Unit 3: Apparent Motion of Celestial Objects

Name: _____ Class / No: _____ Date: _____

Learning outcomes

- AST.3.1 — The celestial sphere and coordinates
- AST.3.2 — Daily apparent motion
- AST.3.3 — The Sun’s yearly path

Questions

1. (AST.3.1) About how many degrees above the horizon is Polaris in Erzurum (φ ≈ 39.9°)?
   ○ A) 23° ○ B) 40°
   ○ C) 50° ○ D) 90°
2. (AST.3.1) A star with a right ascension of 6 h is how many degrees east of the vernal equinox?
   ○ A) 6° ○ B) 45°
   ○ C) 90° ○ D) 180°
3. (AST.3.1) What is the greatest altitude of Antares (δ ≈ −26.4°) seen from Ankara?

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4. (AST.3.2) A star rose at 22:00 this evening. At about what time will it rise a month from now?
   ○ A) 22:00 ○ B) 21:00
   ○ C) 20:00 ○ D) 24:00
5. (AST.3.2) Which of the following is direct evidence that the Earth rotates on its axis?
   ○ A) The phases of the Moon ○ B) The turning of a Foucault pendulum’s plane of swing
   ○ C) The seasons ○ D) Eclipses
6. (AST.3.2) Which star never sets as seen from Ankara?
   ○ A) Vega (δ +38.8°) ○ B) Capella (δ +46.0°)
   ○ C) Dubhe (δ +61.8°) ○ D) Deneb (δ +45.3°)
7. (AST.3.3) What is the Sun’s noon altitude in Istanbul (φ ≈ 41.0°) at the summer solstice?

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8. (AST.3.3) Refute the statement “Summer is hot because the Earth is closer to the Sun” with one piece of data.

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9. (AST.3.3) From which direction does the Sun rise in Antalya on the day of an equinox?

10. (AST.3.3) What causes the width of the analemma?

Score: ____ / 10

Practical tasks

1. AST.3.1: Search the atlas for Sirius, Vega and Canopus and read their declinations from the panel. For Ankara (39.9°), Izmir (38.4°) and Antalya (36.9°), work out whether each one rises and its greatest altitude. Expected result: Canopus (δ = −52.7°) never rises from Ankara or Izmir, and from Antalya climbs only ~0.4° above the horizon. (SpaceTRC records: Star Atlas, Hipparchus)
2. AST.3.2: In the “where is it tonight” lab on the Ursa Major page, record the constellation’s positions at 21:00 and 23:00. Estimate the angle it turned through and compare with the expected 2 hours × 15° = 30°. (SpaceTRC records: Ursa Major, Ali Qushji)
3. AST.3.3: Turn on the ecliptic layer in the atlas. Mark the Sun’s four characteristic positions (α = 0, 6, 12, 18 h) on the map and write down which constellation each falls in. Then recalculate the table above for your own latitude. (SpaceTRC records: Star Atlas, Ulugh Beg, Samarkand Observatory, Zij of Ulugh Beg)

Answer key — Unit 3: Apparent Motion of Celestial Objects

1. B. The altitude of the celestial pole equals the latitude, and Polaris is very close to the pole.
2. C. 1 h = 15°; 6 × 15° = 90°.
3. 90 − 39.9 − 26.4 = 23.7°. This explains why Scorpius looks low from Ankara.
4. C. About 4 minutes earlier each day; about 2 hours over 30 days.
5. B. The other options concern orbital motions and geometry.
6. C. The circumpolar limit is 90 − 39.9 = +50.1°; only Dubhe is above it.
7. 90 − 41.0 + 23.4 = 72.4°.
8. The Earth is closest to the Sun in early January, when it is winter in the Northern Hemisphere. What matters is the axial tilt, and therefore the Sun's altitude and the length of the day.
9. Almost due east; with $\delta_\odot = 0$, cos A = 0 and A = 90° (whatever the latitude).
10. The equation of time: because the Earth's orbit is elliptical and its axis is tilted, the difference between sundial time and clock time varies by up to ±16 minutes over the year, so at the same clock time the Sun sits sometimes further west, sometimes further east.

Teacher note

Lesson flow (40-minute class hour): 5 min prediction question, 15 min explanation and worked example, 15 min activity on the site, 5 min two questions. Without computers, screenshots of the atlas and a printable coordinate table can be used.

Assessment criteria: Using coordinates — beginning: defines the terms; secure: finds a star from α and δ; advanced: calculates altitude for a given latitude. Daily motion — beginning: describes east-to-west motion; secure: explains it by the Earth's rotation; advanced: calculates which stars are circumpolar. The Sun's yearly path — beginning: notices the seasonal difference; secure: explains it by the axial tilt; advanced: recalculates the table for their own province.

Common misconceptions: (1) The seasons are caused by the distance to the Sun. (2) The Sun always rises due east. (3) Polaris is the brightest star in the sky (its magnitude is ~2; the brightest night-time star is Sirius). (4) Stars never change their place in the sky; in fact they rise ~4 minutes earlier each evening.

For self-study and classroom use. Based on the Turkish Ministry of National Education Astronomy and Space Sciences curriculum.
https://spacetrc.com/en/academy/astronomy-and-space-sciences/apparent-motion-of-celestial-objects/