Planetarium Round: Procedure

You will have 30 minutes to read the questions and prepare, 30 minutes inside the planetarium and 30 minutes to process your observations and complete the answer sheet.

The preparation area is outside the planetarium. Go to the table matching the name of your team for the Group Competition. It will also be marked with the sector, row and seat number assigned to you inside the planetarium.

Open the envelope only when the supervisor gives the command to 'START'. You have 30 minutes, the supervisor will give the remaining time e.g. "10 minutes left", "2 minutes left". On the command 'STOP', stop working but do not leave your place until you are shown the 'GO NOW' sign. Take only your question papers, clipboard and pen/pencil (leave the atlas). Follow the directions into the planetarium keeping your distance from other participants and take your place. Do not talk to other participants.

During the tasks you may stand up to get a better view, but do not move around, change seats, talk to other participants, or shine your light at others or at the sky. **The light must be pointed down at all times.**

The round is in 3 parts of 10 minutes each. The first part is for task 1. The second part is for task 2. The third part is for task 3. At 5, 2 and 1 minute before the end a warning will appear briefly on the sky.

At the end of the round wait in your seat until shown the 'GO NOW' sign. Follow the directions to the processing area and find the table matching your team as before (leave the light). Keep your distance from other participants and do not talk to them. After everybody is seated you will have 30 minutes to process your observations and complete the answer sheet (there will be a calculator, geometrical instruments etc. and a clock displaying the remaining time). At the end of 30 minutes place your answer sheets in the envelope and wait at your desk until told to leave the area.

Planetarium Round 3: 'TRAPPIST-1'

Aliens have found out that Earth's astronomers discovered planets in the TRAPPIST-1 system by observing numerous transits. They have used their flying saucer (similar to the one you were in for the observation round) to take you to the 5th planet (designated f) of TRAPPIST-1, and have asked you to show them the methods Earthlings use to uncover the parameters of the system. A clock displaying time in Earth hours will be visible. The whole presentation lasts 520 h (1 s represents 1 h).

(Projection time 10 minutes)

Based on your observations (you can use the space on the last sheet for observing notes),

(a) determine the following quantities for the planet you are on (use Earth hours for the times): (7 points)

i. length of the sidereal day [h]	
ii. orbital period [h]	
iii. length of the 'solar' day [h]	
iv. circular orbit	YES / NO
v. obliquity (axial tilt)	

(b) and the following quantities for each planet b, c, d and e: (16 points)

	b	c	d	e
synodic period [h]				
maximum elongation [°]				

(c) calculate the orbital period in hours and the semi-major axis in *tau* (where 1 tau = "TRAPPIST-1f astronomical unit" = the semi-major axis of the orbit of TRAPPIST-1f) of each planet: (8 points)

	b	c	d	e
orbital period [h]				
semi-major axis [tau]				

(d) The term 'gravitational resonance' is used to describe the phenomenon when ratio of the orbital periods of two planets in a system is close to the ratio of two integers. The table below lists some of the resonances observed in the TRAPPIST-1 system. Find which pair(s) of planets correspond to each of the listed resonances if any.

(4 points)

Resonance	Pair of planets
3:2	
8:5	
5:3	
8:3	
4:1	
6:1	

(Total: 35 points)

Solution

(a)

i. length of the sidereal day [h]	221 ± 5
ii. orbital period [h]	221 ± 5 (the same)
iii. length of the 'solar' day [h]	infinity
iv. circular orbit	YES
v. obliquity (axial tilt)	0 ($\leq 1°$)

For determining the orbital period – 3 points, for other quantities – 1 point each.

(b)

	b	*c*	*d*	*e*
synodic period [h]	43.6 ± 2	78.9 ± 2	173.5 ± 2	433.8 ± 2
maximum elongation [°]	17.5 ± 2	24 ± 2	37 ± 2	49 ± 2

(c)

	b	*c*	*d*	*e*
orbital period [h]	36.2 ± 2	58.1 ± 2	97.2 ± 2	166.4 ± 2
semi-major axis [tau]	0.30 ± .02	0.41 ± .02	0.60 ± .03	0.75± .04

(d)

Resonance	Pair of planets
3:2	e/d and f/e
8:5	c/b
5:3	d/c
8:3	d/b
4:1	e/b
6:1	f/b

Each resonance for 0.5 point, apart from f/e, which is worth 1 point.