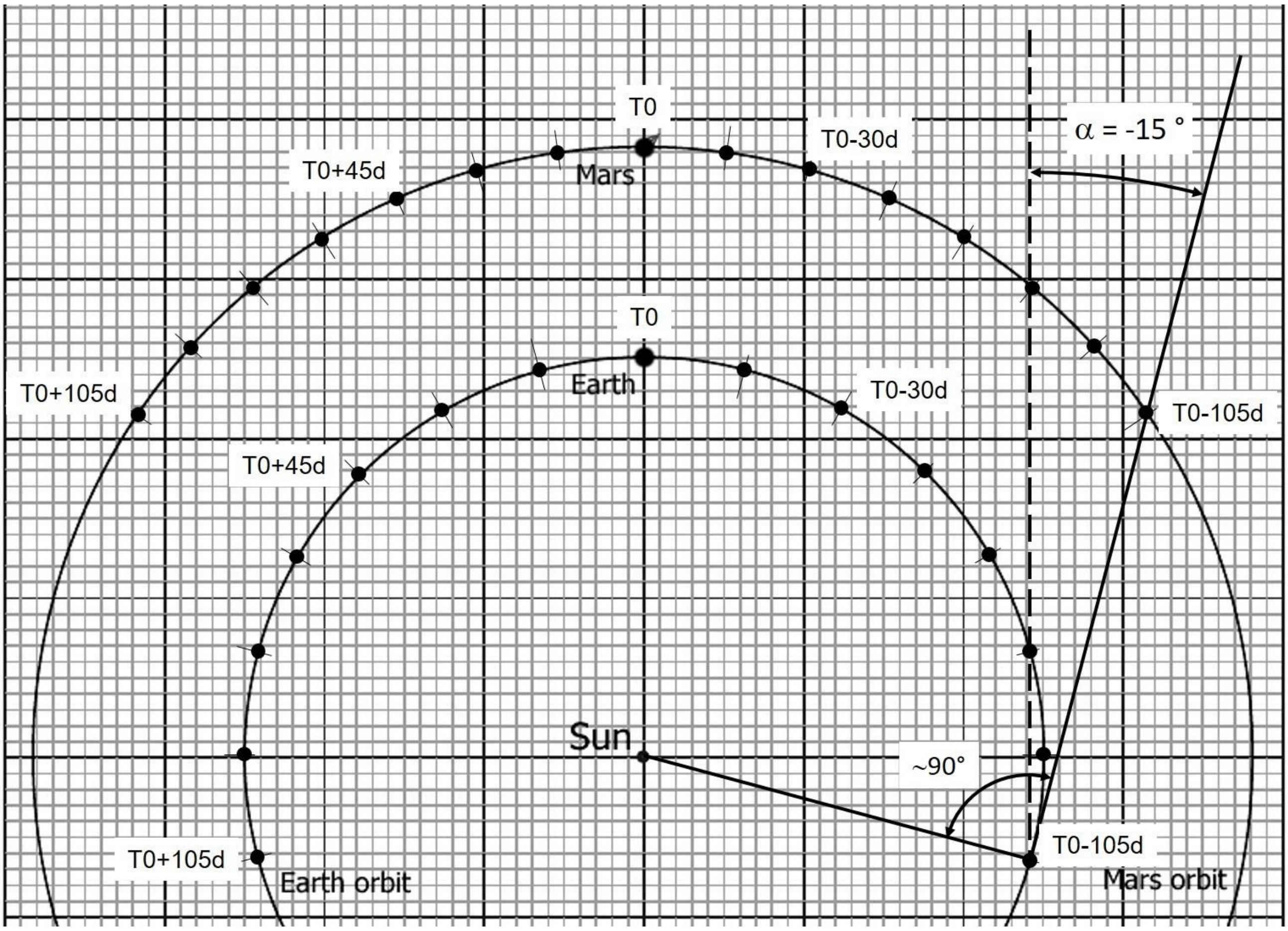
Practical Round - Sketches for solutions. For jury job ONLY

These solutions are written for jury members, so they contain some explanations in the form of text. Students are instructed to use only formulas, calculations, drawings, graphs and filling tables. Writing texts is not allowed in the solutions.

12. Mars motion as seen from the Earth

12.1 The sidereal period of Mars, with a good approximation, can be obtained from the III Kepler law considering that orbits of Earth and Mars are in scale. Starting from the configuration where Mars is in opposition, the positions of the two planets every 15 days are as follows:

12.a - positions of Mars and Earth



12.2 By measuring in the graph the Earth-Mars distance **D**, it then can be converted to km considering that the Sun-Eart distance is equal to 1 AU

12.3 Once the position of the two planets every 15 days are known, the angle α of Mars as seen from the Earth with reference to the up-down direction can be measured (for clarity only the value for t0-105d is shown in picture 12.a)

12.4 Looking at the positions of Earth and Mars at the same epoch, Mars would be in quadrature (or nearby) for t0 - 105d and for t0 + 105d

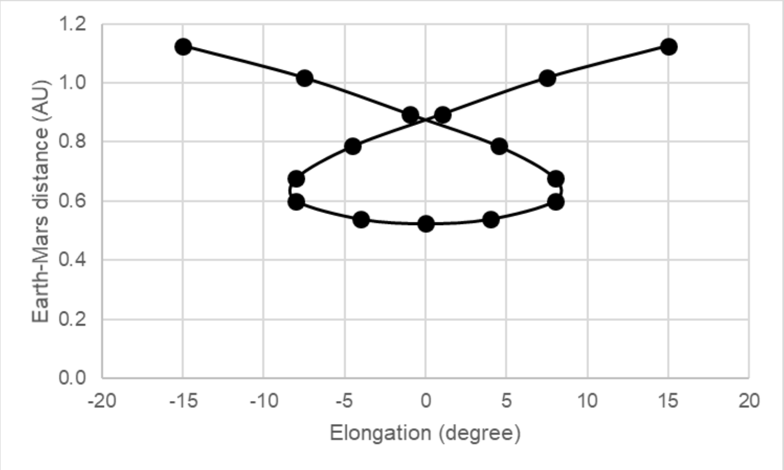
12.b - solution for questions 12.2, 12.3, 12.4 and 12.5

1	2	3	4
Day	**D (km)**	**α (°)**	**Quadrature / Stationing**
t0 - 105^d	$169 \cdot 10^6$	-15	Q
t0 - 90^d	$153 \cdot 10^6$	-7.5	
t0 - 75^d	$133 \cdot 10^6$	-1	
t0 - 60^d	$118 \cdot 10^6$	4.5	
t0 - 45^d	$102 \cdot 10^6$	8	S
t0 - 30^d	$89.7 \cdot 10^6$	8	S
t0 - 15^d	$80.8 \cdot 10^6$	4	
t0 (opposition)	$77.8 \cdot 10^6$	0	
t0 + 15^d	$80.8 \cdot 10^6$	-4	
t0 + 30^d	$89.7 \cdot 10^6$	-8	S
t0 + 45^d	$102 \cdot 10^6$	-8	S
t0 + 60^d	$118 \cdot 10^6$	-4.5	
t0 + 75^d	$133 \cdot 10^6$	1	
t0 + 90^d	$153 \cdot 10^6$	7.5	
t0 + 105^d	$169 \cdot 10^6$	15	Q

12.5 Once the distance Mars-Earth as a function of the position angle is plotted in Figure 12.c, the days, with the precision allowed by the data, when Mars appears stationing in the sky are inferred

12.6 The motion in the sky of Mars appears retrograde among the points of stationing

12.c - Position angle of Mars as function of Earth-Mars distance



T (retrograde) = 75 days

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

13.1 On Dec 23 the mean Sun has a RA of about 18h. Hence at local midnight the stars closest to culmination have RA $\simeq$ 6h.
Each day the RA of the mean Sun increase of about 3.93 m; from Dec 23 to Jan 24 lasted 32 days, while from 25 Nov to Dec 23 lasted 28 days.
The RA of the mean Sun on 24 Jan is of about 18h + 32 · 3.93 $\simeq$ 20h 6m hence at local midnight the stars closest to culmination have RA $\simeq$ 8h 6m.
The RA of the mean Sun on 25 Nov is of about 18h - 28 · 3.93 $\simeq$ 16h 10m hence at local midnight the stars closest to culmination have RA $\simeq$ 4h 10m.

13.2 The length of each CCD side is 2048 · 20 · 10^{-6} m $\simeq$ 41 mm. Taking into account the focal length of the telescope the FoV is a square with a side of $\alpha = \arctan\frac{41\,mm}{9800\,mm} \simeq 14'$

13.3 Given the angular diameter **β** and the distance **D** of the clusters, the radius **R**, after transforming the distance in ly can be computed using the formula:

$$R = \mathrm{D} \cdot \tan\frac{\beta}{2}$$

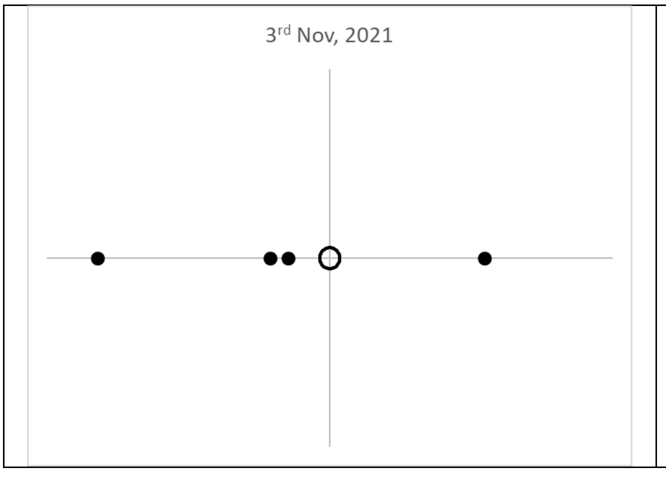
13.b – Answers to questions 12.1, 12.2 and 12.3

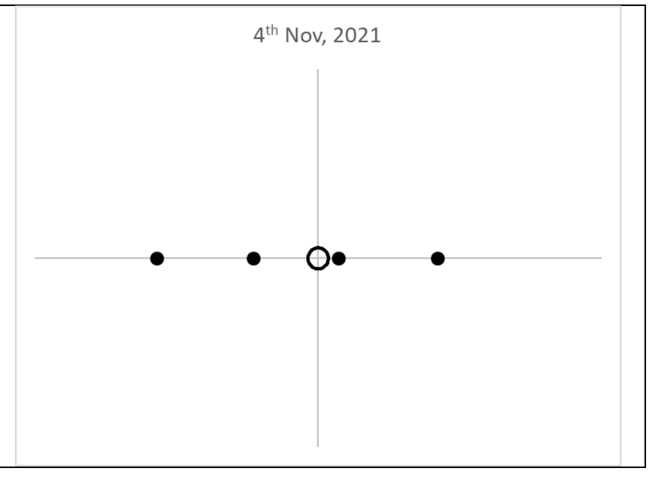
1	2	3	4
Date	Cluster	Image with a single acquisition (Yes/Not)	Radius (ly)
23 December 2021	NGC 2129	Yes	5.9
24 January 2022	NGC 2548	Not	11.1
25 November 2022	NGC 1502	Yes	2.8

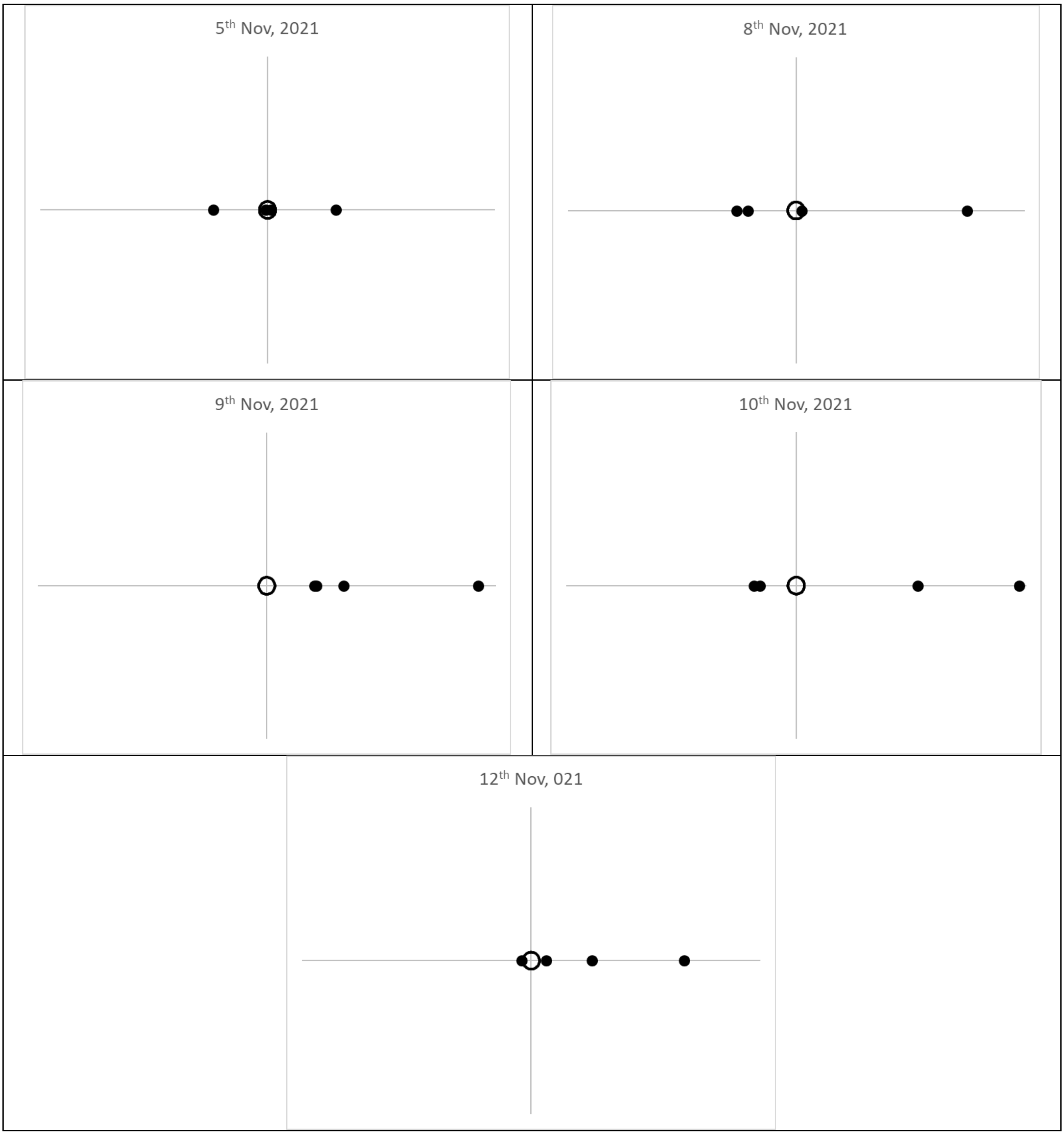
14. Galilean Moons

Starting from the sidereal periods listed in Table 14.a, the angular velocity of each satellite around Jupiter can be computed. Then, from the initial configuration shown in Figure 14.1 and 14.2, all the other configurations can be inferred

14.3 – Configuration of the Galilean moons in the requested dates







14.2 – among the computed 2021 configurations, the one of 9 nov appears quite similar (although not identical) to the second configuration observed by Galileo on 15 Jan 1610

2021 configuration	1610 configuration
9 Nov	15 Jan

Below is the marking scheme (Basic Criteria) for the PRACTICAL ROUND.

Practical Round - Basic criteria. For work of Jury

Note. Everywhere terms as “positioning” means “correct positioning”, “values” means “correct values”, “identification” means “correct identification”, etc..

12. Mars motion as seen from the Earth

N	Description	Points (up to)
1	Positioning of Earth and Mars on the graph	4
2	Values of the distance	2
3	Values of the α angle	2
4	Identification of the days of quadrature	1
5	Identification of the days of stationing	1
6	Plot of position angle of Mars as function of Earth-Mars distance	1
7	Time interval of retrograde motion of Mars (the point will be given only if the reported value, 75 days $\pm$ 15, is inferred from correct assumptions; it will not be given if it results by wrong assumptions)	1

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

N	Description	Points (up to)
1	Identification of the first cluster	2
2	Identification of the second cluster	2
3	Identification of the third cluster	2
4	Indication if the first cluster can be observed with a single acquisition	1
5	Indication if the second cluster can be observed with a single acquisition	1
6	Indication if the third cluster can be observed with a single acquisition	1
7	Estimation of first cluster radius in light years (0.5 points max if the values is not provided in light years)	1
8	Estimation of second cluster radius in light years (0.5 points max if the values is not provided in light years)	1
9	Estimation of third cluster radius in light years (0.5 points max if the values is not provided in light years)	1

14. Galilean Moons

N	Description	Points (up to)
1	Positioning of Galilean moons on 3 nov graph	1.5
2	Positioning of Galilean moons on 4 nov graph	1.5
3	Positioning of Galilean moons on 5 nov graph	1.5
4	Positioning of Galilean moons on 8 nov graph	1.5
5	Positioning of Galilean moons on 9 nov graph	1.5
6	Positioning of Galilean moons on 10 nov graph	1.5
7	Positioning of Galilean moons on 12 nov graph	1.5
8	Identification of 1610 configuration corresponding to the 9 nov 2021 one	1.5