Answers to examination-style questions

Answers	Marks	Examiner's tips
1 (a) (i) 409 mm	**1**	Five measurements are given of the length of the wire that gives a different given frequency; the calculation of the mean value and probable error of these measurements are required.
(ii) 12 mm	**1**	
(b) (i) If f is inversely proportional to L, then fL should be the same (provided the tension is not changed).	**1**	A hypothesis on the link between the frequency and the wire length is suggested for discussion.
At 256 Hz, fL = 210 Hz m;	**1**	
at 510 Hz, $fL = 209 \pm 6$ Hz m.	**1**	
The measurements support the hypothesis.	**1**	
(ii) Without changing the tension, use different tuning forks of known frequency to find the length of wire that gives the same frequency.	**1** **1**	The question asks what further measurements need to be made and how they should be used to test the hypothesis more fully.
For each frequency f, make several measurements of L and calculate the mean value for each length.	**1**	
Plot a graph of frequency against 1/length.	**1**	
The graph should be a straight line through the origin if f is inversely proportional to L.	**1**	
2 (a) use of $c = f\lambda$ gives speed $c = 29 \times 10^3 \times 5.3 \times 10^{-2}$	**2**	An easy calculation based on the wave equation $c = f\lambda$.
$= 1540$ m s^{-1}	**1**	Note that 29 kHz = 29×10^3 Hz.
(b) distance travelled by the wave between transmission and detection $= c\,t = 1540 \times 0.23 = 354$ m	**1**	The sound travels at constant speed through the water, from the ship to the sea bed and then back again.
$\therefore$ depth of water $= \frac{1}{2} \times 354 = 180$ m (to 2 significant figures)	**1**	
3 (a) (i) *Longitudinal waves*: particle vibration or oscillation	**1**	You have to be clear about the essential distinction between longitudinal and transverse waves. All waves involve particle vibration or oscillation in one form or another; it is the direction of these vibrations in relation to the direction in which the wave travels that defines which is which.
is same as direction of propagation or energy transfer	**1**	
(ii) *Transverse waves*: particle vibration or oscillation is perpendicular to direction of propagation or energy transfer	**1**	

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(b) as the polarising filter is rotated through 360° the intensity transmitted will vary between maxima and minima (or light and dark) there will be two maxima (and two minima) in each 360° rotation	**1** **1**	Light is transmitted through both filters when their transmission axes are parallel to each other. When the transmission axes are at 90° to each other, the second filter no longer transmits light. A polarising filter always appears slightly grey because it absorbs all incident light except the component that is aligned with its own transmission axis.
4 **(a)** transverse waves can be polarised	**1**	Longitudinal waves cannot be polarised because the particle vibration is the same as the direction of travel.
(b) any correct example, e.g. waves on strings, waves on the surface of water, any type of electromagnetic wave	**1**	You need to know examples of both longitudinal and transverse waves. Waves **through** water would be longitudinal. Electromagnetic waves include light and all the other waves in the electromagnetic spectrum.
(c) *Relevant points include:* • in transverse waves the vibrations take place perpendicular to the direction of energy transfer • in longitudinal waves the vibrations take place in the same direction as the energy transfer • polarisation restricts the vibrations to one plane by absorbing the vibrations at right angles to this plane • longitudinal waves cannot be polarised because the vibrations have to take place for energy to be transmitted	**3**	You could clarify much of this answer with some clearly labelled sketches. Electromagnetic waves such as light consist of an electric vector which is at right angles to a magnetic vector. Polarising filters work by absorbing the component of the electric vector in a particular plane. A vector has no component at right angles to its own direction, hence this perpendicular component of the electric vector is transmitted by the filter. The transmitted (plane polarised) component of the light could then be absorbed by a second polarising filter that had its transmission axis at right angles to the first filter.
5 **(a)** a longitudinal wave	**1**	You are told at the outset that this is a sound wave, and the diagram shows particles moving in the wave's direction of travel.

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(b) BB': an arrow to the left CC': an arrow to the right both arrows the same length as AA' (or length of AA' > BB' > CC')	1 1	Distance AC is one wavelength, meaning that A and C move in phase. Distance AB is half a wavelength, consequently B moves 180° out of phase with A and C. If there is no absorption (or no spreading out) the displacements will have the same magnitude. If there is absorption (or spreading out) these magnitudes will decrease along the wave.
(c) particles in the transmitting medium are made to vibrate longitudinally these cause nearby particles to vibrate in the same direction	1 1	**Alternatively**, regions of compression (or rarefaction) produce other regions of compression (or rarefaction) further along the wave.
6 (i) wavelength = 0.80 m	1	The distance between adjacent nodes is $\lambda/2$. This stationary wave has three loops.
(ii) use of $c = f\lambda$ gives $f = \frac{c}{\lambda} = \frac{200}{0.80} = 250$ Hz	1	You could be awarded this mark for applying an incorrect value of λ from **(i)** in correct physics here.
(iii) use of $T = \frac{1}{f}$ gives time period of vibrations $T = \frac{1}{250} = 4.0 \times 10^{-3}$ s 3.0 ms corresponds to $\frac{3}{4}$ of a full vibration string shown on diagram as a straight line, along the undisturbed position	1 1 1	First you have to work out the meaning of 3.0 ms as a multiple (or fraction) of the time period. In half of a full vibration, the string will have moved to the position shown in the diagram by the dotted line. In a further quarter of a vibration, it will have returned to the central position.
7 (a) distance travelled by wave = 2 × 18 = 36 m speed of sound = $\frac{\text{distance}}{\text{time}} = \frac{36}{0.11}$ = 330 m s^{-1}	1 1 1	The echo is caused by the reflection of the sound waves from the wall. The waves travel at constant speed to the wall and back again. This is a useful pointer to what happens in **(b)**.
(b) stationary waves are formed in air by the superposition of two waves these are the wave travelling towards the wall and its reflection from the wall minima are formed by destructive interference at points where the two waves are continuously in antiphase	1 1 1	Whilst moving towards the wall, the observer will notice maxima and minima of intensity at fixed positions in the air. The maxima are at the antinodes of the stationary wave and the minima at nodes. You are only asked to explain how the **minima** of intensity occur.

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8 (a) *Relevant points include*: • the effect is caused by interference (or superposition) between waves • the two waves interfering have the same frequency (or wavelength) • waves are reflected from the plate • the waves travel in opposite directions • maxima are produced at points where the waves are in phase (or interfere constructively) • minima are produced at points where the waves are in antiphase • there is a stationary wave (or nodes and antinodes) in the region of the detector	**4**	This is another example of a stationary wave being produced by the superposition of a wave travelling towards a reflecting surface and the wave reflected from it. These waves have the same frequency and speed, and similar amplitudes. The waves responsible are microwaves, with a wavelength of a few centimetres. The detector would normally be connected to a sensitive ammeter, (or to an amplifier and loudspeaker if the microwaves are modulated). This time you are required to explain the formation of both the maxima and the minima of intensity.
(b) (i) length of one loop of the stationary wave = 144/9 = 16 mm use of $\frac{\lambda}{2}$ = 16 gives λ = 32 mm	**1**	The detector travels across exactly 9 loops of the stationary wave, from one node to the ninth node after it. The distance between adjacent nodes is (λ/2).
(ii) use of $c = f\lambda$ gives $f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{32 \times 10^{-3}}$ $= 9.4 \times 10^9$ Hz	**1**	The only complication in **(ii)** is that you must realise that microwaves travel at the speed of all electromagnetic waves, c, the value of which is given in the Data Booklet.