solutions

1 The diagram is a copy of Fig. 4.

R is a place with latitude 45° north and longitude 60° west. Show the position of R on the diagram.

M is the sub-solar point. It is on the Greenwich meridian and the declination of the sun is +20°. Show the position of M on the diagram. **[2]**

1

label clearly!

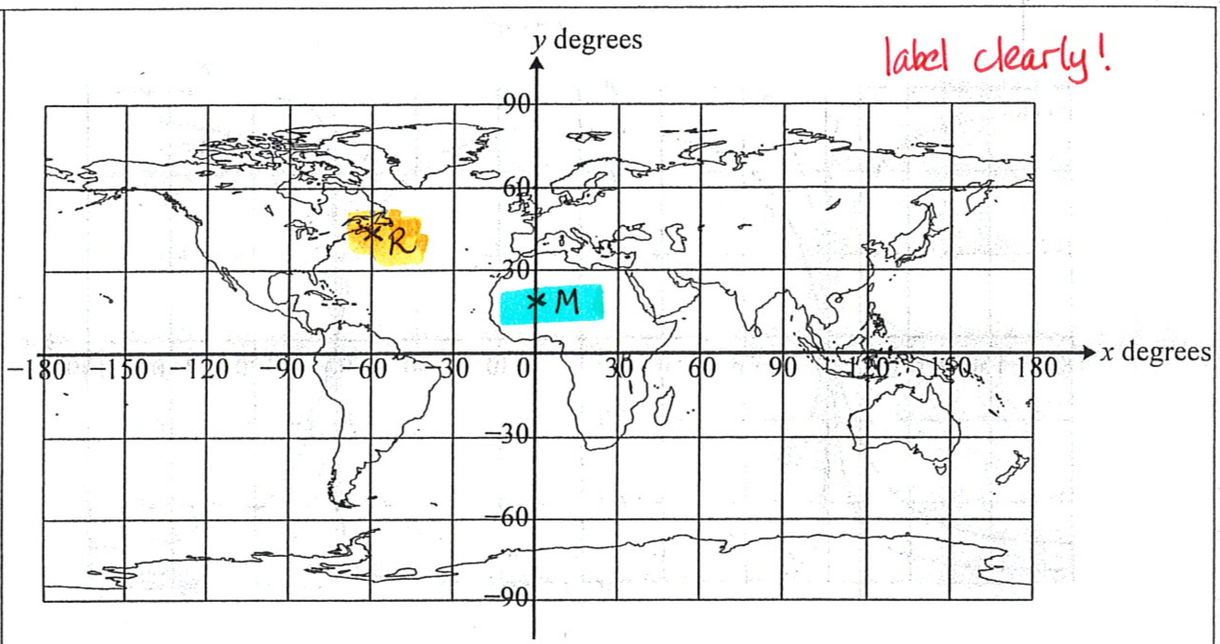

Fig. 4

2 Use Fig. 8 to estimate the difference in the length of daylight between places with latitudes of 30° south and 60° south on the day for which the graph applies. **[3]**

2 30° south daylight from −5 to 5 ⇒ 10 hours

60° south −2.7 to 2.7 ⇒ 5.4 hours

∴ diff. in length of daylight is

10 − 5.4 = 4.6 hours

this had to be between 5 and 6, but not including 5 or 6

$5 < t < 6$

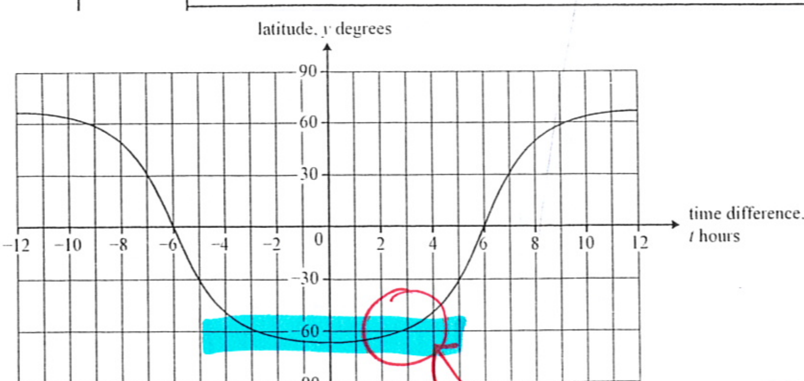

Fig. 8

$t < 3$ at $y = -60$

3 The graph is a copy of Fig. 6.

The article says that it shows the terminator in the cases where the sun has declination 10° north, 1° north, 5° south and 15° south.

Identify which curve (A, B, C or D) relates to which declination. **[2]**

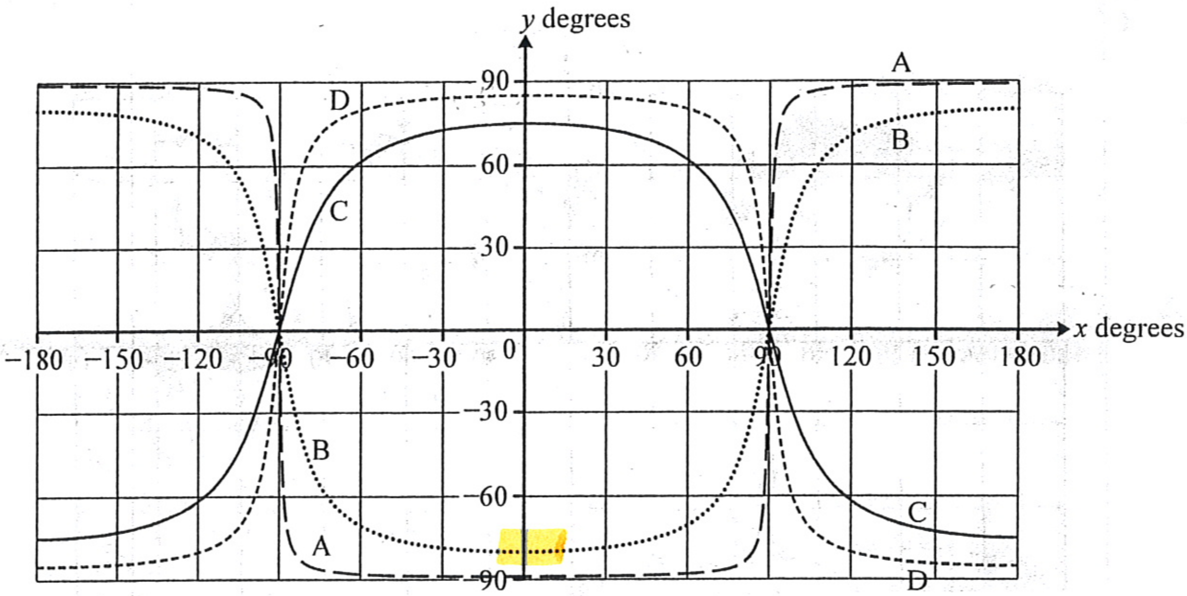

Fig. 6

3	10° north: B	using y-intercept at $\arctan\left(-\left(\frac{1}{\tan 10°}\right)\right)$ [$\cos 0 = 1$]
	1° north: A	which is −80° for B etc. y-int where $x=0$
	5° south: D	
	15° south: C	

4 In lines 94 and 95 the article says

"Fig. 8 shows you that at latitude 60° north the terminator passes approximately through time +9 hours and –9 hours so that there are about 18 hours of daylight."

Use Equation (4) to check the accuracy of the figure of 18 hours. **[4]**

4

$\tan y = -\frac{1}{\tan\alpha}\cos(15t)$ given $\alpha = 23.44°$

$\tan 60° = -\frac{1}{\tan 23.44}\cos(15t)$ $y = 60°$

solve for t

$-\sqrt{3}\tan 23.44° = \cos(15t)$

show full, clear working

$\frac{1}{15}\arccos(-\sqrt{3}\tan 23.44°) = t$

$t = 9.24$ (3 s.f.)

by symmetry, no. of daylight hours is $2t$

$\therefore\ 2(9.24) = 18.5$ (3 s.f.) hours of daylight.

Close to 18 hours (value given), but with about 3% error.

Alternatively, using $t=9$, we get $y = \arctan\left(-\frac{1}{\tan 23.44}\cos(15(9))\right)$

$= 58.5°$ (3 s.f.)

This is close to 60°, but again approx. 3% error.

5 **(i)** Use Equation (3) to calculate the declination of the sun on February 2nd. [3]

(ii) The town of Boston, in Lincolnshire, has latitude 53° north and longitude 0°.

Calculate the time of sunset in Boston on February 2nd.

Give your answer in hours and minutes using the 24-hour clock. [4]

5 (i)	$\alpha = -23.44\cos\left(\frac{360}{365}(n+10)\right)$ Jan 1st is day 1
	$\Rightarrow$ Feb 2nd $n = 31+2 = 33$
	$= -23.44\cos\left(\frac{360}{365}(43)\right)$ $\leftarrow$ subst
	$= \underline{\underline{-17.3°}}$ (3s.f.) (stored in A on calc)
	NOTE: 1 mark lost if you didn't know there are 31 days in January!
5 (ii)	For sunset, we use the terminator (equation 4)
	$y = 53°$, $\alpha = -17.3°$ (from (i)), solve for t
	$\tan 53° = -\frac{1}{\tan 17.3°}\cos(15t)$ using EXACT value for α from calculator
	$t = \frac{1}{15}\arccos(-\tan 53 \tan(-17.3))$
	show full expression for t (to gain a method mark)
	$= 4.3717$ $0.3717 \times 60 = 22.3$
	interpret in context $\therefore$ 4hrs 22 mins
	sunset is 4 hrs 22 mins after noon, so know how to
	$\underline{\underline{16:22}}$ (or 4:22 p.m.) convert hours (decimal) into hours and minutes!