Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) % difference = $\frac{(240 - 343)}{343} \times 100$ evaluation (1) (-) 30 (%)	 OR 343 – 240 in numerator award full marks for the correct answer without working allow 1 mark for division by 240 yielding 43% allow one mark for $\frac{240}{343} \times 100 = 70$ %	(2)

Question number	Answer	Additional guidance	Mark
(ii)	explanation linking any two of: reaction time is significant (with 0.5s or less) (1) the reaction time will be different for each of the students (1) effects on reaction times (1) students are at different distances (from starting pistol) (1) anticipation of flash / bang (1)	 accept reaction time is large compared with travel time differences in perception / acuity of light and sound	(2)

Question number	Answer	Additional guidance	Mark
(iii)	explanation linking: use a (much) longer distance **OR** use electronic timer (1) with effect (1) reduces/eliminates the significance/impact of the reaction time **OR** gives a more manageable time to measure	all stand the same distance from the starting pistol (1)	**(2)**

Q2.

Question number	Answer	Additional guidance	Mark
	Substitution into $v = \frac{s}{t}$ to find v (1) $v = \frac{1.5 \times 10^{11}}{500}$ Substitution into $v = f \times \lambda$ and unit conversion (1) $v = \frac{1.5 \times 10^{11}}{500} = f \times 670 \times 10^{-9}$ Transposition (1) Rearrangement (1) $f = \frac{(1.50 \times 10^{11})}{500 \times (670 \times 10^{-9})}$ Answer (1) 4.5 x 10^{14} (Hz)	s is distance award full marks for correct numerical answer without working maximum 3 marks if λ in nm 4.4776 x 10^{14} (Hz)	**(4)**

Q3.

Question number	Answer	Additional guidance	Mark
	recall **and** rearrangement (1) $\lambda = \frac{v}{f}$ evaluation (1) 3.08 (m) (so) length of aerial = 1.54 m (1) check working $\frac{3\times10^8}{2} = 1.5 \times 10^8$ gets only 1 mark for ecf	 $\frac{3.0\ (\times 10^8)}{97.4\ (\times 10^6)}$ accept 3.1 (m) award 1 mark for wavelength that rounds to 3.1 to any other power of 10 independent mark. allow ECF from candidate's wavelength accept 1.5 (m) award 2 marks for 1.5 to any other power of 10 award full marks for the correct answer without working Allow 1.46 rounded to 1.5 for 1 mark only if it is ecf from mp2	**(3)**

Q4.

Question Number	Answer	Additional guidance	Mark
	recall and substitution (1) (v =) 0.25 x 1.5 evaluation (1) 0.38 (m/s)	 accept 0.375 or 0.37 (m/s) accept 37.5, 37 or 38 for 1 mark only award full marks for the correct answer without working	**(2)**

Q5.

Question number	Answer	Additional guidance	Mark
	uses data taken from x axis (1) 28(cm) (1)	 award full marks for correct answer without working	**(2)** **AO3**

Q6.

Question Number	Answer	Additional guidance	Mark
(i)	selection and substitution (1) $3(.00) \times 10^8 = 2.45 (\times 10^9) \times \lambda$ rearrangement (1) $(\lambda =) \frac{3(.00)\times 10^8}{2.45 (\times 10^9)}$ evaluation (1) 0.12 (m)	allow substitution and rearrangement in either order $2.45 \left(\times 10^9\right) = \frac{3(.00) \times 10^8}{\lambda}$ $\lambda = \frac{v}{f}$ accept 0.122(m) power of ten error gains 2 marks award full marks for the correct answer without working	**(3)** **AO2**

Question Number	Answer	Additional guidance	Mark
(ii)	selection and substitution (1) $(0.)55=\frac{42\,000}{\text{total energy supplied (to device)}}$ rearrangement (1) $(\text{total energy supplied to device}=)\frac{42\,000}{(0.)55}$ evaluation (1) 76 000(J)	allow substitution and rearrangement in either order $(0.)55=\frac{42\,000}{x}$ accept any value that rounds to 76 000(J) 760/764/763(J) gains 2 marks any other power of ten error gains 1 mark award full marks for the correct answer without working	**(3)** **AO2**

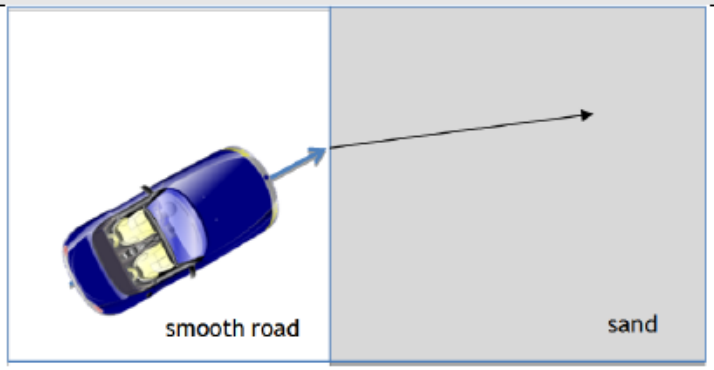
Q7.

Question number	Answer	Mark
(i)	An answer that combines the following points of understanding to provide a logical description: • take time T for waves to pass a fixed point (1) • and frequency = $\frac{\text{number of waves}}{\text{time taken}}$ (1)	**(2)**

Question number	Answer	Mark
(ii)	A	**(1)**

Question number	Answer	Mark
(iii)	D	(1)

Q8.

Question number	Answer	Mark
(i)	 approx	(1)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that combines identification - knowledge (1 mark) and reasoning/justification - understanding (1 mark): • both car and light ray slow down when entering sand / glass (1) • direction changes towards normal (1)	Bend towards the normal	(2)

Q9.

Question Number	Answer	Additional guidance	Mark
	single straight line in upper right quadrant (1) direction change **towards** the normal (1)	ignore arrow direction conditional on first mark point	**(2)**

Q10.

Question number	Answer	Mark
	An answer that provides a description by making reference to: • transverse waves have oscillations perpendicular to direction of travel of the wave (1) • whereas longitudinal waves have oscillations in the same direction as the direction of travel of the wave (1)	**(2)**

Q11.

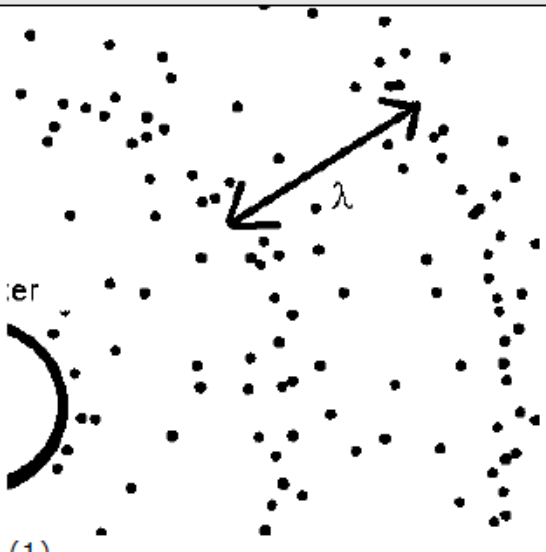
Question Number	Answer	Additional guidance	Mark
	A description including particles (at end) vibrate (more) (about fixed positions) (1) cause neighbouring particles to vibrate (more) (1)	 allow atoms / ions / molecules for particles vibrations passed along OR reference to longitudinal waves / compressions and rarefactions	**(2)**

Q12.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • point A reaches the glass block before point B • A moves into the glass block and slows down • as light travels more slowly in glass than in air • B is still in air so is travelling faster than A • this causes part of the wavefront to change direction/refract • by the time B reaches the block it will have travelled further than A • therefore, the whole wavefront changes direction/refracts towards the normal • at the other face, A exits first so the process is reversed • the wavefront changes direction again so it is parallel to its original direction/refracts away from the normal	**(6)**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q13.

Question number	Answer	Additional guidance	Mark
(i)	 (1)	any similar distance labelled wavelength / λ between the equivalent of 2 consecutive compressions	(1)

Question number	Answer	Additional guidance	Mark
(ii)	description including any two from: particles vibrate / oscillate/ move backwards and forwards (1) along a radius/ parallel to direction of travel/ energy transfer (1) about mean /fixed positions (1)	 allow air for particles in same direction as wave allow one mark for 'sound is a longitudinal wave' if no other mark awarded	(2)

Q14.

Question Number	Answer	Additional guidance	Mark
	An explanation linking: make the distance between students larger (1) OR viable alternative method such as use microphones / sound sensors / datalogger (to start and stop timer) (1) **with:** to give a more measurable time (1) OR to remove (variable) reaction times (at start and end) / to reduce effect of reaction times / improve accuracy of timing (1)	50 m is too short (a distance to produce a measurable time) gives a longer time – more accurate measurement do not accept 'more accurate' without qualification for either method	**(2)**

Q15.

Question number	Answer	Additional guidance	Mark
	explanation linking: wave P refracts (towards the normal) (1) because P slows down (1) AND wave Q is reflected (at an equal angle from the boundary) (1) without change of speed of Q (1)	accept 'upper layer' for 'P' accept 'wavelength decreases' accept 'bends' for 'refracts' in this instance accept 'lower layer' for 'Q' accept 'wavelength unchanged' accept 'wave Q bounces off' (at an equal angle) allow one mark for refraction and reflection if no other mark awarded	**(4)**

Q16.

Question Number	Answer	Additional guidance	Mark
	substitution (1) $\frac{3.0 (\times 10^{8})}{5.8 (\times 10^{-7})}$ evaluation (1) 5.2×10^{14} unit (1) Hz	 answers that round to 5.2×10^{14} award 2 marks for a correct answer without working allow 1 mark for answers that round to 5.2 to any power of ten independent mark accept hz or s^{-1} or per sec(ond) or hertz accept kHz, MHz etc with correct power (10^{11} kHz, 10^{8} MHz)	**(3)** AO 2 1

Q17.

Question Number	Answer	Additional guidance	Mark
	an explanation linking: (the colours have) different wavelengths (1) different wavelengths / colours travel at different speeds (1) so refract by different amounts (1)	 allow the word frequencies for wavelengths for refract allow bend/change direction/follow different path	**(3)** AO 2 1

Q18.

Question number	Answer	Mark
(i)	Any three of • sound waves are longitudinal but radio waves are transverse. • sound waves need a medium but radio waves travel through a vacuum. • sound waves have (much) lower velocity than radio waves. • sound waves have lower frequency / greater wavelength than radio waves • sound waves are vibrations but radio waves are electromagnetic waves.	(3)

Q19.

Question number	Answer	Acceptable	Mark
(i)	An explanation that combines identification - understanding (1 mark) and reasoning/justification - understanding (2 marks): • white light is a mixture of different wavelengths (1) • each wavelength / colour is refracted by a different amount (1) • short <u>wavelengths</u> are refracted more / ORA (1)	ignore colours	(3)

Question number	Answer	Acceptable	Mark
(ii)	An answer that combines the following points to provide a logical description of the method: • Place a thermometer (with blackened bulb) beyond position of red light (1) • Look for rise in temperature (measured by thermometer) (1)		(2)

Q20.

Question Number	Answer	Additional guidance	Mark
	using cold row: evaluate (K=)376 (1) using warm row: substitute K and ρ $\frac{376}{\sqrt{1.16}}$ OR 349.10.... (1) 349 (m/s) to 3 sig figs (1)	 $\frac{\text{other K from earlier calculation}}{\sqrt{1.16}}$ any answer to 3 sig figs 349.10... scores MP1 and MP2 award full marks for the correct answer without working	**(3)**

Q21.

Question Number	Answer	Additional guidance	Mark
(i)	evidence of use of scale on horizontal distance axis only (1) 12 (cm) (1)	may be seen on the diagram range 11.5 to 12.5 (cm) award full marks for the correct answer without working 6 (cm) or 30(cm) scores 1 mark (evidence of use)	**(2)**

Question Number	Answer	Additional guidance	Mark
(ii)	a description to include: moves up and down (1) at right angles / normal / perpendicular to (direction of) wave / travel (1)	independent marking points vertical (oscillations) not in the (direction of) wave / travel accept 'transverse wave' for 2nd MP	**(2)**

Q22.

Question Number	Answer	Additional guidance	Mark
	a description to include: (the prong makes the) air vibrate/oscillate (1) in the same direction as /parallel to the wave travels (1)	causes compressions and rarefactions in air transfers ke to air longitudinal credit can be given for a labelled diagram	**(2)** AO 1 1

Q23.

Question number	Answer	Additional guidance	Mark
(i)	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = number of waves / time (1)	 ignore in one second count the number of waves in one second scores 2 marks (MP1 and MP3) find the time between one wave and the next scores 2 marks (MP1 and MP2)	**(3)** **AO1**

Question number	Answer	Additional guidance	Mark
(ii)	substitution (1) $1.5 = 0.7 \times \lambda$ rearrangement and evaluation 2.1(4) m	 $\frac{1.5}{0.7}$ allow $\frac{0.7}{1.5}$ for 1 mark award full marks for correct answer without working. $\lambda = v/f$ scores 1 mark	**(2)** **AO2**

Question number	Answer	Additional guidance	Mark
(iii)	A description to include: mention of oscillations/vibrations (1) EITHER transverse – (oscillations) perpendicular to direction of wave (travel) (1) OR longitudinal - (oscillations) in same direction as wave (travel) (1)	up and down OR side to side (movements) OR back and forth transverse movement up and down but longitudinal is side to side (1 mark only)	**(2)** **AO1**

Q24.

Question Number		Indicative Content	Mark
QWC	*	An explanation including some of the following points • Longitudinal {vibrations/oscillations} are {along/parallel to/in the same direction as} the direction of {travel/energy transfer} • Transverse {vibrations/oscillations} are {across/perpendicular to/90° to/right angles to} the direction of {travel/energy transfer} • Ultraviolet waves are transverse • Ultrasound waves are longitudinal (ignore sound – not on list) • Some seismic waves are longitudinal and some are transverse • P waves are longitudinal • S waves are transverse • Longitudinal waves need a material for the vibrations whereas electromagnetic waves can pass through a vacuum **IGNORE** irrelevant material	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited explanation of: EITHER the {vibration/movement} direction and direction of {travel/movement} for transverse or longitudinal wave OR correctly identifying the wave type for at least one example from the list, e.g. o Longitudinal waves move in the same direction as the wave moves o Ultraviolet waves are transverse • the answer communicates ideas using simple language and uses limited scientific terminology
2	3 - 4	• a simple explanation linking: EITHER directions of {vibration/oscillation} and wave travel for both types of wave OR direction of {vibration/oscillation} and wave travel of one type of wave with at least one example of a wave from the list OR the direction of 'movement' and direction of {travel/movement} for transverse AND longitudinal waves AND correctly identifying the wave type for at least one example from the list e.g. o In longitudinal waves the vibrations are in the same direction as the wave travels. In transverse waves the vibrations are at right angles to the direction the wave travels. o In longitudinal waves the vibrations are in the same direction as the wave travels. Ultraviolet waves are transverse. o Longitudinal waves move in the same direction as the wave moves. Transverse waves move at right angles to the direction the wave moves. Ultrasound waves are longitudinal. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• a detailed explanation clearly differentiating between the directions of {vibration/oscillation} for longitudinal AND transverse waves AND at least one example of each type of wave from the list, e.g. o In longitudinal waves the vibrations are in the same direction as the wave travels. In transverse waves the vibrations are at right angles to the direction the wave travels. Ultrasound waves are longitudinal and ultraviolet waves are transverse. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q25.

Question Number	Answer	Acceptable answers	Mark
	Substitution (1) (Speed =) $6.67 \times 10^{14} \times 4.5 \times 10^{-7}$ Transposition AND substitution (1) (time =) $\frac{4 \times 10^{16}}{(6.67 \times 10^{14} \times 4.5 \times 10^{-7})}$ Evaluation (1) 1.33×10^{8} (s)	Award full marks for correct answer with no working 3×10^{8} (m/s) seen anywhere $\frac{4 \times 10^{16}}{3 \times 10^{8}}$ ECF candidate's speed maximum 2 marks Allow answers which round to 130 000 000 IGNORE Power of Ten error until evaluation	**(3)**