Mark Scheme

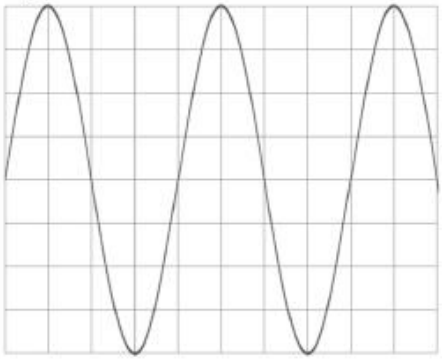
Practical: Investigate the frequency of a sound wave using an oscilloscope.

Q1.

Question number	Answer	Notes	Marks
(a)	microphone;		1
(b) (i)	determination of number of squares for one period; use of timebase to determine appropriate period in seconds; e.g. period = 8/1.5 = 5.3 squares period = (5.3 × 0.002 =) 0.011(s)	allow 5.2 – 5.5 squares '5 x 0.002' or '0.01' scores 1 '8 x 0.002' or '0.016' scores 1 accept 0.0104 – 0.0110 (s) for 2 marks	2
(ii)	use of f = 1 / T to evaluate frequency; e.g. frequency = (1 / 0.011 =) 91 (Hz)	allow ecf from (i) allow 90.9-96.2 (Hz)	1

Total for Question = 8 marks

Q2.

Question number	Answer	Notes	Marks
(a) (i)	microphone;		1
(ii)	measure number of squares for a number of complete cycles / waves and find average number of squares for one cycle; multiply number of squares for one cycle by the time base / eq;	condone 'find number of squares for one cycle' accept 'period' for 'cycle' condone use of 'wavelength' for 'period' or 'cycle' ignore reference to T = 1/f	2
(b) (i)	evaluation of time period of wave; substitution into f = 1 ÷ T; evaluation of frequency; conclusion consistent with frequency value; e.g. time period = 4×10^{-5} s f = 1 ÷ 4×10^{-5} f = 25 000 (Hz) (therefore) sound cannot be heard (since frequency is greater than 20 000 Hz)	reject if candidate uses y-axis allow ecf if frequency is incorrect conclusion must be consistent with candidate's frequency value to be awarded the mark	4
(ii)	wave has amplitude of 4 squares; wave has time period of 4 squares; e.g. 		2
		Total for Question = 9 marks	

Q3.

Question number	Answer	Notes	Marks
(a)	20 (Hz); to 20 000 (Hz);	units (if given) must be consistent with data i.e. 20 Hz - 20kHz max 1 mark if non-frequency unit given	2
(b) (i)	microphone;	ignore sound sensor, ultrasound detector	1
(ii)	any three from: MP1. idea of adjusting oscilloscope to obtain steady trace /eq; MP2. idea of adjusting time base to display (at least) one cycle on screen /eq; MP3. Idea of evaluating number of squares for full cycle /eq; MP4. multiply number of squares (for full cycle) by time base /eq;	e.g. "freeze the screen" condone reference to a wavelength rather than a time period or full cycle	3
(c) (i)	number of squares for full cycle; correct evaluation of time period from candidate's number of squares; e.g. one full cycle = 6 squares time period = $(6 \times 5 \times 10^{-6}) = 3 \times 10^{-5}$ (s)	reject answer that clearly uses the amplitude scale for 0 marks allow 30×10^{-6} (s)	2
(ii)	substitution into f = 1/T; evaluation; e.g. f = 1 / 3×10^{-5} (f =) 3.3×10^{4} (Hz)	allow ECF from (c)(i) allow 33 333.3..., 33 300, 33 000 etc (Hz) allow 30 000	2
		Total for question = 10 marks	

Q4.

Question number	Answer	Notes	Marks
(a)	microphone;		1
(b) (i)	determination of number of squares for 1 period by finding average period from whole diagram; correct use of timebase of 0.5 ms seen; evaluation of time period; evaluation of frequency; e.g. 1 period = 8 squares ÷ 5 = 1.6 squares time period = 1.6 × 0.5($\times 10^{-3}$) time period = 8.0$\times 10^{-4}$ s frequency = (1/8.0$\times 10^{-4}$) = 1250 (Hz)	 ignore units ignore PoT ecf candidate's time period apply PoT here time period of between 1.5 and 1.59 squares giving frequency between 1260 and 1333Hz scores 3 marks max.	4
(ii)	use of speed = frequency × wavelength; dimensionally correct substitution; evaluation; e.g. speed = frequency × wavelength speed = 1250 × 0.27 (speed =) 340 (m/s)	seen or implied allow ecf from (b)(i) -1 for POT error allow 337.5 (m/s)	3
(iii)	idea of adjusting timebase; idea of **decreasing** timebase/eq;	however described DOP ignore reference to y-axis	2
		Total for question = 10 marks	

Q5.

Question number	Answer	Notes	Marks
(a)	any 4 of: MP1. connect oscilloscope to microphone; MP2. adjust the oscilloscope to get a steady trace / eq; MP3. adjust time base / oscilloscope to give a minimum of 1 complete cycle (on the screen); MP4. measure number of squares for a number of complete cycles / waves; MP5. multiply number of squares by the time base / eq. (to find T); MP6. use f = 1/T;	ignore references to wavelength, amplitude, finding number of waves passing a point allow 'use oscilloscope to measure/find the time period / time for one wave' if neither MP4 or MP5 scored	4
(b) (i)	any 1 of: MP1. force / tension (on the string); MP2. material string is made from; MP3. diameter / thickness of the string; MP4. temperature;		1
(ii)	correctly calculated mean; given to nearest whole number; e.g. 34.3... gains first mark 34 gains both marks	 mark independently	2
(iii)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and unit; all plotting correct to nearest half square;	ignore orientation ignore point at 60cm	3
(iv)	acceptable curve of best fit drawn;	i.e. smooth curve within 1 small square of each point ignore parts of curve outside plotted points if extrapolated	1
(v)	string length in range 26-31cm;	allow ecf from candidate's line	1
(vi)	both 120cm and 140cm strings / eq; (because) humans cannot hear frequencies lower than 20Hz;	allow correctly read string length from graph for 20Hz frequency	2

Practical: Investigate the speed of sound in air.

Q6.

Question number	Answer	Notes	Marks
(a)	Any FIVE from: MP1. measure time for a set distance; MP2. realistic values suggested for experiment to work; MP3. suitable measuring instrument named; MP4. further detail of setup; MP5. idea of repeats **AND** average; MP6. speed = distance / time;	A fully labelled diagram can score all the marks. allow measuring wavelength for a known frequency e.g. • at least 1m for microphones and oscilloscope method • at least 100m for seeing and hearing a clap method • at least 50m for wall and echo method • wavelength measured at least 10cm e.g. stop clock, stopwatch, ruler, tape measure, oscilloscope, trundle wheel, timer e.g. • two microphones on bench connected to oscilloscope • start timing when see a clap and stop when hear it • clap by wall and time how long for clap to come back • moving a microphone until waveforms line up on oscilloscope • For echo method, idea time and distance is "there and back" allow speed = frequency × wavelength for appropriate method	5

(b)	(i)	Measurement of one period on oscilloscope; Use of x-scale; Evaluation of period in s; e.g. Period = 4 squares Period = 4 x 0.25 (ms) Period = 1.0×10^{-3} (s)	 -1 POT error Allow 1 SF answer Condone period = 0.0005 (s) or 0.002 (s) or in standard form for 2 marks MAX.	3
	(ii)	Substitution into given equation f = 1/ T; Evaluation; i.e $f = 1/(1.0 \times 10^{-3})$ f = 1000 (Hz)	Allow ECF from b) (i)	2

Q7.

Question number	Answer	Notes	Marks
(a)	any five from: MP1. idea that students stand a **large** distance apart; MP2. measure distance with tape measure / trundle wheel; MP3. start timing when see blocks hit together; MP4. stop timing when hear sound from blocks being hit together; MP5. measure time with stopclock / stop watch; MP6. take repeats and determine mean; MP7. use of speed = distance / time; MP8. use of a distance-time graph to find speed from gradient;	allow alternative approach using echoes from a wall allow stated distance if 50m or greater allow a large distance from a wall (at least 25m) ignore ruler allow idea of setting of a rhythm if wall method used allow dividing total time by number of hits if wall method used ignore timer allow take repeats to identify anomalies allow use of speed = 2×distance / time if wall method used	5
(b) (i)	mean calculated correctly; expressed to 2 decimal places; e.g. (mean time =) 0.866... (s) (mean time =) 0.87 (s)	 DOP 0.86 scores 1 mark only	2
(ii)	idea of ignoring or repeating the anomaly;	ignore 'repeat the experiment'	1
(iii)	300m distance chosen; idea that reaction time is likely to be less significant at greater distances;	allow greatest distance allow 200m only if justified with a speed of sound argument allow idea that it gives a speed closest to the true value allow idea that readings from trials show least variation	2

Q8.

Question number	Answer	Notes	Marks
(a) (i)	measure the distance between microphones; suitable instrument to measure distance; use of speed = distance ÷ time;	e.g. ruler / tape measure	3
(ii)	idea that time will be very small / too hard to measure by a human;	allow idea that human reaction time is an issue ignore speed of sound is very fast / eq.	1
(b) (i)	idea that air needs to be same temperature at all points between microphones;	allow idea that speed will change if temperature not constant ignore 'fair test'	1
(ii)	correctly calculate average; given to 1 decimal place; e.g. 59.97 = 1 mark 60.0 = 2 marks	DOP 59.9 scores 1 mark allow 59.96, 60	2
(iii)	point at (40, 358) circled;		1
(iv)	repeat it / discard it;	allow repeat experiment condone 'ignore it'	1
(v)	line graph suitable for continuous data; **both** variables are continuous;	allow 'data is continuous'	2
(vi)	idea that speed increases as temperature increases; idea of a linear relationship;	ignore positive correlation reject mark if relationship described as directly proportional	2

Q9.

Question number	Answer	Notes	Marks
(a)	any five from: MP1. outlines a viable method; MP2. realistic values suggested for experiment to work; MP3. suitable measuring instrument named; MP4. further detail of setup; MP5. idea of repeats **AND** average; MP6. Correct formula for described method;	a fully labelled diagram can score all the marks e.g. • measuring time for a known distance • measuring wavelength for a known frequency e.g. • at least 1m for microphones/sound sensors and oscilloscope/data logger method • at least 100m for seeing and hearing a clap method • at least 50m for wall and echo method • wavelength measured at least 10cm e.g. stop clock, stopwatch, ruler, tape measure, oscilloscope, trundle wheel, timer e.g. • start timing when see a clap and stop when hear it • clap by wall and time how long for clap to come back • moving a microphone until waveforms line up on oscilloscope • for echo method, idea time and distance is "there and back" allow repeats AND identifying anomalies e.g. • speed = distance / time • speed = frequency × wavelength	5
(b) (i)	period represented by 4 squares; correct use of x-scale; correct evaluation; e.g. period = 4 squares period = 4 × 5.0 ($\times 10^{-3}$) period = 20 ms = 2.0 × 10^{-2} (s)	 allow ECF from wrong number of squares if clear in working -1 POT error answer of 0.01, 0.04 (s) scores 2 marks allow 0.02 (s)	3
(ii)	substitution into given formula; correct evaluation; e.g. frequency = 1 / 0.02 frequency = 50 (Hz)	allow ECF from (i)	2
		Total for Question = 10 marks	

Q10.

Question number	Answer	Notes	Marks
(a) (i)	speed = frequency × wavelength;	allow standard symbols and rearrangements e.g. v = f × λ	1
(ii)	determination of period; conversion from ms to s; evaluation of frequency; substitution into v = f × λ; evaluation of speed; e.g. period = 4 squares period = (4 × 1 =) 4 ms frequency (= 1/4 × 10^{-3}) = 250 (Hz) speed = 1.4 × 250 speed = 350 (m/s)	 allow ECF from incorrect frequency -1 for POT error 175, 700 (m/s) = 3 marks allow 0.004 (s)	5
(b)	any five from: MP1. reference to reaction time; MP2. suggestion that light flash and sound may not be at the same time; MP3. idea that distance is too short (to give accurate value); MP4. idea that ruler is not appropriate to measure this distance; MP5. idea of mis-counting the number of ruler lengths; MP6. idea of zero error on ruler; MP7. idea of ruler not going in a straight line; MP8. idea of lack of repeats; MP9. idea that time of travel is too short to be measured by a human;	ignore descriptions of different experimental methods allow description of reaction time issues allow suggestion that trundle wheel/tape measure should be used allow ground not being level	5
		(Total for Question = 11 marks)	