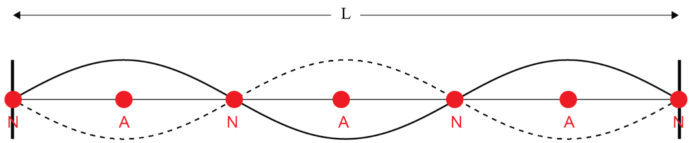
Assessment Schedule – 2022

Physics: Demonstrate understanding of wave systems (91523)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	Third harmonic (or 2nd overtone).  	• Third harmonic (or 2nd overtone) AND Node and antinode labelled correctly.		
(b)	$\boldsymbol{\lambda = 0.43\ m}$ $L = 0.645\text{ m}$ $L = 1.5\lambda$ $\lambda = \dfrac{0.645}{1.5}$ $\lambda = 0.43\text{ m}$ $v = f\lambda$ $v = \dfrac{0.645 \times 995}{1.5}$ $v = 427.8$ $v = 428\text{ m s}^{-1}$ (3sf)	• Correct wavelength. OR Correct working (incorrect λ).	• Correct answer for speed of sound along the string.	
(c)	Since the speed of sound along the string increases when Mele tightens the string, and since the length of the string does not change, the wavelength does not change, the frequency of the note will increase: $v = f\lambda$. Mele's original frequency was 995 – 5 = 990 Hz.	• f increases. OR 990 Hz	• v increases, $v = f\lambda$, (L const), OR λ const, f increases. AND 990 Hz	

(d)	Higher harmonics are multiples of the 1st harmonic. The flute can be modelled as an open pipe, (as waves reflect at the open end with no phase change) only waves that form **antinodes at both ends** will form standing waves (with alternating nodes and antinodes). As higher harmonics are **all multiples of half wavelengths,** all harmonics meet the end conditions and are able to form and fit the length of the flute. Since the clarinet has one end closed, it can be modelled as a closed pipe, (as waves reflect at the fixed end with a 180-degree phase change) only waves that result in **nodes at the closed end** and **antinodes at the open end** will only form standing waves (with alternating nodes and antinodes). Hence only **odd multiples of ¼ wavelengths** can be formed that fit the length of the clarinet.	Either a diagram or a statement. • Closed pipe end condition (A-N) open pipe end condition (A-A) OR To show odd multiples of ¼ wavelengths formed on the clarinet. OR Multiples of half wavelengths on the flute. Note "Can only form odd harmonics" is NOT sufficient.	• Explanation of why 2nd harmonic in closed pipe (clarinet) cannot form OR Explanation of why 2nd harmonic in open pipe (flute) **can** form.	• Explanation of why 2nd harmonic in closed pipe (clarinet) cannot form. AND • Explanation of why 2nd harmonic in open pipe (flute) **can** form.

NØ	**N1**	**N2**	**A3**	**A4**	**M5**	**M6**	**E7**	**E8**
No response; no relevant evidence.	1a	2a	3a	4a	1a + 2m	3m	2a + 1m + 1e	1a + 2m + 1e

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	The fringes on the screen will be closer together. (There will be more maxima present in a given width of screen)	• closer ($x\downarrow$, $\theta\downarrow$ more fringes (in given dist))		
(b)	$n = 3$ $\theta = 54°$ $d = \frac{1}{N}$ $d = \frac{1}{6.00 \times 10^5}$ $d = 1.6667 \times 10^{-6}$ $n\lambda = d\sin\theta$ $3\lambda = \frac{1}{6.00 \times 10^5}\sin 54°$ $\lambda = 4.49 \times 10^{-7}$ m $v = f\lambda$ $3.00 \times 10^8 = f \times 4.49 \times 10^{-7}$ $f = \frac{3.00 \times 10^8}{4.49 \times 10^{-7}}$ $f = 6.68 \times 10^{14}$	• Correct d. OR Correct λ. OR Correct working with incorrect d.	• Correct answer.	
(c)	White light is composed of a mixture of colours, and each colour has its own frequency and wavelength. As there is **no path difference** between the slits to the central maxima all of the colours remain **in phase** and so **constructively interfere** and **combine to produce white light.** Violet, which is at one end of the spectrum, has the shortest wavelength, and therefore **the smallest path difference** ($n\lambda$) of a whole wavelength, hence arriving in phase to its 1st order maxima at the **smallest angle** ($n\lambda = d\sin\theta$), and is therefore **closer to the central maxima**. Red, which is at the other end of the spectrum, has the longest wavelength, and therefore the largest path difference ($n\lambda$) of a whole wavelength, hence arriving in phase to its 1st order maxima at the largest angle ($n\lambda = d\sin\theta$), and is therefore further from the central maxima. So, the pattern on the screen, on each side of the centre would be a **complete spectrum with violet closer to the centre** and red on the outside for each order.	• States a complete spectrum is seen with violet on the inside and red on the outside. (for red $n\lambda\uparrow = d\sin\theta\uparrow$) • Path difference of whole λ result in waves being in phase. • Path difference of whole λ produce maxima. • Waves in phase produce maxima. • All colours constructively interfering combine to produce white light.	• Correct reasoning for white 0th order maxima. OR Correct reasoning for spectrum (violet inside, red outside).	• Correct reasoning for white 0th order maxima. AND • Correct reasoning for spectrum (violet inside, red outside).

(d)	$n\lambda_{\text{violet}} = d\sin 28.05$ $n\lambda_{\text{red}} = d\sin 50.82$ n and d are common, so dividing one by the other: $\frac{\lambda_{\text{violet}}}{\lambda_{\text{red}}} = \frac{\sin 28.05}{\sin 50.82}$ $\lambda_{\text{violet}} = 0.6066\lambda_{\text{red}}$ $\lambda_{\text{red}} - \lambda_{\text{violet}} = 2.54\times10^{-7}$ $\lambda_{\text{red}} - 0.6066\lambda_{\text{red}} = 2.54\times10^{-7}$ $\lambda_{\text{red}}(1-0.6066) = 2.54\times10^{-7}$ $\lambda_{\text{red}} = \frac{2.54\times10^{-7}}{0.3934}$ $\lambda_{\text{red}} = 6.46\times10^{-7}$ m	• n AND d are const (in common).	• Link equations and attempt to rearrange.	• λ_{red} = 646.71 mm (correct working) OR λ_{violet} = 391.71 mm (alternative evidence for E7)

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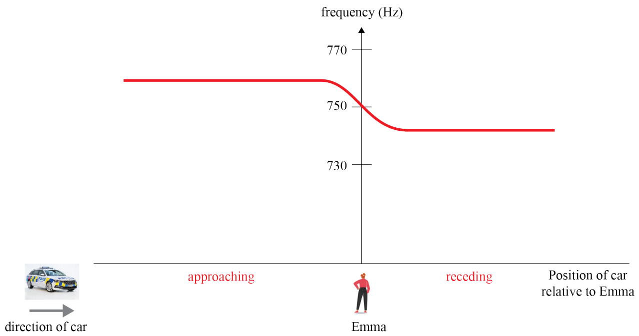
No response; no relevant evidence.	1a	2a	3a	4a	1a + 2m	3m	2a + 1m + 1e	1a + 2m + 1e (+ λ_{red})

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	Emma hears a note of higher pitch, while the driver of the car hears the actual pitch.	• higher frequency		
(b)	$f' = 750 + 8.50$ $f' = 758.5\ \text{Hz}$ $f' = \dfrac{f \cdot v_w}{v_w - v_s}$ $785.5 = 750\dfrac{340}{340 - v_s}$ $340 - v_s = 750\dfrac{340}{758.5}$ $v_s = 3.81015$ $v_s = 3.81\ \text{m s}^{-1}$	• Substitution correct. ($f' = 758.5$ Hz) AND ($v_w - v_s$)	• Correct answer. • $v_s = v_w - \dfrac{f \cdot v_w}{f'}$ *Note: this is a show question* *Cannot use 3.81 in Calculation*	
(c)	approaching $f' = 758.5$ Hz receeding $f' = 750\dfrac{340}{340 + 3.81} = 741.67$ Actual frequency $= 750$ Hz  	• correct calculation of apparent frequency (receding). OR Correct shape of graph.	• correct calculation of apparent frequency (receding). AND Correct shape of graph.	

(d)	As the car is traveling toward Emma the component of the velocity toward her remains constant (i.e. the car is travelling directly toward her) so the apparent frequency is a constant value that is higher than the actual frequency and so this remains a **horizontal line** at a value of 758.5 Hz As the car is going past Emma the component of the velocity toward is changing decreasing $\left(v_{\mathrm{t}} = v\cos\theta\right)$ and so the apparently frequency decreases rapidly and the gradient of the curve is steep. When the car is directly beside her there is no component of the cars velocity toward her and so Emma hears the true frequency of 750 Hz (this will be the steepest part of the curve). The frequency continues to decrease as the component of the velocity decreases further (increasing v, but away from the observer). Once the car is past Emma, the car is effectively travelling directly away from her and so the component of the velocity away from her is unchanging and the frequency remains constant at 741.7 Hz.	• Supplementary evidence Toward, waves bunch, $\lambda\downarrow$, so $f\uparrow$. OR Away, waves spread, $\lambda\uparrow$, so $f\downarrow$.	• ONE section: - f' (toward) is a constant higher value / the gradient is zero because it is travelling directly toward her/ at a const speed. - OR - f' (away) is a constant lower value / the gradient is zero because it is travelling directly away from her / at a const speed. - OR - f' changes because the 'velocity toward Emma is changing' / "the velocity is changing from toward to away. - (or decreases further….) - (or suitable explanation for vertical line) - OR - the f is 750 Hz when inline because the relative velocity toward Emma is zero.	• TWO sections: - f' (toward) is a **constant** higher value / the gradient is zero because it is travelling directly toward her/ at a const speed. - f' (away) is a **constant** lower value / the gradient is zero because it is travelling directly away from her/ at a const speed. - f' changes because the 'velocity toward Emma is changing' / "the velocity is changing from toward to away. - (or decreases further….) - (or suitable explanation for vertical line). - The f is 750 Hz when inline because *t*he relative velocity toward Emma is zero. Note Sections 1 & 5 = E7 Any other combo 1-5 = E8

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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 - 13	14 - 19	20 – 24

2d alternate method

(d)	Red $n\lambda_{\text{red}} = d\sin 50.82$ $\frac{n}{d} = \frac{\sin 50.82}{\lambda_{\text{red}}}$ n and d are common $\frac{\sin\theta_{\text{red}}}{\lambda_{\text{red}}} = \frac{\sin\theta_{\text{violet}}}{\lambda_{\text{violet}}}$ $\frac{\sin\theta_{\text{red}}}{\lambda_{\text{red}}} = \frac{\sin\theta_{\text{violet}}}{\lambda_{\text{red}} - 2.54\times10^{-7}}$ Violet $n\lambda_{\text{violet}} = d\sin 28.05$ $\frac{n}{d} = \frac{\sin 28.05}{\lambda_{\text{violet}}}$ $\lambda_{\text{red}} - \lambda_{\text{violet}} = 2.54\times10^{-7}$ $\lambda_{\text{red}} - 2.54\times10^{-7} = \lambda_{\text{violet}}$ $\left(n\lambda_{\text{red}} - 2.54\times10^{-7}\right)\sin\theta_{\text{red}} = \lambda_{\text{red}}\sin\theta_{\text{violet}}$ $\lambda_{\text{red}}\sin\theta_{\text{red}} 2.54\times10^{-7}\sin\theta_{\text{red}} = \lambda_{\text{red}}\sin\theta_{\text{violet}}$ $\lambda_{\text{red}}\sin\theta_{\text{red}} - \lambda_{\text{red}}\sin\theta_{\text{violet}} = 2.54\times10^{-7}\sin\theta_{\text{red}}$ $\lambda_{\text{red}}\left(\sin\theta_{\text{red}} - \sin\theta_{\text{violet}}\right) = 2.54\times10^{-7}\sin\theta_{\text{red}}$ $\lambda_{\text{red}} = 2.54\times10^{-7}\frac{\sin\theta_{\text{red}}}{\sin\theta_{\text{red}} - \sin\theta_{\text{violet}}}$ $\lambda_{\text{red}} = 2.54\times10^{-7}\frac{\sin\theta_{\text{red}}}{\sin\theta_{\text{red}} - \sin\theta_{\text{violet}}}$ $\lambda_{\text{red}} = 2.54\times10^{-7}\frac{\sin 50.82}{\sin 50.82 - \sin 28.05}$ $\lambda_{\text{red}} = 646.71\text{ nm}$	• n AND d are const (in common).	• Link equations and attempt to rearrang	• $\lambda_{\text{red}} = 646.71\text{ nm}$ (correct working) OR $\lambda_{\text{violet}} = 391.71\text{ nm}$

	Alternate method 2 d and n are the same $n\lambda = d\sin\theta$ $\lambda = \dfrac{d\sin\theta}{n}$ $\lambda_{\text{red}} - \lambda_{\text{violet}} = 2.54\times10^{-7}$ $\dfrac{d\sin 50.82}{n} - \dfrac{d\sin 28.05}{n} = 2.54\times10^{-7}$ $\dfrac{d}{n}\left(\sin 50.82 - \sin 28.05\right) = 2.54\times10^{-7}$ $\dfrac{d}{n} = 8.33\times10^{-7}$ $\lambda_{\text{red}} = \dfrac{d\sin\theta}{n}$ $\lambda_{\text{red}} = 8.33\times10^{-7}\left(\sin 50.82\right)$ $\lambda_{\text{red}} = 646.71\text{ nm}$			