Diploma Programme
Programme du diplôme
Programa del Diploma

Astronomy
Standard level
Paper 1

Thursday 30 April 2015 (morning)

Candidate session number

45 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination is **[30 marks].**

2215 – 9004

11 pages

You may find the following information useful

$1\,\text{AU} = 1.5 \times 10^{11}\,\text{m}$

$H_0 \approx 72\,\text{km s}^{-1}\,\text{Mpc}^{-1}$

1 light year $= 0.31$ parsecs $= 9.5 \times 10^{15}\,\text{m}$

$c = 3.00 \times 10^{8}\,\text{m s}^{-1}$

$G = 6.67 \times 10^{-11}\,\text{N m}^2\,\text{kg}^{-2}$

$\sigma = 5.67 \times 10^{-8}\,\text{W m}^{-2}\,\text{K}^{-4}$

$L_\odot \approx 3.84 \times 10^{26}\,\text{W}$

$T_\odot \approx 5770\,\text{K}$

$M_\odot \approx 1.99 \times 10^{30}\,\text{kg}$

$R_\odot \approx 6.96 \times 10^{8}\,\text{m}$

$k = 1.38 \times 10^{-23}\,\text{JK}^{-1}$

$M_\oplus = 5.98 \times 10^{24}\,\text{kg}$

1 parsec $= 206\,265\,\text{AU} = 3.1 \times 10^{16}\,\text{m} = 3.3$ light years

$1^\circ = 3600$ arc-sec $= 1.75 \times 10^{-2}$ rads

$$M_\text{J} = \frac{9}{4}\left(\frac{1}{2\pi n}\right)^{\frac{1}{2}} \frac{1}{m^2}\left(\frac{\text{k}T}{G}\right)^{\frac{3}{2}}$$

$$F = \frac{GM_1M_2}{r^2}$$

$$e = \sqrt{1 - \left(\frac{b}{a}\right)^2}$$

$$v = \frac{d}{t}$$

$$z = \frac{H_0}{c}d = \frac{\lambda_\text{obs} - \lambda_\text{em}}{\lambda_\text{em}}$$

$$F = ma$$

$$c = f\lambda$$

$$\text{KE} = \frac{1}{2}mv^2$$

$$\lambda_\text{max} = \frac{2.90 \times 10^{-3}}{T}$$

$$\text{GPE} = mgh$$

$$v_\text{esc} = \sqrt{\frac{2GM}{R}}$$

$$m_\text{B} - m_\text{A} = -2.5\log\left[\frac{b_\text{B}}{b_\text{A}}\right]$$

$$\text{PE} = -\frac{GMm}{r}$$

$$E = mc^2$$

$$L \approx 4\pi R^2\sigma T^4$$

$$L = F.4\pi d^2$$

$$\text{f} = \frac{[\text{a} - \text{b}]}{\text{a}}$$

$$N = R\,.\,f_\text{p}\,.\,n_\text{e}\,.\,f_\text{l}\,.\,f_\text{i}\,.\,f_\text{c}\,.\,L$$

$$L.\theta = d$$

Please **do not** write on this page.

Answers written on this page
will not be marked.

Answer **all** questions. Write your answers in the boxes provided.

The Stars

1. Define the following terms. [2]

Main sequence: . . . . . .
. . . . . .

White dwarf: . . . . . .
. . . . . .

2. The luminosity of a star is the total amount of energy emitted by the star, across all wavelengths, per unit time.

Calculate the luminosity of a star which has half the radius of the Sun and twice the temperature. Your answer should be expressed in SI units and to **two** significant figures. [3]

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. . . . . .
. . . . . .

3. Einstein correctly described the equivalence of mass and energy as “the most important upshot of the special theory of relativity”.

Calculate the energy equivalent of 1 kg of mass. Your answer should be given in SI units. [1]

. . . . . .
. . . . . .
. . . . . .

4. Outline how the light from a star can be used to calculate the photospheric temperature. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

The Planets

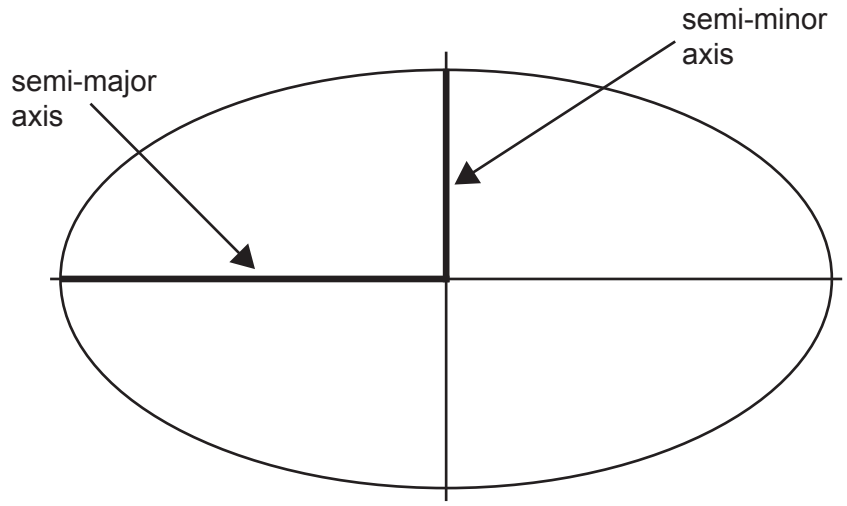
5. Define the following terms. [2]

Retrograde motion: . . . . . .
. . . . . .

Synchronous orbit: . . . . . .
. . . . . .

6. The orbits of many objects around the Sun follow an elliptical path with the semi-major and semi-minor axis shown in **Figure 1**.

Figure 1: An elliptical orbit



If the semi-major axis for an object orbiting the Sun is 5 % greater than the semi-minor axis, calculate the eccentricity of its orbit. [2]

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. . . . . .
. . . . . .
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7. An extinction event is one which produces a sharp decrease in the number of species in a relatively short period of time. Mass extinctions affect an unusually large number of species in a short period.

In the past 550 million years there have been five major events where at least 50 % of the planet's animal species died.

For such mass extinctions to occur, the following two factors are required:

- Long-term pressure on the ecosystem
- A sudden catastrophe towards the end of the period of pressure.

The following table gives some factors which could possibly combine to result in a mass extinction event.

Complete the following table by ticking [✓] **one** box in each row to indicate if the factor is either long-term or short-term. [3]

Possible factors contributing to a mass extinction event		
Factor	**Long-term factor**	**Short-term factor**
Massive volcanic activity		
Sustained global warming		
An evolving biosphere		

8. In 1961, Frank Drake considered how many communicating civilisations existed in our galaxy. To estimate this, he developed what is now known as the Drake equation.

The Drake equation identifies the specific factors thought to play a role in the development of such civilizations, with the factors multiplied together to give the final estimate (N). The equation is shown below.

$$N = R \,.\, f_{\mathrm{p}} \,.\, n_{\mathrm{e}} \,.\, f_{\mathrm{l}} \,.\, f_{\mathrm{i}} \,.\, f_{\mathrm{c}} \,.\, L$$

Considering the Drake equation, choose **one** of the factors and briefly explain it. [1]

Factor: . . . . . .

Explanation: . . . . . .
. . . . . .
. . . . . .
. . . . . .

Galaxies

9. **Figure 2** shows two different types of galaxy. Using the Hubble classification for naming galaxies, state what types of galaxy are shown. [2]

Figure 2: Two different types of galaxy

M101

[Source: http://apod.nasa.gov]

IC 1613

[Source: www.jpl.nasa.gov]

M101: . . . . . .

IC1613: . . . . . .

10. Define the following terms. [2]

Lenticular galaxy: . . . . . .

. . . . . .

. . . . . .

OB stars: . . . . . .

. . . . . .

. . . . . .

11. Calculate the distance from Earth of a distant galaxy with a red-shift of 0.1. [3]

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Cosmology

12. Briefly explain why some stars within the Milky Way show red-shift while others show blue-shift. [2]

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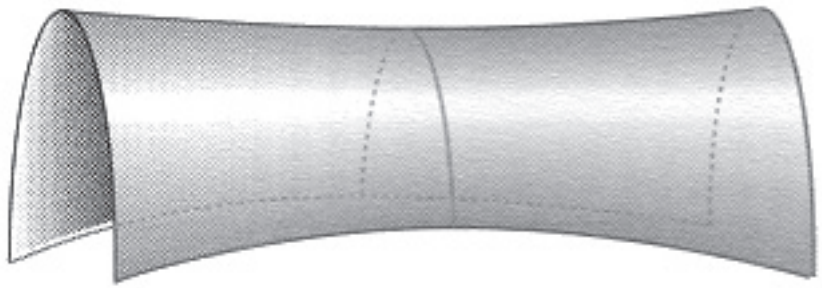
13. Theoretically, the shape of spacetime can be shown by considering parallel lines, the internal angles of a triangle or the circumference of a circle.

For the spacetime shown in **Figure 3**, indicate the result of such tests by ticking [✓] **one** box in each row. [3]

Figure 3: The possible shape of spacetime



[Source: Astronomy and Planetary Science: Cosmology Bk. 4 (Course S281) 074925128X]

Parallel lines	Stay parallel	Diverge	Intersect . . . . .
Internal angles of a triangle	Less than 180°	Equal to 180°	Greater than 180° . . . . .
Circumference of a circle	Less than $2\pi r$	Equal to $2\pi r$	Greater than $2\pi r$ . . . . .

14. State how the density of the universe compares with its critical density and what the ultimate fate of the universe will be, referring to the spacetime in Question 13. [2]

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