



A-Level Physics

Non-Ionising Imaging

Question Paper

Time available: 59 minutes

Marks available: 43 marks

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1.

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.

(Total 6 marks)

2.

(a) State the purpose of the magnetic field in a magnetic resonance scanner.

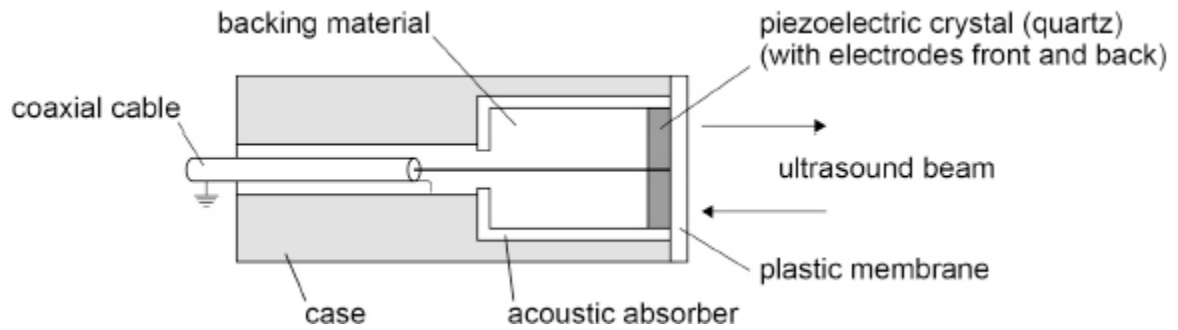
(1)

(b) Describe the role of the radio frequency pulses in a magnetic resonance scanner.

(2)
(Total 3 marks)

3.

The diagram shows an ultrasound transducer used to perform medical scans.



(a) Explain how the transducer in the diagram above operates in medical diagnosis.

In your answer you should explain how

- an ultrasound pulse is produced by the transducer
- the reflected ultrasound pulse is detected by the transducer
- the transducer can both transmit a pulse and receive the reflected pulse.

(6)

(b) Ultrasound of frequency 1.0 MHz is used to scan a person's liver.

Estimate the resolution of the scan.

speed of sound in liver tissue = 1600 m s^{-1}

resolution = _____ mm

(1)

- (c) Ultrasound travels from a transducer through the chest wall to an air pocket inside the lung. From the air pocket, the ultrasound is then incident on lung tissue.

Calculate the percentage of the incident ultrasound intensity that is transmitted into the lung tissue.

speed of sound in lung tissue = 1580 m s^{-1}

density of lung tissue = 1075 kg m^{-3}

speed of sound in air = 330 m s^{-1}

density of air = 1.3 kg m^{-3}

percentage = _____ %

(4)

- (d) Discuss whether an ultrasound scan would be suitable to investigate a tumour inside a lung.

(2)

(Total 13 marks)

4.

- (a) 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.

Bundle 1 _____

Bundle 2 _____

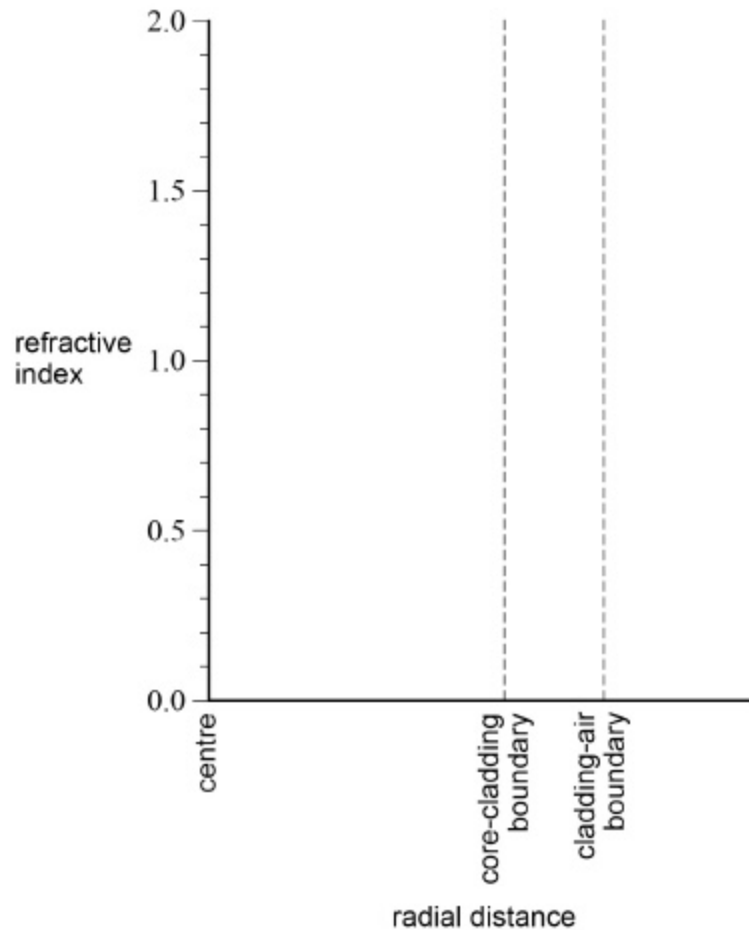
(4)

- (b) 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 the graph 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)

(Total 6 marks)

5.

- (a) An endoscope uses **coherent** and **non-coherent** fibre bundles.

- (i) State the use of the **coherent** bundle and describe its arrangement of fibres.

(2)

(ii) State the use of the **non-coherent** bundle and describe its arrangement of fibres.

(2)

(b) Each fibre has a core surrounded by cladding.
Calculate the critical angle at the core-cladding interface.

refractive index of core = 1.52

refractive index of cladding = 1.49

critical angle = _____ degree

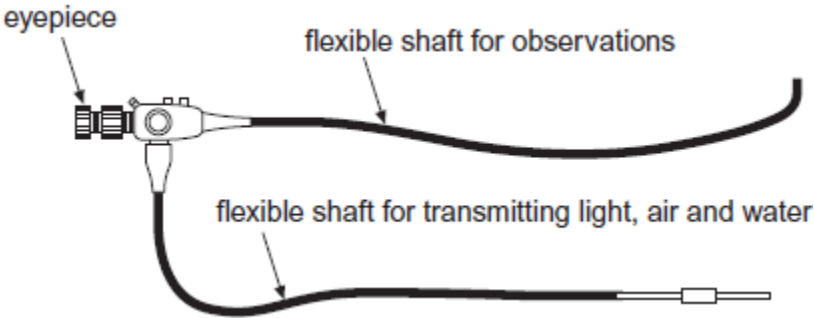
(1)

(Total 5 marks)

6.

Figure 1 shows an endoscope. Some of the optical fibres in the endoscope are arranged in coherent bundles and others are in incoherent bundles. The eyepiece of the endoscope may be replaced with a digital camera.

Figure 1



(a) Explain the difference between **coherent bundles** and **incoherent bundles** of optical fibres and explain which are appropriate for the different parts of the endoscope.

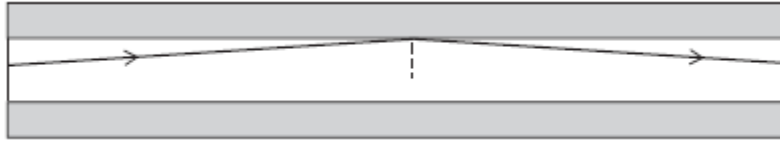
(3)

(b) Explain how a digital camera can store the image produced by the endoscope.

(3)

- (c) **Figure 2** shows a ray of light travelling through an individual fibre consisting of cladding and a core. One part has a refractive index of 1.485 and the other has a refractive index of 1.511.

Figure 2



- (i) State which part of the fibre has the higher refractive index **and** explain why.

(1)

- (ii) Calculate the critical angle for this fibre.

critical angle _____ degrees

(1)

- (iii) The endoscope image quality may be reduced by crosstalk.

Explain what is meant by **crosstalk** and how it limits the usefulness of the endoscope.

(2)

(Total 10 marks)