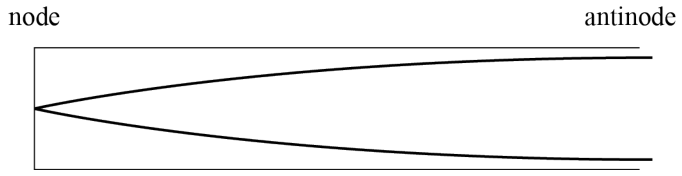
Assessment Schedule – 2017

Physics: Demonstrate understanding of wave systems (91523)

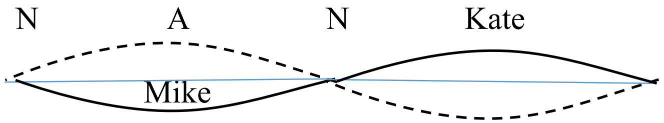
Evidence Statement

Q		Achievement	Merit	Excellence
ONE (a)		Correct labelled diagram. (line doesn't curve back or become parallel, continues to the end of the pipe, in not straight. Only one side needs to be correct)		
(b)	The clarinet is open / closed, so has a node and an antinode at the two ends. The tube can sustain only odd harmonics because the tube "fits" only an odd number of quarter wavelengths (OR $\frac{\lambda}{4}, \frac{3\lambda}{4}, \frac{5\lambda}{4}$). OR The fundamental has a pipe length of $\frac{\lambda}{4}$. The pipe length for even harmonics would require an even number of quarter wavelengths $L = \frac{\lambda}{2}, \lambda, \frac{3\lambda}{2}$ etc. This requires a node / node OR antinode / antinode.	Open end must be an antinode and closed end must be a node. OR standing wave has odd number of ¼ wavelengths. OR explanation good for only second harmonic OR Even harmonics require nodes at both ends/antinodes at both ends.	node at closed end and antinode at open end requires odd number of quarter wavelengths OR even harmonics need nodes at both ends or antinodes at both ends because length is an even number of quarter wavelengths	
(c)	$f' = f\frac{v_w}{v_w \pm v_s}$ $139 = f\frac{341}{341-5}$ $f = 139\frac{336}{341} = 137 \text{ Hz}$ n.b. This is a "show" question. Clear working must be shown.	Shown using 137 Hz to show 139 Hz OR Correct substitution OR correctly shown with the wrong speed of sound	Correct **formula** and **substitution** and **solve**.	Formula can be written with ±.

(d)	The clarinet on the train is moving towards the waves it has already produced. This causes the wavelength to decrease and the frequency of the waves to increase. (The wave speed is constant.) The two sounds arrived with slightly different frequencies, so sometimes they arrived in phase, interfering constructively causing a loud sound and then they arrived out of phase, interfering destructively causing a quiet sound. The beat frequency is the difference between the two frequencies, so the beat frequency is: $f_1 - f_2 = 139 - 137 = 2$ Hz	Different frequencies cause beats. OR Correct beat frequency. OR Links loudness to phase or type of interference to explain beats. OR Waves bunch up / shorter wavelength. *nb: not nodes and antinodes*	Correct answer linking higher frequency to shorter wavelength with reason. AND Links loudness to phase or type of interference to explain beats. OR Correct beat frequency.	Correct answer linking higher frequency to shorter wavelength with reason. AND Explanation linking **phase** and **interference** to loudness changing to produce **beats**. AND Correct beat frequency.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
0	u	2u OR i OR c	3u OR i+u	4u OR 2u+i OR 2i OR c+u	2i+u OR c+i	2i+2u OR 3i	1u + 1i + 1c	2i + 1c

Q		Achievement	Merit	Excellence
TWO (a)	Travelling waves transfer energy, standing waves don't. OR The amplitude is the same at different places on a travelling wave. The amplitude is different at different places on a standing wave. OR Standing waves have nodes and antinodes but travelling waves do not. OR Travelling waves have one source but a standing wave requires 2 sources. OR Standing waves require interference but travelling waves do not.	Correct answer.	Answers must be comparative, relevant and not wrong	Not: Travelling waves move but standing waves stay still Standing wave has a reflected wave / reflects back on itself.
(b)	$f = \frac{v}{\lambda}$ for 3rd harmonic, $L = \frac{3\lambda}{2} \rightarrow \lambda = \frac{2L}{3}$ $f = \frac{v}{\frac{2L}{3}}$ $f = \frac{3v}{2L}$ OR 1st harmonic: $L = \frac{\lambda}{2}$ $f = \frac{v}{2L}$ 3rd harmonic $= 3f_{\text{i}} = \frac{3v}{2L}$	Correct relationship between L and λ for 1st or 3rd harmonic.	working linking wavelength to L, substituted into the wave equation, 3rd harmonic.	
(c)	$f = \frac{1}{T} = \frac{1}{1.8}$ Hz $\quad \lambda = 2L = 48.0$ m $v = f\lambda$ $v = \frac{1}{1.8} \times 48.0 = 26.7 \text{ m s}^{-1}$	Correct frequency, wavelength or distance travelled in one period.	Correct answer and unit (at least 3sf).	

(d)	 By jumping up and down, they send (transverse) waves along the bridge. These waves hit a closed end and reflect inverted. The two sets of waves interfere and set up a standing wave. They must stand at the ¼ and ¾ positions because this is where the antinodes are for the second harmonic. They must jump up and down 180 º out of phase (because adjacent antinodes are out of phase). Mike and Kate must jump at the correct frequency (1.11 Hz or T = 0.9s).	Mike and Kate are at antinodes OR Mike and Kate in antiphase OR Description of standing wave formation. OR 2nd harmonic correctly drawn including labelling of nodes and antinodes. OR Mike and Kate must jump at the correct frequency(1.11Hz). OR Initially the amplitude/energy of the standing wave increases each cycle.	2nd harmonic correctly drawn including labelling of an antinode/ (Mike and Kate drawn at antinodes and statements that they are at antinodes). AND Mike and Kate are at antinodes. OR Mike and Kate in antiphase. OR Mike and Kate must jump at the correct frequency (1.11Hz or T = 0.9s). OR Initially the amplitude / energy of the standing wave increases each cycle.	2nd harmonic correctly drawn including labelling of an antinode / (Mike and Kate drawn at antinodes and statements that they are at antinodes). AND Mike and Kate are at antinodes. AND Mike and Kate in antiphase. AND Mike and Kate must jump at the correct frequency (1.11 Hz or T = 0.9 s)

NØ	N1	N2	A3	A4	M5	M6	E7	E8
0	u	2u OR i OR c	3u OR i+u	4u OR 2u+i OR 2i OR c+u	2i+u OR c+i	2i+2u OR 3i	1u + 1i + 1c	2i + 1c

Q		Achievement	Merit	Excellence
THREE (a)	$n\lambda = d\sin\theta$ $n = 1, \quad \lambda = 2\times10^{-6}\sin 15.4°$ $\lambda = 5.31\times10^{-7}$ m	Correct formula and substitution and answer.		Don't need to substitute in $n = 1$.
(b)	The light passes through the narrow slits and diffracts. The diffracted waves overlap and interfere. The path difference for light reaching the first antinode is one wavelength. So the light waves arrive in phase and add constructively (causing a bright spot).	The path difference is n wavelengths so the interference is constructive / antinode. OR The waves arrive in phase to produce constructive interference / antinode.	Concepts of **path difference of 1 wavelength**, **phase** and **constructive interference** explained and clearly linked.	Crest + crest / trough + trough ok for achieved only.
(c)	Diagram shows pattern with antinodes further apart, and central antinode in same place. Red light has a lower frequency than green so it has a longer wavelength. $\sin\theta = \frac{n\lambda}{d}$ so a longer wavelength means the angle between the antinodes is bigger, so the antinodes are further apart.	Antinodes get further apart (stated or in diagram). AND Red light has a longer wavelength.	Antinodes get further apart (stated or in diagram). AND Explanation using either equation. (NOT λ is proportional to θ). OR correctly uses path difference creating constructive interference explanation.	

(d)	The maximum angle that the spectrum can be formed is 90°. The light which has its antinode at the biggest angle is red because it has the longest wavelength. So we calculate the slit separation that gives an angle of 90° for the red light. $\lambda_{\text{red}} = \frac{v}{f} = \frac{3.00\times10^{8}}{4.30\times10^{14}} = 6.98\times10^{-7}\text{m}$ $\sin\theta = \frac{n\lambda}{d}$ and $n = 3$ $d = \frac{n\lambda}{\sin\theta} = 3\times6.98\times10^{-7}$ $d = 2.09\times10^{-6}$ m	Uses 90 degrees. OR Red has a longer wavelength. (replacement for 3c only) OR Correct wavelength for red light.	Correct answer. OR Both correct explanations.	Correct working and answer. AND Explanations of use of red wavelength. AND 90 degree angle (or maximum path difference = 3 wavelength).

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0	u	2u OR i OR c	3u OR i+u	4u OR 2u+i OR 2i OR c+u OR c+3u	2i+u OR c+i	2i+2u OR 3i	1u + 1i + 1c	2i + 1c

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 – 18	19 – 24