Please write clearly in block capitals.

Centre number | | | | | |

Candidate number | | | | |

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________

A-level
PHYSICS

Paper 3
Section B Medical physics

Thursday 14 June 2018 Morning

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

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.

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.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

Section B

Answer **all** questions in this section.

0 1 . 1 An endoscope is used to view an area inside the body. The endoscope contains two bundles of optical fibres.

Name each bundle and explain its use in the process.

[4 marks]

Bundle 1 ____

____

____

____

____

Bundle 2 ____

____

____

____

____

Do not write outside the box

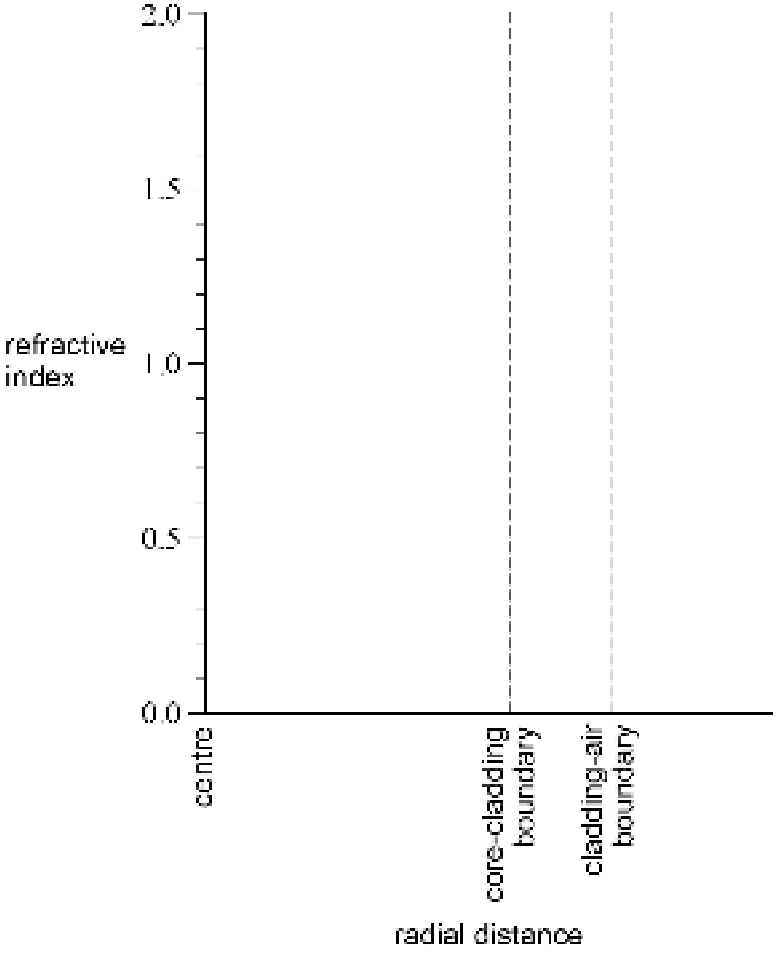
0 1 . 2 A single optical fibre is placed in air. The optical fibre has a core surrounded by cladding. The critical angle is $75°$ at the core-cladding boundary.

Complete **Figure 1** to show how the refractive index varies with radial distance from the centre of the core to the air surrounding the fibre.
Your answer should be supported by a suitable calculation.

refractive index of core $= 1.6$

[2 marks]

Figure 1



6

Do not write outside the box

0 2 . 1 The fovea in a typical human eye consists of cones which have an average diameter of 1.5×10^{-6} m

An eye looks directly at two point sources of light which are 12 mm apart at a distance of 61 m from the centre of the eye lens. The fovea is at the centre of the retina a distance of 21 mm behind the centre of the eye lens.

Deduce whether the eye would be able to resolve the two images formed at the fovea.

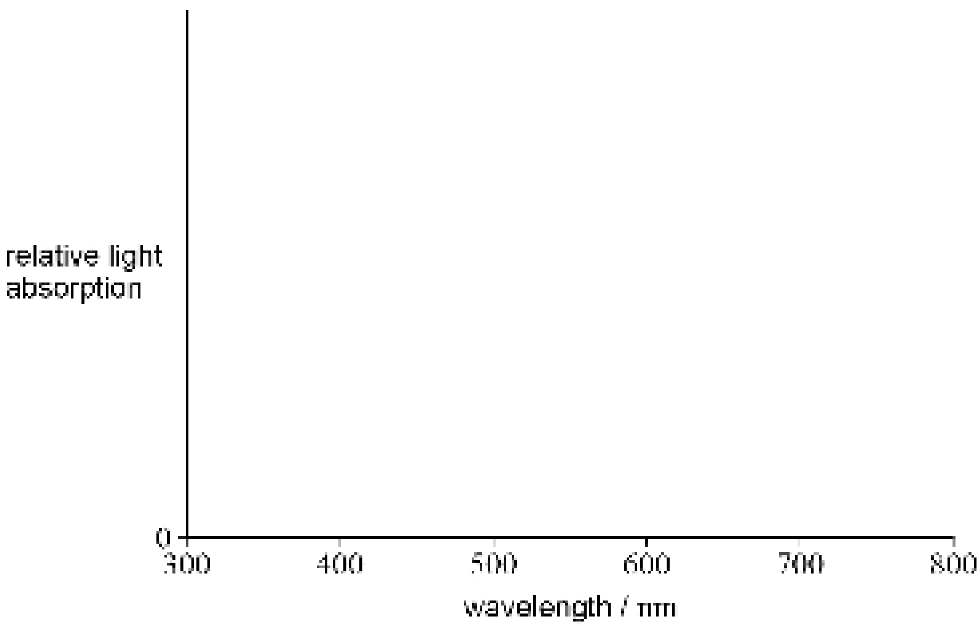
[4 marks]

0 2 . 2 Three types of cone are present at the fovea.

On **Figure 2** sketch and clearly label **three** curves to show how the relative light absorption of each type of cone varies with wavelength.

[3 marks]

Figure 2



7

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 3 In the past, doctors could only use a simple X-ray image to assess head injuries. A CT scan is now a preferred technique.

Discuss why the CT scan has replaced the simple X-ray image to assess head injuries, but a simple X-ray procedure is suitable for assessing other injuries.

In your answer, you should:

- describe the basic principles of a CT scanner
- discuss the advantage of the CT scan over a simple X-ray image for head injuries
- explain why a simple X-ray procedure is more suitable for assessing other injuries.

[6 marks]

Do not write outside the box

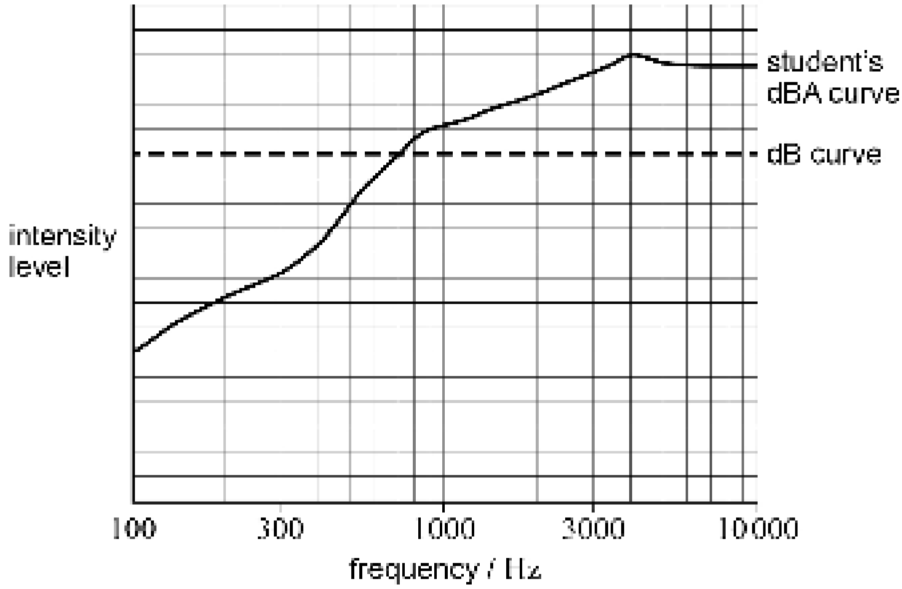
6

Turn over for the next question

0 4 . 1 A source of constant output power is used to generate a sound which is measured using a sound meter.

The dashed line in **Figure 3** shows the intensity level curve over a range of frequencies with the meter set to the dB setting.

Figure 3



A student sketches a curve, over the same frequency range, which he thinks would be obtained when the meter is changed to the dBA setting. The curve drawn by the student is shown as the solid line in **Figure 3**.

Discuss whether the dBA curve drawn is correct.

[4 marks]

0 4 . 2 Mesh barriers are set up to keep pedestrians at a safe distance from a noisy drill.
The maximum noise level which pedestrians should be subjected to is $110\ \mathrm{dB}$
The drill emits sound with a power of $7.8\ \mathrm{W}$ and acts as a point source.
The mesh barriers are set up a distance of $2.0\ \mathrm{m}$ from the drill.

Discuss whether this will keep pedestrians at a safe distance from the sound source.

[4 marks]

8

Turn over for the next question

0 5 . 1 High-energy X-rays are used in the treatment of a cancer tumour inside a patient's body. The patient is given a series of scans before the treatment is started.

Discuss how these scans are used to help provide the best and safest treatment for the patient when using the high-energy X-rays.

[3 marks]

0 5 . 2 Lead is commonly used as shielding when using X-rays due to its small half-value thickness.

Which statement gives the correct meaning of half-value thickness?
Tick (✓) the correct answer.

[1 mark]

The thickness of material needed to reduce the energy of an X-ray photon by half. ☐

The thickness of material needed to reduce the wavelength of the photons in the X-ray beam by half. ☐

The thickness of material needed to reduce the intensity of the X-ray beam by half. ☐

Half the thickness of material needed to stop the X-ray beam. ☐

0 5 . 3 The half-value thickness of lead for $500\ \text{keV}$ X-rays is $4.2 \times 10^{-3}\ \text{m}$

Calculate the mass attenuation coefficient of lead for $500\ \text{keV}$ X-rays.

State an appropriate unit for your answer.

density of lead $= 1.1 \times 10^{4}\ \text{kg m}^{-3}$

[4 marks]

mass attenuation coefficient = ____________________ unit __________

8

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED