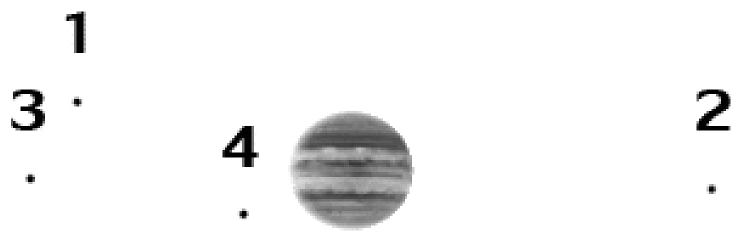
Marking Scheme for Data Analysis Questions

Question 1 **Galilean moons (6 points)**

Computer simulation of the planet Jupiter and its 4 Galilean moons is shown on the screen similar to the view you may see through a small telescope. After observing the movement of the moons, please identify the names of the moons that appear at the end of the simulation. (Simulation will be played on screen 3 times)



Names of the Galilean Moons

1 **Callisto** **(1.5 points)**

2. **Europa** **(1.5 points)**

3. **Io** **(1.5 points)**

4. **Ganymede** **(1.5 points)**

<u>Question 2</u> The Moon's age (7 points)

The 60th anniversary celebrations of King Bhumibol Adulyadej's accession to the throne of Thailand (GMT +07) were held on the 8th to the 13th June, 2006. It was found that the Moon's age of each night was as shown below:

8th June, 2006

9th June, 2006

10th June, 2006

11th June, 2006

12th June, 2006

13th June, 2006

If Albert Einstein's birthday is 14th March, 1879, using the data provided above, find the Moon's age (with uncertainty) on his birth date in Germany (GMT +02). Please show the method used for the calculation in detail.

<u>Answer</u>

From the figures of the Moon's phase depicted above, we can conclude that the full moon occurs on <u>June 11th (+/- 0.5 day), 2006</u>. We are going to use this full moon as the reference for calculating the Moon's age on Albert Einstein's birthday (March 14, 1879).

The student must find out that the approximate time span between June 11th, 2006 and March 14, 1879 is 127 years.

There are 31 leap years between the two years (i.e. 1880, 1884, 1888, 1892, 1896, 1904, 1908, 1912, 1916, 1920, 1924, 1928, 1932, 1936, 1940, 1944, 1948, 1952, 1956, 1960, 1964, 1968, 1972, 1976, 1980, 1984, 1988, 1992, 1996, 2000, and 2004).

So, there are 365*127 + 31 = 46,386 days starting from January 1, 2006 to January 1, 1879. As a consequence, there are <u>46,475 days</u> starting from June 11, 2006 to March 14, 1879.

Number of days / synodic month = 46,475/ 29.5306 = 1573.79~~1254~~ or 1573 synodic months and 0.791254*29.5306 = 23.3662 days.

The remainder of days tells us the number of days into the synodic cycle we've gone. Since we are going backwards in time in these calculations (from 2006 to 1879), this is the number of days from the top of the cycle, rather than from the bottom. To convert to the number of days from the bottom of the cycle (full moon), we simply subtract this value from a full cycle (29.5306 days). This is 29.5306 - 23.3662 = 6.1644 days.
6.1644 days from the bottom of the cycle (full moon = 14.7653 days) or 14.7653 + 6.1644 = 20.9297 days into the synodic month. And that's our answer.

Finally, the Moon's age on Albert Einstein's birthday (March 14, 1879) is **20.9 +/- 0.5 days.**

Marking Scheme:

The student must not use the difference between the time zone of Thailand and Germany to calculate the Moon's age:

: 0.5 point (wrong answer = 0 point)

The student can point out that the June 11, 2006 is a full moon day (an experienced observer realize that a full moon day and a day before full moon , the Moon looks the same by eyes. However, they know that a day after the full moon day, the Moon looks a little bit darker):

: 1 point (wrong answer = 0 point)

The student can point out that there is an uncertainty in the full moon day = 0.5 day (as seen from pictures given in the question)

:1 point (an answer without any uncertainty = 0 point, the student uses an uncertainty > 0.5 day but <= 1 day will get 0.5 points, an uncertainty > 1 day will get 0 point)

The student gives the correct answer

5.5 points (if the answer is wrong, looks at the detail in the process of calculation. Missing one point of the concept used in the correct calculation = missing 0.5 points until the point is over)

An extra 0.2 point for additional considerations

<u>Question 3</u> **Solar System objects (7 points)**

A set of data containing the apparent positions of 4 Solar System objects as observed at Chiang Mai, Thailand, over a period of 1 calendar year is given in Table 1. Analyze the data carefully and answer the questions as well as showing the method used to obtain the results.

Location of observer	Latitude :	N 18° 47’ 00.0”
	Longitude :	E 98° 59’ 00.0”

3.1 Identify the objects A, B, C, and D by names. **(2 points)**

3.2 Which object can be observed with the longest duration at night time by unaided eye? **(0.5 points)**

3.3 What is the date that the object in 3.2 can be observed with the longest duration at night time? **(0.5 points)**

3.4 Indicate the positions of the four objects and the Earth on the date in 3.3, in the orbit diagram provided in your answer sheet. The answer (sheet) must show one of the objects as the Sun at the centre of the Solar System. Other objects including the Earth must be specified together with the correct values of elongation on that date. **(4 points)**

<u>Marking Scheme</u>

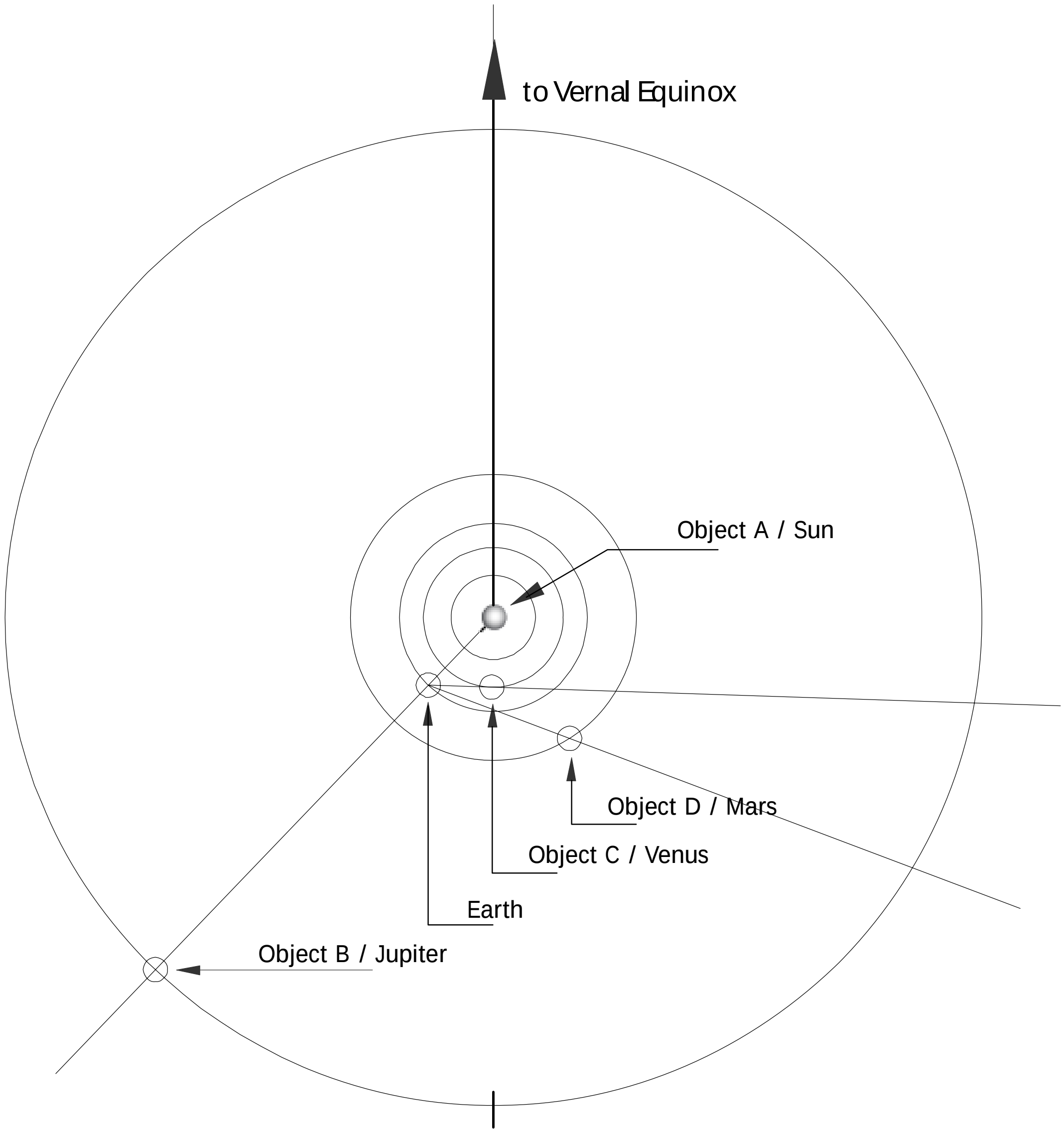
3.1

Object	Name	Point
Object A	**Sun**	**0.50**
Object B	**Jupiter**	**0.50**
Object C	**Venus**	**0.50**
Object D	**Mars**	**0.50**

3.2 **Object B** **(0.5 points)**

3.3 **3^{rd} February** **(0.5 points)**

3.4



- **Correct position of the Earth relative to the Sun (46° before RA=0h) (1 point)**

- **Correct position of object in the orbit**

Venus (C) = 0.5 points

Mars (D) = 0.5 points

Jupiter (B) = 0.5 points

- **Correct value of elongation angle**

Venus (C) = 48.07 º (0.5 points)

Mars (D) = 69.39 º (0.5 points)

Jupiter (B) = 181.20 º (0.5 points)