11.

WORLD LOCATIONS AND TIMES

The Samoan Islands lie in the south Pacific Ocean and are made up of Samoa and American Samoa, 64 km apart. New Zealand governed Samoa until it became an independent country in 1964, and it was called Western Samoa until 1997. American Samoa is a small territory of the USA. Despite being next to each other, when it is Monday in Samoa, it is still Sunday in American Samoa. How can this be so?

CHAPTER OUTLINE

IN THIS CHAPTER YOU WILL:

- locate positions on Earth using latitude and longitude
- convert between 12-hour and 24-hour time
- calculate differences between times of day
- interpret transport timetables and use them to solve problems involving travel
- calculate times in different parts of the world and within Australia using international time zones, taking daylight saving into account
- solve problems involving travelling and communicating across the world using international time zones

TERMINOLOGY

12-hour time
Coordinated Universal Time (UTC)
Equator
latitude
prime meridian
timetable
24-hour time
coordinates
great circle
longitude
small circle
Australian Eastern Standard Time (AEST)
daylight saving time
International Date Line (IDL)
parallel of latitude
time zone

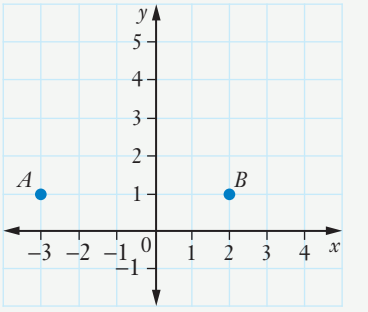
WS
Assignment 11

SkillCheck

1 **a** Write the coordinates of points A and B.

b What is the length of the interval AB?

c Write the coordinates of point C if it is 3 units up and 4 units left from B.



2 **a** Plot the points $D(3, 5)$ and $E(3, 2)$ on a number plane.

b What is the length of the interval DE?

3 How many hours between:

a 4 a.m. and 1 p.m.?

b 9 a.m. and 2 p.m.?

c 12:30 a.m. and 5:30 p.m.?

d 2:30 p.m. and 10:30 p.m.?

4 How many minutes between:

a 3:00 p.m. and 3:17 p.m.?

b 6:00 a.m. and 6:44 a.m.?

c 10:35 a.m. and 11:00 a.m.?

d 7:17 p.m. and 8:00 p.m.?

5 What is the time:

a 7 hours after 7:00 p.m.?

b 8 hours before 2:00 p.m.?

c 11 h 18 min after 1:15 p.m.?

d 7 h 36 min before 2:20 a.m.?

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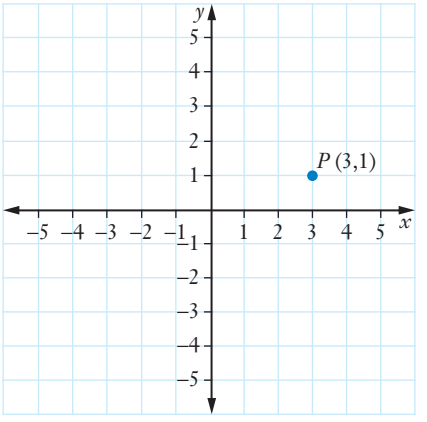
11.01 Latitude and longitude

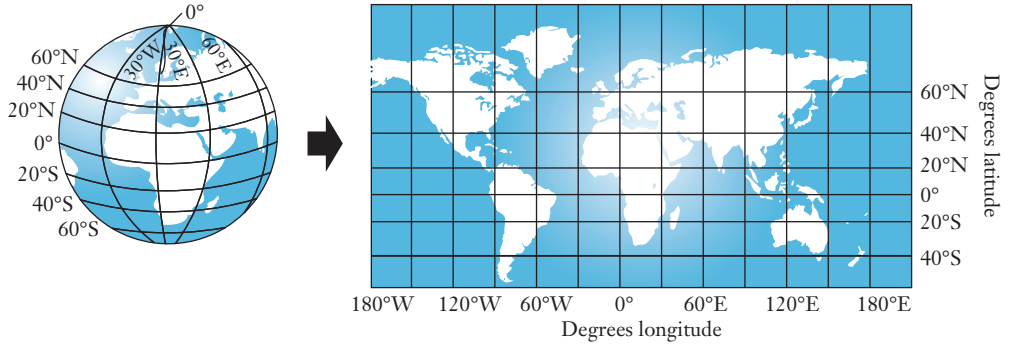
When describing the location of a point on a number plane or map, we use a **coordinate** system involving ordered pairs (x, y).



P has coordinates (3, 1) on this number plane.

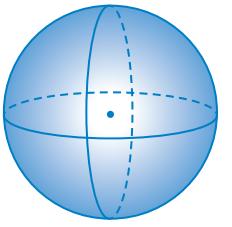
Hunters Hill Girls High School has coordinates D4 here.

Positions on Earth's surface are described by a coordinate system involving **latitude** and **longitude**. However, because Earth is a sphere, we use a special grid of lines that run across and down a sphere. The diagrams below show this grid on a world globe and a flat world map.

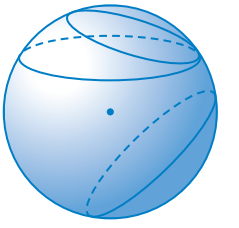


Great and small circles

If you cut a 'slice' through a sphere, its shape is a circle. A slice through the **centre** of a sphere is called a **great circle**, and its radius is the same as that of the sphere. Any other slice is called a **small circle**, because its radius is smaller than that of a great circle.



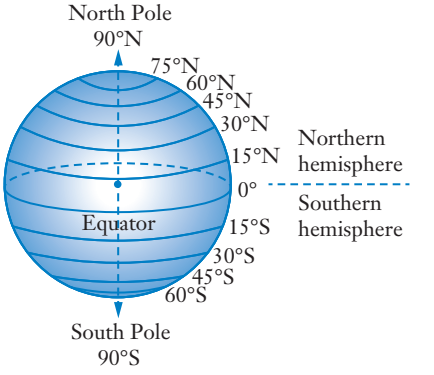
Great circles



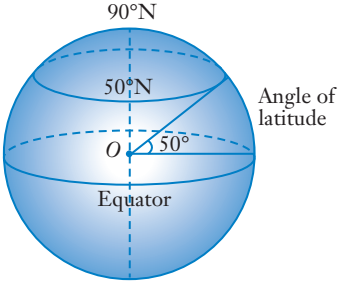
Small circles

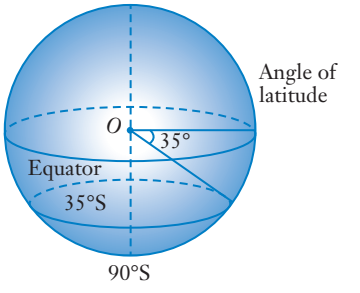
Parallels of latitude

Parallels of latitude are imaginary parallel circles that run around the Earth. The largest parallel of latitude is the **Equator**, 0°, which is a great circle. The other parallels of latitude are all small circles. The North Pole has a latitude 90° north (90°N). The South Pole has a latitude of 90°S.



The **angle of latitude** is the angle the parallel makes with the Equator at the centre, *O*, of the Earth. The diagrams below show the 50°N and 35°S parallels of latitude.





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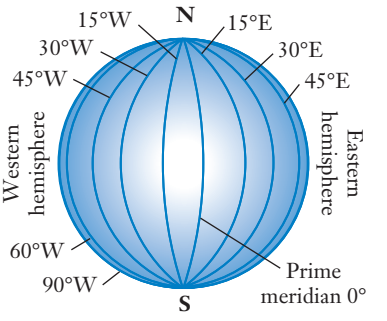
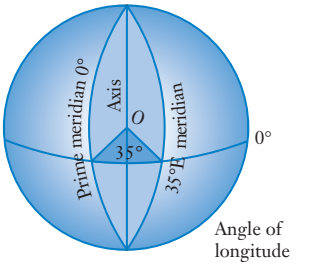
Meridians of longitude

Meridians of longitude are imaginary semicircles that run down the Earth. They are 'half' great circles that meet at the North and South poles. The main meridian of longitude is the **prime meridian** (or **Greenwich meridian**), 0°.

Greenwich is pronounced 'gren-itch'



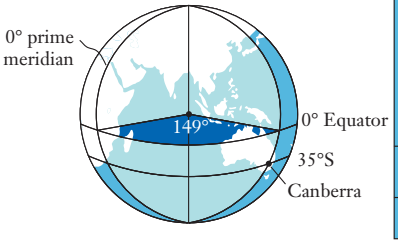
The **angle of longitude** is the angle the meridian makes with the prime meridian at the centre, *O*, of the Earth. The diagram shows the 35°E meridian of longitude.

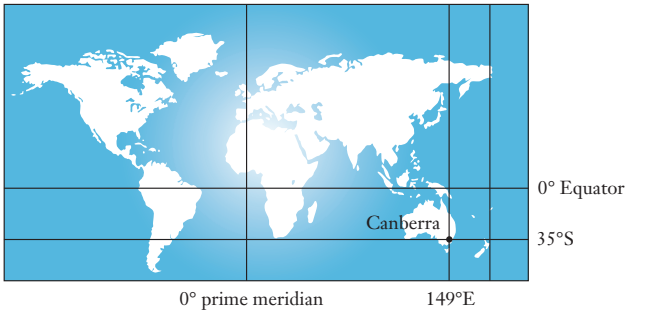


Meridians of longitude range from 180°E to 180°W. 180°E and 180°W are actually the same meridian, on the opposite side of the Earth to the prime meridian. It runs through the Pacific Ocean, east of Fiji and west of Hawaii.

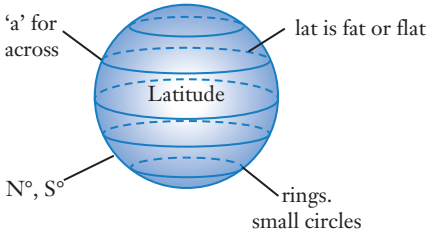
Position coordinates

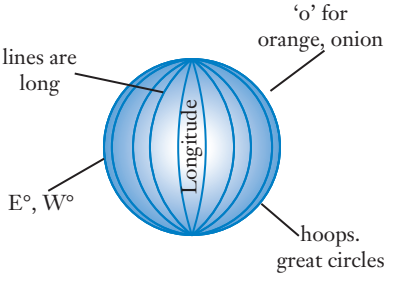
Locations on the Earth are described using latitude (°N or °S) and longitude (°E or °W). For example, Canberra has coordinates (35°S, 149°E), meaning it is 35° south of the Equator and 149° east of the prime meridian.





These diagrams show some mnemonics for understanding latitude and longitude.





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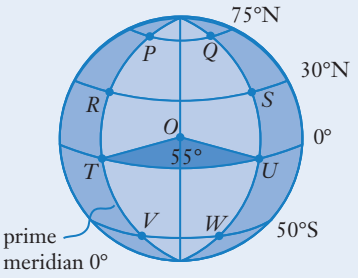
EXAMPLE 1

Match the following coordinates to the points illustrated.

a (50°S, 55°E)
b (30°N, 55°E)
c (75°N, 0°E)
d (0°, 0°)
e (0°, 55°E)
f (75°N, 55°E)



Solution

Since $\angle TOU = 55°$, $QSUW$ is the 55°E meridian of longitude.

a (50°S, 55°E) is W
b (30°N, 55°E) is S
c (75°N, 0°E) is P
d (0°, 0°) is T
e (0°, 55°E) is U
f (75°N, 55°E) is Q

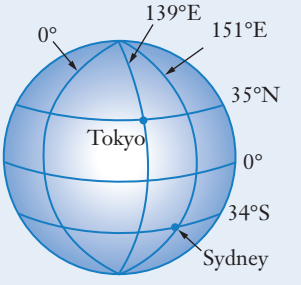
EXAMPLE 2

Sydney's coordinates are (34°S, 151°E) while Tokyo's are (35°N, 139°E).

a Find their difference in latitude.
b Find their difference in longitude.
c Which city is further west?

Solution

Draw a rough sketch to position the cities.



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a Difference in latitude = 35° + 34° = 69° Difference between 35°N and 34°S.

b Difference in longitude = 151° − 139° = 12° Difference between 151°E and 139°E.

c Sydney is further east, so Tokyo is further west.

EXAMPLE 3

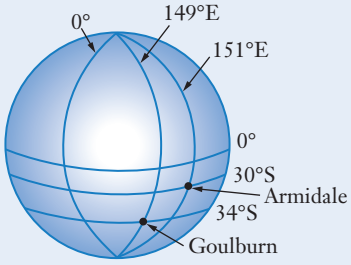
Goulburn has coordinates (34°S, 149°E). If Armidale is 4° north and 2° east of Goulburn, what are its coordinates?

Solution

Latitude = 34°S − 4° = 30°S

Longitude = 149°E + 2° = 151°E

The coordinates of Armidale are (30°S, 151°E).



Exercise 11.01 Latitude and longitude

Note: An atlas and/or a world globe may be helpful for this exercise.

Example 1

1 Match each set of coordinates to a point on Earth.

a (0°, 100°E)

b (40°S, 60°E)

c (60°N, 60°E)

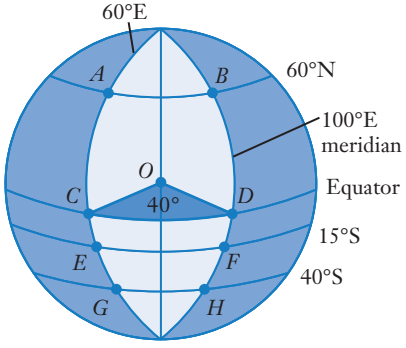
d (0°, 60°E)

e (15°S, 100°E)

f (60°N, 100°E)

g (15°S, 60°E)

h (40°S, 100°E)



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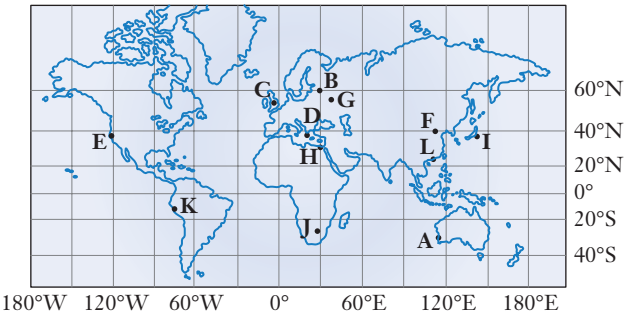
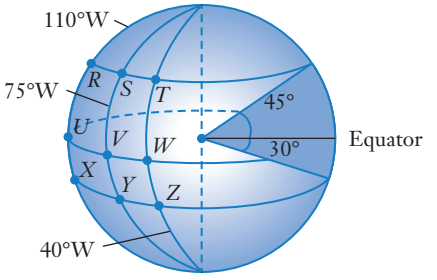
2 Match each city to a letter on the map below.

a Moscow (55°N, 37°E)
b Edinburgh (56°N, 3°W)
c Athens (38°N, 23°E)
d San Francisco (38°N, 122°W)
e Perth (32°S, 116°E)
f Beijing (40°N, 116°E)
g Alexandria (31°N, 30°E)
h Tokyo (35°N, 139°E)
i St Petersburg (60°N, 30°E)
j Johannesburg (26°S, 28°E)
k Lima (12°S, 77°W)
l Hong Kong (22°N, 114°E)



3 Write the coordinates of each of the points on Earth.



a V
b T
c U
d Z
e R
f W
g X
h S

4 What can be found at the 90°S parallel of latitude?

5 Are these small circles or great circles?

a the 30°N parallel
b the prime meridian
c the 145°W meridian

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6 Calculate the difference in latitude between each pair of cities, and state whether the second city listed is north or south of the first.

- **a** Shanghai, China (31°N, 121°E) and New York, USA (40°N, 64°W)
- **b** Nairobi, Kenya (1°S, 37°E) and Bangkok, Thailand (13°N, 100°E)
- **c** Moscow, Russia (55°N, 37°E) and London, UK (51°N, 0°)
- **d** Auckland, New Zealand (37°S, 174°E) and Canberra (35°S, 149°E)
- **e** Melbourne (37°S, 145°E) and Cairo, Egypt (30°N, 31°E)
- **f** Newcastle (33°S, 151°E) and West Wyalong (34°S, 147°E)

7 **a** Deniliquin is 1° due south of Hay. If Hay's coordinates are (34°S, 145°E), what are Deniliquin's coordinates? Select **A, B, C** or **D**.

A (34°S, 144°E) **B** (35°S, 145°E) **C** (33°S, 145°E) **D** (34°S, 146°E)

b Lord Howe Island is 6° due east of Forster. If Forster's coordinates are (32°S, 152°E) what are Lord Howe Island's coordinates? Select **A, B, C** or **D**.

A (32°S, 146°E) **B** (38°S, 152°E) **C** (32°S, 158°E) **D** (26°S, 158°E)

8 Calculate the difference in longitude between each pair of cities, and state whether the second city listed is east or west of the first.

Example 2

- **a** Budapest, Hungary (47°N, 19°E) and Miami, USA (25°N, 80°W)
- **b** Athens, Greece (38°N, 23°E) and Paris, France (49°N, 2°E)
- **c** Havana, Cuba (23°N, 82°W) and Mexico City, Mexico (19°N, 99°W)
- **d** Buenos Aires, Argentina (34°S, 58°W) and Johannesburg, South Africa (26°S, 28°E)
- **e** Manila, Philippines (14°N, 121°E) and Port Moresby, Papua New Guinea (9°S, 147°E)
- **f** Finley (35°S, 145°E) and Bourke (30°S, 146°E)

9 Broken Hill is 7° due west of Dubbo. If Dubbo's position is (32°S, 148°E), what is Broken Hill's position?

10 Ipswich is 2° north and 2° east of Moree (29°S, 150°E). What are Ipswich's coordinates?

Example 3

11 Ballarat is 2° south and 6° west of Batemans Bay (35°S, 150°E). What are the coordinates of Ballarat? Select **A, B, C** or **D**.

A (33°S, 144°E) **B** (37°S, 156°E) **C** (33°S, 156°E) **D** (37°S, 144°E)

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12 **a** In Australia, do Sydney and Tamworth lie on the same line of latitude or longitude?

b Do Athens, Greece and Sicily, Italy, lie on the same line of latitude or longitude?

13 Where on Earth is it possible to stand on every meridian of longitude?

INVESTIGATION

ATLAS ACTIVITIES

Use an atlas or the Internet to locate the positions of different places around the world. Some websites give the coordinates of any city you type in, for example, Google Earth lists the coordinates at the bottom of the page.

1 Use a world map or globe to estimate the coordinates of each city.

a Washington DC, USA **b** Singapore **c** Adelaide, Australia

d Dublin, Ireland **e** Lisbon, Portugal **f** Moscow, Russia

2 Find the actual coordinates of the cities from Question **1**, and then list them in order from:

a west to east **b** north to south.

3 Which city is located at:

a (19°N, 155°W)? **b** (14°N, 121°E)? **c** (34°S, 58°W)?

d (42°N, 12°E)? **e** (12°S, 131°E)? **f** (42°N, 87°W)?

4 How does a flat map distort the positions and sizes of places with high latitudes?

5 Investigate where these regions are in the world and how they got their names.

a the Middle East **b** the Orient **c** Western world

d the Antipodes **e** Ecuador **f** the West Indies

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11.02 Time

Time notation

- **12-hour time:** using a.m. and p.m. and the hours 1 to 12
- **24-hour time:** using 4 digits from 0000 to 2359 with no a.m./p.m.

With **24-hour time,** the hours are numbered from 0 (for midnight) to 12 (for midday) to 23 (for 11 p.m.).

24-hour time	12-hour time
0000	12 a.m. (midnight)
0100	1 a.m.
0200	2 a.m.
0300	3 a.m.
0400	4 a.m.
0500	5 a.m.
0600	6 a.m.
0700	7 a.m.
0800	8 a.m.
0900	9 a.m.
1000	10 a.m.
1100	11 a.m.

24-hour time	12-hour time
1200	12 p.m. (midday)
1300	1 p.m.
1400	2 p.m.
1500	3 p.m.
1600	4 p.m.
1700	5 p.m.
1800	6 p.m.
1900	7 p.m.
2000	8 p.m.
2100	9 p.m.
2200	10 p.m.
2300	11 p.m.

WS 12-hour and 24-hour time

WS 24-hour time on an analog clock

WS TV times

EXAMPLE 4

Convert each 24-hour time to 12-hour time.

a 1020 **b** 2335 **c** 0048

Solution

We know that 1200 is midday, when a.m. becomes p.m.

a 10 is less than 12, so it is a.m. time.

1020 is 10:20 a.m.

b 23 is greater than 12, so it is p.m. time.

23 – 12 = 11

2335 is 11:35 p.m.

c 00 is the midnight hour

0048 is 12:48 a.m.

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EXAMPLE 5

Convert each 12-hour time to 24-hour time.

a 7:18 a.m. **b** 2:50 p.m. **c** 12:33 a.m. **d** 12:04 p.m.

Solution

a For a.m. times from 1 a.m. onwards, write the time with 4 digits, starting with 0 if needed.

7:18 a.m. = 0718

b For p.m. times from 1 p.m. onwards, add 12 to the hour.

2 + 12 = 14.

2:50 p.m. = 1450

c 12 midnight = 0000

12:33 a.m. = 0033

d 12 midday = 1200

12:04 p.m. = 1204

Time differences

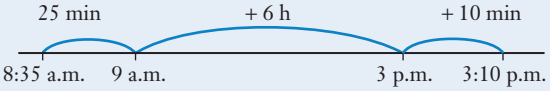
WS Time differences

EXAMPLE 6

What is the difference in time between 8:35 a.m. and 3:10 p.m.?

Solution

Draw a timeline showing the whole hours in between, and calculate the time differences in steps.



Time difference = 6 h + 25 min + 10 min
= 6 h 35 min

Alternative method

Convert to 24-hour time first, then use the calculator's o ' " or DMS key to subtract the times:

Time difference = 3:10 p.m. – 8:35 a.m.
= 1510 – 0835
= 6 h 35 min

15 o ' " 10 o ' " – 8 o ' " 35 o ' " =

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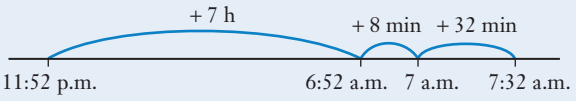
EXAMPLE 7

a What is the time 7 hours 40 minutes after 11:52 p.m.?

b What is the time 9 hours and 30 minutes before 7:38 a.m.?

Solution

a Draw a timeline starting at 11:52 p.m., then add the hours and minutes in steps.



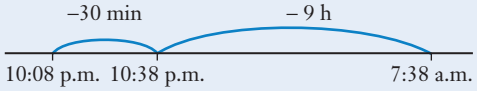
11:52 p.m. + 7 h = 6:52 a.m.

Add the minutes to the next whole hour:
6:52 a.m. + 8 min = 7 a.m.

Add the extra minutes: 7 a.m. + 32 min = 7:32 a.m. 8 min + 32 min = 40 min

So 7 h 40 min after 11:52 p.m. is 7:32 a.m.

b Draw a timeline ending at 7:38 a.m., and subtract the hours and minutes in steps.



7:38 a.m. – 9 h = 10:38 p.m.

Subtract 30 minutes: 10:38 p.m. – 30 min = 10:08 p.m.

So 9 h 30 min before 7:38 a.m. is 10:08 p.m.

Exercise 11.02 Time

1 Convert each 24-hour time to 12-hour time. Example 4

a 0845	**b** 1750	**c** 0019	**d** 1105	**e** 1628
f 0915	**g** 0240	**h** 2000	**i** 0625	**j** 1853

2 Convert each 12-hour time to 24-hour time. Example 5

a 7:35 p.m.	**b** 11:42 a.m.	**c** 11:59 p.m.	**d** 12:17 a.m.
e 12:30 p.m.	**f** 3:40 a.m.	**g** 7:10 a.m.	**h** 9:54 p.m.
i 10:18 p.m.	**j** 1:59 a.m.		

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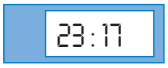
3 Write the time shown on this 24-hour clock in 12-hour time.



4 How would a 24-hour clock show these times?

a 7:30 a.m. **b** 1:15 a.m. **c** 5:10 p.m.

5 Write the time shown on this 12-hour clock in 24-hour time.

6 How would a 12-hour clock show these times?

a 2205 **b** 0545 **c** 1421

Example 6

7 What is the difference in time between 11:42 a.m. and 2:13 p.m.? Select **A, B, C** or **D.**

A 2 h 31 min **B** 3 h 55 min **C** 7 h 29 min **D** 11 h 55 min

8 Calculate the time difference between each pair of times.

a 6:15 p.m. and 8:10 p.m. **b** 1116 and 1206

c 4:10 a.m. and 8:55 a.m. **d** 11:25 p.m. and 3:20 a.m.

e 0725 and 1310 **f** 2120 and 0815

9 A film starts at 3:17 p.m. and ends at 5:09 p.m. How long is the film?

Example 7

10 Find the time:

a 6 hours after 2 p.m. **b** 3 hours before 10 a.m.

c 20 minutes before 7:15 p.m. **d** 2 h 32 min after 10:45 a.m.

e 3 h 29 min after 10:35 p.m. **f** 5 h 40 min before 9:32 a.m.

11 A car rally began at 8:20 a.m. Here are some of the competitors and the times they took. List the competitors in their order of finishing and the time each crossed the finishing line.

Tom 5:24 (5 h 24 min)	Manal 5:23	Eddie 5:44
Robert 6:01	Sarah 5:59	Gianni 5:42

12 Minnie's flight lands in Singapore at 0950 for a stopover. Her next flight leaves for Florida at 1920. How long does Minnie have in Singapore airport?

13 At St Margaret's College the school day begins at 8:25 a.m. and ends at 3:10 p.m. How long is the school day?

14 Klaas wants to go for a run for 1 h 20 min but be back in time to watch Monday Night Football on TV starting at 7:35 p.m. What is the latest time he can leave for his run?

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11.03 Timetables

Public transport trips

A **timetable** is a schedule showing the times at which railway trains, buses, aeroplanes, etc., arrive and depart. It can also be a plan that lists the times things will happen such as the times of your classes at school.

EXAMPLE 8

This is part of a timetable for a bus travelling between Sydney and Wagga Wagga.

Sydney to Wagga Wagga		Wagga Wagga to Sydney	
Sydney	2:30 p.m.	Wagga Wagga	7:15 a.m.
Strathfield	3:00 p.m.	Gundagai	8:25 a.m.
Yagoona	3:20 p.m.	Jugiong	8:54 a.m.
Liverpool	3:45 p.m.	Yass	9:41 a.m.
Mittagong	4:40 p.m.	Goulburn*	10:41 a.m.
Goulburn*	5:40 p.m.	Mittagong	12:10 p.m.
Yass	7:10 p.m.	Liverpool	1:05 p.m.
Jugiong	7:55 p.m.	Yagoona	1:20 p.m.
Gundagai	8:20 p.m.	Strathfield	1:35 p.m.
Wagga Wagga	9:30 p.m.	Sydney	2:05 p.m.

*30 minute meal stop at Goulburn

a What time does the bus from Sydney arrive in Liverpool?

b What time does this bus leave Goulburn?

c How long is the trip from Goulburn to Wagga Wagga?

d After travelling from Wagga Wagga back towards Sydney for 4 hours 55 minutes, where is the bus?

e Addison is waiting at Yass at 9:15 a.m. for the bus to Sydney. How long will he have to wait before the bus arrives?

Solution

a The bus from Sydney arrives in Liverpool at 3:45 p.m.

b This bus stops in Goulburn at 5:40 p.m. for dinner for 30 minutes, so it leaves Goulburn at 6:10 p.m.

c The bus leaves Goulburn at 6:10 p.m. and arrives in Wagga Wagga at 9:30 p.m.

The length of the trip is 3 h 20 min.

d The bus leaves Wagga Wagga at 7:15 a.m. and after 4 h 55 min the time is 12:10 p.m.

The bus is in Mittagong.

e Addison needs to wait from 9:15 a.m. to 9:41 a.m., a period of 26 minutes.

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Exercise 11.03 Timetables

Example 8

1 Refer to the bus timetable from Example **8.**

a How long does the trip from Sydney to Wagga Wagga take?

b How long would the trip take without a meal break?

c What time does the bus from Sydney arrive in Gundagai?

d Ali joins the return bus to Sydney at Jugiong and travels for 4 hours 11 minutes. Where does he stop?

e How long does Cherie have to wait for the bus to Sydney if she arrives in Mittagong at 11:45 a.m.?

f Find the time taken from Sydney to Liverpool and from Liverpool to Sydney. Suggest a reason for the difference.

2 This is part of a bus timetable showing trips between Apollo Bay and Lorne along the Great Ocean Road in Victoria.

Apollo Bay arr	06:05	09:30		14.30
Apollo Bay dep	06:07	09:32		14:32
Skenes Creek	06:10	09:35		14:35
Kennett River	06:30	09:55		14:55
Wye River	06:35	10:00		15:00
Lorne Hotel	06:55	10:20	13:32	15:20
Lorne arr		10:25		15:25
Lorne dep	07:10	10:35	13:47	15:35

a How long is the trip from Wye River to Lorne Hotel?

b You live in Apollo Bay and have an appointment in Lorne at 11 a.m. At what time do you need to catch the bus in Apollo Bay?

c Sia boards the bus at Skenes Creek and her trip takes 50 minutes. Where does she stop?

d At what time does the 2:30 p.m. bus from Apollo Bay get to Wye River?

e Where is this bus at 2:55 p.m.?

3 These tables show the daily flights between Sydney and Merimbula on the NSW south coast.

Sydney to Merimbula									
Flight No	**Depart**	**Arrive**	**Mon**	**Tues**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
NC130	09:05	10:45	✈	✈	✈	✈	✈	✈	
NC133	14:20	15:30	✈	✈	✈	✈	✈		✈
NC139	18:50	20:25	✈	✈	✈	✈	✈		✈

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Merimbula to Sydney									
Flight No	**Depart**	**Arrive**	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
NC114	06:30	08:15	✈	✈	✈	✈	✈	✈	
NC118	11:05	12:20	✈	✈	✈	✈	✈	✈	
NC134	15:50	17:40	✈	✈	✈	✈	✈	✈	✈

a How many flights are there from Sydney to Merimbula on Saturday?

b What times do the flights leave Merimbula for Sydney on Tuesday? Name these flights.

c You want to be in Sydney by 12 noon on Sunday. What is the latest time you can leave Merimbula?

d What is the latest flight arrival time at Merimbula on Friday?

e How long is the NC134 flight from Merimbula to Sydney?

4 Alexis' netball team flies from Sydney to Brisbane for a tournament. Alexis visited the Nelson Air website and found the following daily flight schedule.

Flight no.	Sydney	Brisbane
NA503	0905	1030
NA511	0935	1100
NA038	1005	1130
NA114	1040	1210
NA514	1105	1230
NA051	1135	1300

a When does flight NA038 leave Sydney and how long is the journey?

b What and when is the latest flight before 11 a.m.?

c The team needs to be at Sydney airport 60 minutes before a flight takes off. When should they be at the airport to catch the NA514 flight?

d The team needs to be at the hotel in Brisbane by 12:30 p.m. and it takes 35 minutes to drive from Brisbane airport to the hotel. What is the latest flight the team can catch from Sydney?

e Which flight takes longer to reach Brisbane than the others? Give two reasons why it might take longer.

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5 Here is part of the train timetable from Goulburn to Sydney.

Goulburn to Sydney — Monday to Friday								
	am	**am**	**am**	**pm**	**pm**	**pm**	**pm**	**pm**
GOULBURN	5:08	7:27	8:17	1:47	2:45	4:26	6:47	7:45
MARULAN	5:26	7:45			3:03			8:03
TALLONG	5:32	7:51	Bookings	Bookings	3:09	Bookings	Bookings	8:09
WINGELLO	5:39	7:58	essential	essential	3:16	essential	essential	8:16
PENROSE	5:44	8:03			3:21			8:21
BUNDANOON	5:50	8:09	8:52	2:22	3:27		7:22	8:27
EXETER	5:55	8:14			3:32			8:32
MOSS VALE	6:05	8:24	9:05	2:35	3:42	5:13	7:35	8:42
BURRADOO	6:10				3:47			8:47
BOWRAL	6:13	8:30	9:11	2:41	3:50		7:41	8:50
MITTAGONG	6:17	8:34	9:16	2:46	3:54		7:46	8:54
YERRINBOOL	6:30				4:07			9:07
BARGO	6:41				4:18			9:18
TAHMOOR	6:48				4:25			9:25
PICTON	6:56	9:08			4:33			9:33
CAMPBELLTOWN	7:23	9:30	10:11	3:41	5:00	6:13	8:42	10:00
STRATHFIELD			10:42	4:17		7:00	9:12	
SYDNEY	8:12	10:12	10:54	4:29	6:20	7:13	9:24	11:04

a Wilder lives in Tallong and has an interview in Sydney at 9:10 a.m.

i At what time must he catch the train in Tallong?

ii How long is the journey?

b What is the difference in the time taken to travel from Goulburn to Sydney on the 7:27 a.m. train and the 8:17 a.m. train?

c Yuki travels from Penrose to Picton, arriving at 9:08 a.m. How long did her trip take?

d A train leaves Goulburn at 1:47 p.m. Liam wants to board this train at Bundanoon. What must he do first and when will he board the train?

e Sonya has been visiting friends in Moss Vale and is returning to Sydney. Which train should she catch and why?

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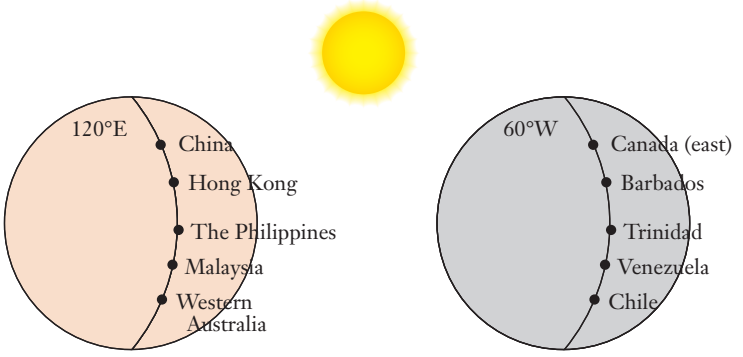
11.04 International time zones

When the Sun shines directly on a meridian of longitude, it is 12 midday at all places along that meridian (meridian means 'midday' in Latin). Directly on the opposite side of the world, it is 12 midnight. For example, when it is 12 midday in Western Australia on the 120°E meridian, it is 12 midnight in Chile on the 60°W meridian.

Table of time zones

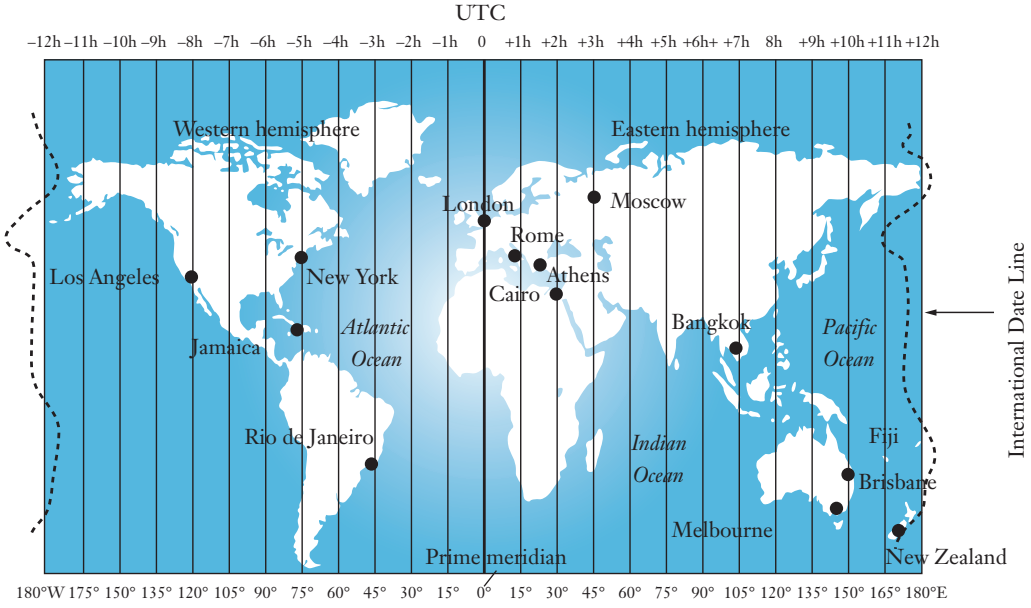
Map of the world



Midday on the 120°E meridian

Midnight on the 60°W meridian

Since the Earth turns 360° in 24 hours, it turns 15° in 1 hour. For every 15° of longitude, the time difference is 1 hour. Local times around the world are measured relative to the time along the prime meridian 0°, called **Coordinated Universal Time (UTC)**, previously called **Greenwich Mean Time (GMT)**. Places east of the prime meridian are *ahead* of UTC, while places west are *behind* UTC.



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Since 1884, the world has been divided into standard **time zones**, with roughly one hour difference for every 15° of longitude. Some countries make variations for geographical and/or administrative reasons. For example, **Australian Central Standard Time (ACST)** is 9.5 hours (not 9 hours) ahead of UTC and China has only one time zone (UTC+8) even though it stretches across four. On the map above, places along the 105°E meridian are 7 hours ahead of UTC, while places along the 150°W meridian are 10 hours behind UTC.

This table lists the international time zones relative to UTC and **Australian Eastern Standard Time (AEST)**, the time zone for eastern Australia, covering Queensland, NSW, ACT, Victoria and Tasmania.

Hours from UTC	Hours from AEST	Places in this zone
–11	–21	American Samoa, Niue Island, Midway Island
–10	–20	Hawaii, Cook Islands, Tahiti
–9	–19	Alaska
–8	–18	USA/Canada Pacific time (west coast), Los Angeles, Vancouver
–7	–17	USA/Canada Mountain time, Mexico (west)
–6	–16	USA/Canada Central time (mid-west), Mexico (east), El Salvador, Nicaragua, Guatemala, Honduras, Belize
–5	–15	USA/Canada Eastern time (east coast), New York, Cuba, Peru
–4	–14	Canada Atlantic time, Chile, Barbados, Brazil (west), Bolivia
–3	–13	Argentina, Brazil (east), Uruguay, Greenland
–2	–12	South Sandwich Islands
–1	–11	Azores
0	–10	UK, Ireland, Iceland, Portugal, Ghana, Liberia, Mali, Morocco
+1	–9	Most of Europe, Algeria, Angola, Chad, Bosnia, Croatia
+2	–8	Finland, Greece, Lebanon, Egypt, South Africa, Bulgaria, Cyprus
+3	–7	Russia (west), Saudi Arabia, Kenya, Madagascar, Iraq
+3.5	–6.5	Iran
+4	–6	Mauritius, United Arab Emirates, Armenia
+4.5	–5.5	Afghanistan
+5	–5	Pakistan, Maldives, Kazakhstan
+5.5	–4.5	India, Sri Lanka
+6	–4	Bangladesh, Bhutan, Kazakhstan, Kyrgystan
+6.5	–3.5	Myanmar (Burma), Cocos Islands

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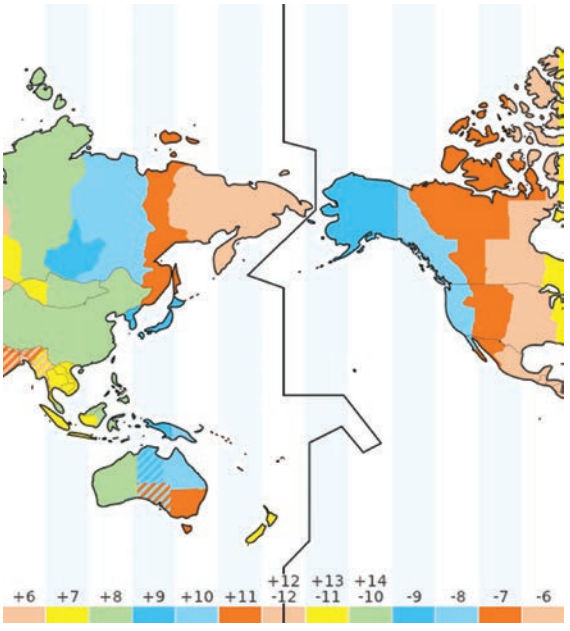
Hours from UTC	Hours from AEST	Places in this zone
+7	–3	Vietnam, Cambodia, Thailand, Indonesia (west), Laos
+8	–2	Australian Western Standard Time (WA), Malaysia, China, the Philippines, Indonesia (central), Mongolia, Taiwan
+9	–1	Japan, North Korea, South Korea, Indonesia (east), East Timor
+9.5	–0.5	Australian Central Standard Time (NT, SA, Broken Hill)
+10	0	Australian Eastern Standard Time, Papua New Guinea, Guam
+10.5	+0.5	Lord Howe Island
+11	+1	Vanuatu, New Caledonia, Solomon Islands, Micronesia
+11.5	+1.5	Norfolk Island
+12	+2	New Zealand, Fiji, Nauru
+13	+3	Samoa, Tonga

The International Date Line

The **International Date Line (IDL)**, on the opposite side of the world to the prime meridian, runs from the North Pole to the South Pole through the Pacific Ocean between Fiji and Hawaii. It is shown by the black line on the map below, and is 'bent' to ensure that it does not run through any countries.



Aman Bhagat/Quora

The IDL also runs between the Samoan islands mentioned at the start of this chapter. Suppose it is 1 am Monday in London, or UTC. Samoa's time zone is 13 hours *east* of UTC, or UTC+13, so its local time is 2 pm Monday. American Samoa's time zone is 11 hours *west* of UTC, or UTC-11, so its local time is 2 pm *Sunday*. So even though the two countries are only 64 km apart, their local times are 24 hours or a day apart.

If you cross the IDL travelling east (such going from Australia to the USA), today becomes yesterday (for example, Monday becomes Sunday) and you 'gain' a day. The reverse occurs when you cross the IDL travelling west (the opposite direction): today becomes tomorrow (for example, Sunday becomes Monday) and you 'lose' a day.

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International time zones

EXAMPLE 9

Habib is flying from New York, USA to Istanbul, Turkey to visit his grandfather. New York is 5 hours behind UTC while Turkey is 2 hours ahead of UTC.

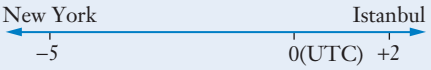
a Habib wants to call his grandfather on the phone before he leaves New York. At what time should he call so that it is 6:00 p.m. in Turkey?

b Habib boards the plane at 1:45 p.m. New York time and the trip lasts 8.5 hours. What is the local time in Istanbul when he arrives?

Solution

a Time difference = 5 + 2 = 7 hours

New York is 7 hours behind Istanbul.



New York time = 6:00 p.m. – 7 hours

= 11:00 a.m.

b Arrival time = 1:45 p.m. + 8.5 hours — New York time

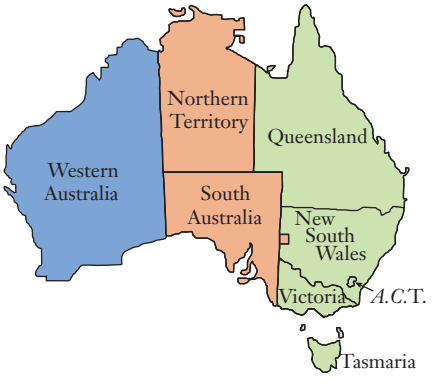
= 10:15 p.m.

= 10:15 p.m. + 7 hours — Istanbul time

= 5:15 a.m. (next day)

Australian standard time zones

There are three time zones in Australia (ignoring daylight saving), shown on the following map.



Australian Western Standard time (AWST) UTC + 8	Australian Central Standard time (ACST) UTC + 9.5	Australian Eastern Standard time (AEST) UTC + 10

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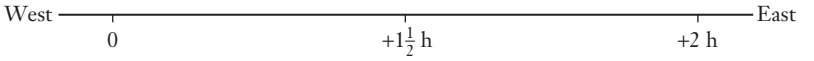
These time zones can also be shown on a timeline.



Western Standard Time	Central Standard Time	Eastern Standard Time
Perth	Adelaide	Sydney
	Alice Springs	Brisbane
	Darwin	Canberra
	Broken Hill (NSW)	Hobart

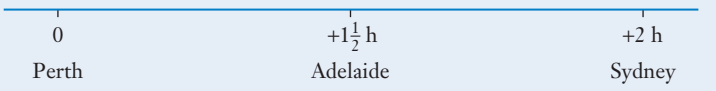
EXAMPLE 10

a Pete is in Perth and it is 11:30 a.m. He wants to ring his mother in Sydney. What time is it in Sydney?

b Nic has just finished work at 5 p.m. in Sydney. What time is it in Adelaide?

Solution

a



Moving from west (Perth) to east (Sydney) **ADD** 2 hours.

Time in Sydney = 11:30 a.m. + 2 hours

= 1:30 p.m.

It is 1:30 p.m. in Sydney.

b Moving from east (Sydney) to central (Adelaide) **SUBTRACT** $\frac{1}{2}$ hour or 30 minutes.

Time in Adelaide = 5 p.m. – 30 min

= 4:30 p.m.

It is 4:30 p.m. in Adelaide.

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Daylight saving time

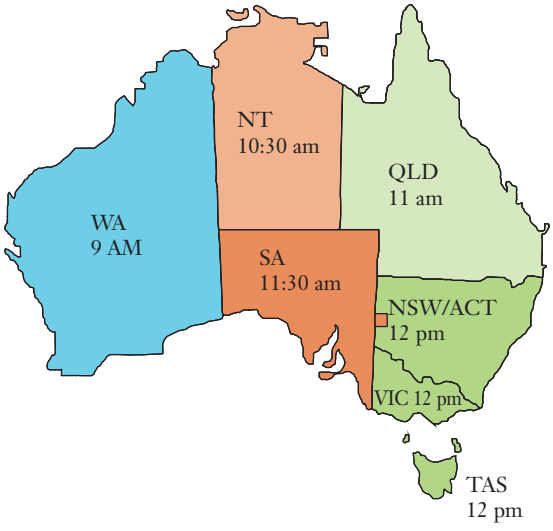
In summer, many countries adopt **daylight saving time**, or **summer time**, and turn their clocks forward one hour to take advantage of the increased hours of sunlight. By 'losing' that hour at the start of daylight saving, people are actually working and sleeping 1 hour earlier and gaining maximum use of the daylight.

Daylight saving has been operating in Australia since 1971, although Queensland, Western Australia and the Northern Territory do not participate in the scheme. Each year, it runs from the first Sunday in October (mid-spring) to the last Sunday in April (mid-autumn).

Daylight saving time

For daylight saving time, add one hour.

This map shows the local times around Australia during daylight saving when it is 12:00 midday in NSW.



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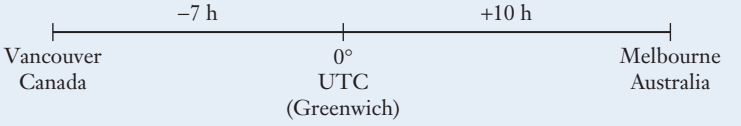
EXAMPLE 11

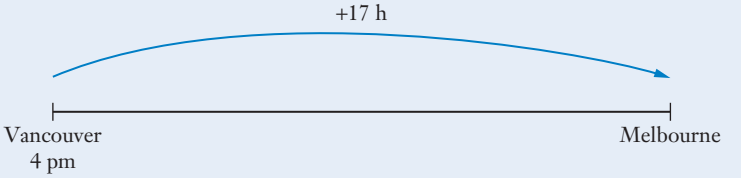
Simone, in Melbourne, wants to chat online with her cousin, Zac, in Vancouver, Canada. Canadian Pacific Standard Time is 8 hours behind UTC while Melbourne is 10 hours ahead of UTC. Daylight saving is operating in Canada. When should Simone log on to reach Zac at 4 p.m. Friday in Vancouver?

Solution

Vancouver time is UTC–8 but adding one hour for daylight saving gives UTC–7.



Time difference = 7 + 10 = 17 hours.



Melbourne is 17 hours ahead of Vancouver.

Log-on time = 4:00 p.m. Friday + 17 hours

= 9:00 a.m. Saturday.

Exercise 11.04 International time zones

Refer to the table on pages 486–487 or the worksheet 'Table of time zones' for this exercise.

WS
Table of time zones
Example 9

1 When it is 4:00 p.m. Saturday in Sydney, what is the time in:

a India? **b** Russia (west)? **c** Greece? **d** Tonga?

2 When it is 10:00 a.m. Tuesday in London, UK, what is the time in:

a Greenland? **b** Bosnia-Herzegovina?

c Myanmar? **d** New Caledonia?

3 What is the time difference (in hours) between:

a Malaysia and New Zealand? **b** Brazil (east) and Chile?

c Iceland and the Philippines? **d** Algeria and Salt Lake City, USA (Mountain time)?

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4 The Australian Open Tennis competition is broadcast live from Melbourne at 8:30 p.m. local time. At what time is it seen in:

a Dallas, USA (Central time)? **b** Japan? **c** Sweden (Europe)?

5 It takes $8\frac{1}{2}$ hours for a plane to fly from Sydney to Hawaii. If Heath leaves Sydney at 1:30 p.m. Friday, what is the local time when he arrives in Hawaii? Select **A, B, C** or **D**.

A 2:00 p.m. Thursday **B** 5:30 p.m. Thursday

C 2:00 a.m. Friday **D** 10:00 p.m. Friday

Example 10

6 If the time in Sydney is 6:00 p.m., what is the time in:

a Melbourne? **b** Hobart? **c** Alice Springs?

d Perth? **e** Adelaide? **f** Surfers Paradise?

7 Queensland, Northern Territory and Western Australia do not participate in daylight saving. If the daylight saving time in Sydney is 10:30 a.m., what is the time in:

a Melbourne? **b** Hobart? **c** Alice Springs?

d Perth? **e** Adelaide? **f** Surfers Paradise?

8 **a** What is the time in Santiago, Chile when it is 12:00 noon in Perth?

b What does this say about the positions of Perth and Santiago on the world globe?

9 A plane takes 12 hours to fly from Adelaide (UTC+9.5) to Cape Town, South Africa (UTC+2). If Shaunna leaves Adelaide at 10:00 a.m., what is the local time when she arrives in Cape Town?

Example 11

10 Robert in Tasmania wants to call his brother in Scotland, UK when the time there is 4:30 p.m. daylight saving time. At what time should Robert call? Select **A, B, C** or **D**.

A 1:30 a.m. **B** 2:30 a.m. **C** 3:30 a.m. **D** 5:30 a.m.

11 Indira flew from New Delhi, India to Sydney, leaving at 6:30 p.m. and arriving the next day at 12:00 p.m. local time. How long did her plane trip take?

12 The Superbowl is broadcast live from New York, USA (Eastern time) at 6:30 p.m. Monday. At what time and day is it seen in:

a Sydney? **b** Berlin, Germany (Europe)? **c** Dublin, Ireland?

13 Wallaby Airlines flies from Adelaide to Mt Isa, Queensland, via Sydney. The flight left Adelaide at 2:30 p.m. and arrived in Sydney 2 h 40 min later. The plane stayed in Sydney for 35 minutes for refuelling and to take extra passengers on board.

The flight from Sydney to Mt Isa took 2 h 45 min. Find the local time when the plane arrived in:

a Sydney **b** Mt Isa.

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14 Laire boards a flight in Coffs Harbour at 9:50 a.m. Tuesday morning. The flight to Sydney takes 40 minutes. Laire then waits in Sydney for one hour and boards a flight to Perth, which takes 4 hours 25 minutes. What time is it in Perth when the plane lands?

15 A plane takes 2 hours and 45 minutes to fly from Wellington, New Zealand (UTC+12) to Sydney (UTC+10). If Paula leaves Wellington at 4:20 p.m. (daylight saving time) in September, what is the local standard time when she arrives in Sydney (standard time)?

16 A plane leaves Sydney at 1:00 p.m. Thursday and flies 20 hours to Paris, France. At what time does the plane arrive in Paris if daylight saving is operating in France but not in Sydney?

17 A plane leaves Hawaii on Monday at 12 noon and flies 6 hours west to Tokyo, Japan.

a When the plane crosses the International Date Line, what day does it become?

b What is the local time in Tokyo when the plane arrives?

18 Liz flew west from Buenos Aires, Argentina (UTC–3) to Melbourne (UTC+10). To her surprise, she discovered that when she arrived in Melbourne it was the same time, 7:30 p.m., as when she left Buenos Aires.

a How long did her plane journey take?

b Was it still the same day? If not, what day was it?

INVESTIGATION

RESEARCHING TIME ZONES

a Why is UTC also known as GMT, Z time, Zulu time or Zebra time?

b How is time measured at the North and South poles, where all the meridians of longitude meet?

c How is time measured in Australia's external territories such as Norfolk Island, Lord Howe Island, Cocos Islands and Christmas Island (Indian Ocean)?

d Which country stretches across 11 time zones?

e Australia, USA and Canada are roughly the same length, but Australia has three time zones while USA and Canada have four and five time zones respectively. Why do you think this is so? (*Hint*: Look at the countries on a world globe or map.)

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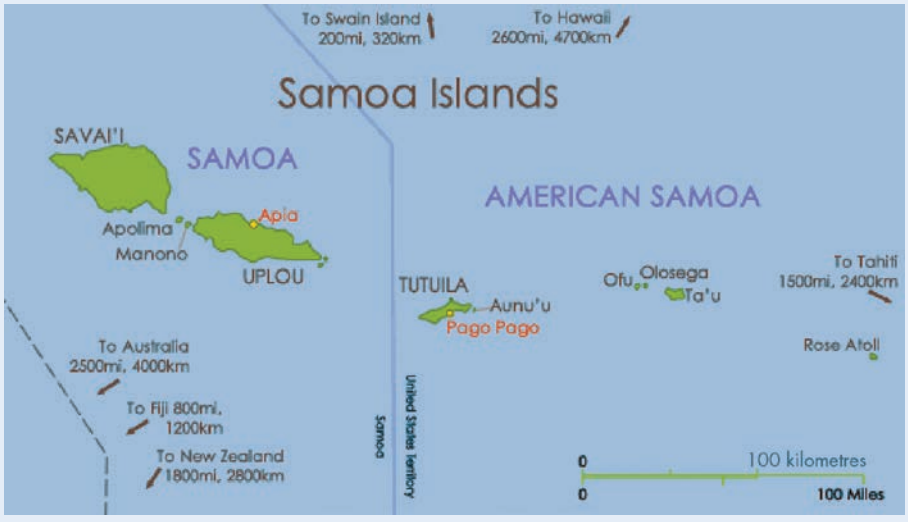
DID YOU KNOW?

Samoa lost an entire day in 2011



The Sun rises in Australia before most of the rest of the world, and compared to us it is still yesterday in the USA. The only places that are 'ahead' of us in time are the Pacific islands such as New Zealand, Fiji, Vanuatu, Samoa and Tonga.

Samoa has undergone much change in the 21st century. In 2009, it switched from driving on the right side of the road to the left side. At the end of 2011, it changed time zones from being UTC-11 like American Samoa to UTC+13. This meant that the date jumped from 29 December to 31 December, skipping the day Friday, 30 December 2011.

Find out the main reasons Samoa changed time zones (and therefore day zones) and driving orientation.

INVESTIGATION

PLAN AN OVERSEAS HOLIDAY

Use an atlas or a world globe to plan a trip to visit up to five different places in the world. Design an itinerary that lists the places you'll be visiting. You will need to take into account:

- distances between places
- mode of transport and travelling speeds: by air, land or sea
- arrival and departure times
- international time zones
- climate/seasonal conditions (these also affect the popularity of destinations).

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SAMPLE HSC PROBLEM

Crystal is travelling by plane from Seattle, USA (48°N, 122°W) to Sydney (34°S, 151°E) for a holiday.

a What is the difference in latitude between Seattle and Sydney?

b Crystal leaves Seattle at 9:45 a.m. on Tuesday and arrives in Sydney at 4:10 a.m. Wednesday *Seattle time*. How long was the journey in hours and minutes?

c Calculate the local time and day in Sydney when Crystal arrives if Seattle is UTC-7 and Sydney is UTC+10.

Study tip

Before an exam

- Make a study plan early – don't leave it to the last minute.
- Read and memorise your topic summaries.
- Work on your weak areas – learn from your mistakes.
- Don't spend too much time studying work you know already.
- Use revision exercises and past exams/assignments for practice.
- Vary the way you study so that you don't become bored: Have someone quiz you, voice-record your summary, design a poster or mind map, explain the work to someone.
- Anticipate the exam:
  - How many questions?
  - What type of questions: multiple-choice, short answer, long answer, problem-solving?
  - Which topics will be tested?
  - How many marks for each section?
  - How long is the exam?
  - How much time should be spent on each question/section?

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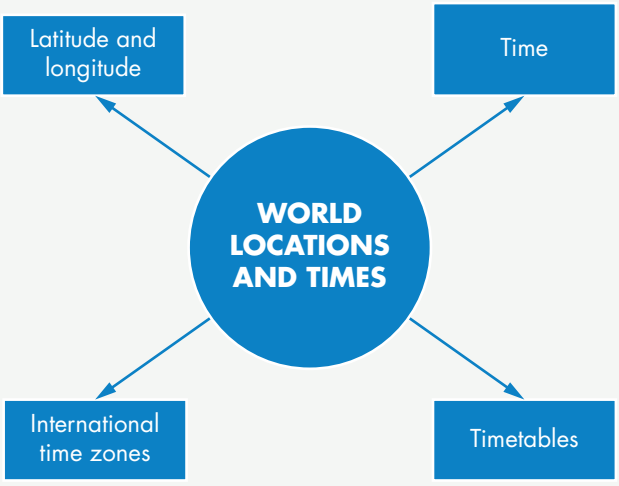
11. CHAPTER SUMMARY

World crossword

This chapter, World locations and times, focused on position and time measurement of locations around the world. Make sure that all theory, rules, terminology and worked examples are included in your summary. Students often experience difficulty in calculating differences in latitude, longitude and time, but such confusion can be overcome by developing a deep and structured understanding of the topic.

Make a summary of this topic. Use the outline at the start of this chapter as a guide. An incomplete mind map is shown below. Use your own words, symbols, diagrams, boxes and reminders. Gain a 'whole picture' view of the topic and identify any weak areas.



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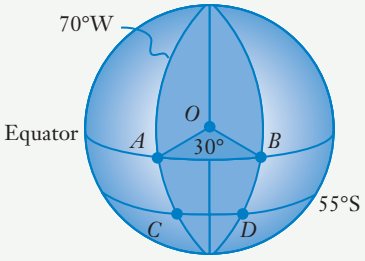
11. TEST YOURSELF

1 What are the position coordinates of A, B, C and D on the Earth?



Exercise 11.01

2 Albury, NSW has coordinates (36°S, 147°E).

Exercise 11.01

a What is the longitude of Albury?

b How many degrees is Albury north of the South Pole?

c Broome has coordinates (18°S, 122°E). What is the difference in longitude between Albury and Broome?

3 Amsterdam, The Netherlands is 15° north and 122° west of Seoul, South Korea (37°N, 127°E). What are the coordinates of Amsterdam?

Exercise 11.01

4 Convert each 24-hour time to 12-hour time.

Exercise 11.02

a 1436 **b** 0505 **c** 2218 **d** 0027

5 Convert each 12-hour time to 24-hour time.

Exercise 11.02

a 5:23 a.m. **b** 4:32 p.m. **c** 9:05 p.m. **d** 12:55 p.m.

6 Calculate the time of day:

Exercise 11.02

a 2 h 34 min after 6:21 a.m. **b** 5 h 8 min before midday

c 7 h 12 min after 0315 **d** 4 h 27 min before 1532.

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Exercise 11.03

7 The City Explorer Bus stops at places of interest in the city. This is the timetable for the Explorer bus in Brisbane.

GPO terminal	9:00	9:45	10:30	11:15	12:00	12:45	1:30	2:15	3:00	3:45	4:30	5:15
City Hall	9:05	9:50	10:35	11:20	12:05	12:50	1:35	2:20	3:05	3:50	4:35	5:20
Treasury Casino Hotel	9:10	9:55	10:40	11:25	12:10	12:55	1:40	2:25	3:10	3:55	4:40	5:25
Riverside Centre	9:15	10:00	10:45	11:30	12:15	1:00	1:45	2:30	3:15	4:00	4:45	5:30
Old Windmill	9:20	10:05	10:50	11:35	12:20	1:05	1:50	2:35	3:20	4:05	4:50	5:35
Transit Centre	9:28	10:13	10:58	11:43	12:28	1:13	1:58	2:43	3:28	4:13	4:58	5:43
Suncorp Stadium	9:32	10:17	11:02	1147	12:32	1:17	2:02	2:47	3:32	4:17	5:02	5:47
Regatra Hotel	9:45	10:30	11:15	12:00	12:45	1:30	2:15	3:00	3:45	4:30	5:15	6:00
Park Rd	9:48	10:33	11:18	12:03	12:48	1:33	2:18	3:03	3:48	4:33	5:18	6:03
Cultural Centre	9:54	10:39	11:24	12:09	12:54	1:39	2:24	3:09	3:54	4:39	5:24	6:09
Southbank	10:00	10:45	11:30	12:15	1:00	1:45	2:30	3:15	4:00	4:45	5:30	6:15
Maritime Museum	10:44	10:49	11:34	12:19	1:04	1:49	2:34	3:19	4:04	4:49	5:34	6:19
City lookout	10:10	10:55	11:40	12:25	1:10	1:55	2:40	3:25	4:10	4:55	5:40	6:25
Chinatown	10:20	11:05	11:50	12:35	1:20	2:05	2:50	3:35	4:20	5:05	5:50	6:35
ANZAC Square	10:24	11:09	11:54	12:39	1:24	2:09	2:54	3:39	4:24	5:09	5:54	6:39
GPO terminal	10:30	11:15	12:00	12:45	1:30	2:15	3:00	3:45	4:30	5:15	6:00	6:45

a How long is a complete round trip on an Explorer bus?

b How many buses are needed to meet the Explorer bus timetable? Explain how you arrived at your answer.

c Vo, Ben and Fatima arrived at Old Windmill at 11:45 a.m. They caught the Explorer bus to Southbank. What is the earliest time they could expect to arrive at Southbank? Explain your answer.

d If you miss a bus, what is the longest you would have to wait before the next one arrives?

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e Manuel and Sofia are dropped off by car at the Riverside Centre at 10:25 a.m. They arrange to meet their friends at the City Lookout at 4:30 p.m. They want to spend at least an hour at Suncorp Stadium, ride on the Ferris wheel at Southbank and do some souvenir shopping at the Maritime Museum. Plan a list of times for them to catch the Explorer bus to do these things and meet their hosts on time.

8 The time in Anchorage, Alaska (USA) is 9 hours behind UTC while the time in Lusaka, Zambia is 2 hours ahead of UTC.

Exercise 11.04

a When the time in Anchorage is 8:00 a.m., what is the time in London?

b When the time in Lusaka is 6:30 p.m., what is the time in Anchorage?

9 What is the time in Brisbane (AEST) when it is:

Exercise 11.04

a 4 p.m. in Perth? **b** 6 a.m. in Adelaide? **c** 2:30 a.m. in Hobart?

10 A plane leaves Darwin on Thursday at 6:00 p.m. and travels east for 8 hours to reach Niue Island.

Exercise 11.04

a When the plane crosses the International Date Line, what day does it become?

b If Darwin is UTC+9.5 and Niue Island is UTC−11, what is the time on Niue Island when the plane arrives there?

11 Kerrie, living in Perth, wants to call her sister in Los Angeles, USA when the time there is 12 noon Sunday. At what time should she call if Perth is UTC+8 and Los Angeles is usually UTC−8 but the USA is on daylight saving time?

Exercise 11.04

Qz Chapter quiz