Israel Open Astronomy Olympiad 2025

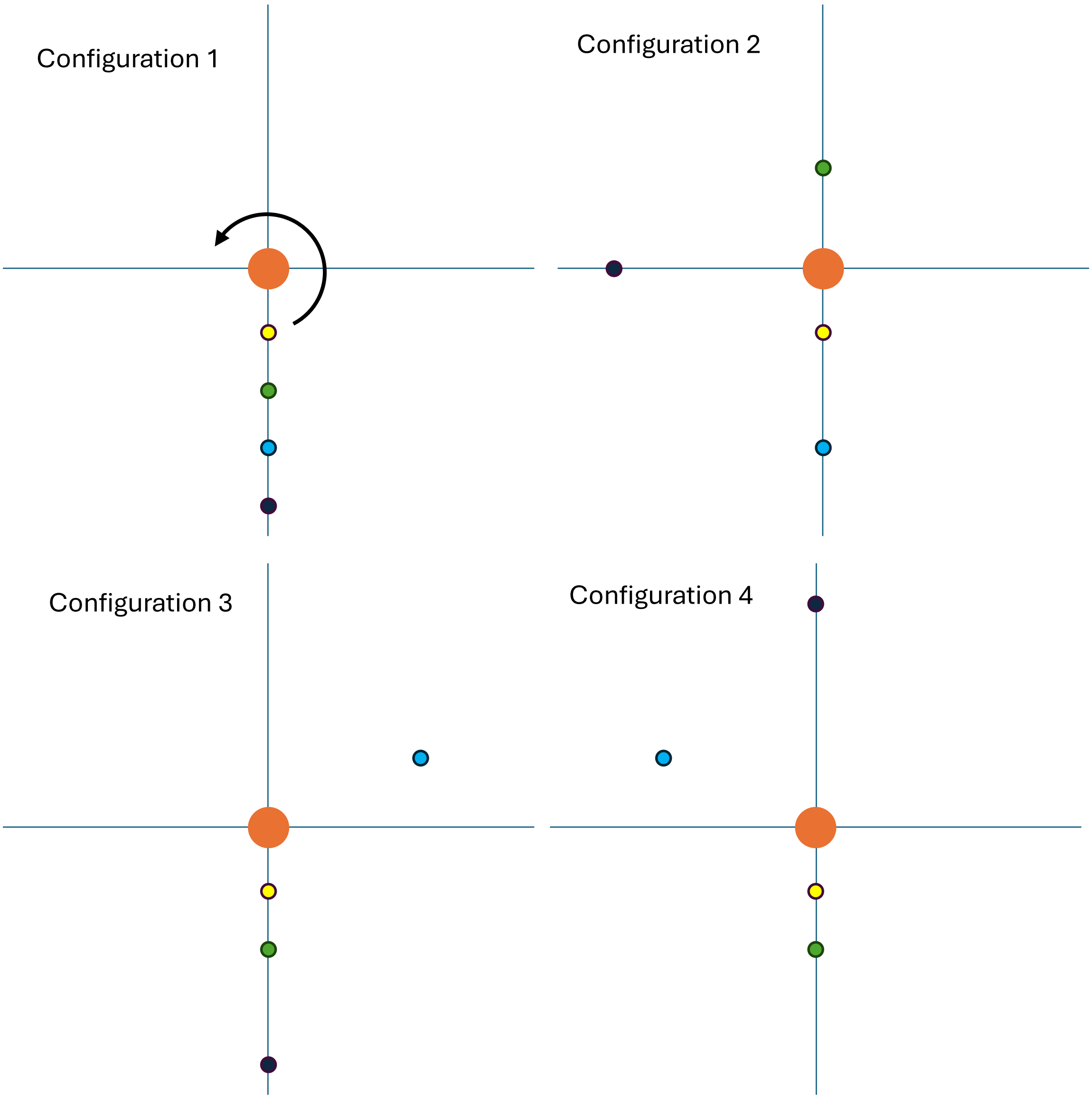
Junior and Senior age group set

Planetary system of Alphabet (50 p.)

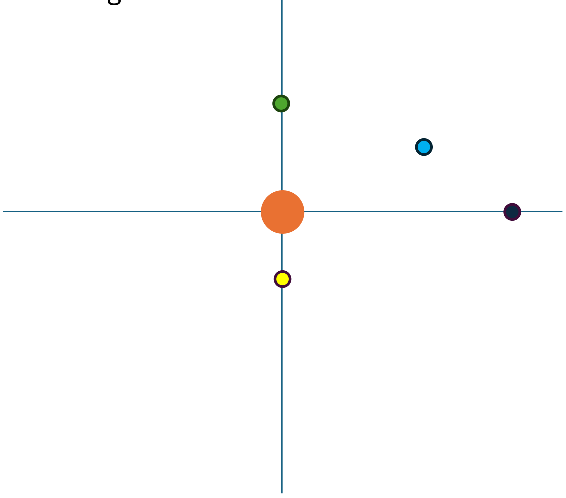
A planetary system exists around the star called Alphabet. The system contains four planets, which we will call A, B, C and D in the order from the central start outwards. The planets rotate around the star in one plane, in the same direction and on circular orbits. Two of the planets (B and C) are inhabited by a civilization that initially developed on the planet B.

The ancient astronomers of planet B called the distance from the Alphabet to their planet B as *absolute unit* (au). By coincidence, 1 year of the planet B contains exactly 100 sols (solar days) of this planet.

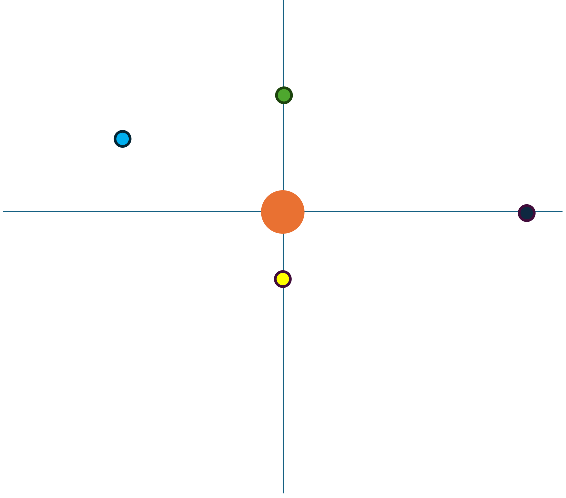
A The images below show the planetary configurations as seen from the top, taken after each period of planet A. Orbiting direction of all planets is shown on the first image (Configuration 1) that corresponds to the initial time moment. Order the planetary configurations in time!



Configuration 5



Configuration 6



Answer: (2 p for each correct answer) The correct planetary configuration order is

- Configuration 1
- Configuration [2]/[3]/[4]/[5]/[6]
- Configuration [2]/[3]/[4]/[5]/[6]
- Configuration [2]/[3]/[4]/[5]/[6]
- Configuration [2]/[3]/[4]/[5]/[6]
- Configuration [2]/[3]/[4]/[5]/[6]

B If the planets move around the star as shown on configuration diagrams above, then after how many years (orbital periods) of planet B the configurations of all planets will repeat? That is, after how many years from Configuration 1 the planets will first be in Configuration 1 again? (2 p.)

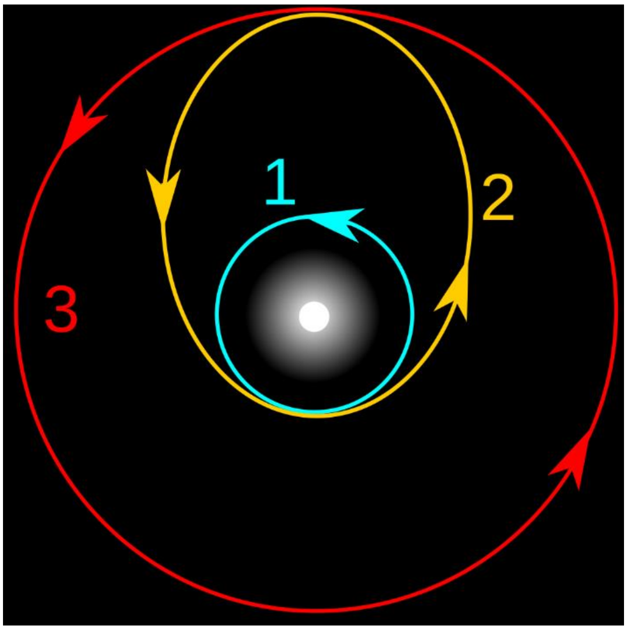
Answer: The Configuration 1 will repeat after each [ ] years of planet B.

C From planet B, all other planets are beautifully seen. The astronomers of planet B observed synodic periods of the inner planet A and outer planets C and D are shown in the table below. From this they computed their orbital (sidereal) periods in sols and orbital radii in au. The astronomers were also able to compute synodic periods of planets as seen from planet C. Repeat their calculations! *Note that the values you obtain here may differ from what you obtained in previous parts of the problem.*

Answer: Fill in the empty cells with the values that you compute (2 p. for every value).

	A planet	B planet	C planet	D planet
Synodic period as seen from B, sols	100	---	300	200
Orbital period, sols		1.0		
Orbit radius, au		1.0		
Synodic periods as seen from C, sols			---	

D How long should the spaceship fly from planet B to C? (5 p.) Assume that the radius of orbit of planet C is 1.5 au (*this may differ from the value you obtained previously*). The trajectory used by the spaceship is an ellipse touching in pericenter the orbit of planet B, and in apocenter touching the orbit of planet C. No engines are operated when moving on this trajectory.



The image shows the elliptical transfer orbit (2) used by the spaceship. It connects circular orbits of planet B (1) and planet C (3).

Answer: The flight time from B to C is [ ] sols

Astronomers of planet B were followers of decimal system and defined their time and distance units as factors of 10 and 100. According to them,

- The solar day (*sol*) contains 100 *minute* parts (*minute* means small), 1 sol = 100 min
- One *minute* part contains 100 *second* small parts, 1 min = 100 sec

Note that sols, minutes and seconds of planet B have no relation to our days, minutes and seconds.

E On the sky of planet B, its star Alphabet culminates exactly every one sol (which is also the definition of sol). How often does the Sun culminate in the sky of planet B? Remember that from planet B, the Sun is just one of many fixed stars.
Note: like Earth, the B planet rotates around its axis in the same direction as it orbits its star.

Answer: The Sun culminates every [ ] min. (3 p)

The scientists of planet B defined the distance unit, *moter*, in such a way that the planet B radius is 1 million *moters* = 1 000 000 m, or 1 000 *kilomoters* = 1000 km.

F The free fall acceleration on planet B is measured to be 100 m/sec^2. Determine the circular velocity a spaceship must have to orbit the planet B on a low circular orbit! (5 p.) Determine the escape velocity a spaceship must have to escape the gravity of planet B! (2 p.) Express the answers in *kilomoters* per second, written as km/sec.

Answer: On planet B, the circular velocity is [ ] km/sec, and the escape velocity is [ ] km/s.

G To determine the connection between the *moter* m and the *absolute unit* au, the astronomers measured that the angular diameter of planet B, when observed from planet C, was equal to 1/100 000 of the full angle (that we on Earth call 360°), when the distance between the planets was 0.5 au. Determine, how many *moters* equals one *absolute unit*.

Answer: 1 au = [ ] m (5 p.)

H Knowing that the distance from planet B to the star Alphabet equals 10^{10} *moters* (*this value may differ from the one received previously*), find the orbital speed of planet B in km/sec.

Answer: The orbital speed of planet B is [ ] km/sec. (5 p.)