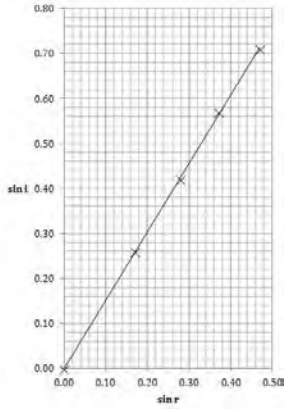
Question number	Answer	Notes	Marks
1 (a)	MP1. pitch is <u>frequency</u>;	allow 'it' for pitch ignore references to amplitude, wavelength	2
	MP2. any one of: • whether sound/note sounds high or low; • high sound has high frequency ORA;	allow vibrates more often / with shorter time period 'high pitch has high frequency' ORA gains 2 marks	
(b) (i)	ruler / measuring tape; oscilloscope / mobile phone app / data logger / (guitar) tuner;	ignore microphone frequency meter frequency gauge frequency counter	2
(ii)	dependent – frequency / pitch; independent – length (of pipe);		2
(c)	any three of: MP1. repeat AND average the readings; MP2. (measure a) larger range of values; MP3. (measure some) intermediate values;	accept 'measure more values' for 1 mark if NEITHER MP2 nor MP3 awarded	3
	MP4. improved precision of a named variable / instrument;	e.g. 'use a cm ruler', 'measure frequency in mHz' etc. ignore references to accuracy	
	MP5. control a named variable (e.g. temperature); MP6. plot a graph of frequency and length; MP7. deal with anomalies;	allow 'blow with controlled apparatus' allow 'plot a graph of the results' allow 'identify anomalies'	

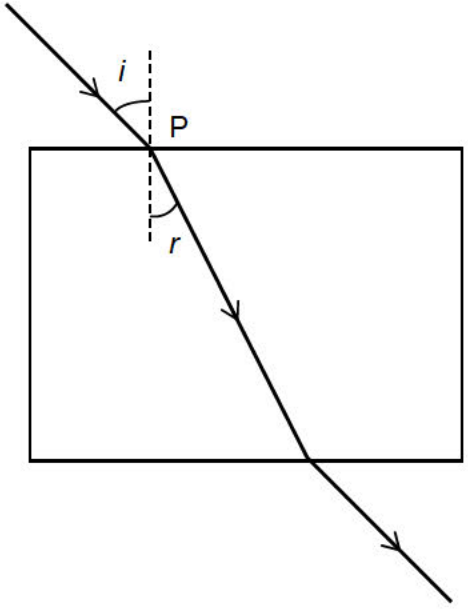
Total 9 marks

Question number	Answer	Notes	Marks
2 a (i)	0.28 0.37	(both for 1 mark)	1
(ii)	suitable scales; axes labelled; plotting of second and fifth points ;; line of best fit;  	Must use > half width and half height of grid no units on axis labels ignore orientation of graph to nearest ½ square, up to two marks available for this line – allow ecf from candidate's third and fourth points If incorrect graph plotted (i◦ against r◦) the only scales and line mark can be awarded (NB in this case can only get first MP in (a)(iii))	Max 5
(iii)	Attempt at gradient of line, seen on graph or in working; Value in range 1.48 to 1.54;	e.g. triangle or equivalent drawn on graph, rise/run bald correct answer is 1 mark only	2

sin i	sin r
0.00	0.00
0.26	0.17
0.42	**0.28**
0.57	**0.37**
0.71	0.47

b	Any two of - MP1. Idea that value relates to all the data collected; MP2. Idea that method allows for anomalies; MP3. Idea that effects of uncertainty/error can be reduced or accounted for;	 Method checks reliability, anomalies can be seen graph is an averaging technique Ignore comments about accuracy	2

(Total for Question 2 = 10 marks)

Question number	Answer	Accept	Reject	Marks
3 (a)	Refraction into glass towards the normal (r > 0); Angle of incidence <u>and</u> angle of refraction both labelled correctly at the same surface; Refraction at the lower surface into air away from the normal; Emergent ray parallel to incident ray after correct refraction (by eye);  	Accept dotted lines Ignore any reflections Ignore a second incorrectly labelled pair		4

<table>
<tr><th>Question number</th><th>Answer</th><th>Accept</th><th>Reject</th><th>Marks</th></tr>
<tr><td>3 (b) (i)</td><td>One mark for either sin i or sin r correct;

<table><tr><td>i</td><td>60°</td></tr><tr><td>r</td><td>34°</td></tr><tr><td>sin i</td><td>0.87</td></tr><tr><td>sin r</td><td>0.56</td></tr></table></td><td>sin i = 0.866;
sin i = 0.8660;
sin r = 0.559;
sin r = 0.5592;

Ignore degree sign

Ignore any other values</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>n = sin i ÷ sin r;</td><td>Accept
refractive index = sin i ÷sin r</td><td></td><td>1</td></tr>
<tr><td>(iii)</td><td>Two marks for correct answer
Refractive index = 1.55;;
Or
Refractive index = 1.6;;
Or
Refractive index = 1.5;;</td><td>Accept for one mark only any other value in the range
1.5 < n < 1.6;
Any power of 10 error, e.g. 155.3</td><td></td><td>2</td></tr>
</table>

Question number	Answer	Accept	Reject	Marks
3 (c)	Any three of: MP1 any mention of repetition / take an average of readings; MP2 vary *i* to obtain more values ; MP3 plot a graph of sin i against sin r ; OR Calculate/work out/ find n; MP4 find gradient of graph ; OR Calculate average of n; MP5 sensible experimental precaution / improvement to method (e.g. mark lines on paper, thinner beam, fix block firmly in position, remove anomalies, sharper pencil, use a more precise protractor e.g. ½°);	Ignore reference to critical angle Ignore second glass block Ignore different colours		3

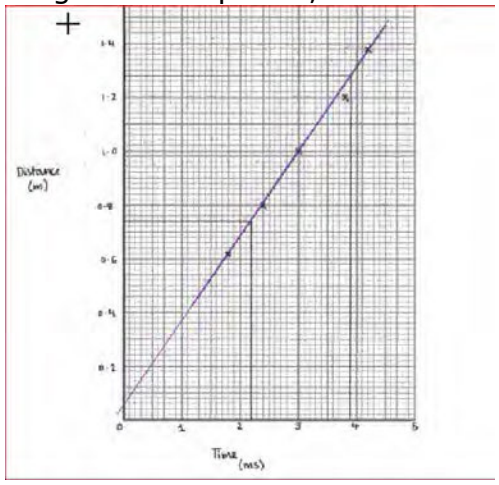
Total 11 marks

Question number	Answer	Notes	Marks
4 (a) (i)	set-up showing any **two** from- clear indication of equipment needed; correct refraction at one surface of glass block shown; protractor shown in use;	 ray-box or pins Allow ruler for apparent depth method	2
(ii)	angle of incidence; angle of refraction; OR critical angle; idea of grazing emergence;	Allow apparent depth method, i.e. real depth; apparent depth;	2
(iii)	find sin i and sin r; refractive index is the ratio of sines; OR find sin c; refractive index is 1/ sin c;	Accept for two marks • (n =) sin i/sin r • (n =) 1/ sin c • graph of sin i vs sin r Allow refractive index = real depth ÷ apparent depth for two marks	2
(b) (i)	Diagram – reflection at first back surface; reflection at second back surface;	judge by eye • straightness of ray and correctness of angle • emergent ray parallel to incident ray	2
(ii)	Refracted / slows down / wavelength decreases	Ignore: direction change ideas it does nothing / nothing happens	1

Total 9 marks

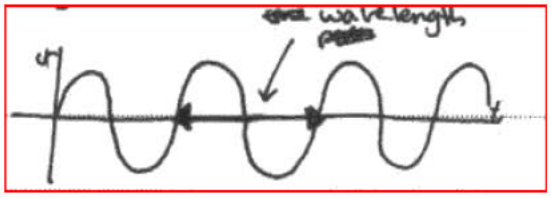
Question number	Answer	Notes	Marks
5 (a)	cooking – micro(waves) OR infrared (waves); treating cancer – ultraviolet OR x-rays OR gamma (rays); identifying broken bones - x-rays;	if more than one example given for each use then reject mark if any incorrect	3
(b)	C - the same speed;		1
(c) (i)	drawn ray shows refraction in the correct direction (downwards) at **both** surfaces; drawn ray is above yellow ray and diverges from it (if ray had entered at the original point);	judge by eye ignore arrows and labels dependent on previous allow if ray drawn enters **parallel** to original ray	2
(ii)	A- black;		1

Total 7 marks

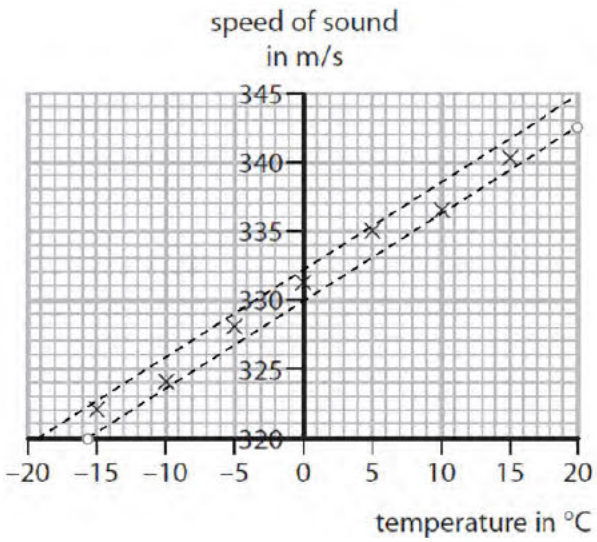
Question number	Answer	Notes	Marks
6 (a)	B;		1
(b) (i)	MP1. Axes labelled with units; MP2. Correct scales (to occupy at least ¼ of the area of the graph and in sensible intervals); MP3. Plotting; MP4. Plotting; MP5. straight line of best fit which extends beyond given data points;  Distance in m / Time in ms 0.62 / 1.8 0.80 / 2.4 1.00 / 3.0 1.20 / 3.8 1.38 / 4.2	• ignore orientation of graph • scale intervals on axes should be 2 or 5 or 10 • points should be less than 0.5 sq in diameter • -1 each incorrect plot to max of -2 • tolerance = +/- ½ square • if zero is not included, then line should go through all points except 3rd or 4th • if zero included, look for balance of points	5

(ii)	Attempt to find slope or gradient of line ; AND evaluation of value; matching unit; e.g. = 0.6/0.0018 = 333 m/s	Δ seen or two lines from same axis seen or rise/run seen value in range of 310-350 allow 0.333 km/s 0.333 m/ms	3
(iii)	Any one specific variable from the experiment; e.g. hitting the block in the same place Use the same microphone/timer/wires Ensure there is no 'hammer bounce'	These must be specific to the experiment Accept same • temperature • humidity • density • draughts • force • block ignore • 'keep everything the same' • use control variables • repeat experiment	1
(iv)	Any 2 suggestions from MP1. repeat the time readings (for each distance); MP2. measure the distance to the sensor of the microphone; MP3. use wider range of distance readings (<0.62 or >1.38); MP4. use intermediate distances (between points);	ignore imprecise suggestions e.g. • 'be careful with timer' • 'change the distance'	2

(Total for Question 6 = 12 marks)

Question number	Answer	Notes	Marks
7 (a)	standard definition of wavelength; e. • distance between two points on a wave/ two peaks/ two troughs • distance between each wavefront • distance travelled by wave in one time period 	allow: from clear diagram crest for peak ignore: • 'the length of a wave' • 'distance taken for 1 cycle' • distance between one wave and the next one	1
7 (bi)	Speed of wave = frequency x wavelength;	allow: in any rearrangement $v = f.\lambda$	1
(bii)	substitution into any form of the equation ; evaluation; e. $3(m/s) = 1.5(Hz) \times \lambda$ $(\lambda) = 2(m)$;	accept for 1 mark $\frac{3}{1.5}$	2

Question number	Answer	Notes	Marks
7 (ci)	Diffraction; And one of • The incoming wave spreads out at the gap; • The energy carried by the wave spreads out ;	allow: • diffraction seen in (cii) • recognisable spelling for 'diffraction' ignore: • the wave gets bigger • wave is bent • (wavefront is) curved	2
7 (cii)	idea that (diffraction only apparent when) λ and size of gap comparable/RA; wavelength of light is very small / smaller than water waves /smaller than the gap;	Allow RA	2
		Total	**9**

Question number	Answer	Notes	Marks
8 (a)	idea that higher frequency gives higher pitch;	allow reverse argument condone idea of proportionality / linearity	1
(b) (i)	(wave) speed = frequency × wavelength	allow abbreviation, e. $v = f \times \lambda$ or rearrangements	1
(ii)	substitution into correctly rearranged equation; evaluation; e. (v =) 340 / 160 (v =) 2.1 (m)	 allow 2.125, 2.12, 2.13 or 2 (if supported)	2
(c) (i)	straight line of best fit drawn within indicated area;  	line does not need to be extended beyond data range for this mark	1
(ii)	line of best fit extended to 20°C; student's own value from graph ± half a square;		2

(d)	any 2 from: MP1. speed (of sound) decreases (with temperature); MP2. frequency is constant; MP3. so wavelength decreases (with temperature);	 allow 'sound slows down' ignore references to particle speed allow λ is smaller	2

Total 9 marks