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International Baccalaureate®
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SCHOOL BASED SYLLABUS

ASTRONOMY
STANDARD LEVEL
PAPER 1

Candidate session number

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Monday 30 April 2012 (morning)

Examination code

2	2	1	2	–	9	0	0	3

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 paper is *[30 marks]*.

0112

The following information may be useful

$1\,\text{AU} = 1.496\times10^{11}\,\text{m}$

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

1 light year $= 0.307$ parsecs $= 9.47\times10^{15}\,\text{m}$

$c = 3.00\times10^{8}\,\text{m s}^{-1}$

$G = 6.67\times10^{-11}\,\text{N m}^2\,\text{kg}^{-2}$

$\sigma = 5.67\times10^{-8}\,\text{W m}^{-2}\,\text{K}^{-4}$

$L_\odot \approx 3.84\times10^{26}\,\text{W}$

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

$M_\odot \approx 1.99\times10^{30}\,\text{kg}$

$R_\odot \approx 6.96\times10^{8}\,\text{m}$

$k = 1.38\times10^{-23}\,\text{JK}^{-1}$

$M_\oplus = 5.98\times10^{24}\,\text{kg}$

1 parsec $= 206\,265\,\text{AU} = 3.09\times10^{16}\,\text{m} = 3.26$ light years

$1^\circ = 3600$ arcsec $= 1.75\times10^{-2}$ rads

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

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

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

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

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

$$F = ma$$

$$c = f\lambda$$

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

$$\lambda_\text{max} = \frac{2.90\times10^{-3}}{\text{T}}$$

$$\text{GPE} = mgh$$

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

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

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

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

$$E = mc^2$$

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

$$L = F4\pi d^2$$

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

$$L\theta = d$$

$$F = \frac{L}{4\pi d^2}$$

$$d = \frac{1}{\phi}$$

$$\frac{\text{b}_1}{\text{b}_2} = 2.5^{(\text{m}_2-\text{m}_1)}$$

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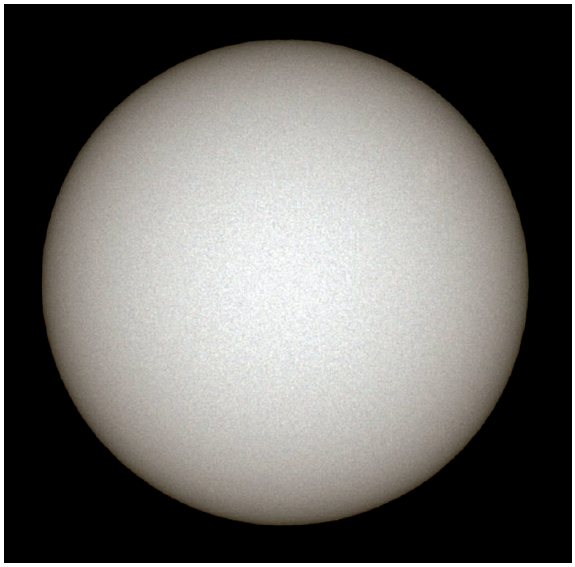
*Answer **all** questions. Write your answers in the boxes provided.*

The Stars

1. *Limb darkening* is the term used to indicate that when an image of the Sun is closely inspected, it is seen that the brightness of the solar disc fades as you move towards the edges (or "limbs"). This is shown in Figure 1.

Figure 1: Limb darkening on the solar surface



Briefly explain why limb darkening occurs. You may find that a sketch will help you. *[1]*

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2. Name **one** constellation you have studied and state **two** stars which form part of it. *[2]*

Constellation: . . . . . .

Star 1: . . . . . .

Star 2: . . . . . .

3. The Homestake solar neutrino experiment resides in an abandoned gold mine in South Dakota, USA. The experiment is essentially an enormous tank containing 615 tons of liquid perchloroethylene (C_2Cl_4) which is under careful examination for the appearance of atoms of radioactive ^{37}Ar – produced when a neutrino interacts with one of the chlorine atoms. Part of the tank is shown in Figure 2.

Figure 2: The Homestake solar neutrino detector

Briefly explain why the detection of solar neutrinos is important in understanding the nuclear fusion rate occurring at this moment in time. *[2]*

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4. Two stars, A and B, have the same spectral type but luminosities of $L_{\mathrm{A}} = 10^{3} L_{\odot}$ and $L_{\mathrm{B}} = 10^{-3} L_{\odot}$.

What is the approximate ratio of their radii, $\frac{R_A}{R_B}$? *[3]*

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The Planets

5. Briefly explain what is meant by the term, the *albedo* of a planet. *[2]*

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6. The eccentricity e of Jupiter's orbit is 0.04878. Calculate the ratio of the semi-major to semi-minor axis and express your answer to an appropriate number of significant figures. *[3]*

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7. It is thought that the development of life on Earth requires a number of contributing factors. For the factors listed below, briefly explain why it is thought to be important in the development of life on a planet. *[2]*

Liquid Water:

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Temperature:

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8. Figure 3 shows the image of an important impact crater on Earth. It has a squared-off outline, thought to be due to pre-existing cracks in the underlying material, present before the impact. This was the first crater on Earth to be proven to be the result of an impact and is approximately 50 000 years old. It is one of the few sites on the planet where the geological details of crater excavation and ejecta are preserved and it is used both for scientific research and for testing robot hardware in preparation for future exploratory missions within the solar system.

Give the location on Earth of the impact event shown in Figure 3. *[1]*

Figure 3: Image of an impact event on the Earth

Location: . . . . . .

Galaxies

9. The two images in Figure 4 are of different galaxies. Using the Hubble classification for naming galaxies, state what type of galaxy is shown. *[2]*

Figure 4: Examples of galaxies

NGC 1569

M31

NGC 1569: . . . . . .

M31: . . . . . .

10. Define the following terms. *[2]*

Rotation curve:

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Blue-shift:

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11. Describe the motion of the Sun as it moves in the Milky Way. *[2]*

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12. Give **one** constituent of cosmic rays. *[1]*

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Cosmology

13. Theoretically, the geometry of spacetime can be shown by considering (1) parallel lines, (2) the internal angles of a triangle or (3) the circumference of a circle. For the spacetime shown in Figure 5, indicate the result of such tests by ticking **one** box in each row of the table below. *[3]*

Figure 5: A possible geometry for spacetime

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. Two relatively nearby galaxies, A and B, are both shown to be red-shifted. The red-shift for A is twice as large as for B. State **two** things that can be said about these galaxies using this information. *[2]*

1: . . . . . .

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2: . . . . . .

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15. Explain briefly the concept of cosmological *inflation* and explain why this idea was conceived. *[2]*

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