Assessment Schedule – 2019

Physics: Demonstrate understanding of wave systems (91523)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	 Third overtone, 4th harmonic.	• Correct diagram. *(Count 4 antinodes.)*		
(b)	3rd overtone = 4th harmonic wavelength = $\frac{L}{2}$ = 0.368 m • f(4th harmonic) = $\frac{v}{\lambda} = \frac{289}{0.368} = 785.326$ Hz	• Correct wavelength (*of 4th harm).* OR • Correct calculation of frequency using an incorrect wavelength (formula & substitution).	• Correct frequency.	
(c)	The tension ∝ velocity ∝ Frequency . • as $v = f\lambda$ (fixed wavelength) *(Accept thickness argument, only if stating thicker/thinner & clear understanding.)*	• • One point.	• Both points.	
(d)	• Explains formation - two waves of slightly different frequencies interfere, when in phase, constructive (loud), (when 180° phase diff, destructive (quiet)). • Increasing tension, increased velocity (fixed length) results in increased frequency. • So D string must have been lower than 147 Hz. $F_{beat} = f_1 - f_2$, 145 Hz. *(accept lower 2Hz than 147Hz)*	• One point.	• Two bullet points.	• Full answer.

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$v = 338$ m s^{-1} $L = 0.446$ m $\lambda = 2L = 0.892$ m $f = \frac{v}{\lambda} = \frac{338}{0.892} = 378.92$ Hz	• Correct frequency with working. NB this is a SHOW question.		
(b)	 Open pipe $\lambda = 2L$. Closed pipe $\lambda = 4L$. As $v = f\lambda$, velocity const, L const, the closed pipe has a larger (twice) wavelength, so the frequency will be **less** (half) than the open pipe *($f = 189.46$ Hz)*	• Correct diagrams OR Description to justify that frequency will be **less**.	• Correct diagrams. AND Description to justify that frequency will be **less**.	
(c)	 *(Count 3 nodes.)* $n = \frac{1138}{379} = 3.0026$ Third harmonic or second overtone.	• Identifies correct harmonic or overtone. OR Draws waveform with correct nodes and antinode positions (no labels required).	• Correct diagram and harmonic / overtone stated.	
(d)	• Calculation $f' = 1138 \times \frac{338}{338 + 12.2} = 1098$ Hz • Explain f': as source is moving away from M, (wavefronts are stretched), so λ increases, since $v = f\lambda$, frequency decreases. • Explain **why** Sam hears original frequency (due to moving at same speed as source).	• One bullet point . 1098 not 1180.	• Two bullet points.	• Full answer.

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$n\lambda = d\sin\vartheta \quad \lambda\uparrow, \quad \vartheta\downarrow$ When d is constant as wavelength increases (the path difference increases) and so the angle (to successive maxima) increases OR $n\lambda = \frac{dx}{l}$ When d and l are constant as wavelength increases the distance between maxima increases.	• Correct answer. DO NOT ACCEPT longer wavelengths of light diffract by larger angles .	•	
(b)(i) (ii)	$d = \frac{1\text{ m}}{400\,000} = 2.5\times10^{-6}$ $n\lambda = d\sin\theta$ $2\lambda = \left(2.5\times10^{-6}\right)\sin 20.7°$ $\lambda = 4.4184\times10^{-7}$ m $\lambda = 442$ m (if in rad $\lambda = 1.2 \times 10^{-6}\ m$)	• One point. Watch $\frac{\sin\theta}{2} \neq \sin\left(\frac{\theta}{2}\right)$ so $\lambda = \left(2.5\times10^{-6}\right)\sin\left(\frac{20.7}{2}\right)$ Will give an incorrect answer of 449 nm.	• Both points. Accept incorrect $\times10^{x}$ provided substitution correct.	
(c)	(Light diffracts through the grating and acts as a point source) (not req). • Constructive/destructive interference explained (linked) (when the light sources are [in phase] a [bright region] is produced). • Answer includes path difference (when the path difference is a whole number *all* of the light constructively interferes to produce a bright , narrow, well defined maxima). nb a grating produces multiple waves	• One point. Path difference $n\lambda$ p.d.	• Both points.	

(d)	• Calculation $n\lambda = d\sin\theta$ $n\left(5.32\times10^{-7}\right) = \left(2.5\times10^{-6}\right)\sin 28.6°$ $n = \dfrac{\left(2.5\times10^{-6}\right)\sin 28.6°}{\left(5.32\times10^{-7}\right)}$ $n = 2.249$ Therefore it will be dark **because**: • (where) n is not a whole number (it lies a qurter of the way between the 2nd and the 3rd maxima) *(looking for students to recognise this is a grating, not just 2 point source (ie node not just at n=2.5))* • (Why) It will **not** be an antinode (as the maxima are narrow/well defined with a diffraction grating) / OR • At this point the overall effect is distructive interfernce. Note large angle $\sin\theta \neq \tan\theta$.	• One bullet point .	• Two bullet points.	• Full answer.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 14	15 – 19	20– 24

Alternative to 3(d)

Each wavefront is produced further from the one preceding it, so takes an adtional time to cover the distance. And so the time between fronts increases. As there are was wavefronts per sec, the freqency decreases

Examples

3(c)

- The light interferes to produce constructive interferrence (n).
- The light interferes to produce an antinode (n).
- The light interferes to produce an antinode which is seen as a bright spot (a).
- The light arrives such that C meets C and T meets T and so makes a bright spot (OR an antinode) (a).
- When the light sources are in phase a bright region is produced (a).
- The light is in phase and so constructively interferes to produce a bright spot (a).
- The light is in phase and so constructively interferes to produce an antinode(a).
- The light has a path difference of a whole number of wavelengths and so arrives in phase and constructively interferes to produce a maxima (m).