Ultrasound and Doppler Effect practice question answers

1. Time **(1)** 1

Reflections occur at boundary between head and surrounding fluid **(1)**
1st reflection entering head, 2nd reflection on leaving **(1)** 2

Time between peaks found from trace **(1)**
Knowing speed of ultra sound, v in head, distance can be calculated $l = ut$ **(1)**
Width of head = $l/2$ **(1)** 3

A change in frequency **(1)**
caused by relative movement between transducer and object **(1)** 2

[8]

2. Why warm surface water floats:

Cold water is denser than warm water **(1)** 1

Explanation of why ultrasound waves reflect thermocline:

This is surface separating layers of different density **(1)** 1

Explanation of why submarine is difficult to detect:

Ultrasound from ship partially reflects upwards from thermocline so little is transmitted **(1)**

Any reflected sonar from submarine partially reflects downwards from thermocline **(1)** 2

Explanation of why sonar cannot be used from a satellite:

Lack of medium to transmit sound waves from satellite 1

Calculation of time between emission and detection of radar pulse:

$2s/c$ **(1)**

$= 2 \times 6.0 \times 10^7$ m $\div$ 3.0×10^8 ms^{-1} = 0.4 s **(1)** 2

Calculation of minimum change in height of ocean:

Minimum observable distance

$= ct = 3.0 \times 10^8$ m s^{-1} $\times$ 1.0×10^{-9} s = 0.30 m **(1)**

so change in ocean height = 0.15 m **(1)** 2

Possible problem:

Sensible answer eg **(1)**

atmospheric pressure could change ocean height

bulge not large enough compared with waves

tidal effects

whales 1

[10]

3. <u>Speed of ultrasound</u>

Use of $\upsilon = s/t$ **(1)**

$= 150 \times 10^{-3}$ (m) $\div 132 \times 10^{-6}$ (s)

= 1140 m s^{-1} **(1)** 2

Change of trace

Extra pulse(s)

OR

Reflected pulse moves closer 1

Principle of Doppler probe

3 points from:

- Arrange probe so that soup is approaching
- Soup reflects ultrasound
- with changed frequency/wavelength
- change in frequency/wavelength depends on speed
- Probe detects frequency of reflected ultrasound

Use of diagrams showing waves 3

Determination of speed

1 point from:

- Frequency/wavelength change

Angle between ultrasound direction and direction of flow of soup 1

Comment

Lumps give larger reflections

Lumps travel slower 1

[8]

4. Movement of water molecules

Molecules oscillate/vibrate **(1)**

Movement parallel to energy flow **(1)** 2

Pulses

To prevent interference between transmitted and reflected signals **(1)** 1

OR allow time for reflection before next pulse transmitted

Calculation

Time for pulse to travel to fish and back again = distance ÷ speed

$$\Delta t = \frac{\Delta x}{\upsilon}$$

$$= \frac{2 \times 300\,\text{m}}{1500\,\text{ms}^{-1}}$$ **(1)**

= 0.4 s **(1)** 2

[0.2 s = 1 mark]

Effect used in method

Doppler effect **(1)**

Any two from:

- a change in frequency of the signal
- caused by relative movement between the source and the observer
- size and sign of change relate to the relative speed and direction of the movement between shoal and transmitter
- frequency increase - moving towards
- frequency decrease - moving away **(1) (1)** 3

[8]

5. Emitted pulse

Greater amplitude/pulse is larger/taller **(1)** 1

Depth of rail

$2d = vt = 5100 \text{ m s}^{-1} \times 4.8 \times 10^{-5} \text{ s}$

$= 0.24 \text{ m}$

Hence $d = 0.12$ m

Reading from graph [4.8 or 48 only] **(1)**

Calculation of 2d [their reading × timebase × 5 100] **(1)**

Halving their distance **(1)** 3

Description of trace

A reflected peak closer to emitted/now 3 pulses **(1)**

Exact position e.g. 1.6 cm from emitted **(1)** 2

Diagram

Shadow region **(1)**

Waves curving round crack **(1)** 2

Properties

Any two from:

- durable
- elastic
- hard
- stiff
- strong
- tough **(1) (1)** 2

[10]