

CHAPTER 25

Time (2)

Arc-to-Time conversion, Local Mean Time, UTC, Zone Time, and the International Date Line.

 Arc ↔ Time LMT & UTC Zone Time Date Line

Conversion of Arc to Time

Since the Earth rotates 360° in 24 hours, there is a direct relationship between *longitude (arc)* and *time*. This is the fundamental link between geographic position and local time.

The Core Conversion Rule

360° of longitude = 24 hours → divide by 360:

360°
= 24 h 00 min

15°
= 1 h 00 min

1°
= 0 h 04 min

$1'$
= 0 h 00 min 04 sec

$30'$
= 0 h 02 min

$45'$
= 0 h 03 min

Worked Example (Q1 from practice set): Convert $153^\circ 30'$ to time.

$153^\circ \times 4 = 612 \text{ min} = 10 \text{ h } 12 \text{ min}$

$30' \times 4 \text{ sec} = 120 \text{ sec} = 2 \text{ min}$

Total = 10 h 14 min ✓ (Answer: c)

Degrees

Hours:Min

Degrees

Hours:Min

Degrees

Hours:Min

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15°	1:00	90°	6:00	180°	12:00
30°	2:00	105°	7:00	270°	18:00
45°	3:00	120°	8:00	300°	20:00
60°	4:00	135°	9:00	330°	22:00
75°	5:00	150°	10:00	360°	24:00

Local Mean Time (LMT)

Local Mean Time is based on the position of the *mean Sun* relative to the observer's own meridian. It is the most natural form of local time.

 **Definition:** When the mean Sun transits (crosses) your meridian, it is **1200 LMT** at your location.

 When the mean Sun crosses your anti-meridian (opposite meridian), it is **0000 LMT** (midnight).

 Every degree of longitude represents exactly **4 minutes** of LMT difference.

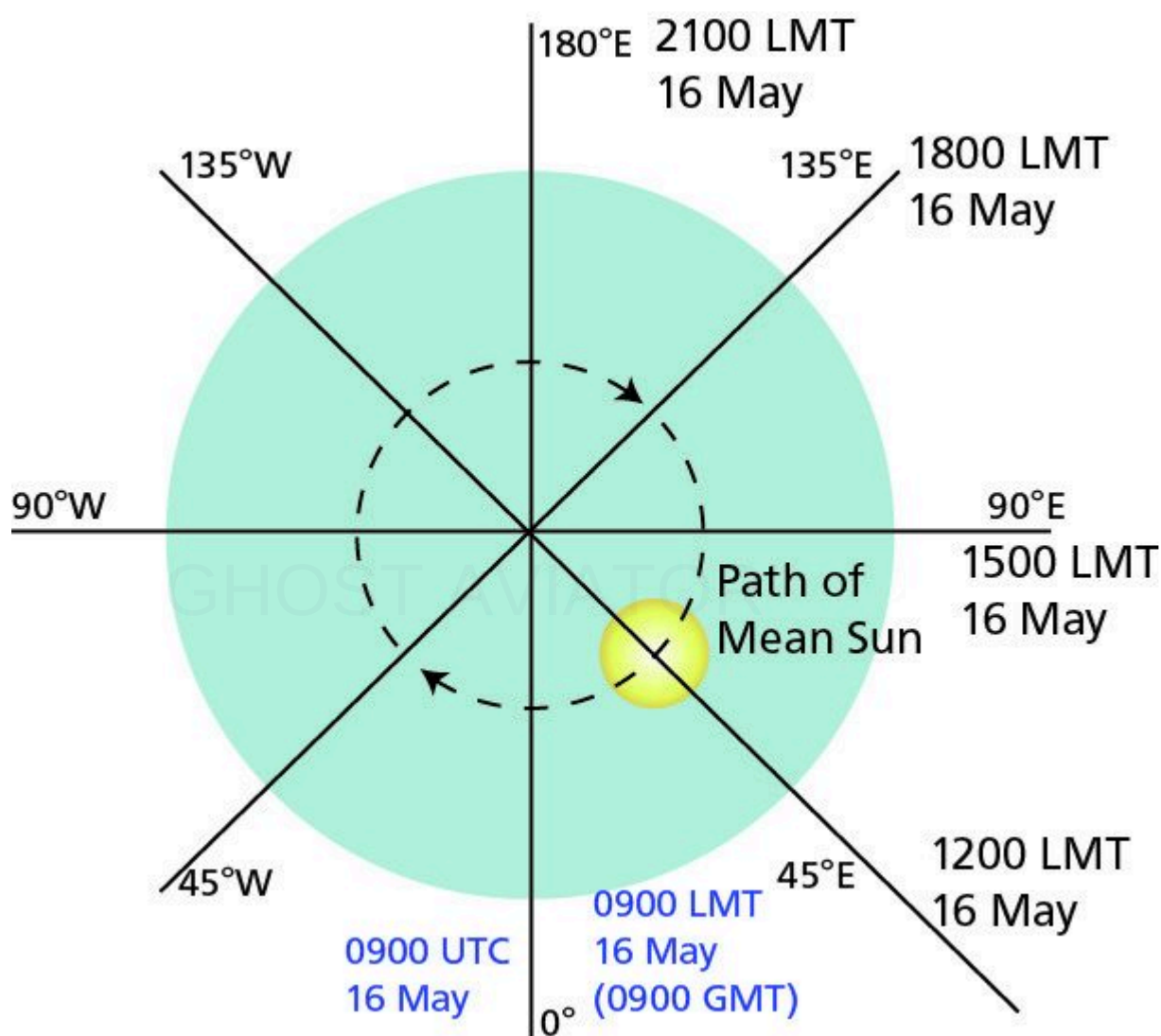


Figure 1 — Local Mean Time illustration — the mean Sun transiting the 45°E meridian shows 1200 LMT at all places on that meridian

LMT Calculation Rules

To convert LMT at one location to LMT at another — or to/from UTC:

→ **East of Greenwich:** $LMT = UTC + \text{arc/time}$ (East is ahead of UTC)

→ **West of Greenwich:** $LMT = UTC - \text{arc/time}$ (West is behind UTC)

Memory aid: **East = Add, West = Subtract** (EAWS / "Longitude East, UTC least")

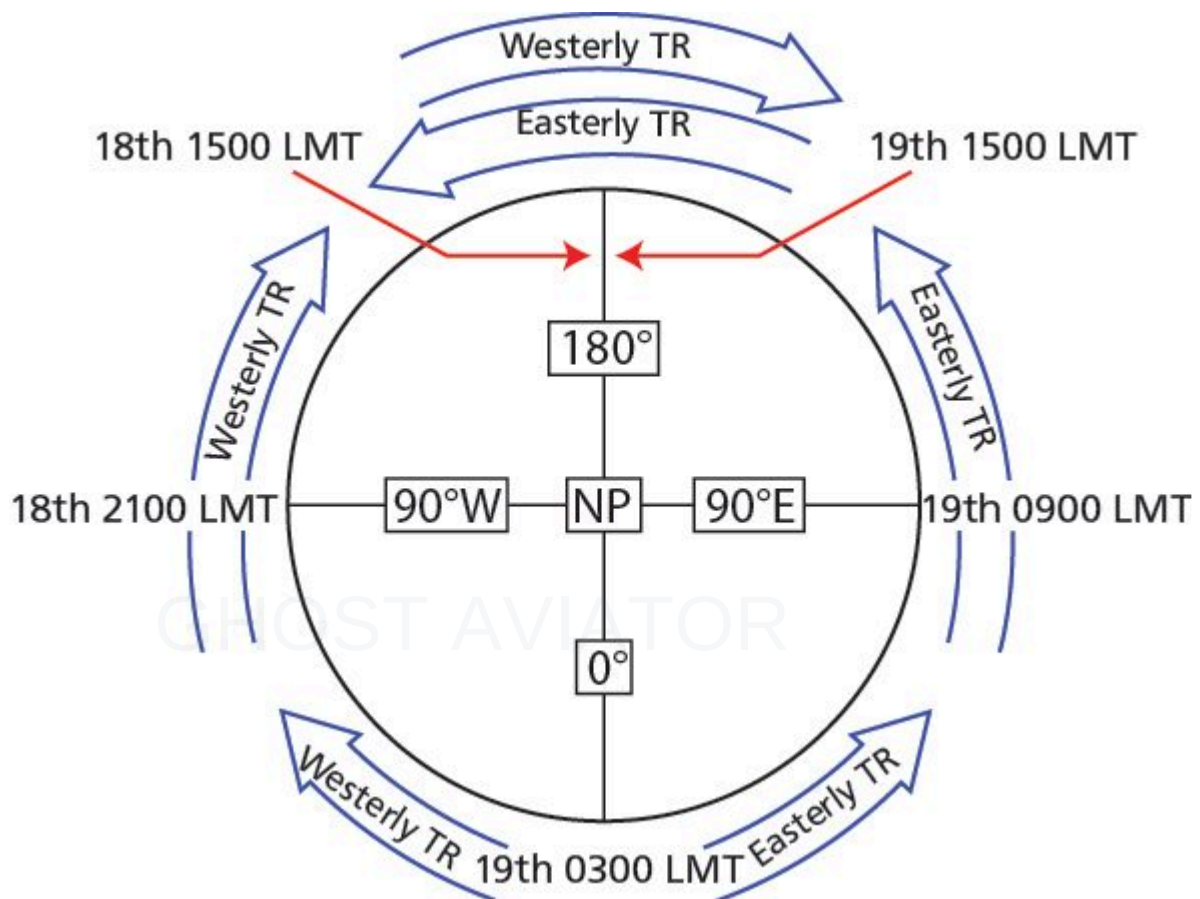


Figure 2 — The relationship between LMT at different longitudes, showing how the date can change when crossing the 180° meridian

Co-ordinated Universal Time (UTC)

UTC is a single, worldwide time standard based on the mean Sun as seen from the Greenwich Meridian (0°). All aviation uses UTC (also called Zulu time) for flight plans, NOTAMs, METARs, AIPs and ATC.

- ✓ UTC = LMT at 0° longitude (Greenwich)
- ✓ No seasonal adjustments — UTC is constant year-round
- ✓ Used for ALL aviation operations globally

Zone Time (ZT)

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Zone Time divides the Earth into 25 time zones, each approximately 15° of longitude wide (1 hour).

Zone Time is the system used by ships at sea and on trans-oceanic routes.

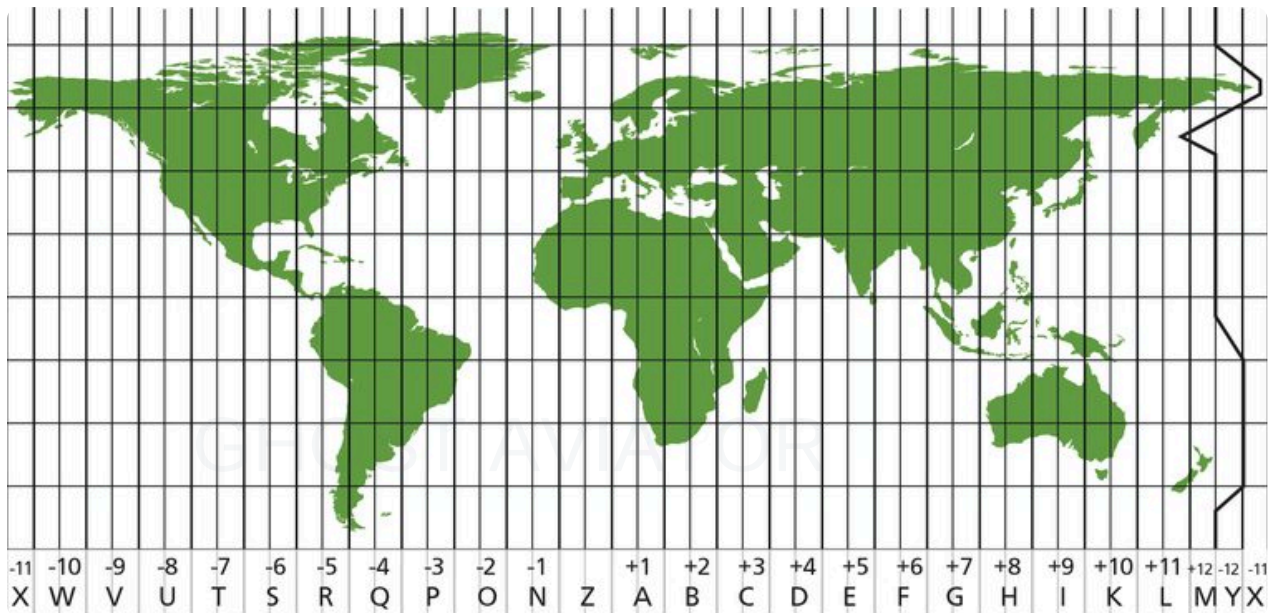


Figure 3 — The 25 Zone Time zones — each 15° wide, labelled A through Z (excluding J). Zones east of Greenwich are Fast (+); zones west are Slow (–)

Zone Time System

Each zone is assigned a *Zone Description (ZD)* — the number of hours to add or subtract to get UTC:

- Zone A (+1 hour from UTC), Zone B (+2 hours), ... Zone M (+12 hours)
- Zone N (–1 hour from UTC), Zone O (–2 hours), ... Zone Y (–12 hours)
- Zone Z = UTC itself (Greenwich meridian area)

Formula: $UTC = ZT + ZD$ (where ZD is negative for East zones when converting — add ZD to ZT to get UTC means subtract the fast description)

Simpler: $UTC = ZT - \text{Zone Description}$ (where zone descriptions are +ve for East, –ve for West)

Ship/aircraft use: At Zone boundary crossings, ships advance or retard clocks by 1 hour. Aircraft on polar routes may use a specific fixed Zone Time (often UTC or the departure/arrival zone).

The International Date Line

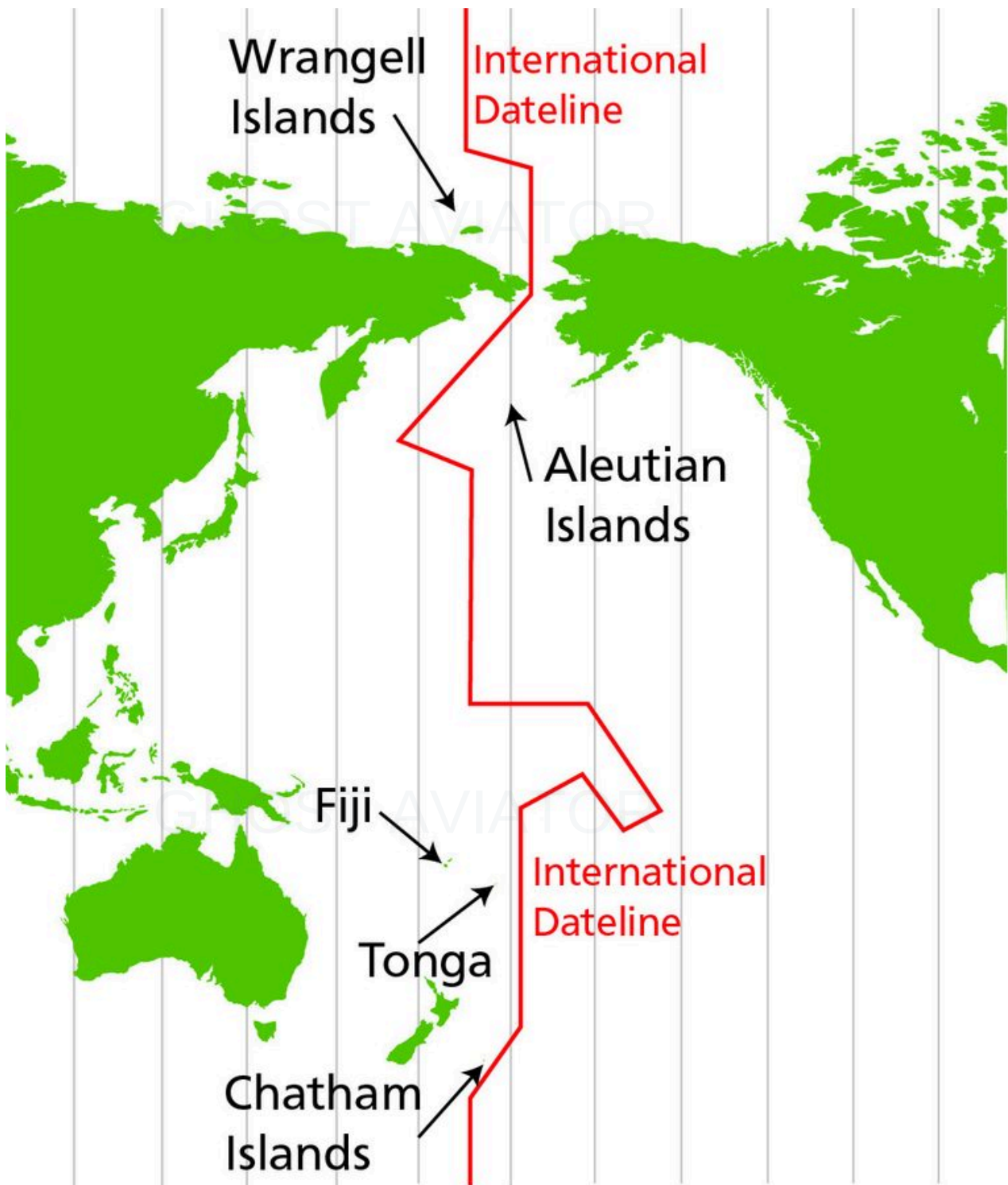


Figure 4 — The International Date Line — following the 180° meridian with deviations for Fiji, Tonga and other Pacific islands

The **International Date Line (IDL)** runs approximately along the 180° meridian (with deviations to keep island groups together). It is where the calendar date changes.

- **Crossing West to East** (travelling eastwards, e.g. Pacific → Americas): go **BACK one day** (subtract 24 hours / repeat the day).
- **Crossing East to West** (travelling westwards, e.g. Americas → Pacific): go **FORWARD one day** (add 24 hours / skip a day).

LMT boundary: At 180°E the LMT is 12 hours ahead of UTC. At 180°W the LMT is 12 hours behind UTC. These two times differ by 24 hours — hence the date must change at this meridian.

IDL Deviations: Fiji, Tonga and other islands have the IDL bent around them to maintain the same calendar date within each island group, even though some straddle the 180° line.

Standard Time (ST)

Standard Time is the *legal time* kept by a country, established by government legislation. It is usually based on Zone Time but can differ by half-hours or non-standard amounts.

Country/Region	Standard Time	Offset from UTC
Iraq	UTC+3	+3 hours
Libya	UTC+1	+1 hour
Tonga	UTC+13	+13 hours
Canada (Labrador)	UTC−4	−4 hours
New York (USA)	UTC−5	−5 hours
Ghana	UTC (no offset)	0 hours

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Hong Kong	UTC+8	+8 hours
Australia (NSW/QLD)	UTC+10	+10 hours
New Zealand	UTC+12	+12 hours
India	UTC+5:30	+5 h 30 min

Summer Time (Daylight Saving Time / DST): Many countries advance clocks by 1 hour during summer. Countries marked * in the Air Almanac may keep summer time. When DST is in effect, add 1 hour to Standard Time for the offset.

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Practice Questions

Set 1 — Multiple Choice

▼ **Q1. Without using the Air Almanac, convert $153^{\circ}30'$ of arc of longitude into time.**

- a) 10 hrs 24 min
- b) 10 hrs 22 min
- c) 10 hrs 14 min**
- d) 10 hrs 8 min

Answer: (c) — $153^{\circ} \times 4 \text{ min} = 612 \text{ min} = 10 \text{ h } 12 \text{ min}$. Plus $30' \times 4 \text{ sec} = 120 \text{ sec} = 2 \text{ min}$. Total = 10 h 14 min.

▼ **Q2. The definition of Local Mean Time (LMT) is:**

- a) time based upon the average movement of the Earth around the Sun.
- b) when the mean Sun is transiting your meridian, it is 1200 hrs LMT.

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c) when the mean Sun is transiting your anti-meridian, it is 0000 hrs LMT (2400 hrs LMT, previous day).

d) all of the above.

Answer: (d) — All three statements correctly define or describe properties of Local Mean Time. LMT is based on the *mean* (average) Sun, it is 1200 at meridian transit, and 0000 at anti-meridian transit.

▼ **Q3. Local Mean Time (LMT) always changes by a day when crossing:**

a) the Greenwich Meridian

b) 180°E/W

c) the International Date Line

d) the Equator

Answer: (b) — LMT (unlike Standard Time) changes by a full day at the *mathematical* 180° meridian. The International Date Line (IDL) follows this meridian but deviates for political reasons. The question asks specifically about LMT, which changes at the geometric 180°E/W line.

▼ **Q4. Zone Time (ZT) is used:**

a) by aircraft on trans-oceanic routes

b) as legal time in all countries

c) by ships at sea

d) in polar regions

Answer: (c) — Zone Time is the system used specifically by ships at sea. Aircraft use UTC. Countries use Standard Time (not necessarily Zone Time). Polar regions often use UTC or a designated Standard Time.

▼ **Q5. A ship at longitude 83°E observes sunrise at a Zone Time of 0500 ZT on Zone Date 15th May. What is the UTC?**

a) 2300 UTC 14th May

b) 1100 UTC 15th May

c) 2328 UTC 14th May

d) 1032 UTC 15th May

Answer: (a) — At 83°E, the zone description is +6 (nearest full zone: $83 \div 15 = 5.5 \rightarrow$ round to +6). $UTC = ZT - \text{Zone Description} = 0500 - 0600 = 2300$ on the previous day (14th May). Note: the zone boundary is at 82.5°E, so 83°E falls in Zone +6.

▼ **Q6. On Mid-summer Day in the Southern hemisphere, the Sun will be overhead:**

a) 66½°S

b) 23½°N

c) 23½°S

d) the Equator

Answer: (c) — SH Midsummer = December 21 (NH Winter Solstice). The Sun is overhead the Tropic of Capricorn at 23½°S.

▼ **Q7. On Mid-winter Day in the Northern hemisphere, the Sun will be overhead:**

a) 66½°S

b) 23½°N

c) 23½°S

d) the Equator

Answer: (c) — NH Midwinter = December 21. The Sun is overhead the Tropic of Capricorn at $23\frac{1}{2}^{\circ}\text{S}$. (Same solar position as Q6 — different hemisphere perspective, same answer.)

Set 2 — Calculation Problems

- ▼ **Q1.** At $48^{\circ}30'\text{N}$ $103^{\circ}15'\text{E}$ the time is 1045 LMT on 17th May. What is the LMT and local date at $48^{\circ}30'\text{S}$ $007^{\circ}15'\text{E}$?

LMT @ $103^{\circ}15'\text{E}$ 17th 10:45

Arc/Time $103^{\circ}15'\text{E}$ - 6:53 ($103^{\circ}\times 4\text{min} + 15'\times 4\text{sec} = 412+60 = 472\text{min} = 6\text{h}52\text{m} \rightarrow 6:53$ rounded)

UTC 17th 03:52

Arc/Time $007^{\circ}15'\text{E} + 0:29$ ($7^{\circ}\times 4 = 28\text{min} + 15'\times 4\text{sec} = 60\text{sec} = 1\text{min} \rightarrow 29\text{min}$)

LMT @ $007^{\circ}15'\text{E}$ 17th 04:21

Answer: 04:21 LMT on 17th May at $007^{\circ}15'\text{E}$.

- ▼ **Q2.** When LMT at 46°N $008^{\circ}30'\text{W}$ is 2300 on 9th May, what is the LMT at (a) 46°N $108^{\circ}30'\text{W}$ and (b) 46°N $108^{\circ}30'\text{E}$?

LMT @ $008^{\circ}30'\text{W}$ 9 May 23:00

a) Diff to $108^{\circ}30'\text{W} = 100^{\circ}00' \rightarrow \text{arc/time} = 6:40$

- 6:40

LMT @ $108^{\circ}30'\text{W}$ 9 May 16:20

b) Diff from $008^{\circ}30'\text{W}$ to $108^{\circ}30'\text{E} = 117^{\circ}00' \rightarrow \text{arc/time} = 7:48$ (note direction change: first to UTC then to East)

From LMT $008^{\circ}30'\text{W} \rightarrow \text{UTC}: +0:34$

UTC 9 May 23:34

Arc/Time $108^{\circ}30'\text{E} + 7:14$ ($108^{\circ}\times 4 + 30'\times 4\text{sec} = 432+120\text{sec} = 432+2 = 434\text{min} =$

7h14min)

LMT @ 108°30'E 10 May 06:48

Answers: (a) 16:20 LMT 9 May | (b) 06:48 LMT 10 May

- ▼ **Q3. At 1300 UTC on 1st April, find LMT and local date at (a) 54°30'N 007°15'E, (b) 16°27'S 107°43'W, (c) 18°46'N 168°35'E.**

UTC = 1300 on 1 April

a) 007°15'E Arc/Time +0:29

LMT 13:29 on 1 April

b) 107°43'W Arc/Time -7:11 (107×4=428, 43'×4sec=172sec=2m52s ≈ 7:11)

LMT 05:49 on 1 April

c) 168°35'E Arc/Time +11:14 (168×4=672, 35'×4sec=140sec=2m20s → 11:14:20)

LMT 00:14 on 2 April (crosses midnight → next day)

Answers: (a) 13:29 LMT 1 Apr | (b) 05:49 LMT 1 Apr | (c) 00:14 LMT 2 Apr

- ▼ **Q4. At 30°N 046°30'E the time is 0300 LMT. What is the time at 60°N 016°15'W in (a) UTC and (b) LMT?**

LMT @ 046°30'E 03:00

Arc/Time 046°30'E - 3:06

UTC 23:54 previous day

a) UTC = 23:54

Arc/Time $016^{\circ}15'W$ - 1:05 ($16 \times 4 = 64$, $15' \times 4 \text{sec} = 60 \text{sec} = 1 \text{min} \rightarrow 1:05$)

b) LMT @ $016^{\circ}15'W$ = 22:49 previous day

Answers: (a) UTC = 23:54 | (b) LMT @ $016^{\circ}15'W$ = 22:49 (previous day)

▼ **Q5. At 1400 UTC on 6th November, what is the Standard Time at Iraq, Libya, Tonga, Canada (Labrador), New York, and Ghana?**

UTC = 1400 on 6 November

Iraq +3 = 1700 ST 6 Nov

Libya +1 = 1500 ST 6 Nov

Tonga +13 = 0300 ST 7 Nov

Labrador -4 = 1000 ST 6 Nov

New York -5 = 0900 ST 6 Nov

Ghana UTC = 1400 ST 6 Nov

▼ **Q6. In position $48^{\circ}30'N$ $063^{\circ}57'W$ the LMT is 1430 on 10th February. What is the Standard Time in Hong Kong ($22^{\circ}20'N$ $114^{\circ}07'E$)?**

LMT @ $063^{\circ}57'W$ 10 Feb 14:30

Arc/Time $063^{\circ}57'W$ + 4:16 ($63 \times 4 = 252$, $57' \times 4 \text{sec} = 228 \text{sec} = 3 \text{m} 48 \text{s} \rightarrow 4:15:48 \approx 4:16$)

UTC 10 Feb 18:46

ST correction HK + 8:00

ST Hong Kong 11 Feb 02:46

Answer: 02:46 ST on 11th February in Hong Kong.

- ▼ **Q7. Wellington NZ (41°10'S 174°54'E) to Samoa (13°50'S 171°45'W), flight time 6h 15min. ETA Samoa is 2350 LMT 8th September. Find departure ST from Wellington.**

Arrival Samoa (LMT) 8 Sep 23:50

Arc/Time 171°45'W +11:27 (171×4=684, 45'×4sec=180sec=3min → 11:27)

Arrive Samoa (UTC) 9 Sep 11:17

Flight time - 6:15

Depart Wellington (UTC) 9 Sep 05:02

ST correction NZ +12:00

Depart Wellington (ST) 9 Sep 17:02

Answer: Depart Wellington at 17:02 ST on 9th September. Note: by flying east across the IDL, you effectively gain a day — Samoa LMT 2350 on 8th September is UTC 1117 on 9th September.

Set 3 — Extended Problems

- ▼ **Q1. Determine the LMT in Wellington, New Zealand (174°46'E) at 0730 UTC.**

UTC 0730

Arc/Time 174°46'E +11:39 (174×4=696, 46'×4sec=184sec=3m04s → 11:39:04 ≈ 11:39)

LMT Wellington 19:09

- ▼ **Q2. LMT in Boston, Massachusetts (071°08'W) is 1200. What is the UTC?**

LMT Boston 12:00

Arc/Time 071°08'W + 4:45 (71×4=284, 8'×4sec=32sec → 4:44:32 ≈ 4:45)

UTC 16:45

- ▼ **Q3. For 1335 UTC, find LMT in Honolulu ($157^{\circ}52'W$) and Standard Time in Sydney NSW ($151^{\circ}13'E$).**

UTC = 1335

a) Honolulu $-10:31$ ($157 \times 4 = 628$, $52' \times 4 \text{sec} = 208 \text{sec} = 3\text{m}28\text{s} \rightarrow 10:31:28 \approx 10:31$)

LMT Honolulu 03:04

b) Sydney NSW ST correction = $+10:00$

ST Sydney 23:35

- ▼ **Q4. Aircraft departs Brisbane QLD ($153^{\circ}02'E$) at 2200 UTC on 4th May, lands Manila Philippines ($120^{\circ}58'E$) 6h 45min later. Find LMT and ST at landing.**

Departure 2200 UTC 4 May

Flight time $+6:45$

Arrival UTC 04:45 UTC 5 May

Arc/Time $120^{\circ}58'E$ $+8:04$

LMT Manila 12:49 5 May

ST Philippines $+8:00$

ST Manila 12:45 5 May

- ▼ **Q5. By how much is LMT Bangkok ($101^{\circ}00'E$) later than LMT San Francisco ($122^{\circ}25'W$)?**

Bangkok $101^{\circ}E$ is ahead of UTC by: 6h 44min

San Francisco $122^{\circ}25'W$ is behind UTC by: 8h 10min

Total difference: 14h 54min

Bangkok LMT is 14h 54min LATER than San Francisco LMT.

- ▼ **Q6. Aircraft departs New York (075°W) at 0915 New York Summer Time for Vancouver BC ($123^{\circ}20'\text{W}$), flight time 5h 25min. Find ETA in Vancouver Standard Time.**

Departure 0915 New York Summer Time (DST = UTC-4)

ST correction +4:00 (Summer time → subtract 1 hour from normal ST
correction of -5 → effective UTC offset is -4)

Departure UTC 13:15

Flight time +5:25

Arrival UTC 18:40

Vancouver ST -8:00

ETA Vancouver ST 10:40

- ▼ **Q7. Rome ($012^{\circ}30'\text{E}$) to Hong Kong ($114^{\circ}00'\text{E}$), 21h 40min flight. Must land HK at 1835 ST. What is the Standard Time of departure from Rome?**

Arrival HK ST 18:35

HK ST correction -8:00

Arrival UTC 10:35

Flight time -21:40

Departure UTC 12:55 previous day

Rome ST +1:00

Departure Rome ST 13:55 previous day

- ▼ **Q8. Sydney NSW to Honolulu ($157^{\circ}52'\text{W}$), 9h 50min flight. Departs Sydney at 0930 ST on 8th May. Find LMT and local date of arrival in Honolulu.**

Departure Sydney ST 0930 8 May

ST correction NSW -10:00

Departure UTC 23:30 7 May

Flight time +9:50

Arrival UTC 09:20 8 May

Arc/Time 157°52'W -10:31

Arrival LMT Honolulu 22:49 7 May

Answer: 22:49 LMT on 7th May. The aircraft crosses the IDL travelling eastward, going back one calendar day despite flying forward in physical time.

- ▼ **Q9. Honolulu to Sydney NSW, 10h 20min flight. Departs Honolulu at 2300 ST on 10th May. Find ST of arrival at Sydney.**

Departure Honolulu ST 2300 10 May

Hawaii ST +10:00

Departure UTC 09:00 11 May

Flight time +10:20

Arrival UTC 19:20 11 May

NSW ST +10:00

Arrival ST Sydney 05:20 12 May

- ▼ **Q10. New York (073°45'W) to Madrid (003°33'W), departs 2000 ST 16th February, flight time 7h 45min. Find ST and date of arrival at Madrid.**

Departure New York ST 2000 16 Feb

NY ST correction +5:00

Departure UTC 01:00 17 Feb

Flight time +7:45

Arrival UTC 08:45 17 Feb

Madrid ST +1:00

Arrival Madrid ST 09:45 17 Feb

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