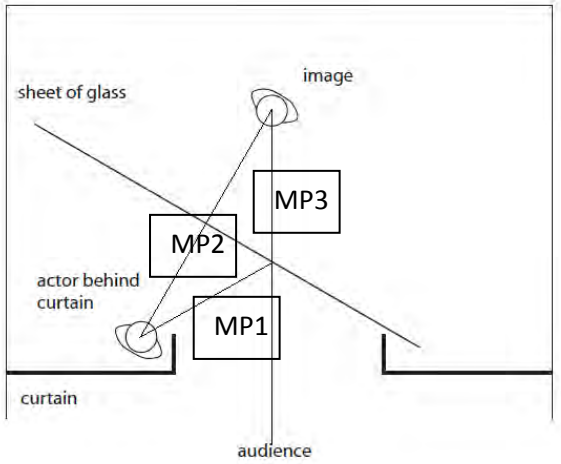
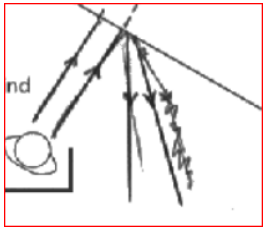
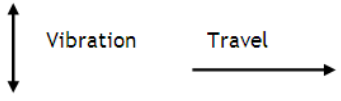
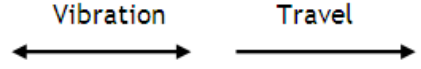
Question number			Answer	Notes	Marks
1	(a)		MP1. Ray <u>reflects</u> correctly (by eye, any ray straight down the page (allow +/- 10°), ignore horizontal displacement); MP2. Normal shown / construction line between actor and image; MP3. Reflected ray projecting back to image;	  not spread out from 1 point for MP1	3
1	(b)		any **one** from: cannot be formed on a screen/eq ; rays do not actually come from there ; rays {diverge/don't actually cross} after reflection; image formed by extension (backwards) of light rays	ignore what is seen in a mirror not real properties of image in mirror, e.g. inverted, same distance	1

	(c)	(i)	Any suitable example; e. sound, ultrasound, deep water waves	Allow seismic (P-) waves, waves in a (slinky) spring	1
		(ii)	vibrations/oscillations are parallel or perpendicular; To direction of energy transfer/ direction of travel; Correct identification of both types;	allow vibrations up and down for perpendicular vibrations back and forward for parallel Accept suitably labelled diagrams a correct description of either wave = 2 marks e. Transverse:  Longitudinal:  ignore: examples of either type of waves if no other mark, accept descriptions of pressure changes or clear diagram(s) showing compression and rarefaction for 1 mark only	3

Total 8 marks

Question number			Answer	Notes	Marks
2	(a)		MP1. Substitution into correct equation; MP2. Rearrangement; MP3. Divide by 2; MP4. Conversion between km and m; e. 1.5 x 1000 = 1500 Speed = $\frac{\text{distance}}{0.26}$ Distance = 1500 x 0.26 = 390 (m) So distance to fish = 195 m	Accept x 1000 at any point in calculation 0.39 gets 2 marks 390 gets 3 marks	4
	(b)		Any **two** of MP1. Reflected from different depths within shoal; MP2. So (reflected pulse(s)) travels different distances; MP3. Fish move; MP4. Reflection from sea bed;		2

Total 6 marks

Question number	Answer	Notes	Marks
3 (a) (i)	Equal to		1
(ii)	Any TWO of - Rays continued and reflected correctly from mirror; Projected back behind mirror (to reasonably the right place) Line perpendicular to the mirror joining object and image positions (roughly equal distances in front and behind);	Judged by eye to be i = r rays should diverge after reflection Judged by eye ACCEPT (for the second mark) projection back to image even if reflected rays not drawn in front of the mirror Rays do not need to have arrows Dotted lines no required behind mirror Image does not have to be labelled Accept dotted lines in front of mirror if meaning is clear Use of ruler not essential, but candidates will find it difficult to draw a convincing diagram freehand	2
(iii)	'rays do not actually meet at the image'		1

Question Number	Answer		Marks
3 (b) (i)	Added to diagram - Reflection inside fibre; At least three (with reasonable angles);	Continuous path shown inside fibre	1 1
(ii)	Must be more (optically) dense to less (optically) dense change; Angle of incidence > critical angle;	IGNORE angle of incidence = critical angle DO NOT ALLOW angle of incidence greater than 42^0	1 1
(iii)	Any ONE sensible point – e.g. Less prone to noise; less prone to heating; send more information (per second); more data (per second);	IGNORE references to cost IGNORE references to speed	1
		Total	**9**

Question number	Answer	Notes	Marks
4 (a)	change in direction of waves at a boundary	ALLOW change in speed ALLOW idea of 'boundary' such as changing medium, or examples such as 'going from air into a glass block'	1
(b)	correct label for *i* correct label for *r*	ALLOW labels written out in full as "incidence" or "angle of incidence" etc REJECT if angles are the wrong way around	2
(c) (i)	refractive index = sin *i* / sin *r*	ALLOW 'n' for refractive index REJECT speed in 1/speed in 2	1
(ii)	Method max 4 marks: draw around block; mark positions of incident and emergent rays; (remove block and) draw refracted ray; measure i; measure r; measure angle(s) to the normal; range of values; Data max 2 marks: (graph of) sin i against sin r; graph is straight line; DOP gradient gives refractive index; DOP	Accept pin or pencil method Ignore mention of protractor i.e. different values of i not just repeating	MAX 6

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>5 (a)</td><td>ANY THREE
vibration / oscillation of (air) molecules / particles;
longitudinal;
directions of vibration and propagation are parallel;
compression / rarefaction /pressure wave;</td><td>
need to include what is vibrating

no need to mention molecules / particles</td><td>3</td></tr>
<tr><td>(b) (i)</td><td>0.01 s</td><td>ALLOW 2 s.f. / 2 sig figs / 2 significant figures</td><td>1</td></tr>
<tr><td>(ii)</td><td>speed = distance / time</td><td>ACCEPT equivalent rearrangement
ACCEPT suitable abbreviations e.g. s = d/t or v = s/t
REJECT equation ‘triangles’ alone</td><td>1</td></tr>
<tr><td>(iii)</td><td><table><tr><th>Student</th><th>Mean time in s</th><th>Speed of Sound in m/s</th></tr><tr><td>Andrew</td><td>0.45</td><td>330</td></tr><tr><td>Kefe</td><td>0.5</td><td>300</td></tr></table></td><td>1 mark each correct COLUMN (ignoring sf);;
mean time values as shown in mark scheme
speed = 150/mean time (allow ecf)

1 mark for all significant figures correct;
(i.e. 2 s.f. in first row, 1 s.f. in second row)</td><td>3</td></tr>
</table>

Question number	Answer	Notes	Marks
5 (c)	ANY 5 relevant points, e.g. Explanation of what reaction time is; Reaction time affects readings / reaction time does matter; Reaction times vary; Reaction times do not cancel out; Reaction time should be considered / allowed for; Kefe is right (about reaction times); reaction time typically at least 0.1 s; which is large compared to measured times / large % error; time should only be to 1 s.f.; so final value should also be to 1 s.f. / Kefe's value more suitable; 3 s.f. inappropriate; closer to accepted value does not mean more accurate;	Answers should ideally relate to how *appropriate* the precision of the measurements was, linking this to the number of significant figures merited Consideration of reaction time and its measurement may score a number of marks	MAX 5

Question number	Answer	Notes	Marks
6 (a) (i)	(cm)		1
(ii)	Sketched wave (at least 1 cycle) with a larger amplitude; Sketched wave (at least 1 cycle) with a longer wavelength;	Shape of wave and position of axis unimportant (i.e. ignore conditions of wind and tide)	2
(b)	Any five of - MP1. A method to make a loud enough sound; MP2. Speed = $\frac{\text{distance}}{\text{time}}$; MP3. Need for still air; MP4. Repeat AND average; MP5. Need to check/reset stopwatch zero reading; MP6. Idea of clear visual signal; MP7. measurement of time **interval** (between visual signal and sound); MP8. Idea of reaction time(s) (could be a problem);	ignore measurement of distance bald 'clap' • wooden blocks • noise has to heard over 100m RA allow repeat AND sort out anomalies e. • when the sound is seen to be made • smoke from starting pistol (because) light travels faster than sound	5

Continued

Question number	Answer	Notes	Marks
6 (c) (i) cont	wave speed = frequency × wavelength	Allow abbreviations and rearrangements, e.g. $v=f\lambda$	1
(ii)	Conversion to Hz; Substitution into correct equation and rearrangement; Evaluation; e.g. 31 MHz = 31 000 000 Hz wavelength = 300 000 000 ÷ 31 000 000 9.7 m	Allow 10^6 seen at any stage allow answers which round to 9.7 (9.6774)	3
(d)	Any one of the following ideas - MP1. the two waves travel at different speeds; MP2. the two waves travel the same distance (or 1 wavelength) in different times;	ignore references to • transverse and longitudinal • em spectrum	1

Total 13 marks