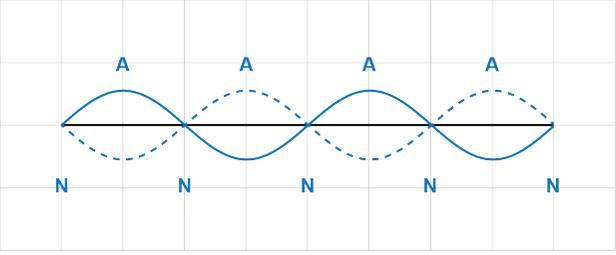## Assessment Schedule – 2025

Physics: Demonstrate understanding of wave systems (91523)

Evidence

Q	Evidence	Achievement	Merit	Excellence
ONE (a)	$f' = f \dfrac{v_w}{v_w - v_s}$ $= 1043 \dfrac{343}{343 - 27.3}$ $= 1133.19$ $= 1130$ Hz	• States correct answer.		
(b)	As the jet ski approaches Kerryn, the wave fronts bunch up in front of the jet ski, resulting in the apparent wavelength being shorter. The wave speed remains the same. Since $v = f\lambda$, when wavelength decreases, the frequency will increase.	• States: Higher f. OR Lower wavelength. OR Speed of sound constant.	• Complete answer: AND Higher f. AND Lower wavelength. AND Speed of sound constant.	

| (c) | At A the frequency heard was the same (of approx 1130 Hz) because when the jet ski is far away, it can be considered as coming directly toward both observers (the component of the velocity towards both observers is the source velocity).

Between A and B Erin hears a lower frequency that decreases more gradually because as Erin is back from the path of the jet ski, the angle to her position is increases more quickly, so the component of the velocity toward her decreases and so the apparent freq decreases.

At B both observers hear the source frequency of 1043 Hz because, when the jet ski passes the observers there is no movement toward or away from them (the component of the velocity towards her is zero) and so there is no doppler shift.

Between A and C Erin hears a lower frequency that decreases more gradually because as the angle to her decreases more slowly the component of velocity away from her increases more slowly, causing the frequency to gradually decrease.

At C the frequency heard was the same (of approx 970 Hz) because when the jet ski is far away it can be considered as going directly away from both observers. | • Explains:
  A
  OR
  C. | • Explains :
  B
  OR
  Transition. | • Complete answer |

(d)				
	$f' = f\dfrac{v_w}{v_w + v_s}$	• Identifies "+". OR Substitutes correctly.	• Provides calculation with minor error or insufficient working.	• Correct answer.

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

$563.6 = 574.0\dfrac{v_w}{v_w + 27.3}$

$563.6(v_w + 27.3) = 574.0v_w$

$563.6 + 15\,386.28 = 574v_w$

$15\,386.28 = 574.0v_w - 563.6v_w$

$15\,386.28 = 10.4v_w$

$v_w = \dfrac{15\,386.28}{10.4}$

$= 1479.45$

$= 1480 \text{ ms}^{-1} \text{ (3 sf)}$

Alternatively:

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

$f'(v_w + v_s) = fv_w$

$f'v_w + f'v_s = fv_w$

$f'v_s = fv_w - f'v_w$

$f'v_s = v_w(f - f')$

$v_w = \dfrac{f'v_s}{(f - f')}$

$v_w = \dfrac{563.6(27.3)}{(574.0 - 563.6)}$

$v_w = 1479.45$

$v_w = 1480 \text{ m s}^{-1} \text{ (3 sf)}$

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

Q	Evidence	Achievement	Merit	Excellence
TWO (a)		• Correct diagram (labelled).		
(b)	The equation shows that as the tension in the string decreases, the velocity of the wave in the string decreases. Since $v = f\lambda$, and wavelength is constant, the frequency of the wave must have decreased.	• States ONE of: - v decreased. - Frequency decreased.	• Correct answer: - v decreased. - Frequency decreased. - Wavelength constant.	
(c)	$\lambda = 2L$ $\lambda = 2)0.69)$ $\lambda = 1.38$ m $v = f\lambda$ $v = 147(1.38)$ $v = 202.86$ m s^{-1} $v = f\lambda$ $202.86 = 207\lambda$ $\lambda = 0.98$ m $L = \dfrac{0.98}{2}$ $L = 0.49$ m	• Calculates ONE of: - $\lambda = 1.38$ m - Calculates v in string with incorrect wavelength. - Correct L.	• Calculates: Correct v in string. OR Correct method from incorrect 1st harmonic wavelength.	• Calculates correct answer and working.

(d)(i)	When the two strings produce similar frequencies, the waves move in and out of phase.	• States one of:	• Explains:	• Complete answer.
	When the waves are in phase, they constructively interfere to produce a loud sound.	- Constructive produces loud, destructive produces quiet.	Beat formation, (in phase, constructive, produces loud, out of phase, destructive produces quiet).	
	When the waves have 180° phase difference, they destructively interfere to produce a quiet sound.	- Pulsating volume heard.		
	This pulsating volume is known as a beat.			
(ii)	(The beat frequency is the number of loud sounds per second.)	- Beat will decrease (then increase).	OR	
	As the length is decreasing, the frequency is increasing until a beat is heard. Therefore f_1 is less than f_2.	- When $f_1 = f_2$. Then no beat is heard.	How the beat frequency will change.	
	As the length continues to decrease / f increases, then the beat frequency will decrease (and the time between pulses will increase).			
	This will continue until the two frequencies are equal and no beat is heard.			
	(If l decreases further, the beats will become more frequent until the ear detects them as two separate notes.)			

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

Q	Evidence	Achievement	Merit	Excellence
THREE (a)	$n\lambda = \dfrac{dx}{L}$ $3(\lambda) = \dfrac{1.25 \times 10^{-4}(0.0420)}{3.40}$ $\lambda = 514.7059 \times 10^{-9}$ m $(\lambda = 515$ mm$)$	• Correct answer. $\lambda = 514.66 \times 10^{-9}$ m $(\theta = 0.7077°)$ if approximation not used.		
(b)	When the path difference is a whole number of wavelengths, so that the phase difference is 360°. This results in the sources being exactly in phase, and so the waves will superimpose to form a maxima / bright region. When the path difference is a half number of wavelengths, so that the phase difference is 180°. This results in the sources being exactly out of phase, and so the waves will superimpose to form a minima / dark region.	• Explains changing brightness in terms of path difference OR phase difference OR consequent superposition.	• Explains changing brightness in terms of: path difference OR phase difference AND consequent superposition.	
(c)	The pattern formed by the diffraction grating will be brighter, more well defined, with the maxima further apart. As there are many slits, more light is able to pass through, resulting in maxima that are brighter. The maxima are narrower and more well defined (maxima with sharp edges), with wider dark regions between maxima. With a diffraction grating, if the adjacent slits are only slightly out of phase, then the resulting interference from many slits results in overall destructive interference. The slit separation for the diffraction grating will be much smaller than for the double slit, as $n\lambda = d\sin\theta$, decreasing d will increase the angle to the maxima, causing the pattern to cover a wider area with the maxima further apart.	• Identify brighter. OR Identify more well defined OR Identify maxima further apart.	• Justify ONE of: - brighter - more well defined. - maxima further apart.	• Complete answer where: - brighter - more well defined - maxima further apart are justified.

(d)	7 maxima so 3 either side of central maxima.	• States / calculates ONE of:	• Calculates:	• Correct answer giving a correct upper and lower limit of d.

(d) 7 maxima so 3 either side of central maxima.

$3 \le n \le 4$

As $n\lambda = d\sin\theta$, biggest gap possible is when 4th fringe is <u>just off</u> the screen. Smallest gap possible is when 3rd fringe is <u>just on</u> the the screen.

Biggest when $n = 4$.

$\tan\theta = \dfrac{x}{L}$

$\tan\theta = \dfrac{0.45}{1.2}$

$\theta = 20.556°$

$n = 3$	$n = 4$
$\sin\theta = \dfrac{n\lambda}{d}$	$\sin\theta = \dfrac{n\lambda}{d}$
$d = \dfrac{3(515 \times 10^{-9})}{\sin 20.556°}$	$d = \dfrac{4(515 \times 10^{-9})}{\sin 20.556°}$
$d = 4.4002 \times 10^{-6}$ m	$d = 5.8669 \times 10^{-6}$ m

Therefore the grating has a slit spacing d of more than 4.40×10^{-6} but less than 5.87×10^{-6}.

(It is most likely to have a spacing of 5.00×10^{-6} (200 lines / mm)).

States / calculates ONE of:
- $n = 3$
- $\theta = 20.556°$
  ($\theta = 0.3587$ rad)

Calculates:
$d = 4.4002 \times 10^{-6}$ m
($n = 3$)
OR
- ($n = 3$).
OR
Recognises range, but uses
$n\lambda = \dfrac{dx}{L}$
(for both $n = 3$ and $n = 4$)
$n\lambda = \dfrac{dx}{L}$
$n = 3$
$d = 4.120 \times 10^{-6}$ m
$n = 4$
$d = 5.493 \times 10^{-6}$ m

Correct answer giving a correct upper and lower limit of d.

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

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14– 18	19 – 24