## AQA

Please write clearly in block capitals.

Centre number


Candidate number


Surname
Forename(s) $\qquad$
Candidate signature $\qquad$

## A-level PHYSICS

## Paper 3

Section B Astrophysics
Thursday 14 June 2018 Morning

## Materials

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet.


## Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer all questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

| For Examiner's Use |  |
| :---: | :---: |
| Question | Mark |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| TOTAL |  |

## Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.


## Section B

Answer all questions in this section.

| $\mathbf{0}$ | $\mathbf{1}$ | The Griffith Observatory in Los Angeles includes an astronomical refracting telescope |
| :--- | :--- | :--- | (Griffith telescope) with an objective lens of diameter 305 mm and focal length 5.03 m


| 0 | 1 | 1 |
| :--- | :--- | :--- | angular resolution of $1.8 \times 10^{-6} \mathrm{rad}$

$\qquad$ m

| $\mathbf{0}$ | $\mathbf{1} . \mathbf{2}$ The Griffith telescope is used to observe two point objects which subtend an angle of |
| :--- | :--- | :--- | $1.8 \times 10^{-6} \mathrm{rad}$ at the unaided eye.

The typical human eye has a minimum angular resolution of approximately $3.2 \times 10^{-4} \mathrm{rad}$

Calculate the focal length of the eyepiece lens so that an observer can just resolve the two objects when observing them through the Griffith telescope.

| $\mathbf{0}$ | $\mathbf{1} \cdot \mathbf{3}$ The asteroid Apophis has a diameter of 325 m |
| :--- | :--- | :--- |

It has been calculated that, in 2029, its distance of closest approach to the Earth's surface will be $3.0 \times 10^{4} \mathrm{~km}$

The Griffith telescope may be used to view Apophis using the eyepiece calculated in question 01.2

Deduce whether this telescope is suitable to obtain a detailed view of Apophis. Support your answer with a calculation.


| 0 | 2 | 1 |
| :--- | :--- | :--- |

Figure 1
intensity ! arbitrary units

| $\mathbf{0}$ | $\mathbf{2} .2$ | Explain, with reference to the SI units involved, how the curve you have drawn can be |
| :--- | :--- | :--- | used to determine the black-body temperature of the star.

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Question 2 continues on the next page

| $\mathbf{0}$ | $\mathbf{2}$. | $\mathbf{3}$ Two stars, 61 Cygnus $A$ and 61 Cygnus B, can be seen very close together in the |
| :--- | :--- | :--- | constellation Cygnus. Early astronomers were unsure whether the two stars form a binary system, or simply appear in the same line of sight.

Table 1 shows some of the properties of the two stars.
Table 1

|  | Temperature / K | Radius / km | Apparent magnitude |
| :--- | :---: | :---: | :---: |
| 61 Cygnus A | 4500 | $4.7 \times 10^{5}$ | 5.2 |
| 61 Cygnus B | 4100 | $4.1 \times 10^{5}$ | 6.1 |

Evaluate whether the data support the suggestion that the two stars form a binary system.

In your answer you should

- compare the two stars as seen by an observer on Earth
- support your evaluation with suitable calculations.
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| $\mathbf{0}$ | $\mathbf{3}, \mathrm{A}$ | Describe the links between galaxies, black holes and quasars. |
| :--- | :--- | :--- |

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| 0 | 3 | 2 |
| :--- | :--- | :--- | At a distance of $5.81 \times 10^{8}$ light year, Markarian- 231 is the closest known quasar to the Earth. The red shift $z$ of Markarian-231 is 0.0415

Use these data to estimate an age, in seconds, of the Universe.

| $\mathbf{0}$ | $\mathbf{3}$. 3 A typical quasar is believed to be approximately the size of the solar system, with a |
| :--- | :--- | :--- | power output similar to that of a thousand galaxies.

Estimate, with reference to the inverse-square law, how much further the most distant visible quasar is likely to be compared to the most distant visible galaxy.

| 0 | 4 | Evidence to support the Big Bang theory comes from cosmological microwave |
| :--- | :--- | :--- | background radiation and the relative abundance of hydrogen and helium in the Universe.


| $\mathbf{0}$ | $\mathbf{4}$ | $\mathbf{1}$ Explain what is meant by cosmological microwave background radiation and how its |
| :--- | :--- | :--- | existence supports the Big Bang theory.

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| $\mathbf{0}$ | $\mathbf{4}$ | .2 | Explain how the relative abundance of hydrogen and helium supports the Big Bang |
| :--- | :--- | :--- | :--- | theory.

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