

CHAPTER 26

Sunrise & Sunset

Sunrise, sunset and twilight calculations using the Air Almanac. Polar day, polar night, and high-latitude phenomena.



Sunrise/Sunset



Twilight Types



Polar Day/Night



Air Almanac

Sunrise and Sunset

Local noon occurs at the same Local Mean Time on *all* meridians — it is always 1200 LMT. By extension, **sunrise and sunset occur at the same LMT at all places on the same parallel of latitude**, on any given day.



Sunrise LMT and Sunset LMT are the same at a given latitude on a given date, regardless of longitude.



To find UTC of sunrise/sunset: look up LMT from Air Almanac → convert using arc-to-time for your longitude.



As the Sun rises due East and sets due West only at the equinoxes — at other times of year, the Sun rises/sets north or south of East/West.

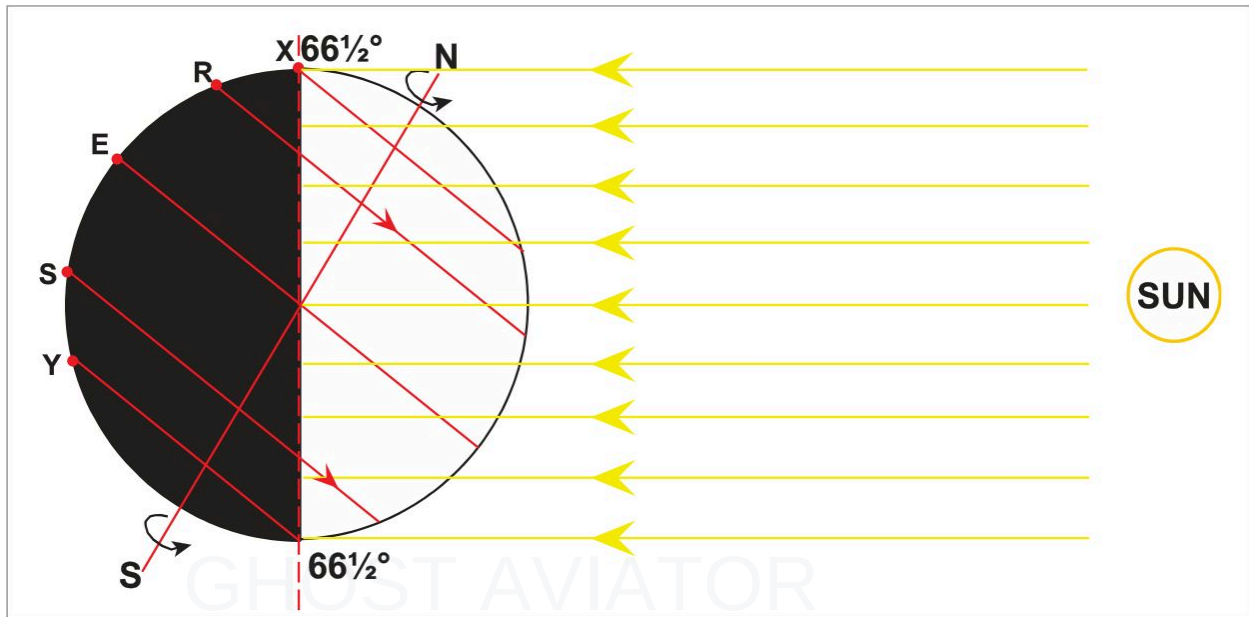


Figure 26.1 — Sunrise/sunset

Figure 1 — The illuminated and dark halves of Earth — sunrise and sunset positions changing with declination and season

Polar Phenomena

The combination of Earth's axial tilt and high latitudes produces remarkable seasonal effects:

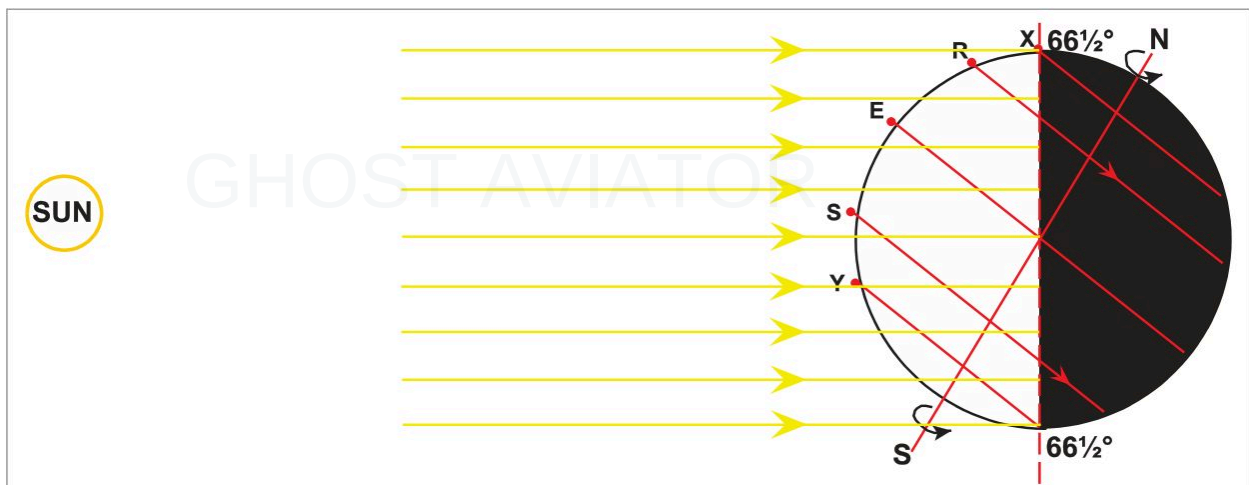


Figure 26.2 — Sunrise/sunset 2

Figure 2 — Polar day and polar night — the Arctic and Antarctic circles mark the boundaries of 24-hour day and 24-hour night

Phenomenon	Condition	Where?	When (NH)?
Midnight Sun (☀ all day)	Sun above horizon 24 hrs	66°N and higher	Around 21 June
Polar Night (❄ all night)	Sun below horizon 24 hrs	66°N and higher	Around 21 December
Equal Day/Night	12 hrs day, 12 hrs night	Equator (all year)	Equinoxes (all lat)

Air Almanac Symbols at polar latitudes:

☀ (filled circle) = Sun above horizon all day (Midnight Sun — no sunrise/sunset)

☾ (empty circle/crescent symbol) = Sun below horizon all day (Polar Night — no sunrise/sunset)

// (slashes) = Permanent twilight during the period the Sun is below the horizon

The lowest latitude at which Midnight Sun occurs is approximately **66°N/S** — the Arctic/Antarctic Circle — on the relevant solstice. In the Air Almanac, this is listed as approximately **66N** for June and **66N** for December polar night (when the question asks for lowest latitude where Sun never rises).

Twilight

Twilight is the period before sunrise and after sunset when the Sun is below the sensible horizon but still illuminates the sky. It is defined by how far the *centre* of the Sun is below the sensible horizon.

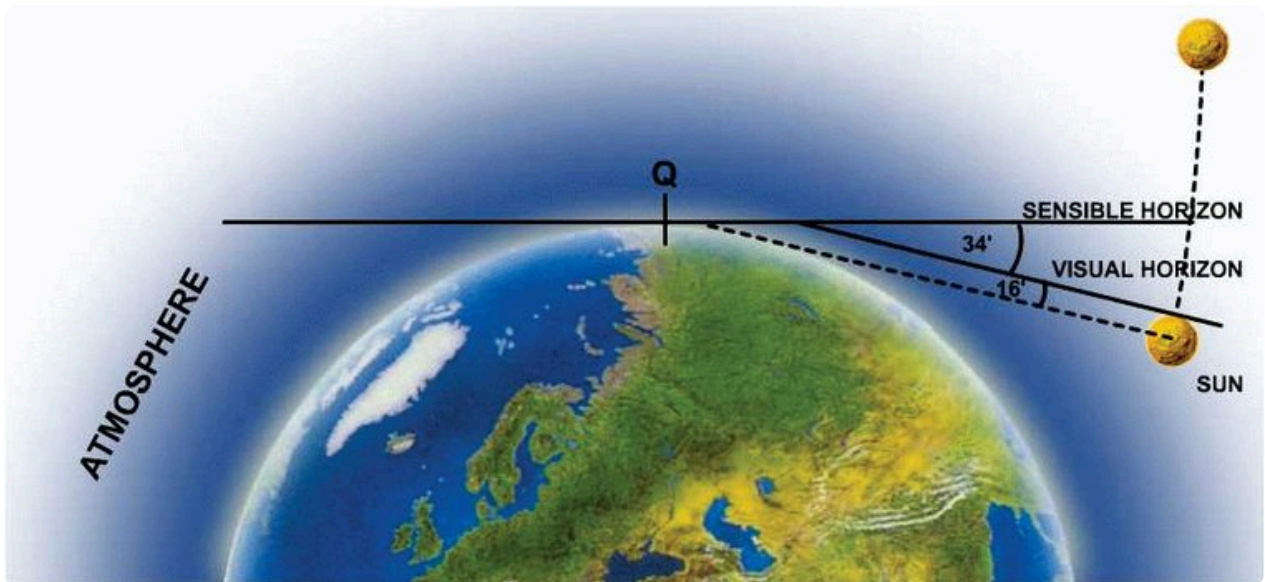


Figure 3 — The three twilight zones — Civil (0° – 6°), Nautical (6° – 12°), and Astronomical (12° – 18°) below the horizon



Civil Twilight

Sun 0° to 6° below horizon
Enough light for most outdoor tasks
Used in EU-OPS day/night definition



Nautical Twilight

Sun 6° to 12° below horizon
Horizon visible, stars visible for navigation
Used by mariners for star sights



Astronomical Twilight

Sun 12° to 18° below horizon
Sky not completely dark
Ends when full darkness begins

Civil Twilight definition (full):

- The period between sunset and End of Evening Civil Twilight (ECT)
- The period between Start of Morning Civil Twilight (MCT) and sunrise
- Related to the centre of the Sun being 6° below the sensible horizon
- A period when it is possible to carry out daylight tasks without artificial lighting
- Used in the EU-OPS definition of day flying / night flying

Air Almanac Abbreviations:

SR Sunrise (start of civil day)
SS Sunset (end of civil day)

- MCT** Morning Civil Twilight (beginning – when Sun is 6° below, morning)
- ECT** Evening Civil Twilight (end – when Sun is 6° below, evening)
- G** Midnight Sun – Sun continuously above horizon (no SR/SS)
- Polar Night – Sun continuously below horizon (no SR/SS)
- ////** Permanent twilight (Sun below horizon but within 6° – twilight all night)

Twilight at the Equator

Despite popular belief, it is **not** immediately dark after sunset at the Equator. Civil twilight still exists. However, because at the Equator the Sun sets almost vertically (perpendicular to the horizon), the twilight period is *short*.

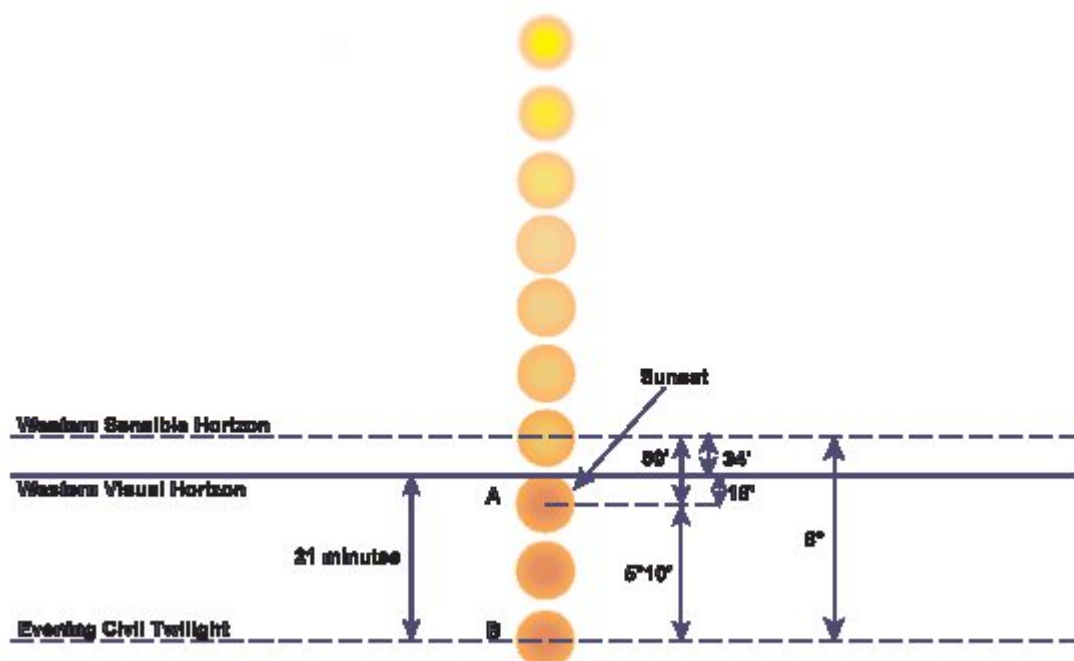


Figure 4 — At the Equator, the Sun sets nearly perpendicular to the horizon, giving a short but definite twilight period

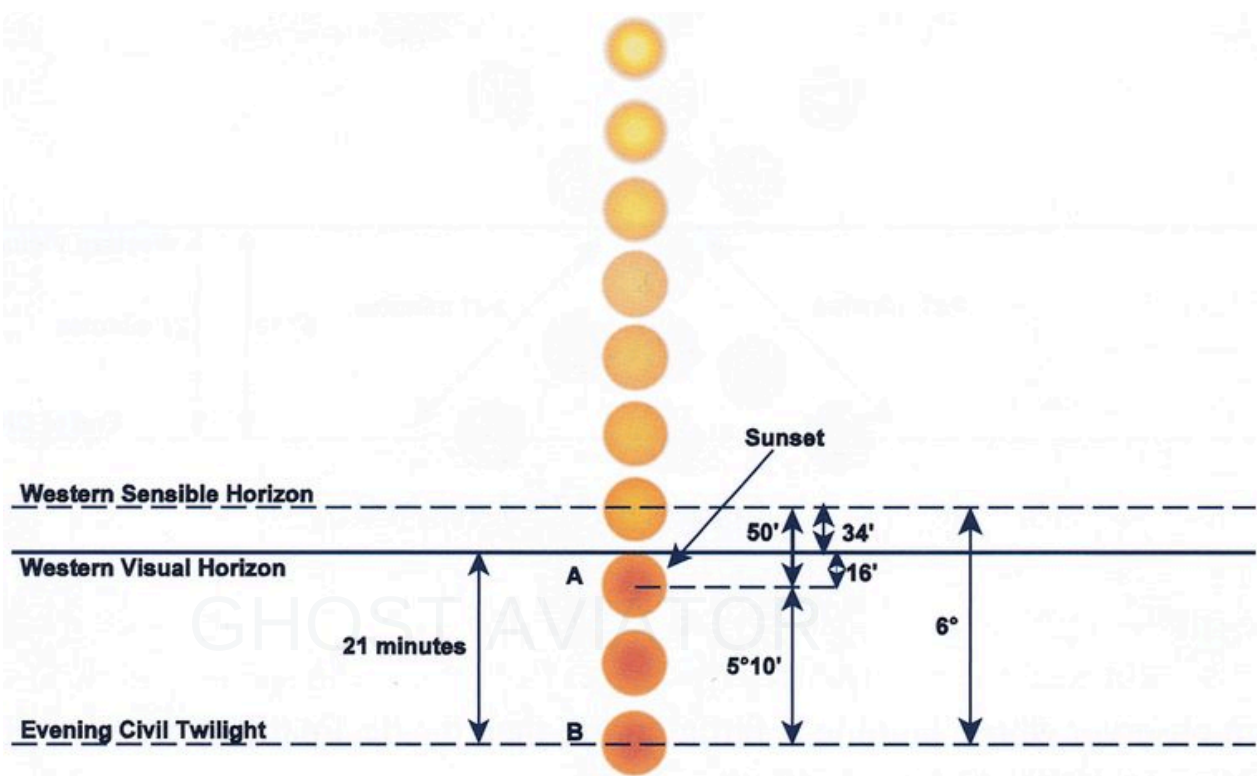


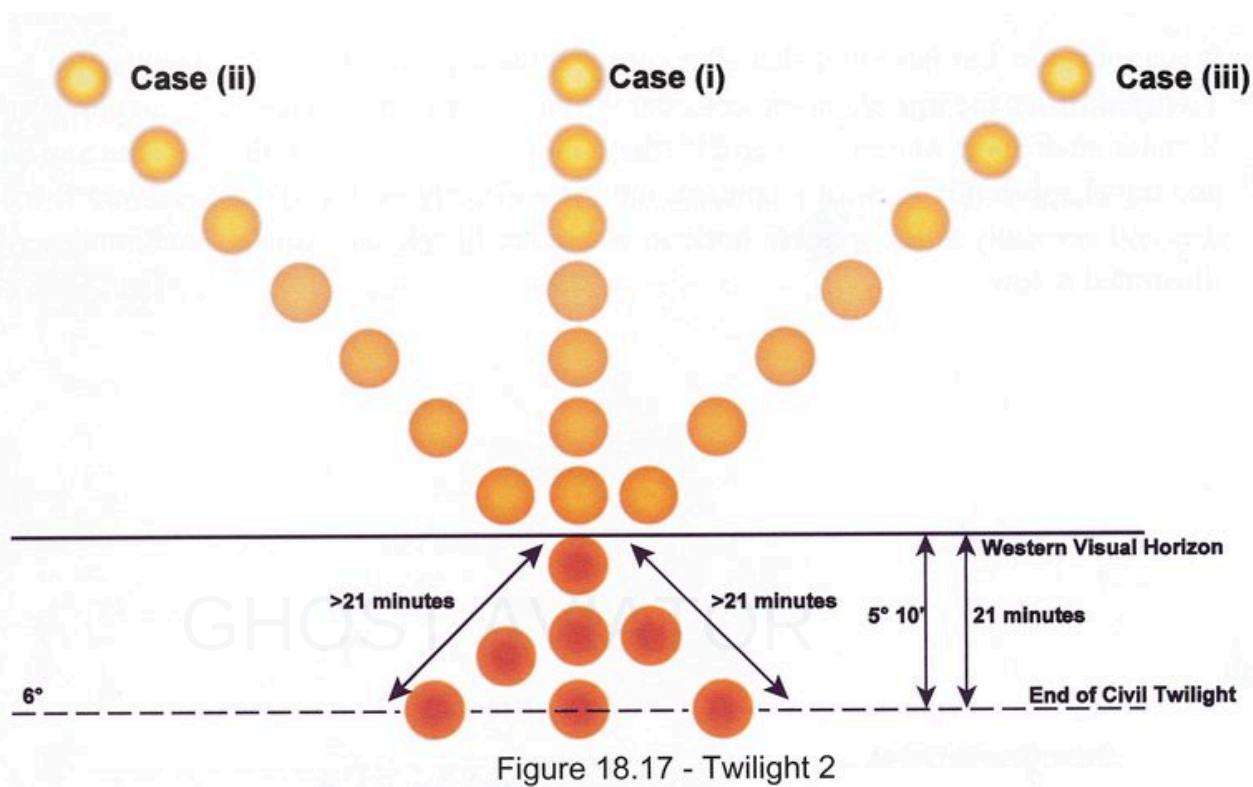
Figure 5 — Duration of civil twilight varies with latitude and season — shortest at the Equator and around the equinoxes

Minimum Duration of Civil Twilight

Between 60°N and 60°S, the minimum duration of civil twilight is **21 minutes**. This occurs at the Equator at the equinoxes, when the Sun sets most steeply.

Twilight Between the Equator and 60°N/S

As latitude increases, the Sun's path makes a shallower angle with the horizon at sunset. This means it takes longer for the Sun to descend through the 6° zone, so **twilight duration increases with latitude**.



Case (ii)

Figure 6 — Twilight duration comparison — at mid-latitudes, the Sun's shallower sunset path lengthens twilight considerably

Twilight in High Latitudes (above $\sim 60^\circ$)

In polar and sub-polar regions, extraordinary effects can occur:

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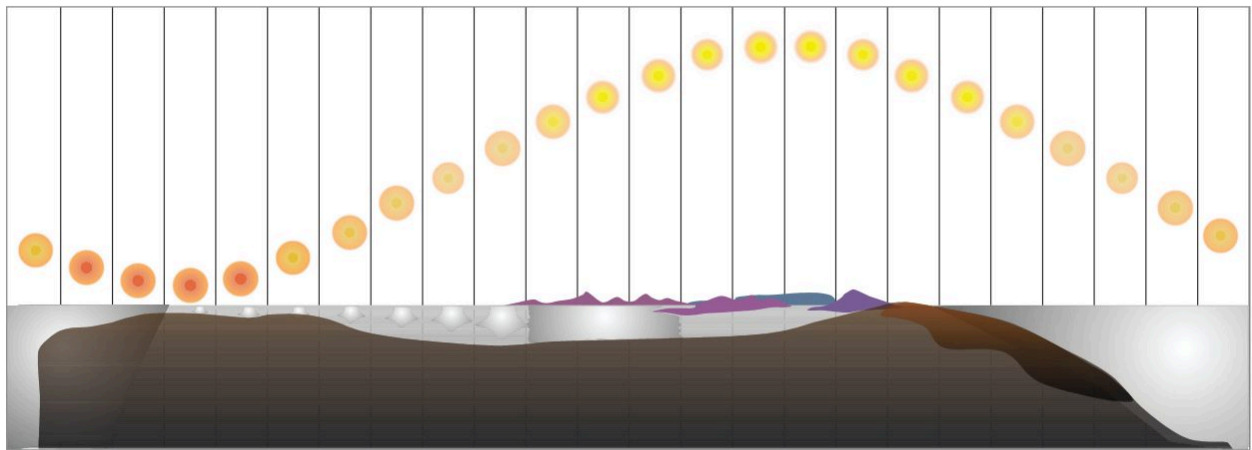


Figure 26.6 Twilight 3

The above illustration is based on a 360° time-lapse photograph taken in Lapland in mid-summer. Using the same diagram, we can illustrate what happens earlier or later than June 21 when the Sun is lower in the sky. Similarly, the Sun will be lower in the sky as the latitude of

Figure 7 — High latitude summer scenario — midnight Sun; the Sun remains above the horizon throughout the night

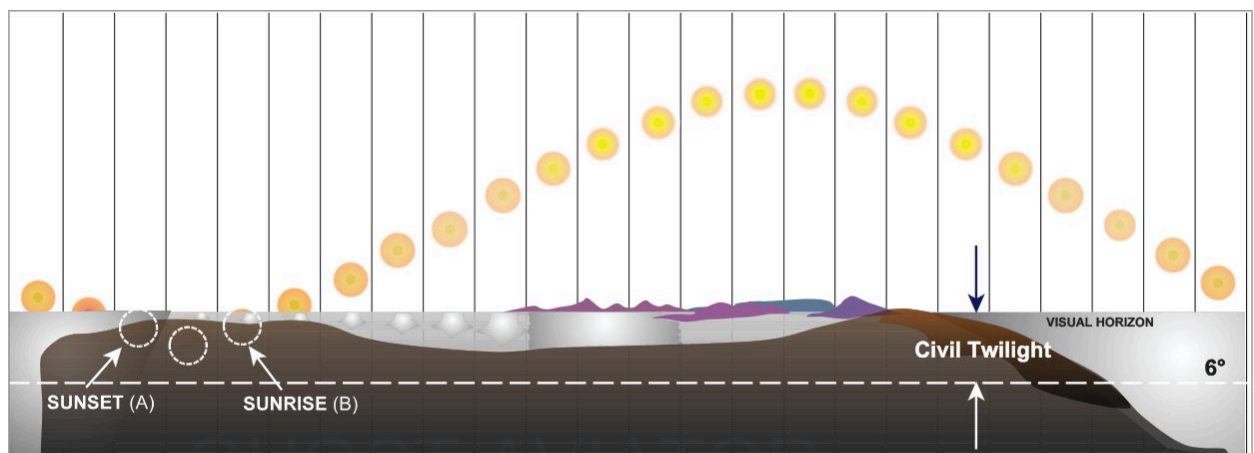


Figure 26.7 Twilight 4

In **Figure 26.7** the Sun sets at position A and rises at position B. Between the times of sunset (A) and sunrise (B), the Sun never goes below 6° below the sensible horizon. Thus it is:

Figure 8 — High latitude: permanent twilight — the Sun dips below the horizon but stays within the civil twilight zone (6°), so it is never truly dark

Permanent Twilight (////) — In high latitudes in summer, the Sun may remain within 6° of the horizon all night. It never rises (so no sunrise time listed) but never reaches true darkness

— this is shown as "//// " in the Air Almanac, indicating permanent civil twilight through the night.

Effect of Altitude on Sunrise/Sunset

The Air Almanac tables assume a *sea-level observer*. An aircraft at altitude has a depressed sensible horizon (the dip increases with altitude).

✈ At **FL350**, the depression of the horizon is approximately **3°**.

↑ **Sunrise is earlier** — you can see the Sun before it rises above the sea-level horizon.

↓ **Sunset is later** — you can still see the Sun after it has set at sea level.

🕒 **Duration of twilight is shorter** — because the Sun must travel 6° below the depressed sensible horizon (not the geometric horizon), and with the horizon already depressed by ~3°, this 6° arc is covered faster.

Air Almanac Table Methodology

The Air Almanac sunrise/sunset tables list LMT times for specific latitudes at 3-day intervals. To use them for an arbitrary position:

Step 1 — Interpolate for exact latitude between the two tabulated latitudes.

Step 2 — Interpolate for date between the two bracketing dates in the table.

Step 3 — Result is *LMT* of sunrise/sunset at your latitude.

Step 4 — Convert LMT → UTC using arc-to-time for your longitude (East: subtract; West: add).

Step 5 — If Standard Time is required, apply ST correction to UTC.

Practice Questions

Set 1 — Multiple Choice

- ▼ Q1. On June 21, what is the lowest northerly latitude (in the Air Almanac) at which the Sun is above the horizon for 24 hours?

a) 64°N

b) 66°N

c) 68°N

d) 70°N

Answer: (b) — The Arctic Circle is at approximately 66.5°N. On June 21 (summer solstice), the Air Almanac shows 66°N as the lowest tabulated latitude where the Sun stays above the horizon all day.

- ▼ Q2. On December 21, what is the lowest northerly latitude at which the Sun never rises?

a) 64°N

b) 66°N

c) 68°N

d) 70°N

Answer: (c) — On the winter solstice (December 21), the Air Almanac extract shows that polar night (Sun never rises) begins at 68°N as the lowest latitude listed where this occurs.

- ▼ Q3. Civil twilight is: (choose all that apply)

- a) The period between sunset and ECT
- b) The period between MCT and sunrise
- c) Related to the Sun's centre being 6° below the sensible horizon
- d) A period when daylight tasks are possible without artificial lighting
- e) Used in the EU-OPS definition of day/night flying
- f) All of the above**

Answer: (f) — All five statements (a through e) correctly describe civil twilight. It is defined by the Sun being 0° – 6° below the sensible horizon, it encompasses both morning (MCT→SR) and evening (SS→ECT) periods, it is bright enough for most outdoor tasks, and it is used in EU-OPS regulations to define day vs. night operations.

▼ **Q4. Nautical twilight occurs when the Sun is between _____ and _____ below the sensible horizon:**

- a) $0^\circ/6^\circ$
- b) $6^\circ/12^\circ$**
- c) $12^\circ/18^\circ$
- d) $18^\circ/24^\circ$

Answer: (b) — Twilight types: Civil = 0° – 6° , Nautical = 6° – 12° , Astronomical = 12° – 18° below the sensible horizon.

▼ **Q5. Between 60°N and 60°S , the minimum duration of Civil Twilight is:**

- a) 21 minutes**
- b) 16 minutes
- c) 14 minutes
- d) 30 minutes

Answer: (a) — The minimum duration of civil twilight between 60°N and 60°S is 21 minutes. This minimum occurs at the Equator at the equinoxes, where the Sun sets most steeply (perpendicular to the horizon) and traverses the 6° twilight zone most quickly.

▼ **Q6. An aircraft at FL350 would experience: Sunrise _____, Sunset _____, twilight duration _____**

- a) later / earlier / longer
- b) earlier / later / not change
- c) later / earlier / not change
- d) earlier / later / shorter

Answer: (d) — At altitude, the sensible horizon is depressed by approximately 3° at FL350. This means the Sun is visible before it rises above the sea-level horizon (earlier sunrise) and after it has set at sea level (later sunset). Twilight is SHORTER: since the horizon is depressed ~3°, the Sun only needs to travel a net ~3° below the geometric horizon to be 6° below the depressed sensible horizon — reaching ECT/MCT faster.

Set 2 — Air Almanac Calculation Problems (Worked Solutions)

▼ **Q1. At 30°00'S 124°14'E on 9th August: LMT of SR, SS, MCT, ECT?**

From Air Almanac, 30S on 9 August:

SR 0640 LMT | SS 1732 LMT

MCT 0615 LMT | ECT 1757 LMT

These values are read directly from the Air Almanac for 30°S on 9th August. Interpolation for exact latitude (30°S = tabulated exactly) gives the values above.

▼ **Q2. Duration of morning civil twilight for all positions in lat 55°N on 28th June. What do symbols ●, ☾, //// mean?**

At 55°N on 28 June:

SR 0323 LMT

MCT 0225 LMT

Duration of MCT: 58 minutes

Symbols:

● = Sun continuously above horizon (Midnight Sun)

☾ = Sun continuously below horizon (Polar Night)

//// = Permanent twilight (Sun below horizon but within 6° – never fully dark)

▼ **Q3. UTC of sunset at Karachi (24°54'N 067°10'E) Pakistan on 18th August. Also find duration of evening civil twilight.**

SS @ 25N, 18 Aug 1833 LMT

Arc/Time 067°10'E -4:29

SS UTC 1404 UTC

ECT 1857 LMT

SS 1833 LMT

Duration of ECT: 24 minutes

▼ **Q4. Interval between ECT on 14th October and MCT on 15th October at 60°N.**

14 Oct ECT @ 60N 1738 LMT

15 Oct MCT @ 60N 0556 LMT

Interval (darkness): 12h 18min

▼ **Q5. For Perth (31°57'S 115°57'E) Western Australia on 3rd January: (a) LMT SR, (b) UTC SS, (c) ST of ECT**

a) SR LMT (Perth, 3 Jan) 0458 LMT

b) SS LMT (Perth, 3 Jan) 1910 LMT

Arc/Time 115°57'E -7:44

SS UTC 1126 UTC

c) ECT LMT 1938 LMT

Arc/Time 115°57'E -7:44

ECT UTC 1154 UTC

WA ST correction +8:00

ECT Standard Time 1954 ST

▼ **Q6. Buenos Aires (35°00'S 052°29'W): (a) UTC of SR on 9th September, (b) ST of SS on 25th July**

a) SR @ 35S, 9 Sep 0609 LMT

Arc/Time 052°29'W +3:30

SR UTC 0939 UTC

b) SS @ 35S, 25 Jul 1713 LMT

Arc/Time 052°29'W +3:30

SS UTC 2043 UTC

Argentina ST -3:00

SS Standard Time 1743 ST

- ▼ **Q7. At 1500 UTC on 4th July, what is the Standard Time at (a) New York DST, (b) Christmas Island Indian Ocean, (c) Algeria, (d) Tonga?**

UTC = 1500 on 4 July

- a) New York (DST=-4) 1100 DST on 4 July
- b) Christmas Is (IO +7) 2200 ST on 4 July
- c) Algeria (+1) 1600 ST on 4 July
- d) Tonga (+13) 0400 ST on 5 July

- ▼ **Q8. Find UTC and date for: (a) 0400 ST Madrid Spain 5 Nov, (b) 1215 LMT Wellington 10 Jul, (c) 2200 UTC Singapore Flight Ops clock**

a) Madrid 0400 ST 5 Nov (Spain +1):

ST -1 0300 UTC 5 November

b) Wellington 1215 LMT 10 Jul (174°46'E):

Arc/Time 174°46'E -11:39

0036 UTC 10 July

c) Singapore Flight Ops clock = UTC:

2200 UTC 18 September

Singapore International Airport Flight Operations uses UTC on their clocks — hence the answer is simply 2200 UTC on 18 September.

- ▼ **Q9. Difference in LMT between Kabul (34°30'N 070°00'E) and Thule (69°30'N 054°00'W). Which is fast?**

Total longitude difference: 070°E + 054°W = 124°00'

Arc/Time 124° = 8 hours 16 minutes

Kabul (East) is 8h 16min FAST on Thule

- ▼ **Q10. Rome (41°50'N 012°30'E) departs at sunset 3 Aug → New York (40°00'N 075°00'W) lands at ECT same day. Flight time?**

SS Rome, 3 Aug 1917 LMT

Arc/Time 012°30'E -0:50

SS Rome UTC 1827 UTC

ECT New York, 3 Aug 1942 LMT

Arc/Time 075°00'W +5:00

ECT NY UTC 0042 UTC (4 Aug)

Flight Time: 1827 UTC → 0042 UTC = 6h 15min

- ▼ **Q11. Tokyo (36°N 140°E) to Hawaii (22°N 157°52'W), departs 1h after SR on 14 Nov, flight 6h 12min. Find ST and date of landing Hawaii.**

SR Tokyo, 14 Nov 0634 LMT

Take-off LMT 0734 LMT (1h after SR)

Arc/Time 140°E -9:20

Take-off UTC 2214 UTC 13 November

Flight time +6:12

Landing UTC 0426 UTC 14 November

Hawaii ST (-10) -10:00

Landing ST Hawaii 1826 ST on 13 November

Crossing the IDL westbound (Japan → Hawaii going east), the date goes back — landing UTC 14 Nov becomes 13 Nov Hawaii Standard Time.

- ▼ **Q12. At 018°15'E on 29th October, the observer sees the Sun rise at 0355 UTC. What is his latitude?**

SR UTC 0355

Arc/Time 018°15'E -1:13

SR LMT 0508 LMT

Look up SR = 0508 in Air Almanac for 29 Oct → Latitude 30°S

- ▼ **Q13. South Georgia (60°S 037°15'W) — observer sees sunset at watch time 2257 on 19 November. Is watch fast or slow on UTC?**

SS @ 60S, 19 Nov 2026 LMT

Arc/Time 037°15'W +2:29

SS UTC 2255 UTC

Observer's watch 2257

Difference: watch - UTC = 2257 - 2255 = 2 minutes

Watch is 2 minutes FAST on UTC

- ▼ **Q14. Must land Anchorage (61°N 149°W) Alaska at ECT on 25 Sept. Flight from Hong Kong (22°N 109°14'E) takes 10h 45min. Latest departure ST from HK?**

ECT Anchorage, 25 Sep 1836 LMT

Arc/Time 149°00'W +9:56

ECT Anchorage UTC 0432 UTC 26 September

Flight time -10:45

Take-off UTC 1747 UTC 25 September

HK ST (+8) +8:00

Latest departure HK ST 0147 ST 26 September

▼ **Q15. LMT and date at A (35°N 178°W) when it is 2020 LMT on 28th October at B (70°S 176°E)?**

LMT at B (176°E) 2020 on 28 October

Arc/Time 176°E -11:44

UTC 0836 on 28 October

Arc/Time 178°W -11:52

LMT at A (178°W) 2044 on 27 October

A is at 178°W — west of the 180° dateline. Converting through UTC gives a date one day earlier than at B (which is at 176°E , east of the dateline).

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