participant код участника

МУ – В – 1

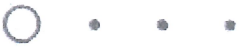
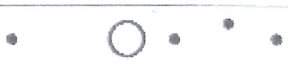
14.3.

3rd Nov, 2021 	4th Nov, 2021 
5th Nov, 2021 	8th Nov, 2021 
9th Nov, 2021 	10th Nov, 2021 
12th Nov, 2021 	

Code of participant код участника

MY – BY

14.4. – 1610:

Fig.	Date.	East.	West.
1	Jan. 7		
2	8		
3	10		
4	11		
5	12		
6	13		
7	15		
8	15		
9	16		
10	17		

2021 configuration	1610 configuration
5 ~~Jan.~~ November	10 January