HALE SCHOOL
PHYSICS
Wave Theory
YEAR 12 Unit 3A
Test 2012

Test Score:

Name: Solutions Set:

Teacher: JAA MV

INSTRUCTIONS:

- ☐ Time Allowed = 40 minutes
- ☐ Total Marks = 40 marks
- ☐ Answer all questions in the space provided.
- ☐ Rough working is permitted on the question paper.
- ☐ Show all relevant working details in order to acquire full marks.
- ☐ Graphic Calculators are Not permitted for this paper.
- ☐ ***Do Not write in pencil. (Note: a 1 mark penalty will be incurred)**
- ☐ ***Do Not borrow materials. (Note: a 1 mark penalty will be incurred)**

POST ASSESSMENT REVIEW (to be completed upon return of your marked paper)

SELF-ASSESSMENT:

Relative Weaknesses –Objective No.

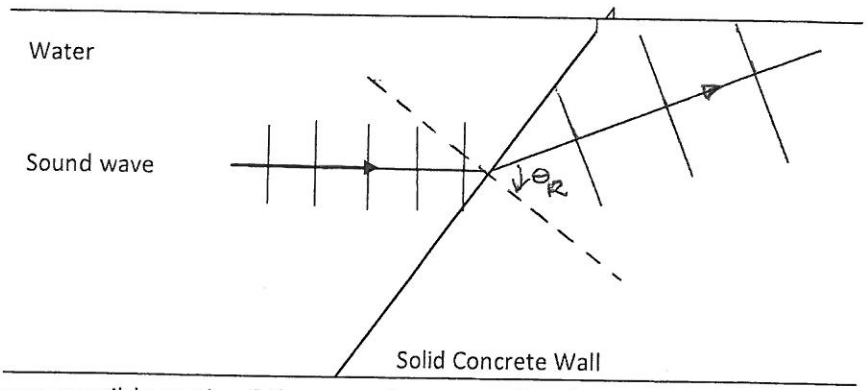
Relative Strengths –Objective No.

Major Concerns: (be specific)

Action Plan: (be specific)

Q1 [5 marks]

A sound wave travels through water to meet a boundary with a solid concrete wall of a dam.



1a) Draw a possible path of the sound wave as it refracts into the concrete. ✓ (1 mark)

1b) Clearly indicate the angle of refraction. θ_R (MEASURED TO NORMAL) ✓(1 mark)

1c) The wave fronts in the water are shown on the diagram. Carefully illustrate the general pattern of wave fronts when the sound wave travels in the solid concrete wall. (1 mark) ✓

$\lambda_C > \lambda_W$

1d) Is it possible for total internal reflection to occur at this boundary? Justify your answer. (2 marks)

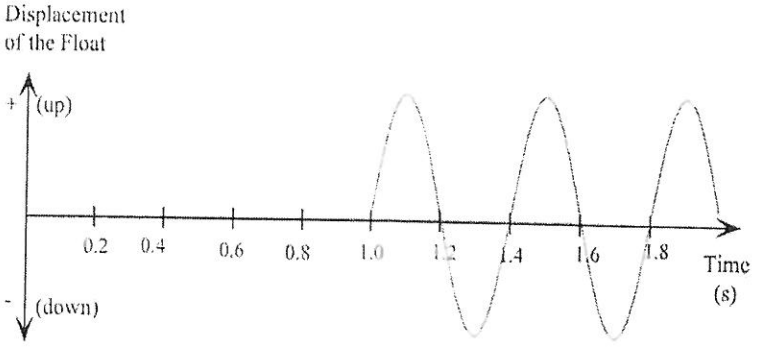
IT CAN OCCUR IF THE SECOND MEDIUM HAS A HIGHER WAVE SPEED ✓

THE SPEED OF SOUND IN CONCRETE (SOLID) > WATER (LIQUID) ∴ A CRITICAL ANGLE IS POSSIBLE. ✓

Q2 [4 marks]

In order to study the characteristics of water waves a student places a Styrofoam float in a pond. Attached to the float is a laser reflector which allows the movement of the float to be monitored remotely.

The student drops a brick into the water at a measured distance of 1.25 m from the float which results in the following graph.



Determine the speed, period, and wavelength of the waves that a propagated.

(I) FIND THE SPEED FROM TIME/DISTANCE TO REACH THE FLOAT

$v = s/t = \frac{1.25}{1.0} = 1.25\ ms^{-1}$ ✓

(II) TIME TO COMPLETE ONE OSCILLATION = PERIOD = 1.4 − 1.0

$= 0.4\ s$ ✓

(III) SINCE $\lambda = \frac{v}{f}$ AND $f = \frac{1}{T}$ THEN $\lambda = v \cdot T$

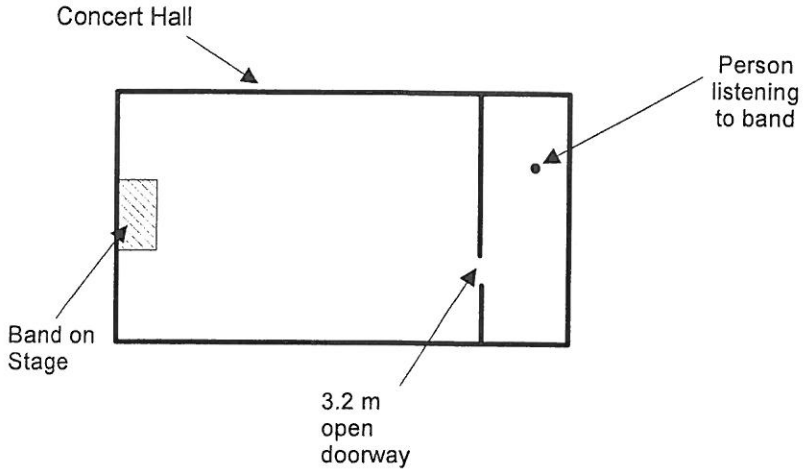
$\therefore \lambda = 1.25 \times 0.4 = 0.5\ m$ ✓

(IV) SINCE $f = \frac{1}{T} = \frac{1}{0.4} = 2.5\ Hz$ ✓

(4marks)

Q3 [3 marks]

An open double doorway in a concert hall is 3.2 m wide. With reference to the diagram provided, carefully explain why an "observer" standing outside the hall notices that lower pitched sounds from a band playing inside the hall can be heard more clearly than higher pitched sounds.



✓ THE KEY IDEA HERE IS DIFFRACTION. THE GREATER THE WAVELENGTH OF THE SOUND, THE GREATER THE DIFFRACTION.

✓ THE LOWER PITCH (FREQUENCY) NOTES HAVE WAVELENGTHS MORE LIKELY TO BE DIFFRACTED TOWARDS THE OBSERVER THROUGH A 3.2 M APERTURE.

✓ HIGHER FREQUENCY (PITCH) NOTES HAVE SHORTER WAVELENGTHS AND ARE MORE DIRECTIONAL BECAUSE THEY DIFFRACT LESS THROUGH AN APERTURE OF THIS SIZE AND MAY NOT REACH THE OBSERVER. (3marks)

Q4 [4 marks]

Opera Singers have been known to be able to shatter a wine glass by maintaining a certain pitch over a period of several seconds. Explain in detail, and using appropriate scientific terms, how this could be possible.

✓ THE WINE GLASS IS ABLE TO VIBRATE AT A NUMBER OF NATURAL FREQUENCIES

✓ IF THE SINGER'S VOICE HAS A STRONG FREQUENCY COMPONENT THAT MATCHES ONE OF THE NATURAL FREQUENCIES, THE FORCED VIBRATION EFFICIENTLY BUILD CONSTRUCTIVELY (RESONANCE) RESULTING IN INCREASED AMPLITUDE

✓ WHICH LEADS TO LARGE STRESSES IN THE GLASS' STRUCTURE AND IF THIS IS SUSTAINED, MAY CAUSE THE GLASS TO SHATTER.

– MATCHING FREQUENCY ⇒ CONSTRUCTIVE INTERFERENCE

⇒ INCREASED AMPLITUDE OF VIBRATION

⇒ INCREASED STRESS

(4marks)

Q5 [4 marks]

While using a 440 Hz tuning fork to tune the first string of his guitar, a musician detects beats of 5 Hz and he discovers that the number of beats is reduced by tightening the string.

5a) Determine the original frequency of the guitar string.

BEAT FREQUENCY = $|f_2 - f_1| = 5\ Hz$

$\therefore$ ORIGINAL FREQUENCY IS $440 \pm 5\ Hz$ ✓

SINCE INCREASING TENSION INCREASES FREQUENCY

AND THIS NEW FREQUENCY IS CLOSER TO REFERENCE (FORK)

THEN THE ORIGINAL FREQUENCY IS $435\ Hz$ ✓

(2 marks)

5b) If the maximum length of the string is 60 cm long, determine the speed at which the sound travels through the string.

SINCE $\lambda = 2l$ (FUNDAMENTAL) ✓

USING $v = f \times \lambda$

$= 435 \times (2 \times 0.60)$

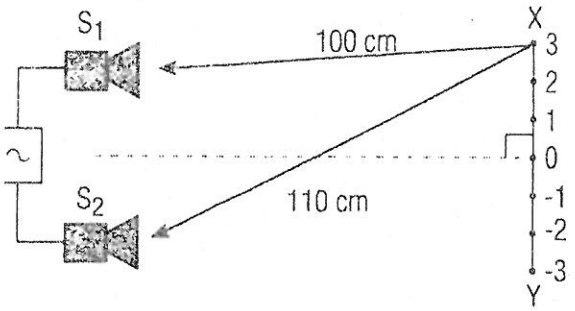
$\therefore v = 522\ ms^{-1}$ ✓

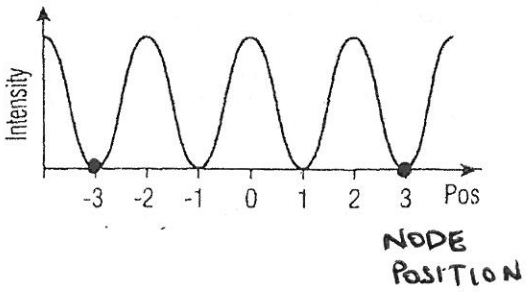
(2 marks)

Q6 [4 marks]

Two loudspeakers emit sound of the same frequency in phase. A student records the sound intensity at different positions along the line XY and obtains the following pattern:

What is the frequency of the sound being emitted?





NODE POSITION

NODES ARE POSITIONS OF DESTRUCTIVE INTERFERENCE FROM SPEAKERS.

POSITION 3 IS A NODAL POSITION

THE PATH DIFFERENCE IS $\frac{3\lambda}{2}$

$\therefore \frac{3\lambda}{2} = 110 - 100 = 10\ cm$

$\therefore \lambda = {}^{2}/_{3} \times 10 = 6.67\ cm$

$\therefore f = {}^{v}/_{\lambda}$

$= \frac{346}{6.67 \times 10^{-2}}$

$= 5.19 \times 10^{3}\ Hz$

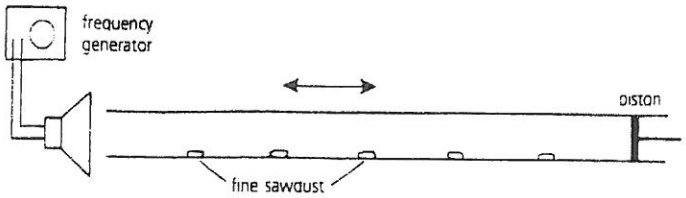
$\therefore f = 5\ kHz$ (1.S.F)

(4 marks)

Q7 [4 marks]

A long glass tube containing fine sawdust is fitted with a piston and adjacent to a speaker of a signal (frequency) generator as shown.

When the signal generator is switched on, the piston is adjusted until the sawdust collects at regular intervals along the tube.



8a) Discuss the significance of the points where the sawdust collects and carefully explain (in detail) why this occurs.

✓ A STANDING WAVE IS PRODUCED IN THE AIR COLUMN AS A RESULT OF THE SUPERPOSITIONING OF THE SOUND WAVE AND ITS REFLECTION.

✓ THE REFLECTION IS IDENTICAL IN CHRACTERISTICS BUT IS 180° OUT OF PHASE (AND TRAVELLING IN THE OPPOSITE DIRECTION)

✓ AS A RESULT OF DESTRUCTIVE INTERFERENCE, DISPLACEMENT NODES ARISE AT REGULAR INTERVALS AND DUST SETTLES IN THESE POSITIONS.

✓ THESE POSITIONS ARE SEPARATED BY A DISTANCE OF HALF WAVELENGTH

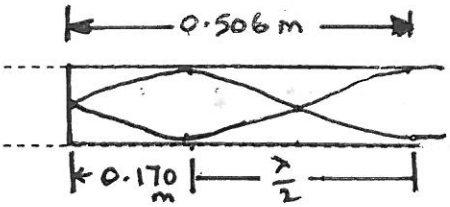
(4 marks)

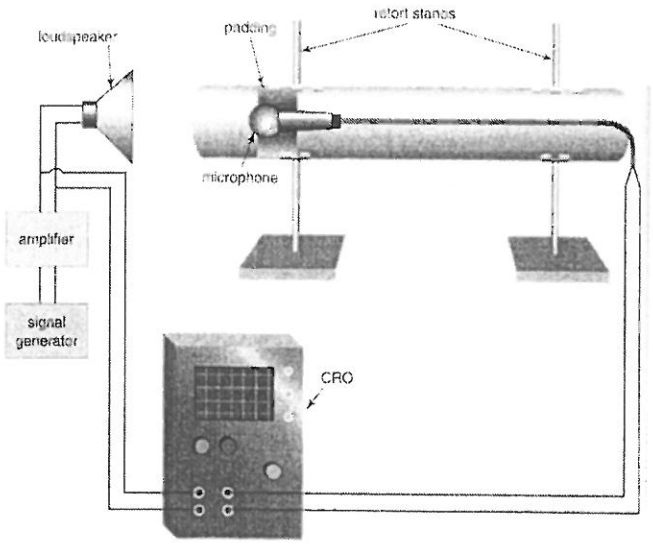
Q8 [4 marks]

The apparatus illustrated is used to determine the speed of sound in air. The microphone can be easily moved along the tube and effectively act as the closed end.

The signal generator is used to produce a tone of 500.0 Hz via the audio amplifier. The CRO is then used to locate the first two resonating positions at 17.0 cm and 50.6 cm.

Determine the speed of sound in air.





SINCE $\lambda/2 = 0.506 - 0.170$

$\therefore \lambda = 0.672$ m

USING $v = f\lambda$

$= 500 \times 0.672$

$\therefore v = 336$ ms^{-1}

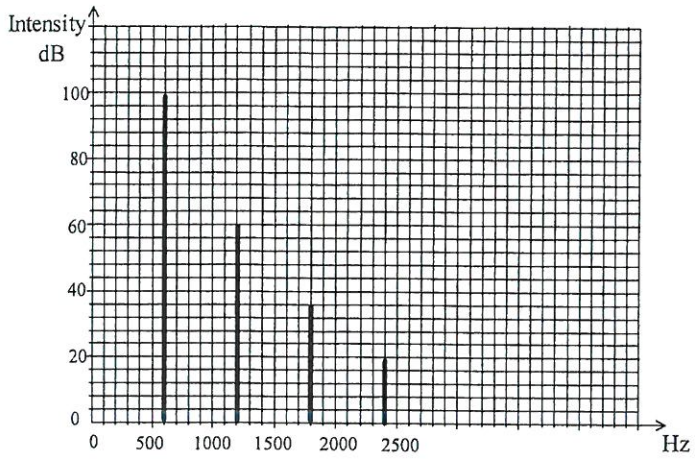
(MUST USE INTERNODAL DISTANCE TO AVOID END CORRECTION)

(4 marks)

Q9 [4 marks]

The diagram provided is a representation of the frequency spectrum for a wind instrument playing a certain note.

The amplitude of each component is indicated by the intensity on the y axis.



The Frequency Spectrum of a Wind Instrument

9a) Is the instrument a closed or open pipe? Justify your answer.

OPEN PIPE ✓

ALL HARMONICS ARE PRESENT ✓

$f_1 : f_2 : f_3 : f_4$

$1 : 2 : 3 : 4$ $(\times 600\ Hz)$

(2 marks)

9b) Determine the effective length of the musical instrument producing this musical note.

USING THE FUNDAMENTAL FREQUENCY = 600 Hz

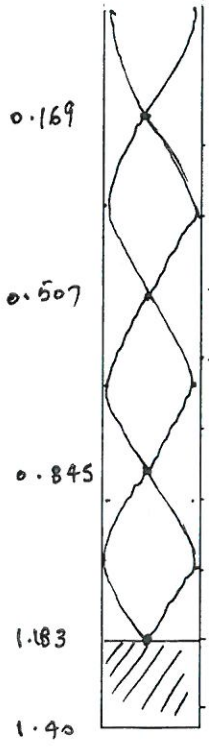
1ST MODE OF VIBRATION : $\lambda = 2 \times \ell$

$\therefore \lambda = v/f = 2 \times \ell \quad \therefore \ell = \frac{346}{2 \times 600} = 29\ cm$

(2 marks)

Q10 [4 marks]

A vertical pipe of length 1.40 m is filled with water which is allowed to run out slowly from the lower end, while a vibrating tuning fork is held over the open end. If the frequency of the tuning fork is 512 Hz, how many positions of resonance will be obtained?



USING $v = f\lambda$ THEN $\lambda = v/f = \frac{346}{512} = 0.676\ m$ ✓

$\therefore$ INTERNODAL DISTANCE IS $(\lambda/2) = 0.338\ m$

1ST RESONANT POSITION IS AT $(\lambda/4) = 0.169\ m$ ✓

THEN RESONATES EVERY $(\lambda/2)$ THERE AFTER

i.e $0.169 + N(0.338) = 1.40$

$\therefore N = \frac{1.40 - 0.169}{0.338} = 3.64$ ✓

$\therefore$ THERE WILL BE 3 RESONANT POSITIONS AFTER THE FIRST

i.e 4 RESONANT POSITIONS WITHIN THIS LENGTH OF PIPE ✓

(NB: MUST BE WHOLE NUMBERS)

(4 marks)