NATIONAL UNIVERSITY OF SINGAPORE

DEPARTMENT OF MATHEMATICS

SEMESTER 1 EXAMINATION 2009–2010

GEK1506   Heavenly Mathematics: Cultural Astronomy

November 2009 — Time allowed: 2 hours

Matriculation Number:

INSTRUCTIONS TO CANDIDATES

 (i) This examination paper contains five questions and comprises seven pages including this page and a blank page at the end.

 (ii) Write your matriculation number on the front page.

 (iii) Write your answers on this question paper. You may also write on the back of the pages. There is a blank page at the end if you need more space. Please indicate clearly if you continue a question on the last page.

 (iv) **Explain and justify your answers carefully.**

 (v) Answer all questions.

 (vi) You may use a calculator.

1. (i) [6 marks] What time of the year will the azimuth of the Sun at the time of sunrise on the equator be minimal? What is the minimal value?

   (ii) [14 marks] What time of the year will the azimuth of the full Moon at the time of moonrise on the equator be minimal? It is hard to compute the exact minimal value for a given year, but how small can it possibly be?

2. [20 marks] Figure 1 shows the sunrise and sunset times in Singapore in the course of the year. Explain how you can use the analemma to estimate the dates on which the sunrise and sunset are earliest or latest.
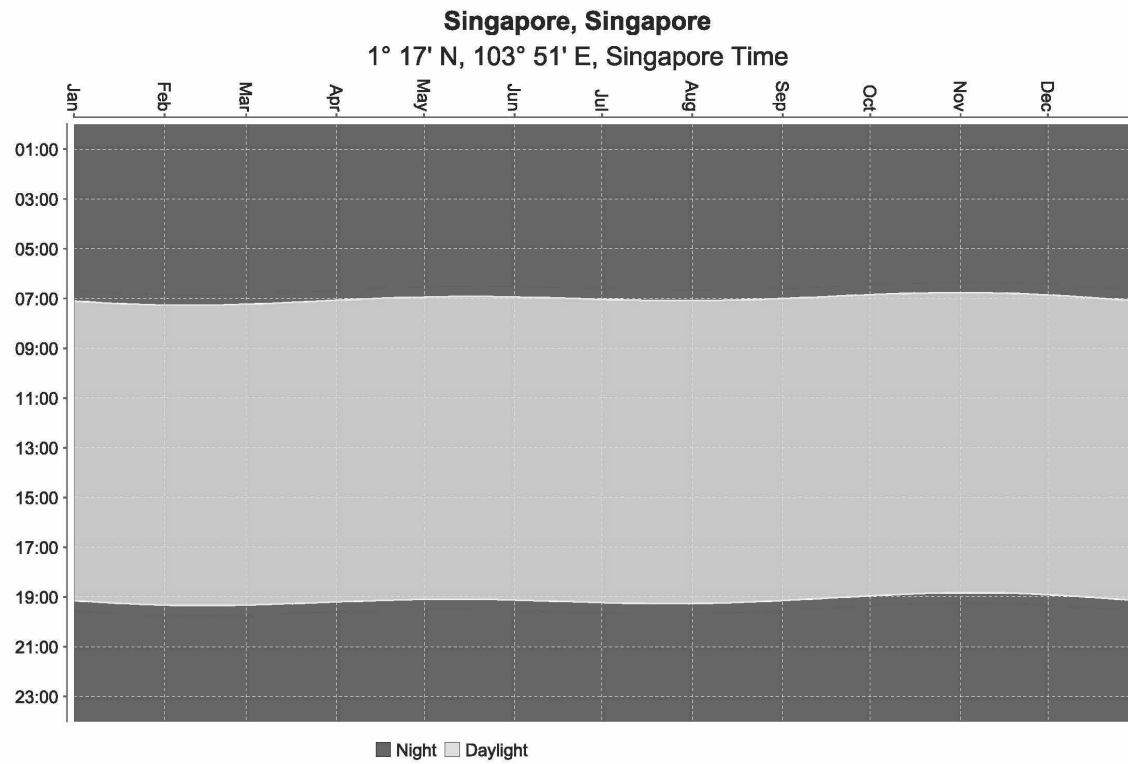

Figure 1: Sunrise and sunset times in Singapore

3. (i) [12 marks] In Great Britain, daylight saving time (DST) is observed from the last Sunday in March to the last Sunday in October. In 2009 this was from March 29 to October 25. In London the earliest sunrise is at 4:42 a.m., and the latest sunset is at 9:21 p.m. Draw a chart similar to the one in Figure 1 estimating the time of sunrise and sunset in London in the course of the year. Make sure you indicate whether the dates of earliest/latest surnrise/sunet will be before, on or after the days of the solstices.

(ii) [4 marks] San Francisco is in the UTC $- 8$ time zone and observes DST from the second Sunday in March to the first Sunday in November. In 2009 this was from March 8 to November 1. Construct a table showing the time difference between Singapore and San Francisco at different times of the year in 2009.

(iii) [4 marks] Sydney is in the UTC $+ 10$ time zone and in 2009 DST ended on April 5 and started on October 4. Construct a table showing the time difference between Singapore and Sydney at different times of the year in 2009.

4. [20 marks] The latitude of San Francisco is about $38°$ north and $122°$ west and it lies in the UTC $- 8$ time zone. The equation of time is about 2 minutes on the December solstice. Estimate where and when the Sun will cross the meridian on the day of the December solstice.

5. [20 marks] In the Indian calendar, the lunar month is divided into 30 tithis. The day starts at sunrise and takes its number (name) from the number (name) of the tithi at the time of sunrise.

In South India the main Deepavali celebration is at sunrise on the 29th (Chaturdasi) day in a certain lunar month (Asvina). In northern India the main Diwali celebration is on the 30th (Amavasya) day of the same month during a certain time period after sunset (Pradosha). However, in northern India it is more important that the celebration takes place during the 30th tithi than during the 30th day, so it will sometimes fall on the 29th day. Give a rough estimate of how often the southern Deepavali and the northern Diwali will fall on the same day. To simplify, you can assume that both the tithi and the solar day are 24 hours and that you are located on the equator.

END OF PAPER