

1)

(a)	(progressive waves travel from centre) to ends and reflect ✓ two (progressive) waves travel in opposite directions along the string ✓ waves have the same frequency (or wavelength) ✓ waves have the same (or similar) <b>amplitude</b> ✓ superposition (accept 'interference') ✓	<b>max 3</b>
(b) (i)	wavelength (= $2 \times PQ = 2 \times 1.20\text{ m}$ ) = 2.4 m ✓ speed (= wavelength $\times$ frequency = $2.4 \times 150$ ) = 360 $\text{m s}^{-1}$ ✓ (answer only gets both marks)	<b>4</b>
(b) (ii)	diagram to show three 'loops' ✓ <b>and</b> of equal length and good shape ✓ (or loop of one third length ✓)	
<b>Total</b>		<b>7</b>



2)

(a) (i)	one 'loop' (accept single line only, accept single dashed line) + nodes at each bridge ( $\pm$ length of arrowhead) + antinode at centre ✓	<b>1</b>
(a) (ii)	$\lambda_0 = 2L$ or $\lambda = 0.64 \times 2$ ✓ = 1.3 (m) ✓ (1.28)	<b>2</b>
(a) (iii)	$(c = f\lambda) = 108 \times (a)(ii)$ ✓ = 138 to 140(.4) ( $\text{m s}^{-1}$ ) ✓ ecf from (a)(ii)	<b>2</b>
(b) (i)	four antinodes ✓ (single or double line) first node on 0.16 m (within width of arrowhead) + middle node between the decimal point and the centre of the 'm' in '0.64 m' + middle 3 nodes labelled 'N', 'n' or 'node' ✓	<b>2</b>
(b) (ii)	$(4 f_0 =) 430$ (Hz) ✓ (432) or use of $f = \frac{v}{\lambda}$ gives 430 to 440 Hz correct answer only, no ecf	<b>1</b>
(c)	decrease the length/increase tension/tighten string ✓	<b>1</b>
<b>Total</b>		<b>9</b>

3)

	<p><b>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.</b></p> <p>The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria.</p> <p><b>High Level (good to excellent) 5 or 6 marks</b></p> <p>The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.</p> <p>Mentions <b>waves</b> travelling in <b>opposite directions</b> or waves of <b>same frequency</b> (and amplitude) and superpose or interfere or add together.</p> <p><b>Intermediate Level (modest to adequate) 3 or 4 marks</b></p> <p>The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.</p> <p>Mentions <b>waves</b> travelling in <b>opposite directions</b> (accept 'waves reflect/rebound back or from clamp') or <b>superposition/addition/interference of waves</b> or waves of same frequency/wavelength.</p> <p><b>Low Level (poor to limited) 1 or 2 marks</b></p> <p>The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate.</p> <p>One correct key feature or one relevant remark regarding formation given.</p> <p><b>The explanation expected in a competent answer should include a coherent account of the following points concerning the physical principles involved and their consequences in this case.</b></p> <ul style="list-style-type: none"> <li>● 4 nodes where there is no movement/zero amplitude</li> <li>● 3 antinodes where amplitude is maximum</li> <li>● wavelength 0.80 m</li> <li>● end antinodes in phase/middle and ends in antiphase</li> <li>● between node and antinode, amplitude of oscillation increases</li> <li>● waves reflect off the clamp (and the rod)</li> <li>● waves travelling in opposite directions superpose/add/interfere</li> <li>● wave have same wavelength and frequency (similar amplitude)</li> <li>● always cancellation at nodes/always constructive superposition at antinodes</li> <li>● energy is not transferred along string</li> </ul>	<p>max 6</p>
	<p><b>Total</b></p>	<p><b>6</b></p>

4)

a	i	oscillates / vibrates ✓ ( allow goes up and down / side to side / etc, <u>repeatedly, continuously,etc</u> )  about <u>equilibrium</u> position / perpendicularly to central line ✓	2
a	ii	X and Y: antiphase / 180 (degrees out of phase) / $\pi$ (radians out of phase) ✓ X and Z: in phase / zero (degrees) / $2\pi$ (radians) ✓	2
b	i	$v = f\lambda$ $= 780 \times 0.32 / 2$ or $780 \times 0.16$ OR $780 \times 320 / 2$ or $780 \times 160$ ✓ THIS IS AN INDEPENDENT MARK  $= 124.8$ ✓ (m s <sup>-1</sup> ) correct 4 sig fig answer must be seen	2
b	ii	$\frac{1}{4}$ cycle ✓ $T = 1 / 780$ OR $= 1.28 \times 10^{-3}$ ✓ $0.25 \times 1.28 \times 10^{-3}$ $= 3.2 \times 10^{-4}$ (s) ✓  Allow correct alternative approach using distance of 0.04m ✓ travelled by progressive wave in $\frac{1}{4}$ cycle divided by speed. $0.04 / 125$ ✓ $= 3.2 \times 10^{-4}$ (s) ✓	3
c	i	<u>antinode</u> ✓	1
c	ii	$2 \times 0.240$ ✓ $= 0.48$ m ✓ '480m' gets 1 mark out of 2	2
c	iii	$(f = v/\lambda = 124.8$ or $125 / 0.48 ) = 260$ (Hz) ecf from cii ✓	1

5)

5/6	<p><b>Good / Excellent</b>  <b>The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.</b>                  The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.</p> <p><b>High Level (Good to excellent): 5 or 6 marks</b>                  The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.</p> <p>Mentions:</p> <ul style="list-style-type: none"> <li>• (1) waves (meet when) travelling in <u>opposite</u> directions / cross/ wave meets a reflected wave / etc</li> <li>• (2) same wavelength (or frequency)</li> <li>• (3) node – point of minimum or no disturbance</li> <li>• (4) antinode – point of maximum disturbance / maximum displacement/amplitude occurs</li> <li>• (5) node - two waves (always) cancel/ destructive interference / <math>180^\circ</math> phase difference (between displacements of the two waves at the node)</li> <li>• (6) antinode – reinforcement / constructive interference occurs / (displacements) in phase</li> <li>• (7) mention of <u>superposition</u> of the two waves</li> </ul> <p>5 marks: points (1) <b>AND</b> (2) with three points from (3), (4), (5), (6) or (7)                  for 6 marks: points (1) to (6) must be seen</p>	5/6	<p>can say disturbance, amplitude or displacement</p> <p>labelled diagram can provide supporting evidence but labels: 'node' / 'antinode' by themselves cannot replace points 3 and 4</p>
3/4	<p><b>Modest</b>  <b>Intermediate Level (Modest to adequate): 3 or 4 marks</b>                  The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.</p> <p>Mentions any 3 of the 7 points.</p> <p>4 marks: (1) <b>OR</b> (2) <b>AND</b> three others.</p>	3/4	
1/2	<p><b>Limited</b>  <b>Low Level (Poor to limited): 1 or 2 marks</b>                  The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.</p> <p>One relevant point  <b>OR</b> a relevant, labelled diagram</p> <p>2 marks: two points <b>OR</b> one point and a relevant labelled diagram</p>	1/2	
total		6	