Chapter 11: Keeping Time with the Skies

Exercises — Keep the Curiosity Alive

Q1 State whether the following statements are True or False.
(i) We can only see that part of the Moon which reflects sunlight towards us.
(ii) The shadow of Earth blocks sunlight from reaching the Moon causing phases.
(iii) Calendars are based on various astronomical cycles which repeat in a predictable manner.
(iv) The Moon can only be seen at night.

SOLUTION

(i) TRUE — The Moon is a spherical body that shines by reflecting sunlight. We see only the part of the Moon's near side whose reflected sunlight reaches our eyes; the rest (the dark portion) is not visible.

(ii) FALSE — The phases of the Moon are caused by the changing relative positions of the Sun, Moon, and Earth as the Moon revolves around Earth. Earth's shadow on the Moon causes a lunar eclipse, not the Moon's phases.

(iii) TRUE — Calendars are built on predictable astronomical cycles: the day (Earth's rotation), the month (Moon's revolution around Earth), and the year (Earth's revolution around the Sun). These cycles are regular and repeating.

(iv) FALSE — The Moon can be seen during the daytime as well. A waxing Moon is often visible in the afternoon and evening sky, and a waning Moon can be seen in the morning sky before and after sunrise.

Answer: (i) True, (ii) False, (iii) True, (iv) False

Q2 Amol was born on 6th of May on a full Moon day. Does his birthday fall on the full Moon day every year? Explain your answer.

SOLUTION

A solar (Gregorian) calendar year is approximately 365.25 days, while the Moon completes one full cycle of phases (synodic month) in approximately 29.53 days.

Number of synodic months in one solar year = 365.25 ÷ 29.53 ≈ 12.37

Since 12.37 is not a whole number, 12 complete lunar months (≈ 354.4 days) fall short of one solar year by about 11 days. The full Moon therefore shifts approximately 11 days earlier each year relative to the Gregorian calendar.

This means the full Moon day moves to a different calendar date each year. Only after about 19 years (the Metonic cycle — 19 solar years ≈ 235 lunar months) does the full Moon nearly coincide with the same calendar date again, and even then it may differ by a day.

Therefore, Amol's birthday (6th May) does NOT fall on a full Moon day every year.

Answer: No. Because a solar year (~365.25 days) is not an exact multiple of a lunar month (~29.53 days), the full Moon shifts by about 11 days each year in the solar calendar. Amol's birthday will fall on a full Moon day only occasionally, not every year.

Q3 Name two things that are incorrect in Fig. 11.10.
[Fig. 11.10 shows a Moon surrounded by clouds, with stars drawn on the dark face of the Moon.]

SOLUTION

Examining Fig. 11.10 carefully:

Incorrect feature 1 — Stars on the dark face of the Moon: Stars are shown as glowing dots ON the dark face of the Moon itself. This is impossible because the Moon is an opaque, solid body. Stars cannot appear on the Moon's surface; they are located far beyond it in space. The Moon blocks the view of any stars behind it.

Incorrect feature 2 — Clouds surrounding the Moon: Fig. 11.10 shows the Moon wrapped in clouds. The Moon is in outer space (about 3,84,000 km from Earth), far beyond Earth's atmosphere. There are no clouds in outer space, and the Moon itself has no atmosphere. Clouds exist only within Earth's atmosphere, not around the Moon.

Answer: (1) Stars are shown on the dark face of the Moon, which is impossible — the Moon is an opaque body in space. (2) Clouds surround the Moon, which is incorrect — the Moon is in outer space where there are no clouds.

Q4 Look at the pictures of the Moon in Fig. 11.11 (panels A, B, C, D, E, F), and answer the following questions.

(i) Write the correct panel number corresponding to the phases of the Moon shown in the pictures above.
Phase of Moon | Picture label
Three days after New Moon | ?
Full Moon | ?
Three days after Full Moon | ?
A week after Full Moon | ?
Day of New Moon | ?

(ii) List the picture labels of the phases of the Moon that are never seen from Earth.

SOLUTION

Analysing Fig. 11.11 — the six panels show the Moon's appearance as follows (from left to right: A, B, C, D, E, F):
A — Mostly lit Moon with a dark shadow on the left side (waning gibbous, ~3 days after Full Moon).
B — Completely dark disc (New Moon, no illumination visible).
C — Half lit diagonally (Last Quarter / waning half moon, about a week after Full Moon).
D — Thin bright crescent on the lower-right with most of the disc dark (waxing crescent, ~3 days after New Moon).
E — Fully and evenly illuminated Moon (Full Moon).
F — Mostly lit Moon with a dark shadow on the upper-left (this shows the illuminated far side of the Moon — a view never seen from Earth, because the Moon's synchronous rotation always keeps the same face (near side) turned towards Earth).

(i) Phase-to-panel matching:
Three days after New Moon → D
Full Moon → E
Three days after Full Moon → A
A week after Full Moon → C
Day of New Moon → B

(ii) Panel F shows the phase that is never seen from Earth.

Because the Moon rotates synchronously with its revolution around Earth, the Moon's far side always faces away from Earth. The illuminated far side (lit when the near side is dark, as during New Moon) is never visible from Earth. Panel F depicts this configuration and cannot be observed from Earth's surface.

Answer: (i) Three days after New Moon = D; Full Moon = E; Three days after Full Moon = A; A week after Full Moon = C; Day of New Moon = B. (ii) Panel F — the illuminated far side of the Moon is never seen from Earth.

Q5 Malini saw the Moon overhead in the sky at sunset.
(i) Draw the phase of the Moon that Malini saw.
(ii) Is the Moon in the waxing or the waning phase?

SOLUTION

At sunset, the Sun is on the western horizon. If the Moon is directly overhead (at the zenith), the Moon is approximately 90° east of the Sun in the sky.

A Moon that is 90° ahead (east) of the Sun corresponds to the First Quarter phase (waxing half moon). In this phase, exactly half of the Moon's near side is illuminated.

(i) Drawing description: Draw a circle divided by a vertical line. The RIGHT half (western half, facing the setting Sun) is bright/white, and the LEFT half is dark. This represents the First Quarter (waxing half moon) as seen by Malini.

(ii) The Moon is in the WAXING phase.
The Moon is 90° east of the Sun, meaning it has moved a quarter of the way around its orbit from the New Moon position. The bright portion is growing — it will continue to grow towards Full Moon over the next week. This is the waxing (Shukla Paksha) phase.

Answer: (i) First Quarter phase — a half moon with the right (western) half lit and the left half dark. (ii) Waxing phase (Shukla Paksha).

Q6 Ravi said, 'I saw a crescent Moon, and it was rising in the East, when the Sun was setting.' Kaushalya said, 'Once I saw the gibbous Moon during the afternoon in the East.' Who out of the two is telling the truth?

SOLUTION

Analysing Ravi's claim:

A crescent Moon (waxing or waning) is always close to the Sun in the sky — separated by only a small angle.

At sunset, the Sun is on the western horizon. For the Moon to be RISING in the EAST at the same moment, the Moon would need to be roughly 180° away from the Sun — near the Full Moon position, not a crescent.

A waxing crescent sets in the West shortly after the Sun; a waning crescent rises in the East just before sunrise.

A crescent Moon rising in the East at sunset is geometrically impossible.

Ravi is NOT telling the truth.

Analysing Kaushalya's claim:

A waxing gibbous Moon is more than half lit and is between First Quarter and Full Moon in its orbit.

The waxing gibbous Moon rises around midday, well before sunset, and is visible in the afternoon sky.

In the afternoon, when the Sun is in the South or South-West, a waxing gibbous Moon would indeed be in the Eastern part of the sky — this is consistent with its orbital position.

Kaushalya's observation is physically possible.

Kaushalya is telling the truth.

Answer: Kaushalya is telling the truth. A crescent Moon cannot rise in the East at sunset (it would need to be near Full Moon for that). A waxing gibbous Moon, however, can be visible in the eastern sky during the afternoon.

Q7 Scientific studies show that the Moon is getting farther away from the Earth and slower in its revolution. Will luni-solar calendars need an intercalary month more often or less often?

SOLUTION

Currently, a lunar month is approximately 29.53 days, giving a lunar year of 12 × 29.53 ≈ 354.4 days.
A solar year is approximately 365.25 days.
The difference is about 10.9 days per year, which is why luni-solar calendars add an intercalary (extra) month roughly every 3 years to keep the lunar calendar aligned with the seasons.

If the Moon gets farther from Earth and slows in its revolution:
A slower Moon means each orbit takes longer → the synodic (lunar) month becomes longer.
A longer lunar month means 12 lunar months would add up to more days — closer to the length of a solar year.
The gap between 12 lunar months and one solar year would shrink.
The lunar calendar would drift less from the solar calendar each year.
Therefore, an intercalary month would be needed LESS OFTEN.

Answer: Less often. A slower Moon means a longer lunar month. As the lunar month grows longer, 12 lunar months approach the length of a solar year, reducing the annual drift. An intercalary month is therefore needed less frequently.

Q8 A total of 37 full Moons happen during 3 years in a solar calendar. Show that at least two of the 37 full moons must happen during the same month of the solar calendar.

SOLUTION

This problem is solved using the Pigeonhole Principle.

Number of full Moons in 3 years = 37
Number of calendar months in 3 years = 3 × 12 = 36

We need to distribute 37 full Moons among 36 months.

By the Pigeonhole Principle: if you place n + 1 objects into n containers, at least one container must contain at least 2 objects.

Here: 37 full Moons (objects) distributed among 36 months (containers).

Since 37 > 36, it is impossible for every month to have at most one full Moon.
At least one month must contain at least two full Moons.

Verification using known data: A lunar month is about 29.53 days. A calendar month ranges from 28 to 31 days. Occasionally, a 31-day (or even a 30-day) calendar month fits two full Moons — the second full Moon in a month is popularly called a 'Blue Moon'. This confirms that two full Moons in one calendar month is a real phenomenon, consistent with the mathematical argument above.

Answer: By the Pigeonhole Principle: 37 full Moons into 36 months means at least one month must contain two full Moons (since 37 > 36, one container must hold two objects).

Q9 On a particular night, Vaishali saw the Moon in the sky from sunset to sunrise. What phase of the Moon would she have noticed?

SOLUTION

At sunset, the Sun sets in the West.
At sunrise, the Sun rises in the East.

For the Moon to be visible from sunset to sunrise (the entire night):
It must rise in the East at sunset AND set in the West at sunrise.

A Moon rising in the East when the Sun sets means the Moon is roughly 180° opposite the Sun in the sky.
A Moon setting in the West when the Sun rises confirms the same geometry.

A Moon that is 180° opposite the Sun is the Full Moon.
On Full Moon night, the Moon rises at sunset, is overhead at midnight, and sets at sunrise — meaning it is above the horizon the entire night.

Vaishali would have seen a Full Moon.

Answer: Full Moon. The Moon rises in the East at sunset and sets in the West at sunrise only when it is directly opposite the Sun — the Full Moon phase.

Q10 If we stopped having leap years, in approximately how many years would the Indian Independence day happen in winter?

SOLUTION

The tropical (solar) year is approximately 365.2422 days.
Without leap years, every calendar year = 365 days.
Shortfall per year = 365.2422 − 365 = 0.2422 days

This means the calendar falls behind the seasons by about 0.2422 days (roughly 6 hours) each year.
Equivalently, for a fixed calendar date like August 15, its actual seasonal position in Earth's orbit drifts about 0.2422 days earlier every year.

Indian Independence Day (August 15) currently falls during the hot/monsoon season in India.
Winter in India typically spans November through February.
To reach mid-winter (approximately December 21 — winter solstice), August 15 must drift by approximately 128 days earlier in the tropical year:
Days from Aug 15 to Dec 21 = (31 − 15) + 30 + 31 + 30 + 21 = 128 days

Years needed = 128 ÷ 0.2422 ≈ 528 years
(Using the common approximation of 0.25 days/year drift: 128 ÷ 0.25 = 512 years)

Therefore, approximately 500 years (roughly 500–530 years) would need to pass before Independence Day falls in winter.

Answer: Approximately 500 years (more precisely ~528 years). Without leap years, the calendar drifts ~0.24 days/year relative to the seasons. August 15 would need to drift about 128 days to reach the winter solstice position, taking roughly 128 ÷ 0.24 ≈ 528 years.

Q11 What is the purpose of launching artificial satellites?

SOLUTION

Artificial satellites are human-made objects launched into orbit around Earth (or other celestial bodies). They serve several important purposes:

1. Communication: Satellites relay telephone calls, television broadcasts, and internet data across long distances and to remote areas.

2. Navigation: GPS and other satellite navigation systems help people find

locations and guide aircraft, ships, and vehicles.

3. Weather monitoring: Satellites track cloud patterns, storms, and atmospheric conditions, enabling weather forecasting and early warning for cyclones and floods.

4. Disaster management: Satellite images help assess damage from floods, earthquakes, and other disasters and coordinate relief efforts.

5. Scientific research: Satellites like AstroSat observe stars and other celestial objects from above Earth's atmosphere. India's missions such as Chandrayaan (Moon), Aditya-L1 (Sun), and Mangalyaan (Mars) gather scientific data about our Solar System.

6. Earth observation: Satellites like ISRO's Cartosat series capture high-resolution images of Earth for mapmaking, urban planning, agricultural monitoring, and environmental studies.

Answer: Artificial satellites are launched for communication, navigation (GPS), weather monitoring, disaster management, scientific research (observing stars, studying the Moon/Mars/Sun), and Earth observation (mapping, agriculture, environment).

Q12 On which periodic phenomenon are the following measures of time based: (i) day (ii) month (iii) year?

SOLUTION

(i) Day — based on Earth's rotation on its own axis.
Earth completes one full rotation in approximately 24 hours. The cycle of day and night caused by this rotation defines one day.

(ii) Month — based on the Moon's revolution around the Earth.
The Moon takes approximately 29.53 days to complete one cycle of phases (from one New Moon to the next), which forms the basis of a lunar month. The word 'month' itself is derived from 'Moon'.

(iii) Year — based on Earth's revolution around the Sun.
Earth takes approximately 365.25 days to complete one full orbit around the Sun. This journey determines the cycle of seasons and defines one year.

Answer: (i) Day — Earth's rotation on its axis (~24 hours). (ii) Month — Moon's revolution around Earth (~29.5 days per lunar cycle). (iii) Year — Earth's revolution around the Sun (~365.25 days).