**M1.The student's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The student's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria.

*Answers may cover some of the following points:*

- *(1) a wave and its reflection / waves travelling in opposite directions meet / interact / overlap / cross / pass through etc*

  *point (1) must be stated together i.e it should not be necessary to search the whole script to find the two parts namely the directions of the waves and their meeting*
- *(2) same wavelength (or frequency)*
- *(3) node − point of minimum or no disturbance*

  *points (3) may come from a diagram but only if the node is written in full and the y-axis is labelled amplitude or displacement*
- *(4) antinode − is a point of maximum amplitude*

  *point (4) may come from a diagram but only if the antinode is written in full and the y-axis is labelled amplitude or displacement*
- *(5) node - two waves (always) cancel / destructive interference / 180° phase difference / in antiphase [out of phase is not enough] (of the two waves at the node) [not peak meets trough]*
- *(6) antinode − reinforcement / constructive interference occurs / (displacements) in phase*
- *(7) mention of <u>superposition</u> [not superimpose] of the two waves*
- *(8) energy is not transferred (along in a standing wave)*.

  *if any point made appears to be contradicted elsewhere the point is lost − no bod's*

**High Level (Good to excellent): 5 or 6 marks**
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.

*6 marks: points (1) **AND** (2) **with** 4 other points which must include point (4) or the passage must indicate that the wave is oscillating at an antinode*

*5 marks: points (1) **AND** (2) **with** any three other points*

*although point (1) may not be given as a mark the script can be searched to see if its meaning has been conveyed as a whole before restricting the mark and not allowing 5 or 6 marks*

**Intermediate Level (Modest to adequate): 3 or 4 marks**
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.

*4 marks: (1) **OR** (2) **AND** any three other points*
*3 marks: any three points*

**Low Level (Poor to limited): 1 or 2 marks**
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.

*2 marks: any two points*
*1 marks: any point or a reference is made to both nodes and antinodes*

**[6]**

**M2.**(a) 110 Hz

B1

**1**

(b) (Use finger on the fret so that) a ¼ length of the string is used to sound the note or hold string down on 24$^{th}$ fret

B1

**1**

(c) Mention or description of beats or description of rising and falling amplitude / louder and quieter

*Regular rising and falling of loudness owtte*

B1

B1

Beat frequency 10(.0Hz) Allow beat frequency = 430 - 420

**2**

**[4]**

**M3.**(a) Initially the path difference is zero/the two waves are in phase when they meet/the (resultant) displacement is a maximum ✓

*Alternative:*

*Constructive interference occurs when the path difference is a whole number of wavelengths and the waves are in phase*

**1**

As the movable tube is pulled out, the path difference increases and the two waves are no longer in phase, so the displacement and loudness decrease ✓

*Destructive interference occurs when the path difference is an odd number of half wavelengths and the waves are in antiphase*

**1**

When the path difference is one half wavelength, the two are in antiphase and sound is at its quietest. ✓

*Initially the path difference is zero and the sound is loud*

**1**

As the path difference continues to increase, the two waves become more in phase and the sound gets louder again. ✓

*As the pipe is pulled out the path difference gradually increases, changing the phase relationship and hence the loudness of the sound*

**1**

(b) Use of *wavelength = speed / frequency*

*The first mark is for calculating the wavelength*

**1**

To give: 340 / 800 = 0.425 m ✓

Path difference = one half wavelength = 0.21 m ✓

*The second mark is for relating the wavelength to the path difference*

Path difference = 2 ($d_2 - d_1$) = 2 (distance moved by movable tube)

**1**

Distance moved by movable tube = 0.10 m. ✓

*The final mark is for relating this to the distance moved by the tube and working out the final answer.*

**1**

(c) Start with d1 = d2

*(Alternative mark scheme involving changing frequency and measuring to first min for each one can gain equal credit)*

Measure distance moved by movable tube for each successive minima and maxima ✓

*Start with d1 = d2*

*Measure distance moved by movable tube for first minimum.*

**1**

Each change in distance is equal to one quarter wavelength. ✓

*Distance is equal to one quarter wavelength*

**1**

Continue until tube is at greatest distance or repeat readings for decreasing distance back to starting point. ✓

*Repeat for different measured frequencies.*

**1**

Use speed = frequency x wavelength ✓

*Use speed = frequency x wavelength)*

**1**

**[11]**

**M4.** D

**[1]**

**M5.** (a) (i) oscillates / vibrates ✓

(allow goes up and down / side to side / etc, repeatedly, continuously, etc)

about equilibrium position / perpendicularly to central line ✓

**2**

(ii) X and Y: antiphase / 180 (degrees out of phase) / π (radians out of phase) ✓

X and Z: in phase / zero (degrees) / 2π (radians) ✓

**2**

(b) (i) $v = f\lambda$

**= 780 x 0.32 / 2** or **780 x 0.16 OR 780 x 320 / 2** or **780 x 160** ✓

THIS IS AN INDEPENDENT MARK

= 124.8 ✓ ($m\ s^{-1}$) correct 4 sig fig answer must be seen

**2**

(ii) ¼ 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 ¼ cycle divided by speed.

0.04 /125 ✓ = $3.2 \times 10^{-4}$ (s) ✓

**3**

(c) (i) <u>antinode</u> ✓

**1**

(ii) 2 x 0.240 ✓

= 0.48 m ✓ '480m' gets 1 mark out of 2

**2**

(iii) ($f = v/\lambda$ = 124.8 or 125 / 0.48 ) = **260** (Hz) ecf from cii ✓

**1**

**[13]**

**M6.** (a) the **maximum displacement** (of the wave or medium) ✓

from the equilibrium position ✓

accept 'rest position', 'undisturbed position', 'mean position'

**2**

(b) (vertically) **down**wards (¼ cycle to maximum negative displacement) ✓

then **upwards** (¼ cycle to equilibrium position and ¼ cycle to maximumpositive displacement) ✓

**down** (¼ cycle) to **equilibrium position/zero** displacement **and** correctreference to either **maximum** positive **or** negative displacement or correctreference to fractions of the cycle ✓

candidate who correctly describes the motion of a knot 180 degrees out ofphase with the one shown can gain maximum two marks(ie knot initially moving upwards)

**3**

(c) **max 3 from**

**stationary wave** formed ✓

by **superposition or interference** (of two progressive waves) ✓

knot is at a **node** ✓

waves (always) cancel **where the knot is** ✓

allow 'standing wave'

**3**

**[8]**

**M7.** (a) **max 2 from**

in progressive waves, all points have the same amplitude (in turn),
in stationary waves, they do not

B1

in stationary waves, points between nodes are in phase, in progressive

waves, all points within one wavelength are out of phase with each other

B1

in stationary waves, there is no energy transfer along the wave, in progressive waves, there is

B1

stationary waves have nodes and antinodes but progressive waves do not

B1

where there are single relevant statements but no clear comparison between stationary and compressive waves, award 1 mark for two such statements

2

(b) $f \propto 1/l$ or $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ *or* $fl$ = const

C1

657/660 (Hz)

A1

2

**[4]**

**M8.** (a) (i) rearrangement of $f = \frac{1}{2l}\sqrt{\frac{T}{u}}$ to give $l = \frac{1}{2f}\sqrt{\frac{T}{u}}$ C1

correct subs $l = \frac{1}{2 \times 92.5}\sqrt{\frac{681}{1.87 \times 10^{-2}}}$ or $92.5 = \frac{1}{2f}\sqrt{\frac{681}{1.87 \times 10^{-2}}}$

C1

1.0(3) (m) condone sf

A1

3

(ii) 2 loops roughly equal

B1

1

(iii) (lightly) stop (in centre) B1

pluck or bow B1 2

(b) keeps tension or mass per unit length constant

B1

way of measuring frequency or producing vibration of known *f*

B1

way of measuring length (at resonance)

B1

use of suitable graph (*f vs 1/l* or *l vs 1/f)* to display results

B1

marks may be awarded for information seen on diagram

4

**[10]**