

## Ultrasounds Answers - Medical Physics Option

1. (a) (i) electric field across a transducer causes a change in physical dimensions (1)  
if alternating voltage is applied the transducer vibrates at the same frequency (1)
- (ii) maximum energy transfer when frequency of applied voltage = natural  
mechanical vibration frequency of the transducer (1)  
causing resonance (1) 4
- (b) (i) ultrasound transmitter or receiver or transducer is placed in contact with skin (1)  
transmission is improved using oil layer between transducer and skin (1)  
pulses of ultrasound are transmitted into the body (1)
- (ii) echoes reflected back to transducer appear as voltage peaks or pulses on c.r.o. (1)  
spacing of peaks gives time delay between transmitted pulse and echoes (1)  
distance  $s$  between transmitter and a reflecting surface is given by  $s = \frac{1}{2} c \Delta t$   
where  $c$  = speed of ultrasound in tissue,  $\Delta t$  = time delay between pulses (1)
- (iii) amplitude of pulses is attenuated as it penetrates deeper (caused by absorption and  
dispersion) (1)  
amplitude of echo pulses depends on the proportions of ultrasound which are  
reflected and transmitted at each surface or boundary or  
depends on the acoustic impedances of the two materials at the interface (1)
- (iv)  $\Delta t = 0.32 - 0.08 = 0.24$  ms (1)  
 $s = \frac{1}{2} c \Delta t = 0.5 \times 1500 \times 0.24 \times 10^{-3} = 0.18$  m (1)      allow e.c.f.    max 8
- [12]**
2. (a) two faces of a thin slice of crystal (coated with a thin layer of silver) act as electrodes (1)  
electrodes connected to high frequency (several MHz) source of e.m.f. (1)  
as applied e.m.f. alternates it applies alternating (rapidly reversing direction) electric  
field across the slice of crystal between the electrodes (1)  
crystal expands and contracts at the same frequency as the applied e.m.f. (1)  
the vibrations of the faces of the crystal slice produce  
ultrasound pressure waves (1) max 4
- (b) (i) pulse short compared with the transit time (1)  
pulses are used for timing echoes which give measurements of depth in the body (1)  
pulse must be short enough to ensure the leading edge returns after the  
trailing edge departs (1)
- (ii) behind the crystal a vibration-absorbing backing material is attached (1)  
this stops the vibrations quickly after the electrical signal is stopped, ensuring  
that the pulse is short (1) max 3
- (c) (i) when there is a large difference in acoustic impedance  
[or significant change in density or significant change in elasticity or texture of  
tissue] (1)
- (ii) tissue density (1)  
tissue elasticity/texture (1)

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- (iii) ultrasound is reflected back at boundaries with air  
 [or replacement of air prevents reflection] (\*)  
 gel between transducer and skin  
 (prevents loss of signal due to boundary reflection) (\*)  
 acoustically well -matched gel gives good transmission  
 (with minimum reflection at skin boundary) (\*)  
 (\*) any two **(1) (1)**

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**[12]**

3. (a) surface of body covered with an oil to improve transmission  
 from ultrasound transducer to body **(1)**  
 short ultrasound pulses sent into the body and echoes received  
 from surfaces detected by the transducer **(1)**  
 oscilloscope sweep time synchronised with the ultrasound pulse frequency **(1)** 3
- (b) (i)  $\text{thickness} = \frac{1}{2} v \Delta t$  **(1)**  $= \frac{1}{2} \times 1500 \times 0.08 \times 10^{-3}$  (m) **(1)**  
 $= 0.06$  m **(1)**
- (ii) pulse duration  $= 0.3 \times 0.02 = 0.006$ ms **(1)** max 3
- (c) extra distance in tissue results in more signal absorption (\*)  
 smaller fraction of signal reflected at second surface (\*)  
 pulse more spread over time (\*)  
 signal is diffracted (\*)  
 (\*) any two **(1) (1)** 2

**[8]**

4. (a) (i) probe is used as a generator and receiver **(1)**  
 (ii) electrodes connected to (high frequency/alternating) emf **(1)**  
 crystal expands and contracts at frequency of emf **(1)**  
 vibration of faces produce ultrasound (pressure) waves **(1)**  
 backing material damps oscillation of crystal **(1)**  
 to stop crystal oscillating between end of transmitted pulse  
 and start of received pulse **(1)** max 5

The quality of Written communication marks were awarded for quality of answers to this question **(2)**.

- (b) advantage: e.g. not harmful to living cells or soft tissue **(1)**  
 disadvantage: e.g. cannot penetrate bone or low resolution **(1)** 2

**[7]**

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5. (a) electrodes connected to **alternating/high frequency** emf/voltage/pd (1)  
crystal expands and contracts at frequency of emf (1)  
[or resonates at same frequency]  
vibration of faces produces ultrasound/pressure waves (1)  
backing material damps oscillations of crystal (1)  
to stop crystal oscillating between end of transmitted pulse  
and start of reflective pulse (1)
- Max 3  
QWC 1
- (b) (i) (probe acts as receiver and) received signal causes crystal to vibrate (1)  
vibration of crystal produces alternating pd (1)
- (ii) transmission must stop so that reflected pulse can be received (1) 3

[6]