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| Surname             |  |  |  |  |  |  |  |  |  |  | Other Names      |  |  |  |  |  |  |  |  |  |  |
| Centre Number       |  |  |  |  |  |  |  |  |  |  | Candidate Number |  |  |  |  |  |  |  |  |  |  |
| Candidate Signature |  |  |  |  |  |  |  |  |  |  |                  |  |  |  |  |  |  |  |  |  |  |

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| For Examiner's Use |
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General Certificate of Education  
January 2008  
Advanced Level Examination

**APPLIED SCIENCE**  
**Unit 8 Medical Physics**

**SC08**



Tuesday 22 January 2008 9.00 am to 10.30 am

|                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>For this paper you must have:</b></p> <ul style="list-style-type: none"> <li>• a pencil and a ruler</li> <li>• a calculator.</li> </ul> |
|-----------------------------------------------------------------------------------------------------------------------------------------------|

Time allowed: 1 hour 30 minutes

**Instructions**

- Use black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

**Information**

- The maximum mark for this paper is 80.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.

| For Examiner's Use  |      |          |      |
|---------------------|------|----------|------|
| Question            | Mark | Question | Mark |
| 1                   |      | 5        |      |
| 2                   |      | 6        |      |
| 3                   |      |          |      |
| 4                   |      |          |      |
| Total (Column 1) →  |      |          |      |
| Total (Column 2) →  |      |          |      |
| TOTAL               |      |          |      |
| Examiner's Initials |      |          |      |

**There are no questions printed on this page**

Answer **all** questions in the spaces provided.

- 1 Psychology research students have discovered that they can tell when a person is under severe stress by attaching the person to either EEG or ECG machines and looking at the traces produced.

- (a) (i) Which organ is monitored using an EEG machine?

.....  
(1 mark)

- (ii) How would a research student be able to tell, from the EEG trace, that the person was under stress?

.....  
.....  
(1 mark)

- (b) (i) Which organ is monitored using an ECG machine?

.....  
(1 mark)

- (ii) When the ECG is taken, gel is smeared between the electrodes and the skin. Why is this necessary?

.....  
.....  
.....  
(2 marks)

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| 5 |
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**Turn over for the next question**

- 2 Screening for breast cancer is normally carried out by sending low dose X-rays into breast tissue. In some countries thermography is used instead.

(a) What are *X-rays*?

.....

.....

.....

(2 marks)

(b) Why does breast cancer show up on X-ray images?

.....

.....

.....

(2 marks)

(c) What is *thermography*?

.....

.....

.....

(2 marks)

(d) Why does breast cancer show up on a thermograph?

.....

.....

.....

(2 marks)

(e) Using thermography is a much safer way of detecting breast cancer than using X-rays.

(i) Explain why thermography is safer.

.....

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.....

.....

(3 marks)

(ii) Suggest why some doctors prefer to use X-rays rather than thermography even though thermography is safer.

.....

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.....

(2 marks)

(f) CAT scans make use of X-rays.

State **two** reasons why CAT scans are **not** used in routine screening for breast cancer.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

- 3 The practice nurse in a health centre measures the blood pressure of patients. One patient, a 20-year-old female, has a blood pressure value of 80/50 mm Hg.

(a) (i) What does this value suggest about the patient's blood pressure?

.....  
(1 mark)

(ii) What do the figures 80 and 50 represent?

80 is .....

50 is .....  
(2 marks)

- (b) Blood pressure can be measured using either invasive or non-invasive methods. State and explain **two** reasons why non-invasive methods are usually used to measure blood pressure, even though invasive measurements give more accurate readings.

Reason 1 .....

.....

.....

Reason 2 .....

.....

.....  
(4 marks)

- (c) When a sphygmomanometer is used to measure blood pressure, the cuff is placed around the upper arm.

(i) Explain why it is placed here.

.....

.....

(1 mark)

(ii) What would be the effect on the blood pressure value obtained if the cuff were placed just above the patient's ankle?

.....

.....

(1 mark)

- (d) Complete the passage below, describing how the nurse uses the sphygmomanometer to measure blood pressure.

‘The patient is asked to sit down. The nurse wraps the sphygmomanometer cuff around the patient’s upper arm...’

.....

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.....

(4 marks)

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| 13 |
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**Turn over for the next question**

- 4 There are many different ways to treat soft tissue cancers, such as liver cancer. Two of these methods are described below.

**Microwave Treatment**

A small probe is inserted into the area to be treated. Microwaves are sent down the probe into the cancer cells. The energy from the microwaves destroys the cancer cells. The probe can be inserted using keyhole surgery.

**Radiotherapy Treatment**

A radioisotope is implanted in the area to be treated. It is then left in position for several weeks. The radiation emitted destroys the cancer cells. The radioisotope can be implanted using keyhole surgery.

- (a) State and explain **two** advantages of using microwave treatment rather than radioisotope implants to treat liver cancer.

Advantage 1 .....

Explanation .....

.....

.....

.....

.....

Advantage 2 .....

Explanation .....

.....

.....

.....

.....

.....

(6 marks)

- (b) Microwave surgery is a very new technique. Use this fact to suggest why radiotherapy, rather than microwave surgery, is used far more often to treat liver cancer.

.....

.....

(1 mark)



- (c) Both probes and implants can be inserted using either traditional open surgery or using keyhole surgery.

State and explain **one** advantage and **one** disadvantage of using keyhole surgery rather than traditional open surgery.

Advantage .....

Explanation .....

.....

Disadvantage .....

Explanation .....

.....

(4 marks)

- (d) Keyhole surgery usually involves the surgeon using an endoscope.

- (i) What is an endoscope?

.....

(1 mark)

- (ii) Explain how an endoscope works.

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(4 marks)

- (e) In traditional open surgery, one incision is usually made. Why does the surgeon usually have to make two incisions when carrying out keyhole surgery?

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(1 mark)

- 5 Medical physicists often use ultrasound to monitor pregnancy. Ultrasound waves have a velocity of  $330 \text{ m s}^{-1}$  in air.  
An ultrasound wave of frequency 2 MHz is used to check the development of a foetus.

- (a) (i) Write down the equation that links the velocity, frequency and wavelength of a wave.

.....  
(1 mark)

- (ii) Calculate the wavelength of the ultrasound wave used.

.....  
.....

Wavelength = ..... m  
(2 marks)

- (b) Ultrasound images are produced by echoes of ultrasound waves. Different tissues have different specific acoustic impedance values. Ultrasound waves reflect at the boundary between different tissues.

The values of specific acoustic impedance for bone and soft tissue are given below.

$$Z_{(\text{bone})} = 7\,780\,000 \text{ kg m}^{-2} \text{ s}^{-1}$$

$$Z_{(\text{soft tissue})} = 1\,630\,000 \text{ kg m}^{-2} \text{ s}^{-1}$$

Calculate the intensity reflection coefficient ( $\alpha$ ) when ultrasound waves travel from bone into soft tissue.

.....  
.....  
.....  
.....  
(3 marks)

- (c) When using ultrasound to investigate soft tissue, a gel is smeared on the patient's skin to ensure that there is no air between the ultrasound probe and the skin.

- (i) Why is it important that there is no air between the probe and the skin?

.....  
 ..... (1 mark)

- (ii) How should the specific acoustic impedance value of the gel compare with that of the skin?

.....  
 ..... (1 mark)

- (d) State **two** reasons why ultrasound is preferred to X-rays for monitoring foetal development.

Reason 1 .....

.....

Reason 2 .....

..... (2 marks)

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**Turn over for the next question**

- 6 A medical physics technician has been asked to check the penetration power of a new radioisotope. She knows that it is a beta ( $\beta$ ) emitter.
- (a) Design an experiment that could be carried out in the laboratory to measure the maximum penetration of the beta particles emitted by the source.

Include the following information

- a diagram showing the equipment you would use and how you would set it up
- a description of how you would use the equipment
- the results you would record
- how you would make sure the experiment was safe
- how you would make sure the results were reliable.

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- (b) Explain why a beta emitter would be more likely to be used as an implant rather than as a tracer.

.....

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.....

(3 marks)

- (c) Suggest a suitable half-life for a beta emitter that would be used as an implant to treat prostate cancer.  
Explain your choice.

Half-life .....

Explanation .....

.....

.....

(3 marks)

- (d) Technetium-99 is a very useful radioisotope. It is one of the most widely used for diagnosis.

- (i) Technetium-99 has a physical half-life of 6 hours.  
A 4 g sample of technetium-99 is placed in a store cupboard. How much radioactive technetium-99 will be left 24 hours later?

.....

.....

.....

(2 marks)

- (ii) Explain why technetium-99's half-life makes it suitable for use as a tracer.

.....

.....

.....

(2 marks)

**Question 6 continues on the next page**

- (iii) State **two** reasons, other than its half-life, why technetium-99 is one of the most widely used radioisotopes.

Reason 1 .....

.....

Reason 2 .....

.....

(2 marks)

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**END OF QUESTIONS**

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