AQA

Please write clearly in block capitals.

Centre number | 4 | 1 | 9 | 7 | 1 | Candidate number | 6 | 9 | 3 | 9 |

Surname Matheson

Forename(s) Lewis

Candidate signature

I declare this is my own work.

A-level PHYSICS

Paper 3
Section B Medical physics

ALevelPhysicsOnline.com

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
- a protractor.

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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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	
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TOTAL	

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Section B

Answer **all** questions in this section.

0 1 An eye condition is corrected using a +4.0D lens.

0 1 . 1 Which eye condition could be corrected by using this lens?
Tick (✓) **one** box.

[1 mark]

astigmatism ☐

hypermetropia ☑ ✓

myopia ☐

0 1 . 2 Calculate the magnification produced by the +4.0D lens when viewing an object 75 cm from this lens.

[3 marks]

$P = \frac{1}{f}$ $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$v = \frac{1}{P - \frac{1}{u}} = \frac{1}{4.0 - \frac{1}{0.75}} = 0.375\,m$ ✓

$m = \frac{v}{u} = \frac{0.375}{0.75}$ ✓ $= 0.50$

magnification = 0.50 ✓

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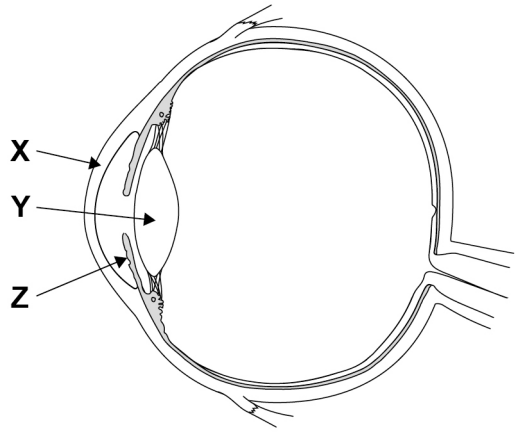
0 1 . 3 **Figure 1** shows a diagram of an eye.

Figure 1



State the name and primary optical function of **X**, **Y** and **Z**.

[4 marks]

Name of **X** Cornea

Primary optical function of **X** Focus image on retina by refracting the light. ✓

Name of **Y** Lens

Primary optical function of **Y** Varies focal length. ✓

Name of **Z** Iris ✓

Primary optical function of **Z** Controls amount of light entering the eye. ✓

8

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ANSWER IN THE SPACES PROVIDED

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0 2 . 1 An X-ray image is to be made of a broken bone.
The image can be formed on

- photographic film
- a flat panel (FTP) detector or
- an intensifying screen using fluoroscopic image intensification.

State and explain which one of these detection methods should be used in this situation.
Go on to discuss why the other two methods are less suitable.

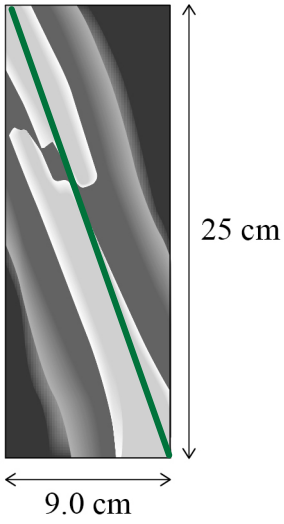
[4 marks]

A flat panel detector should be used ✓. Unlike an intensifying screen it saves a picture ✓ and because the object isn't moving ✓ there is no need for the fluoroscopic image intensification.
FTP digital image is easier to share, ✓ unlike film, and is more sensitive than film.

Question 2 continues on the next page

Figure 2 shows an X-ray of a broken bone.

Figure 2



mean diameter of bone = 0.040 m x

intensity of incident X-rays = 0.013 W m^{-2} I_0

exposure time of X-ray = 0.80 s t

linear attenuation coefficient of bone = 58.3 m^{-1} μ

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0 2 . 2 Calculate an estimate for the X-ray energy that is absorbed by the bone.

[5 marks]

$I = I_0 e^{-\mu x} = 0.013 \times e^{-58.3 \times 0.040}$

$= 1.2623 \times 10^{-3}$ Wm^{-2} transmitted ✓

Absorbed $= I_0 - I = 0.013 - 1.2623 \times 10^{-3} = 0.0117$ Wm^{-2} ✓

Area of bone = length × width

$A = \sqrt{0.25^2 + 0.090^2} \times 0.040$

$A = 0.0106$ m^2 ✓

$E = Pt \quad P = IA \quad E = IAt$

$E = 0.0117 \times 0.0106$ ✓ $\times 0.80$

$E = 9.948 \times 10^{-5}$ J

energy absorbed = 9.9×10^{-5} ✓ J

0 2 . 3 State **two** reasons why the estimate of energy absorption in Question **02.2** may be greater than the actual value.

[2 marks]

1 This assumed the bone was a cuboid with a constant thickness. ✓

2 It also assumed that all the energy was absorbed by the bone and that none of it was absorbed by the soft tissues in the body. ✓

11

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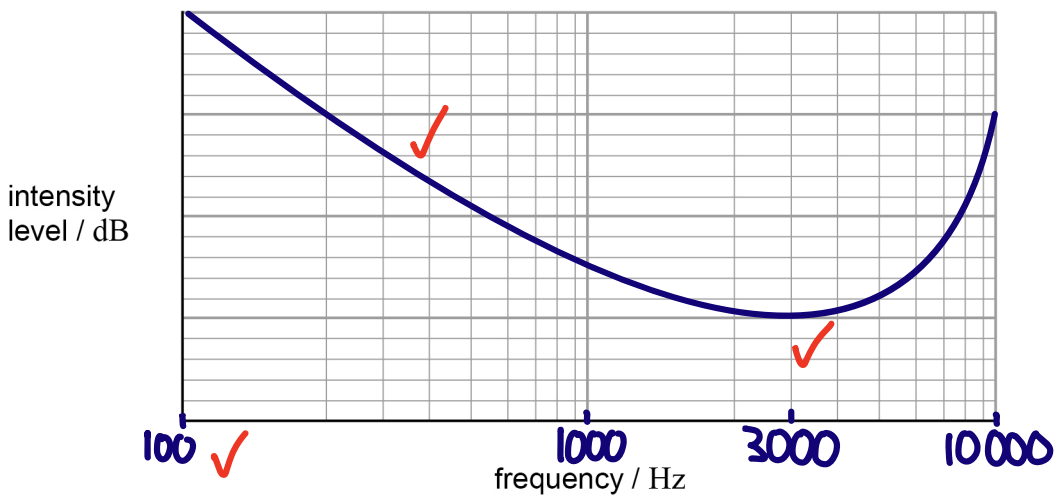
0 3 . 1 Sketch an equal loudness curve on **Figure 3** showing the normal response of a healthy ear.
Annotate the **frequency** axis with an appropriate scale.

[3 marks]

Figure 3



0 3 . 2 Describe the procedure used to gather the data for an equal loudness curve.

[2 marks]

Different frequencies are played and compared to a 1 kHz reference signal. ✓ Volume is adjusted until is sounds the same loudness as the reference signal. ✓

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0 3 . 3 Calculate the intensity of a sound that produces an intensity level of 30 dB.

[2 marks]

$$\text{Intensity level} = 10 \log \frac{I}{1.0 \times 10^{-12}}$$

$$30 = 10 \log \frac{I}{1.0 \times 10^{-12}}$$

$$10^{30/10} = \frac{I}{1.0 \times 10^{-12}} \checkmark \qquad I = 1.0 \times 10^{-12} \times 1000$$

intensity = 1.0×10^{-9} ✓ W m^{-2}

7

Turn over for the next question

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0 4 A patient has calcium kidney stones.
Three types of scan are available to investigate the condition:

- a magnetic resonance (MR) scan
- a CT scan
- an ultrasound scan.

Calcium kidney stones contain no water and appear similar to bone in each of the scans.

Discuss the advantages and disadvantages of each option.
In your answer you should

- refer to the relevant quality of the image obtained from each scan
- identify other factors that should be considered
- justify the type of scan you would recommend.

[6 marks]

An MR scan produces a low quality image of calcium kidney stones. CT scans produce high resolution images whereas ultrasound is low resolution. ✓✓

CT and MR scans take longer and are much more expensive. The CT scan also emits ionising radiation unlike MR and ultrasound. ✓✓

Ultrasound is the best option for this application as it's fastest, cheapest and safe while providing a good enough image for diagnosis. ✓✓

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6

Turn over for the next question

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0 5 . 1 State the purpose of the magnetic field in a magnetic resonance scanner.

[1 mark]

Aligns the spin of the protons. ✓

0 5 . 2 Describe the role of the radio frequency pulses in a magnetic resonance scanner.

[2 marks]

Excites the protons, causing their spin to flip. ✓ When they relax they emit radio frequency signals which can be detected. ✓

3

END OF QUESTIONS

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