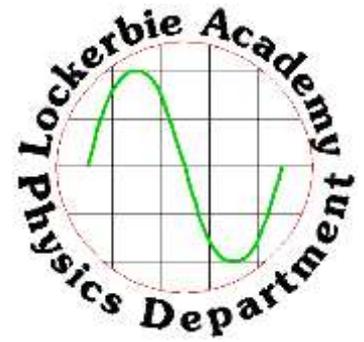


NAME: Mark Scheme



J A
HARGREAVES

NATIONAL 5
LEARNING OUTCOMES ANSWERS



2017/18-Don't Panic!

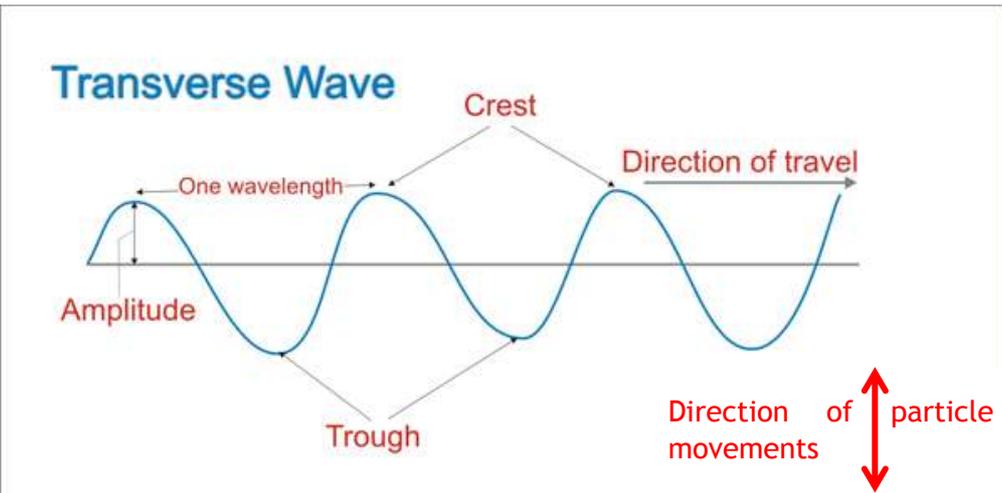
WAVES

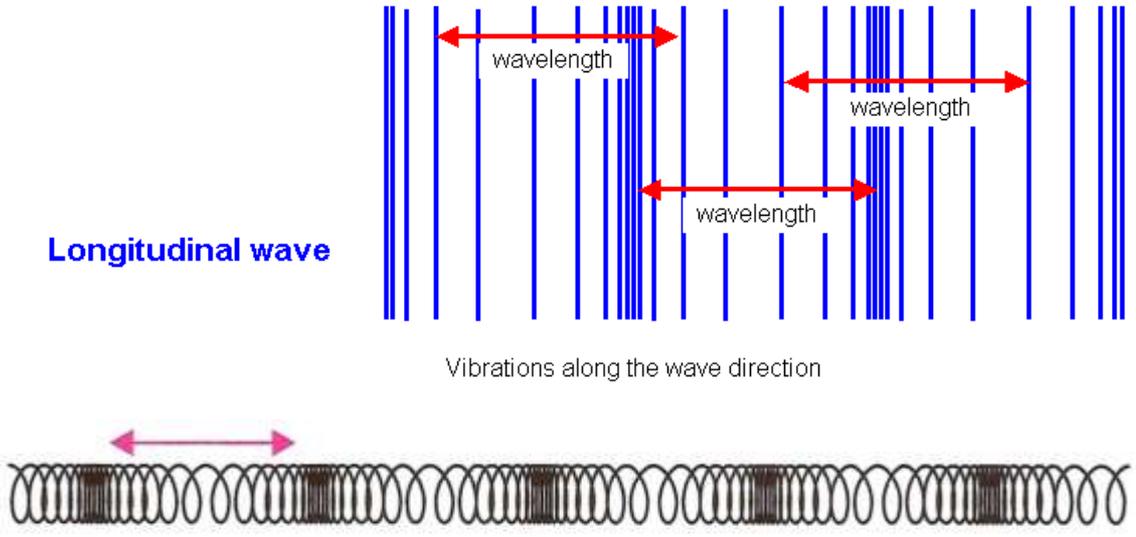
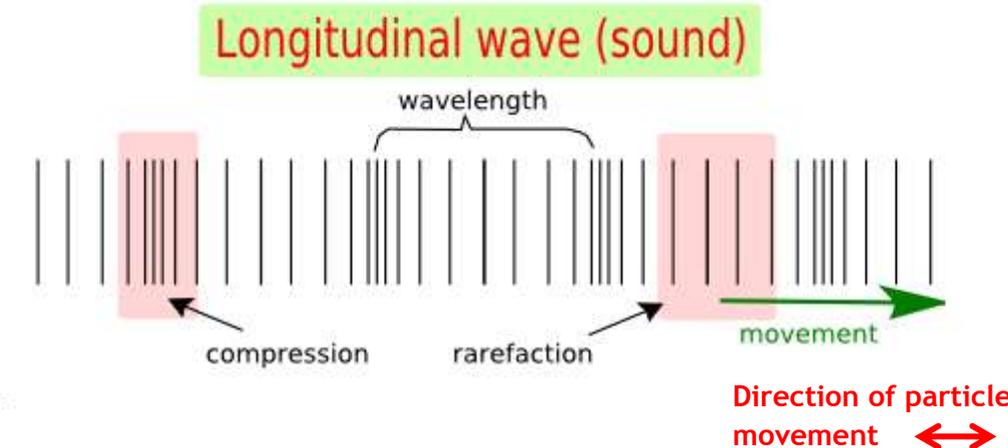
QUANTITIES FOR THE WAVES UNIT

Quantity	Symbol	Unit	Unit Symbol	Scalar / Vector
Time	t	seconds	s	scalar
Period	T	seconds	s	scalar
Frequency	f	Hertz	Hz	scalar
Wavelength	λ	metres	m	scalar
Amplitude	A	metres	m	scalar
Distance	d	metres	m	scalar
Speed	v	Metres per second	ms⁻¹ or m/s	scalar
Velocity	v	Metres per second	ms⁻¹ or m/s	vector

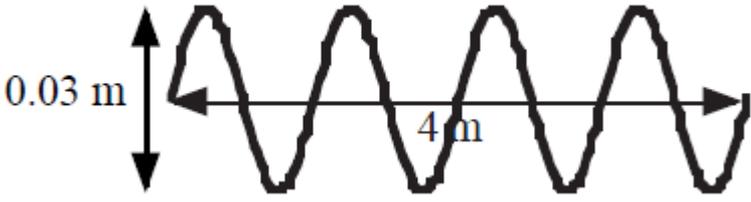
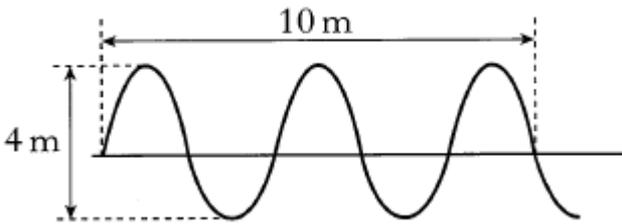
THE WAVES UNIT IN NUMBERS

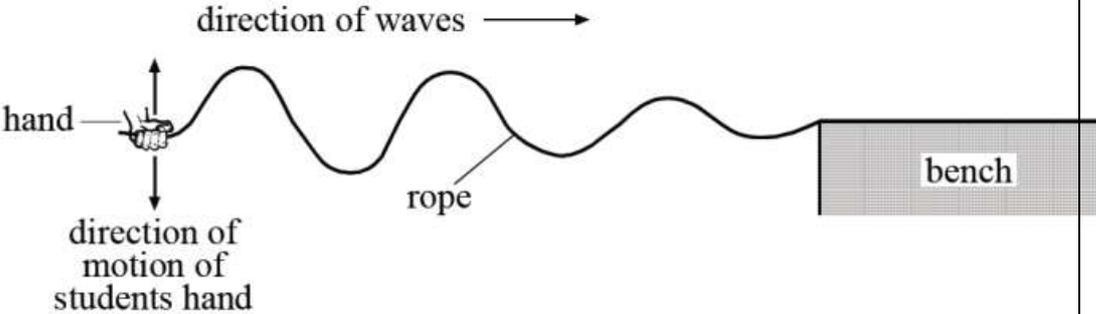
Quantity	Value
What is the approximate speed of sound in air?	340 ms⁻¹
What is the approximate speed of ultrasound in air?	340 ms⁻¹
Does sound travel faster or slower in solids than in air?	Faster
How many seconds in a minute?	60 s
How many seconds in an hour?	3600 s
What is the speed of light in air?	3.0×10^8 ms⁻¹
What is the speed of light in glass, eg in a fibre optic cable?	2.0×10^8 ms⁻¹
What is the speed of microwaves in air?	3.0×10^8 ms⁻¹
What is the speed of a television signal in air?	3.0×10^8 ms⁻¹
What is the speed of a radio signals in air?	3.0×10^8 ms⁻¹
At what speed do X-rays travel in air?	3.0×10^8 ms⁻¹
At what speed does gamma radiation travel in air?	3.0×10^8 ms⁻¹
What is the approximate critical angle for light in glass?	42°
What is the smallest angle at which total internal reflection occurs in glass?	42°

No.	CONTENT
Wave parameters and behaviours	
17.1	I can state what is transferred as waves.
17.1.1	What is transferred when a wave travels from one place to another?
	Energy
17.1.2	What is the connection between waves and energy?
	Energy is transferred by waves
17.2	I can define transverse waves.
17.2.1	Draw and label a diagram showing a transverse wave.
	 <p>The diagram shows a blue transverse wave on a horizontal axis. Labels include: 'Crest' pointing to a peak, 'Trough' pointing to a valley, 'One wavelength' indicating the distance between two consecutive crests, 'Amplitude' showing the height from the equilibrium line to a crest, 'Direction of travel' with a horizontal arrow pointing right, and 'Direction of particle movements' with a vertical double-headed arrow pointing up and down.</p>
17.2.2	Mark on your diagram the wavelength, amplitude, direction of energy transfer and direction of movement of particles.
	See above
17.3	I can define longitudinal waves.
17.3.1	Draw and label a diagram showing a longitudinal wave.

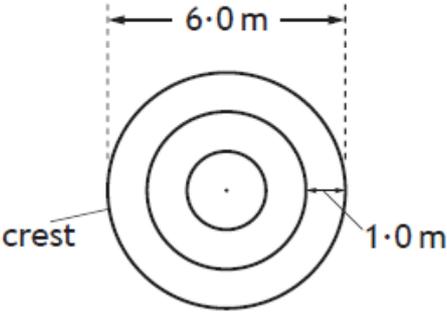
No.	CONTENT
	 <p>Longitudinal wave</p> <p>Vibrations along the wave direction</p>
17.3.2	<p>Mark on your diagram the wavelength, rarefaction, compression, amplitude, direction of energy transfer and direction of movement of particles.</p>
	 <p>Longitudinal wave (sound)</p> <p>wavelength</p> <p>compression rarefaction</p> <p>movement</p> <p>Direction of particle movement \longleftrightarrow</p>
17.3.3	<p>What kinds of materials can sound travel through?</p>
	<p>Sound can travel through solids, liquids and gases.</p>
17.3.4	<p>What can sound not travel through?</p>
	<p>Sound cannot travel through a vacuum.</p>
17.4	<p>I can give examples of longitudinal and transverse waves.</p>

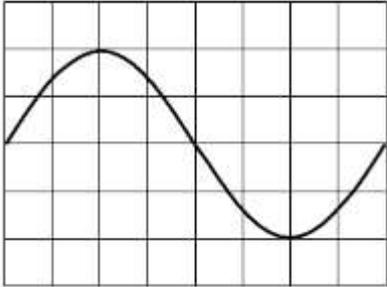
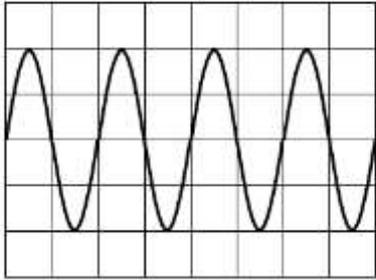
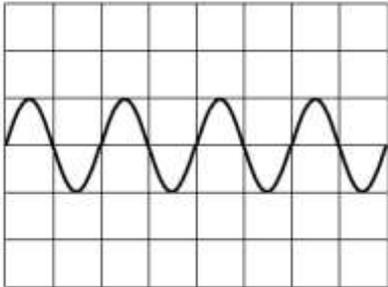
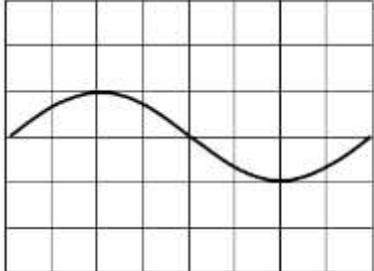
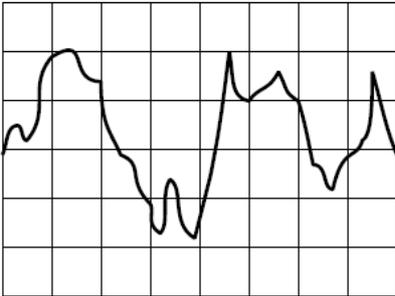
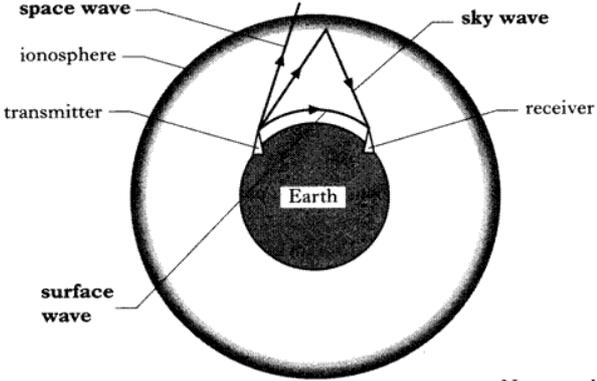
No.	CONTENT				
17.4.1	<p>Copy and complete the table below and place the following waves into the correct section of the table.</p> <p><i>e-m waves (write each member of this group out separately), sound, seismic p-waves, seismic s-waves,</i></p> <table border="1" data-bbox="300 405 1334 674"> <thead> <tr> <th data-bbox="300 405 815 461">Transverse Waves</th> <th data-bbox="815 405 1334 461">Longitudinal Waves</th> </tr> </thead> <tbody> <tr> <td data-bbox="300 461 815 674"> Radio, Microwave, Infra red Visible, Ultraviolet, X-rays Gamma Ray, EM Spectrum Seismic s-waves </td> <td data-bbox="815 461 1334 674"> Sound Seismic p-waves </td> </tr> </tbody> </table>	Transverse Waves	Longitudinal Waves	Radio, Microwave, Infra red Visible, Ultraviolet, X-rays Gamma Ray, EM Spectrum Seismic s-waves	Sound Seismic p-waves
Transverse Waves	Longitudinal Waves				
Radio, Microwave, Infra red Visible, Ultraviolet, X-rays Gamma Ray, EM Spectrum Seismic s-waves	Sound Seismic p-waves				
17.4.2	<p>Waves can be used to transmit signals. What type of waves would be used to</p> <p>(a) tell competitors to start a race, sound waves from starting pistol</p> <p>(b) broadcast TV signals, radio waves from Transmitter</p> <p>(c) warn ships of shallow water, sound waves (sonar or foghorn) or light waves (from lighthouse)</p> <p>(d) warn aircraft of high towers, radio waves (radar) or light waves (warning lights)</p> <p>(e) pass down a fibre optic cable? light waves</p>				
17.4.3	<div data-bbox="300 1223 659 1592" data-label="Image"> </div> <p data-bbox="770 1317 1358 1429">How can a sound wave be shown on an oscilloscope like in the diagram below given the type of wave?</p>				
	<p>Because your oscilloscope is not showing the sound wave, it's showing the output of a microphone which has changed the sound wave to an electrical signal. The frequency behaviour the electrical signal will have the same frequency characteristics as the sound signal.</p>				
17.5	I can determine the frequency, period, wavelength, amplitude and wave speed for longitudinal and transverse waves.				
17.5.1	What is meant by the frequency of a wave?				
	<p>Frequency is the <u>number of waves produced</u> or <u>the number of waves passing a point per second.</u></p>				

No.	CONTENT
17.5.2	What is the link between period and frequency?
	Period = 1/frequency
17.5.3	What is the frequency of a wave, if 20 crests pass a point in two seconds?
	$f = \frac{N}{t} = \frac{20}{2} = 10$ <p style="text-align: center;"><u>10Hz</u></p>
17.5.3	<p>The diagram below represents a wave 0.2 s after it has started.</p>  <p>Calculate the following quantities for this wave:</p> <p>a) wavelength <u>1m</u> (4 waves in 4m) $\lambda = \frac{d}{N} = \frac{4}{4} = 1m$</p> <p>b) amplitude <u>0.015m</u> (middle to top of the wave)</p> <p>c) frequency <u>20Hz</u></p> $f = \frac{N}{t} = \frac{4}{0.2} = 20$ <p>d) speed. <u>20ms⁻¹</u> $v = f\lambda = 20 \times 1 = 20$</p>
17.5.4	<p>The following diagram gives the information about a wave.</p>  <p>a. What is the amplitude of the wave? 2m</p> <p>b. What is the wavelength of the wave? 4.0 m</p> $\lambda = \frac{d}{N} = \frac{10}{2.5} = 4.0m$

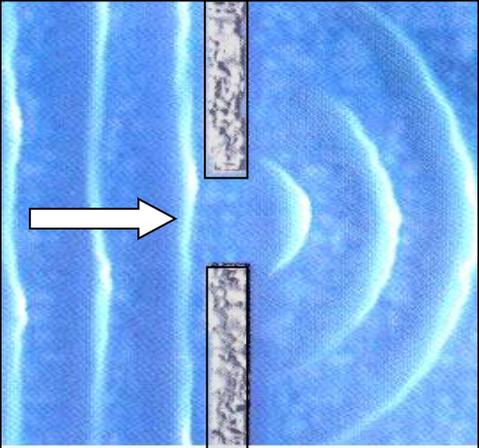
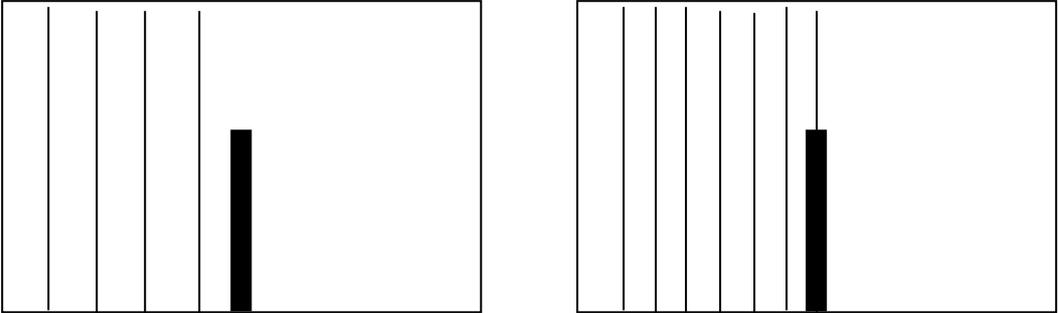
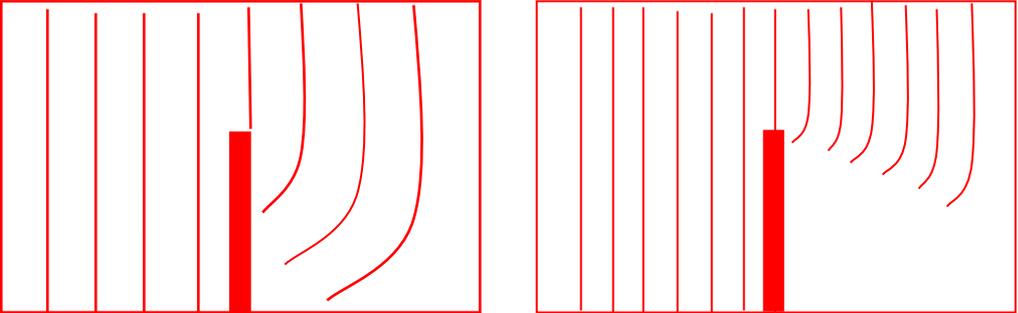
No.	CONTENT
17.5.5	<p>One end of a piece of rope is clamped to the end of a bench. A student produces transverse waves in the rope by moving the free end as shown in Figure 1.</p>  <p style="text-align: center;"><i>Figure 1</i></p> <p>The student measures the frequency and wavelength of these waves.</p> <p>State the relationship she would use to calculate the speed of the waves from this information.</p> <p style="text-align: center;">$v = f \lambda$</p>
17.6	<p>I can make use of the relationships between wave speed, frequency, wavelength, distance, number of waves and time ($v = f \lambda$) ($d = vt$) ($f = 1/T$) ($f = N/t$) ($\lambda = d/N$).</p>
17.6.1	<p>A water wave travels 200m in 15s. What is the speed of the wave?</p> $v = \frac{d}{t} = \frac{200}{15} = 13 \text{ ms}^{-1}$ <p style="text-align: center;"><u>13 ms⁻¹</u></p>
17.6.2	<p>How long would it take for the water wave above to travel a distance of 10 km?</p> $v = \frac{d}{t}$ $13 = \frac{10,000}{t}$ $t = \frac{10,000}{13}$ <p style="text-align: center;"><u>770s</u></p>
17.6.3	<p>Write down the formula linking speed, wavelength, and frequency.</p>
	<p style="text-align: center;">$v = f \lambda$</p>

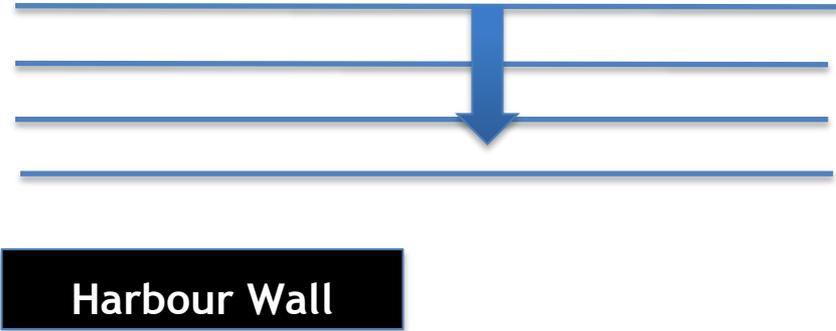
No.	CONTENT
17.6.4	<p>If the speed of sound is 340 ms^{-1}, what is the wavelength of a sound wave with a frequency of 2 kHz?</p> $v = f\lambda$ $340 = 2000 \times \lambda$ $\underline{\underline{0.17\text{m}}}$
17.6.5	<p>Twenty water waves pass a point in 30 seconds. Each wave has a wavelength of 1.2 m</p> <p>(A) What is the frequency of the waves?</p> $f = \frac{N}{t} = \frac{20}{30} = 0.67 \text{ approx } \underline{\underline{1\text{Hz}}}$ <p>(B) Calculate the speed of the waves.</p> $v = f\lambda = 0.67 \times 1.2 = \underline{\underline{0.80\text{ms}^{-1}}}$
17.6.6	<p>A sound wave has a frequency of 2 kHz, state the period of this wave.</p> $T = \frac{1}{f}$ $T = \frac{1}{2000}$ $\underline{\underline{T=5 \times 10^{-4} \text{ s}}}$
17.6.7	<p>A radio wave has a frequency of 97.7 MHz, how many waves are generated per second?</p> <p>Frequency is number of waves per second $\therefore 97.7 \times 10^6$</p>
17.6.8	<p>How long would it take one of the radio waves of frequency 97.7 MHz to pass a point.</p> $T = \frac{1}{f}$ $T = \frac{1}{97.7 \times 10^6}$ $\underline{\underline{T=1.0 \times 10^{-8} \text{ s}}}$

No.	CONTENT
17.6.9	<p>The diagram represents the position of the crests of waves 3 seconds after a stone is thrown into a pool of still water.</p>  <p>Calculate the speed and the frequency of the waves.</p> <p>There are 3 wavelengths (3 waves 4 crests) generated in 3s</p> $f = \frac{N}{t} = \frac{3}{3} = 1 \text{ Hz}$ <p><u>Frequency = 1 Hz,</u></p> $v = f\lambda$ $v = 1 \times 1$ <p><u>Speed = 1ms⁻¹</u></p>
17.6.10	<p>The period of vibration of a guitar string is 8 ms.</p> <p>Calculate the frequency of the sound produced by the guitar string.</p> $T = \frac{1}{f}$ $8 \times 10^{-3} = \frac{1}{f}$ <p><u>125 Hz</u></p>
17.6.11	<p>An oscilloscope can be used to display the signal in a telephone line.</p> <p>Draw diagrams showing what the pattern would be like for:</p> <ol style="list-style-type: none"> a loud, low pitched sound, a loud, high pitched sound, a quiet, high pitched sound, a quiet, low pitched sound, speech.

No.	CONTENT
	<p>(a) a loud, low pitched sound</p>  <p>(b) a loud, high pitched sound,</p>  <p>(c) a quiet, high pitched sound,</p>  <p>(d) a quiet, low pitched sound,</p>  <p>(e) speech.</p> 
17.7	I can describe diffraction and associated practical limitations.
17.7.1	Explain what is meant by the term diffraction?
	<p>Waves can bend round behind barriers and obstacles. This bending is called diffraction.</p> <p>Diffraction is the bending of waves through a gap or around barrier</p>
17.7.2	 <p>This diagram shows three types of signal in which radio waves can be sent between a transmitter and receiver.</p> <p>Which of the signals has the longest wavelength? Give a reason for your answer.</p> <p style="text-align: center;">Not to scale</p>

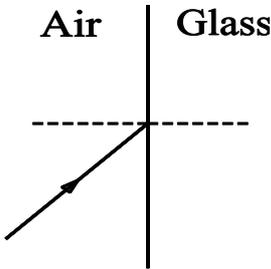
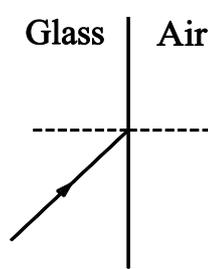
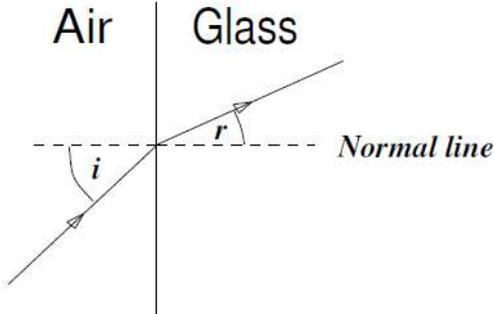
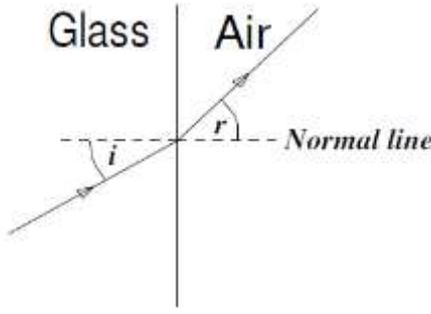
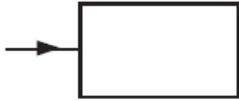
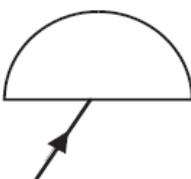
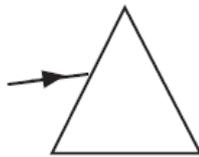
No.	CONTENT
17.8	I can make comparisons of long wave and short-wave diffraction.
17.8.1	Which waves have the longer wavelength - those used for radio or TV?
	The waves used for radio are longer than those used for TV.
17.8.2	Explain in terms of diffraction, why radio reception in an area can be good, but TV reception poor.
	Radio waves have a longer wavelength than those used for TV. Long waves diffract more, and so the radio waves can bend round behind obstacles like hills, while the short waves used for TV cannot.
17.9	I know when diffraction of waves occurs.
17.9.1	State when diffraction occurs.
	Diffraction occurs when a waves meets a barrier
17.9.2	When waves diffract through a gaps state what happens to the a) wave speed b) frequency c) wavelength
	a) wave speed remains the same b) frequency remains the same c) wavelength remains the same
17.10	I can compare how long waves and short waves diffract.
17.10.1	Radio waves have a longer wavelength than TV waves. Explain why this makes radio reception better than TV reception in a hilly area.

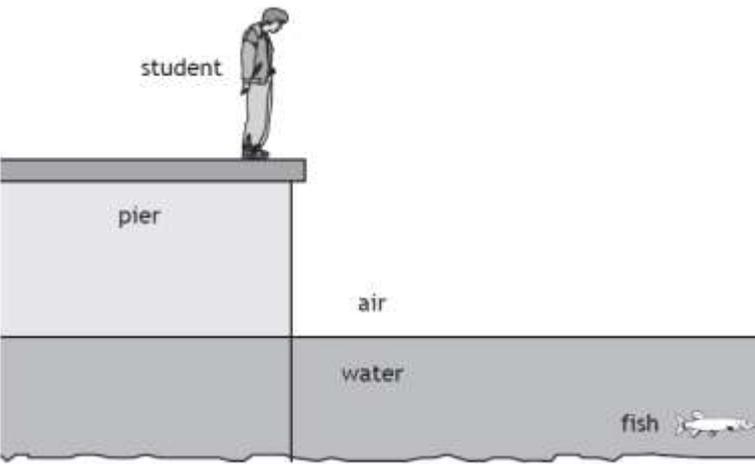
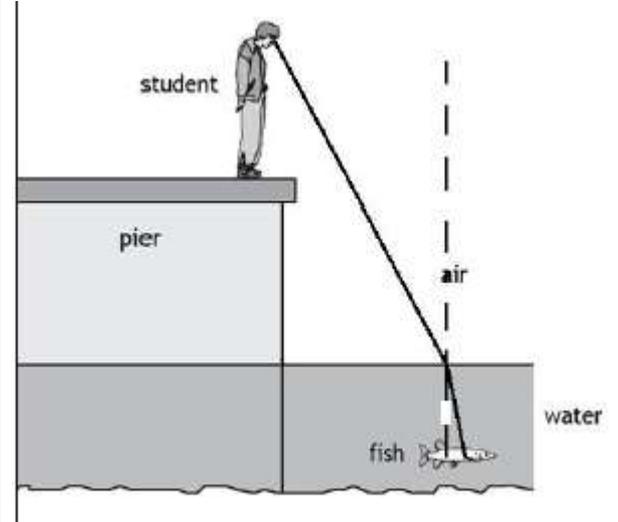
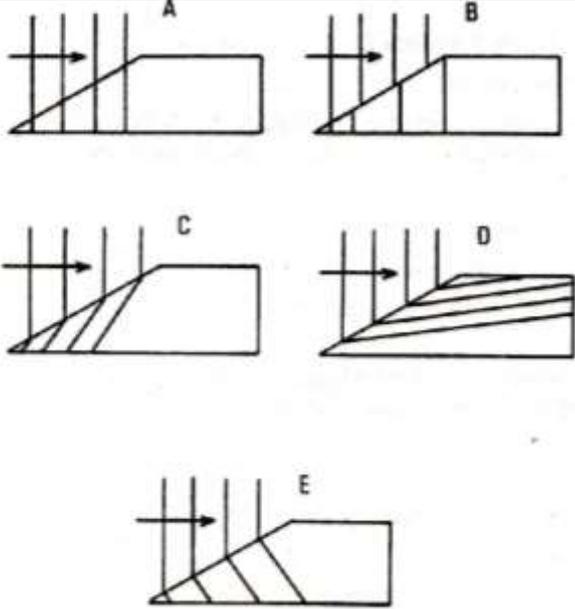
No.	CONTENT
17.10.2	<p>The diagram below shows water waves passing through a gap in a harbour wall.</p> <p>The arrow shows the direction the wave is travelling.</p>  <p>Water waves with a shorter wavelength are now passed through the same gap. What difference, if any, will this have after they have passed through?</p> <p>Less refraction (just curved at the ends) as the gap is less than one wavelength</p> <p>A ship breaks into the harbour wall and breaks a piece off making the gap larger. What difference, if any, will this have after waves pass through the harbour?</p> <p>If gap now greater than one wavelength then the waves will only be curved at the edges.</p>
17.10.3	<p>Copy and complete the diagram to show the difference between long waves and short waves as they diffract around a barrier.</p> 
	

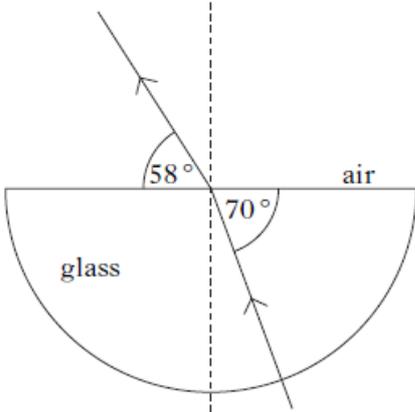
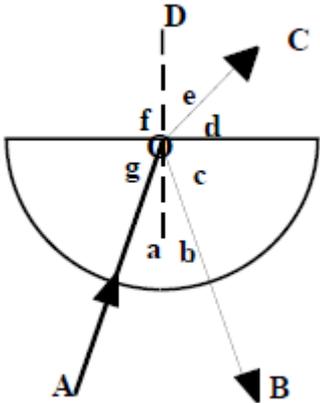
No.	CONTENT
17.10.4	<p>When waves pass through a gap, the width of the gap changes the way the waves emerge from the gap.</p> <p>Draw a diagram</p> <p>(a) to show how waves diffract when the gap is greater than one wavelength.</p> <p>(b) to show how waves diffract when the gap is greater than one wavelength.</p>
17.11	I can draw diagrams using wavefronts to show diffraction when waves pass through a gap or around an object.
17.11.1	<p>The diagram shows wavefronts arriving at a harbour wall. Copy and complete the diagram to show the wavefronts passing the harbour wall.</p> 
17.11.2	
Electromagnetic Spectrum	
18.1	I can state the relative frequency and wavelength bands of the electromagnetic spectrum.
18.1.1	List the members of the electromagnetic spectrum in order of increasing wavelength.
	Gamma, X-Rays, UV, Visible, IR, Microwaves, Radio Waves
18.1.2	As the wavelength of the radiation increases, what happens to its frequency?
	Frequency decreases (as frequency x wavelength = 300 000 000)

No.	CONTENT																					
18.1.3	<p>Radio waves have a wide range of frequencies.</p> <p>The table gives information about different wavebands.</p> <table border="1" data-bbox="331 293 1417 674"> <thead> <tr> <th>Waveband</th> <th>Frequency Range</th> <th>Example</th> </tr> </thead> <tbody> <tr> <td>Low frequency, (LF)</td> <td>30 kHz- 300 kHz</td> <td>Radio 4</td> </tr> <tr> <td>Medium frequency, (MF)</td> <td>300 kHz - 3 MHz</td> <td>Radio Scotland</td> </tr> <tr> <td>High frequency, (HF)</td> <td>3 MHz- 30 MHz</td> <td>Amateur Radio</td> </tr> <tr> <td>Very High frequency, (VHF)</td> <td>30 MHz - 300 MHz</td> <td>Radio 1 FM</td> </tr> <tr> <td>Ultra High frequency, (UHF)</td> <td>300 MHz - 3 GHz</td> <td>BBC1 and ITV</td> </tr> <tr> <td>Very High frequency, (SHF)</td> <td>3 GHz - 30 GHz</td> <td>Satellite TV</td> </tr> </tbody> </table> <p>Coastguards use signals of frequency 500 kHz. What waveband do these signals belong to?</p> <p>MF or Medium Frequency</p>	Waveband	Frequency Range	Example	Low frequency, (LF)	30 kHz- 300 kHz	Radio 4	Medium frequency, (MF)	300 kHz - 3 MHz	Radio Scotland	High frequency, (HF)	3 MHz- 30 MHz	Amateur Radio	Very High frequency, (VHF)	30 MHz - 300 MHz	Radio 1 FM	Ultra High frequency, (UHF)	300 MHz - 3 GHz	BBC1 and ITV	Very High frequency, (SHF)	3 GHz - 30 GHz	Satellite TV
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18.1.4	<p>A student makes the following statements about different types of electromagnetic waves.</p> <p>I Light waves are transverse waves.</p> <p>II Radio waves travel at 340 m s^{-1} through air.</p> <p>III Ultraviolet waves have a longer wavelength than infrared waves.</p> <p>Copy each statement and mark a tick or a cross to indicate if each of the student's statements are correct?</p> <p>I Light waves are transverse waves. ✓</p> <p>II Radio waves travel at 340 m s^{-1} through air. ✗</p> <p>III Ultraviolet waves have a longer wavelength than infrared waves. ✗</p>																					
18.2	I can make reference to typical sources, detectors and applications, of the electromagnetic spectrum.																					
18.2.1	<p>Draw a table listing a detector for each member of the electromagnetic spectrum. For each waveband in the e-m spectrum give an example of the following</p> <p>(a) typical source</p> <p>(b) detector</p> <p>(c) A practical use</p> <p>(see additional excel spreadsheet)</p>																					
18.3	I can state whether radiations in the electromagnetic spectrum are transverse or longitudinal waves.																					

No.	CONTENT
18.3.1	Copy the sentence below inserting the correct type of wave. Radiations in the electromagnetic spectrum are $\frac{\text{transverse}}{\text{longitudinal}}$ waves.
	Radiations in the electromagnetic spectrum are transverse waves
18.4	I can state what all radiations in the electromagnetic spectrum have in common.
18.4.1	State what all waves in the electromagnetic spectrum have in common
	a) all travel at $3.0 \times 10^8 \text{ ms}^{-1}$ in air b) all transfer energy c) are all transverse waves.
18.4.2	State the speed of light in air?
	$3.0 \times 10^8 \text{ ms}^{-1}$
18.4.3	How does the speed of light in air compare to the speed of light in glass?
	Light travels slower in glass than in air $2.0 \times 10^8 \text{ ms}^{-1}$
18.4.4	List the waves that travel at the same speed of light in air.
	Radio, Microwave, Infra red, Visible, Ultraviolet, X-rays, Gamma Ray
Refraction	
19.1	I know when refraction occurs.
19.1.1	State what causes the refraction of light.
	Light moving between materials of different optical densities
19.1.2	State a cause of refraction in water waves at the beach.
	A change between shallow and deep water.
19.2	I can give a description of refraction.
19.2.1	State what is meant by the term refraction.

No.	CONTENT
	<p>??????? The change in direction of a ray of light as it moves from one material to another is called refraction.</p>
<p>19.2.2</p>	<p>Copy and complete these diagrams showing how light passes from air to glass, and glass to air.</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Air Glass</p>  </div> <div style="text-align: center;"> <p>Glass Air</p>  </div> </div>
	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>Air Glass</p>  </div> <div style="text-align: center;"> <p>Glass Air</p>  </div> </div>
<p>19.2.3</p>	<p>On each of your completed diagrams above mark the following</p> <ul style="list-style-type: none"> (a) the angle of incidence, (b) the angle of refraction, (c) the normal line.
<p>19.2.4</p>	<p>Copy and complete the diagrams below to show the path of the rays.</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;"> <p>a)</p>  </div> <div style="text-align: center;"> <p>b)</p>  </div> <div style="text-align: center;"> <p>c)</p>  </div> <div style="text-align: center;"> <p>d)</p>  </div> </div>

No.	CONTENT	
19.2.5		<p>A student looking from a pier into some calm water sees a fish. Copy and complete the diagram to show the path of a ray of light from the fish to the student. (diagrams available on the website and from your teacher)</p> <p>You should include the normal in your diagram</p>
		<p>(1) mark for ray changing direction at water/air boundary (1) mark for angle in water less than angle in air. Angle of incidence in water should be less than the angle of refraction in air. (1) mark for correct normal (must be placed at the point where a ray meets the water/air boundary)</p>
19.2.6	<p>Copy out the correct diagram which represents the refraction of light waves after meeting a glass block as shown?</p> <p>C</p> 	

No.	CONTENT
19.2.7	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <p>State</p> <p>a) the angle of incidence</p> <p>b) the angle of refraction.</p> </div> </div>
	<p>a) the angle of incidence = $90 - 58 = 32^\circ$</p> <p>b) the angle of refraction. = $90 - 70 = 20^\circ$</p>
19.3	<p>I can describe the qualitative (info) relationship between the frequency and the energy associated with a form of radiation.</p>
19.3.1	<p>State the relationship between the frequency and the energy of waves.</p>
	<p>As the frequency of the waves increases the energy of the wave increases</p> <p>Frequency is directly proportional to energy</p> <p>$E = hf$ where E=energy, h=Planck's constant and f=frequency</p>
19.3.2	<p>For electromagnetic waves, $E = hf$ or Energy = Planck's Constant x frequency.</p> <p>a) Find out the value of Planck's constant, and</p> <p>b) Calculate the energy associated with a wave of frequency 6×10^{14} Hz</p>
19.3.3	<p>Do radio waves or infrared radiation have greater energies associated with them? You must justify your answer.</p>
	<p>IR, as these waves have a higher frequency than radio waves.</p>
19.4	<p>I can identify the normal, angle of incidence and angle of refraction in ray diagrams showing refraction.</p>
19.4.1	<p>Identify the following from the diagram shown below.</p> <ul style="list-style-type: none"> i) the incident ray ii) the reflected ray iii) the refracted ray iv) the normal v) the angle of incidence vi) the angle of refraction vii) the angle of reflection. <div style="text-align: right;">  </div>

No.	CONTENT
	<ul style="list-style-type: none">i) the incident rayii) the reflected rayiii) the refracted rayiv) the normalv) the angle of incidencevi) the angle of refractionvii) the angle of reflection.
19.4.2	Explain why a ruler, placed in a beaker of water, appears to change as it enters the water.
	The light is refracted at the surface between the air and water. Our eye is “tricked” and traces the ray back to where it appears to originate and hence it looks off-set.
19.4.3	Draw a diagram to show this, by trying it for yourself
	