

Ultrasound - Medical Physics Option

1. (a) A piezoelectric ultrasound transducer is made from a thin slice of an artificial ceramic such as lead zirconate titanate (PZT).

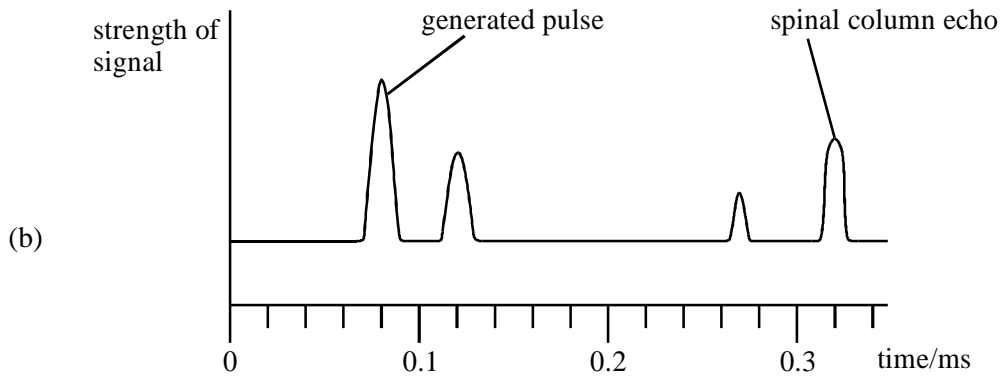
(i) Describe what happens when an alternating voltage is applied to a PZT transducer so that ultrasound is produced.

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(ii) Under what conditions will maximum energy conversion into ultrasound occur?

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(4)



The diagram shows the oscilloscope display of pulse amplitude against time for an ultrasound A-scan through a person's abdomen. Assume that the weaker echoes come from internal organs.

(i) Describe the procedures which are used to obtain this type of scan.

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Ultrasound - Medical Physics Option

(ii) Explain how the spacing of the pulses is interpreted.

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(iii) Give **two** reasons why the amplitude of the reflected pulses varies.

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(iv) If the speed of ultrasound through water and soft tissue is about 1500 ms^{-1} , estimate the distance between the front of the patient's abdomen and the spinal column.

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(8)
(Total 12 marks)

2. (a) Explain how a piezoelectric crystal is caused to generate waves of ultrasound.

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(4)

Ultrasound - Medical Physics Option

(b) In medical applications of ultrasound a short pulse of duration about $1 \mu\text{s}$ is often used.

(i) Explain why the pulse of ultrasound must be short.

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(ii) Short voltage pulses applied to the piezoelectric crystal make it vibrate and emit *short* pulses only if the crystal assembly is modified. Explain the modification which is necessary.

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(3)

(c) (i) Under what conditions is ultrasound reflected strongly at boundaries between two types of material?

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(ii) State **two** physical properties of the materials which determine the proportion of ultrasound which is reflected at a boundary.

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(iii) Explain what a coupling medium or gel is and why, and where, it is used.

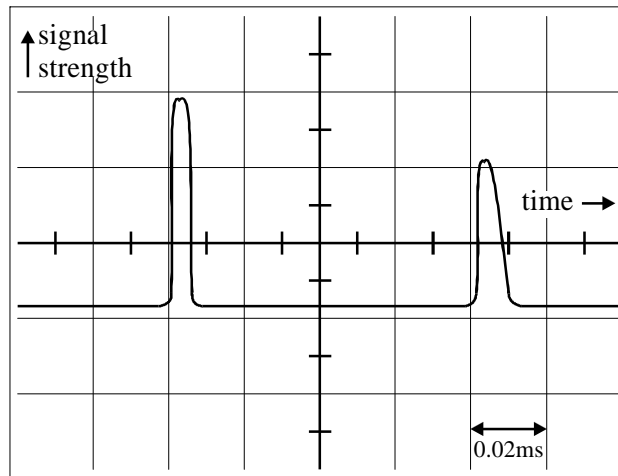
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(5)

(Total 12 marks)

Ultrasound - Medical Physics Option

3. An ultrasound transducer is used to obtain an A-scan of an internal organ. The A-scan pulses shown on the diagram were identified as coming from the front and rear surfaces of the organ.



- (a) Describe the practical process, including details of the use of the transducer and the adjustment of the oscilloscope, required to produce this A-scan.

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(3)

- (b) From the A-scan, estimate
- (i) the thickness of the organ if the speed of ultrasound in the tissue is 1500 m s^{-1} (the horizontal scale is 0.02 ms/cm),

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- (ii) the duration of the first ultrasound pulse.

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(3)

Ultrasound - Medical Physics Option

- (c) Give **two** reasons why the height of the second pulse is smaller than that of the first pulse.

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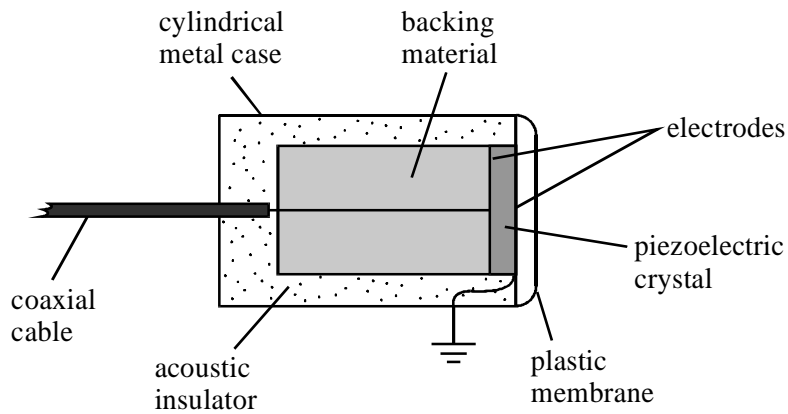
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(2)
(Total 8 marks)

4. The diagram shows an ultrasound transducer as used in A-scans. The transducer produces short pulses of ultrasound.



- (a) (i) Why is it necessary for the pulse to be short?

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- (ii) Explain, with reference to the diagram, the process by which the transducer produces short pulses.

You may be awarded marks for the quality of written communication provided in your answer.

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(5)

Ultrasound - Medical Physics Option

- (b) State **one** advantage and **one** disadvantage of ultrasound compared with X-rays in medical imaging.

advantage:

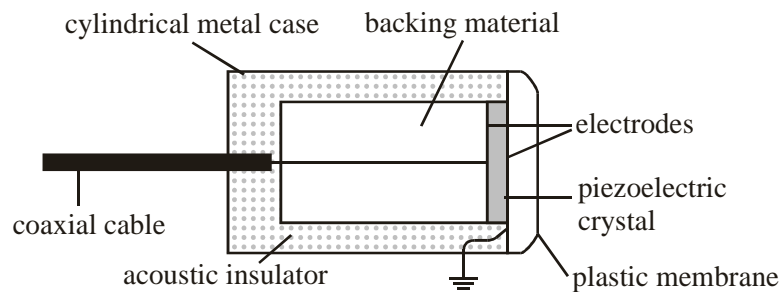
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disadvantage:

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(2)
(Total 7 marks)

5. The figure below shows a transducer used in an ultrasound A scan.



- (a) Describe how pulses of ultrasound are produced by the transducer.

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(3)

- (b) In an ultrasound A scan

- (i) explain how the received signals are detected,

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Ultrasound - Medical Physics Option

(ii) state why it is essential to use short pulses of ultrasound.

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(3)
(Total 6 marks)