1

(a)(i) 3.0 div x 0.0030 ms div^{-1} (1)
= 0.0090 ms *or* 9.0 μs (1)

(ii) 2s = vt (1)
4000 x .0090 = 1.8 cm (1)

(iii) 2 d = 1500 x 2 x 3.0 x 10^{-6} = 9.0 x 10^{-3} (1)
d = 0.45 cm (1)

(b) If gel is not used, most reflection occurs at air / skin boundary so large first peak (1)
Reason: e.g. there is a very large difference in the acoustic impedance either side of this boundary (1)

2

(a) when p.d. applied across crystal, it changes shape (1)
with alternating p.d. it oscillates (at resonant frequency) (to produce u.s) (1)
when u.s. incident on crystal or crystal deformed, it produces (a.c.) p.d. (1)
ref. to resonance e.g. applied a.c. must be at resonant frequency of crystal (1)

(b) speed of sound (in the medium) (1)
density (of the medium) (1)
allow *temperature*

(c)(i) 1 f = $(1.63 \times 10^6 - 4.29 \times 10^2)^2 / (1.63 \times 10^6 + 4.29 \times 10^2)^2$ (1)
f = 0.999 (allow 1.0 if working shown) (1)

1 f = $(1.63 \times 10^6 - 1.42 \times 10^6)^2 / (1.63 \times 10^6 + 1.42 \times 10^6)^2$ (1)
f = 4.74 x 10^{-3} (allow 4.7 x 10^{-3}) (1)

(ii) any 2, one mark each to a maximum of 2 (2)
without it most of the u.s. is reflected / or with it most is transmitted
removes air
small reflection when difference in acoustic impedance is small
closer impedance matching

3

(a)(i) t = s / v or
t = 0.018 / 1.5 x 10^3 1
t = 1.2 x 10^{-5} s 1

(ii) t_2 = 0.016 / 4.0 x 10^3 = 4.0 x 10^{-6} s 1
allow 2 x answer to (a)(i)

(b)(i) 2.4 x 10^{-5} s 1

(ii) 2.4 x 10^{-5} / 4.0 x 10^{-6} = 6 1

(iii) B at 6.0 cm from A 1
C at 2.0 cm from B 1
(ignore heights)

(iv) large reflection at the air / skin boundary 1
due to the large difference in acoustic impedance between air and skin 1
so very little ultrasound penetrates into the body 1
(or there is very little ultrasound to be reflected off subsequent boundaries.)

[10]

4

(a) any from the following up to a maximum of 8 marks

piezoelectric crystal deforms when a p.d. is applied across it (1)
crystal oscillates when alternating p.d. is applied (1)
if this frequency matches resonant frequency of crystal, ultrasound is generated (1)
ultrasound in turn causes crystal to resonate (1)
resonating crystal causes alternating voltage across it (1)
pulsing is needed as reflected signal needs to be compared to initial signal (1)
with a continuous a.c. signal, comparison is not possible (1)
backing material damps the crystal vibration after a.c.pulse ends (1)
so that the crystal is ready to receive the reflected signal (1)

(b) (i) $1.4 \times 5.0 \times 10^{-6}$ s $= 7.0 \times 10^{-6}$ s (1)
(tolerance = 1.4 +/- 0.1)

(ii) s = d / t or d = t x s (0)
$d = 7.0 \times 10^{-6} \times 1.6 \times 10^{3}$ ecf (i) (1)
d = 0.0112 m (0)

(iii) 0.0112 m / 2 ecf (ii) (1)
$= 5.6 \times 10^{-3}$ m (1)

(iv) 0.75 div $\times 5.0 \times 10^{-6}$ s (+/- 0.1 div) (0)
$t = 3.75 \times 10^{-6}$ s (1)
$d = 4.1 \times 10^{3} \times 3.75 \times 10^{-6} / 2$ (1)
$d = 7.7 \times 10^{-3}$ m (+/- 0.5×10^{-3}) (1)

(c) use e.g. monitoring foetal growth (1)
reason e.g. ultrasound is not ionising, X-radiation is ionising (1)

[total 17]

5

(a) <u>density</u> (of medium) (1)

<u>speed</u> of <u>ultrasound</u> (in the medium) (1) or any factors that affect the speed of ultrasound in the medium e.g. the Young modulus

(b)(i) blood:
$f = (1.59 \times 10^{6} - 1.63 \times 10^{6})^2 / (1.59 \times 10^{6} + 1.63 \times 10^{6})^2$ (0)
$f = 1.54 \times 10^{-4}$ (1)

muscle:
$f = (1.70 \times 10^{6} - 1.63 \times 10^{6})^2 / (1.70 \times 10^{6} + 1.63 \times 10^{6})^2$ (1)
$f = 4.4 \times 10^{-4}$ (1)

so the medium is muscle (1) bald muscle gets 0/4

(ii) (s = u x t)

$s = 1.54 \times 10^{3} \times 26.5 \times 10^{-6} = 0.0408$ m (1)

0408 / 2 = 0.020 m (1)

(iii) $1.54 \times 10^{3} / 3.5 \times 10^{6} = \lambda$ (1)

4.4×10^{-4} m (1) 4.4×10^{-7} m gets full credit if 10^{3} penalised in (ii)

6 (a) alternating voltage or alternating E-field across crystal (1)
at resonant frequency (1) allow reference to resonance of crystal

(b) (i) position of 3 lower oxygen ions closer to positive plate (1)

(ii) ref. to change in dimension / shape / distort/ it gets longer (1)

(c) (i) *Z* for air is 429 (kg m^{-2} s^{-1}) and
Z for skin is 1.71 x 10^6 (kg $m^{-2}s^{-1}$) (1)

Substitution into equation leading to $F = 0.999$ (1)

(ii) with gel, more ultrasound enters body / without gel, most ultrasound is reflected (1)

most ultrasound is reflected (without gel) when the difference in *Z* is large
or
most ultrasound enters body when the different in *Z* is small (1)

(d) **1.5** cm x 1 x 10^{-5} = 1.5 x 10^{-5} s (1)

s = vt or **4080** x 1.5 x 10^{-5} (1)

s = 6.12 cm (1) ecf if speed is wrong

/2 = 3.06 cm (1)

7

(a) *[to a max. of **5**]*

- A p.d. / voltage must be applied …
- … causing the (piezoelectric) crystal to change shape.
- A named crystal (eg quartz, lead zirconate titanate [PZT], lithium sulphate, barium titanate)
- An alternating p.d. causes the crystal to oscillate / vibrate (accept resonate).
- If the frequency applied matches the natural frequency of the crystal, resonance occurs.
- The crystal is damped / stops vibrating when the applied voltage stops …
- … due to the backing material / epoxy resin …
- … which also absorbs backward-travelling sound waves (which might give spurious reflections).

(b)(i)

- 5.4 cm +/- 0.1 cm read from the graph **(1)**
- = 5.4 x 20 μs cm^{-1} x 1.5 x 10^3 m s^{-1} **(1)**
- = 0.162 m **(1)**
- 0.162 / 2 = 0.081 m or 8.1 cm **(1)**

(b)(ii)

- High reflection at the air-skin boundary / Little ultrasound enters the body / A very large peak right at the start … **(1)**
- … due to large <u>difference</u> in <u>acoustic impedance</u> / allow '…due to large <u>difference</u> in <u>density</u>'. **(1)**
- Very low <u>peaks</u> / no (subsequent) <u>peaks</u> (not just 'nothing') **(1)**

8 (a) (i) t = s/v (1)

= 2.5 x 10^{-2} / 4.0 x 10^3 = 6.26 x 10^{-6} s (1)

6.25 x 10^{-6} / 2.0 x 10^{-6} = 3.125 cm
3.125 x 2 = 6.25 cm

(ii) correct peak position i.e. >6cm from first peak and < 6.5 cm (2)
3.125 cm position or just > 3 cm (1)

(b) e.g. scanning foetus *owtte* (not *baby*) (1)
safer as no ionising radiation (1)
scanning joints / ligaments (1)
quicker / instant image / cheaper (1)

Question	Expected Answers	Marks
9 **(a)(i)**	3.0 div x 2.5μ s div^{-1}	**1**
	= 0.0075 ms or 7.5 μs	**1**
(ii)	2s = vt	**1**
	4000 x 7.5 x 10^{-6}	
	= 1.5 cm	**1**
(iii)	2 d = 1500 x 2 x 2.5 x 10^{-6} = 7.5 x 10^{-3}	**1,1**
	d = 0.38 cm	**1**
(b)	If gel is not used, (most reflection occurs at air / skin boundary)so <u>large first peak</u> or <u>small subsequent peaks</u>	**1**
	Reason: e.g. the is a very large difference in the acoustic impedance either side of this boundary or large reflection at air / skin boundary	**1**
		Total: 9