

Assessment Schedule – 2020**Physics: Demonstrate understanding of wave systems (91523)****Evidence Statement**

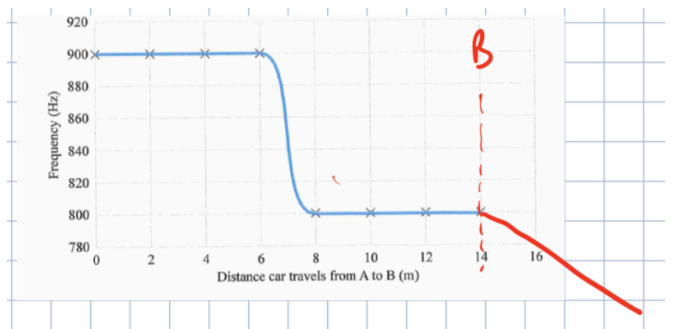
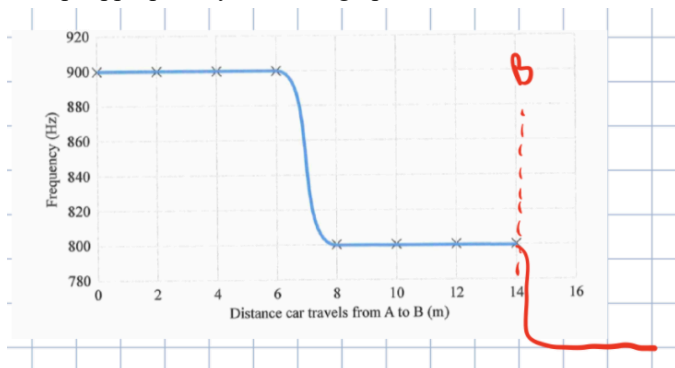
Q	Evidence	Achievement	Merit	Excellence
ONE (a)	4th harmonic.	<ul style="list-style-type: none"> • Correct answer. 		
(b)	$v = 340 \text{ m s}^{-1}$ $L = 0.155 \text{ m}$ $\lambda = \frac{0.155}{2} = 0.0775 \text{ m}$ $f = \frac{340}{0.0775} = 4387 \text{ Hz}$	<ul style="list-style-type: none"> • Correct wavelength or correct method with incorrect harmonic. 	<ul style="list-style-type: none"> • Correct frequency. 	
(c)	<p>Opening the hole effectively reduces the length of the pipe. Hence wavelength of the fundamental is shorter. The wave speed stays the same.</p> <p>Since $v = f\lambda$, the frequency of the fundamental note played with the hole open will be higher.</p> <p>For the fundamental note, opening the hole causes an antinode to form at the hole, effectively reducing the length of the pipe.</p> <ul style="list-style-type: none"> • Hence the fundamental wavelength decreases. • As $v = f\lambda$, (and the wave speed stays the same) the frequency of the note will increase. 	<ul style="list-style-type: none"> • Either point: For opening the hole <ul style="list-style-type: none"> - λ decreases - f increases. 	<ul style="list-style-type: none"> • Both points. 	
(d)	<p>When blowing air into the pipe, vibrations are produced (a whole range of sounds of different frequencies are generated in the pipe).</p> <ul style="list-style-type: none"> • These travel down the length of the pipe and are reflected at the open end. • The reflected wave will interfere / superimpose with the incident wave (to produce nodes (destructive) and antinodes (constructive)). <ul style="list-style-type: none"> - (At the open end, there is no phase change with the reflection, so the two waves are always in phase and hence produce an antinode.) • Only those waves that ‘fit’ the pipe (or $2L = n\lambda$, or dia) having antinodes at both ends (being in phase with the driving vibrations), will resonate to form a standing wave (with stationary nodes and antinodes). 	<p>One bullet point.</p> <ul style="list-style-type: none"> • Reflected • Interference <ul style="list-style-type: none"> - Constructive – A - Destructive – N • Fit Eg. A each end, formula, resonant f. 	<p>TWO (loinked / justified) bullet points.</p> <ul style="list-style-type: none"> • Reflected • Interference <ul style="list-style-type: none"> - Constructive – A - Destructive – N • Fit • E.g. A each end, formula, resonant f. 	<ul style="list-style-type: none"> • THREE bullet points.

Q	Evidence	Achievement	Merit	Excellence
TWO (a)	$\lambda = \frac{340}{2500} = 0.136 \text{ m}$ $n\lambda = d \sin \theta$ $1 \times 0.136 = 1.25 \sin \theta$ $\theta = 6.25^\circ$ $\theta = 0.109 \text{ rad}$	<ul style="list-style-type: none"> Correct answer. If $n\lambda = \frac{dx}{L}$ and $\tan \theta = \frac{x}{L}$ used $\theta = 6.25^\circ$. 		
(b)	$\theta_{\max} = \tan^{-1}\left(\frac{5}{20}\right) = 14.03^\circ$ $n\lambda = d \sin \theta \Rightarrow n = \frac{d \sin \theta}{\lambda} = 2.22$ <p>Hence the highest integer value is 2. Thus there will be 5 loud spots – two either side of central maxima. Note: sin 90 is not a calculation error. <i>There could be replacement evidence for (a) depending on method used.</i></p>	<ul style="list-style-type: none"> ONE error in calculation, e.g. substituting incorrectly calculated λ (refer examples). alternatively θ_{\max} $\tan \theta = \frac{x}{L}$$= \frac{5}{20}$ $\theta = 14.0362$ $n\lambda = d \sin \theta$$n \cdot 0.136 = 1.25 \sin 14.0362$$n = 2.22918$ 	<ul style="list-style-type: none"> Correct answer. Five spots (including a central maxima). alternatively $n\lambda = \frac{dx}{L}$$n \cdot 0.136 = \frac{1.25(5)}{20}$$n = 2.2977$ θ is large, so technically approximation is not valid. 	

(c)	<p>The loud spots would be (3 times) louder because of there are (3 times) more speakers, outputting (3 times) more sound energy.</p> <ul style="list-style-type: none"> • Sharp well-defined maxima <ul style="list-style-type: none"> - Constructive interference will only occur when n is a whole number (all the sources are in phase) producing sharp well-defined maxima (focussed and precise). - Destructive interference can occur with only a small phase difference (when n is not close to a whole number) as it is the result of all sources interfering. This will result in a wide quiet region. • d is smaller therefore the loud sounds would be further apart (and / or there will be fewer loud spots as you go from A to B). (With two speakers, d was larger, so the loud and quiet spots were closer together / and so more loud spots). 	<ul style="list-style-type: none"> • TWO observations / descriptions. 	<ul style="list-style-type: none"> • ONE justified statement. <ul style="list-style-type: none"> - Louder – more speakers - More defined (narrower) – more destructive interference. - $d \downarrow \gg x \uparrow$ ($d \downarrow \gg \theta \uparrow$) 	<ul style="list-style-type: none"> • TWO justified statements.
(d)	<p>If frequency increases (as $v = f\lambda$, and the wave speed is constant), the wavelength will decrease. Since d is constant, $n\lambda = d \sin\theta$, so the angle between maxima decreases and as $\tan\theta = \frac{x}{L}$, the distance between loud and quiet spots will be less. (So, there will be more loud and quiet spots between A and B). Accept reasoning using $n\lambda = \frac{nx}{L}$,</p>	<ul style="list-style-type: none"> • •Maxima closer together <ul style="list-style-type: none"> - θ decreases - x decreases - more loud spots in a given space. 	<ul style="list-style-type: none"> • Justified closer. <ul style="list-style-type: none"> - with formula - path diff. 	

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	900 Hz.	<ul style="list-style-type: none"> • Correct answer. 		
(b)	<p>As the car approaches Dave, each successive wavefront is produced closer to the emitted wave than if the car was stationary causing the sound waves bunch up in front of the car. As $v = f\lambda$, and the wave speed is constant, Dave hears a higher frequency.</p> <p>OR</p> <p>As the car goes past Dave, each successive wavefront is produced further from the emitted wave than if the car was stationary causing the sound waves spread out behind the car. As $v = f\lambda$, and the wave speed is constant, Dave hears a sound of lower pitch.</p>	<ul style="list-style-type: none"> • decreases (moving toward) so f increases. <p>OR</p> <p>λ increases (moving away) so f increases.</p> <p>OR</p> <p>Wavefronts compressed so f increases.</p> <p>OR</p> <p>Wavefronts stretched so f decreases.</p> <p>OR</p> <p>λ compressed (moving toward) so f decreases.</p>	<ul style="list-style-type: none"> • Links reason to f increase (or decrease). - v constant - $v = f\lambda$ - Doppler formula. 	
(c)	<p>When moving TOWARDS:</p> $f' = f \frac{v_w}{v_w - v_s} \text{ (rearrange for } f)$ $f = f' \frac{v_w - v_s}{v_w}$ <p>When moving AWAY:</p> $f = f'' \frac{v_w + v_s}{v_w}$ <p>COMBINE to eliminate f:</p> $f = f' \frac{v_w + v_s}{340} = f'' \frac{v_w - v_s}{340}$ $900 \times \frac{340 - v_s}{340} = 800 \times \frac{340 + v_s}{340}$ $306000 - 900v_s = 272000 + 800v_s$ $34000 = 1700v_s$ $v_s = 20 \text{ m s}^{-1} \text{ (exactly)}$	<ul style="list-style-type: none"> • Attempt to use or rearrange eqn. - Substitute correctly using 850 Hz. - Not using 900 and 800. 	<ul style="list-style-type: none"> • Correct method with minor error. <p>OR</p> <p>Correct answer assuming value for actual f from graph (850 Hz for example).</p> <p>If $f = 850$ is used, then toward $v = 18.9 \text{ m s}^{-1}$ away $v = 21.25 \text{ m s}^{-1}$</p>	<ul style="list-style-type: none"> • Correct speed of the wave. <p>$v_s = 20 \text{ m s}^{-1}$ exactly.</p>

- (d) The frequency will be decreasing because
- If the car is accelerating away, then the v_s is increasing (with formula).
- OR
- The relative velocity of the car and observer is increasing, the distance travelled by the car between the creation of each wave front is increasing, so the apparent wavelength is increasing.
- (Velocity of the wave remains constant.)
- Accept appropriately sketched graph.



Describes what is happening

- The frequency has decreased even more (recognition that it would be lower than 800 Hz).

Note language

Decreasing (continuing to lower) not the same as decreased or lower.

Explains why the frequency is decreasing.

- Relative velocity is increasing.

$$f' = f \frac{v_w}{v_w + v_s}$$

OR

Distance between each successive wavefront is increasing, so λ increasing, so f decreasing.

Cut Scores

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