For Supervisor's use only

3

90520

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 3 Physics, 2005

90520 Demonstrate understanding of wave systems

Credits: Four
9.30 am Tuesday 29 November 2005

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

For all 'describe' or 'explain' questions, the answers should be written or drawn clearly with all logic fully explained.

For all numerical answers, full working must be shown, and the answer must be rounded to the correct number of significant figures and given with an SI unit.

Formulae you may find useful are given on page 2.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

For Assessor's use only

Achievement Criteria		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify or describe aspects of phenomena, concepts or principles.	Give descriptions or explanations in terms of phenomena, concepts, principles and / or relationships.	Give concise explanations that show clear understanding in terms of phenomena, concepts, principles and / or relationships.
Solve straightforward problems.	Solve problems.	Solve complex problems.
Overall Level of Performance		

You may find the following formulae useful.

Assessor's use only

$$d\sin\theta = n\lambda \qquad n\lambda = \frac{dx}{L} \qquad f' = f\frac{v_W}{v_W \pm v_S} \qquad v = f\lambda \qquad f = \frac{1}{T}$$

You are advised to spend 40 minutes answering the questions in this booklet.

QUESTION ONE: USING A PIPE TO MAKE MUSIC

A child's toy consists of a long, flexible, plastic pipe, open at both ends. Holding the pipe at one end, the other end can be swung around so that a standing wave is set up in the pipe, and a musical note heard. If the pipe is swung slowly the 1st harmonic (fundamental) frequency is heard. If the pipe is swung at a faster speed, the note changes to the 2nd harmonic (1st overtone) frequency. Even faster swinging produces the 3rd harmonic (2nd overtone).

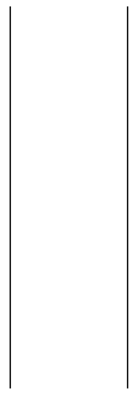
Jessica swings her pipe in such a way that the 3rd harmonic (2nd overtone) is heard. The frequency of the note is 685 Hz. The speed of sound in air is 3.4×10^2 m s^{-1}.

(a) (i) Show that the wavelength of the note heard has an unrounded value of 49.635 cm.

(ii) Justify the number of significant figures this answer should be rounded to.

Assessor's use only

(b) On the diagram below, sketch the standing wave in the pipe for the note that is heard.



(c) On the diagram above, label one antinode (A) and one node (N).

(d) What aspect of the standing wave in a **closed** pipe makes it impossible for it to have the same wavelength as the standing wave in an **open** pipe of the same length?

(e) Calculate the length of the pipe that Jessica was swinging.

length =

Swinging the pipe causes waves with a range of frequencies to be generated in the pipe.

(f) Explain how a standing wave is set up in the pipe.

(g) Joe swung a similar pipe at the same time as Jessica was swinging hers, and his pipe also produced the 3rd harmonic frequency note. There was a 9.0 Hz beat in the sound they heard. Show that the **difference** in the length of the two pipes is 1 cm.

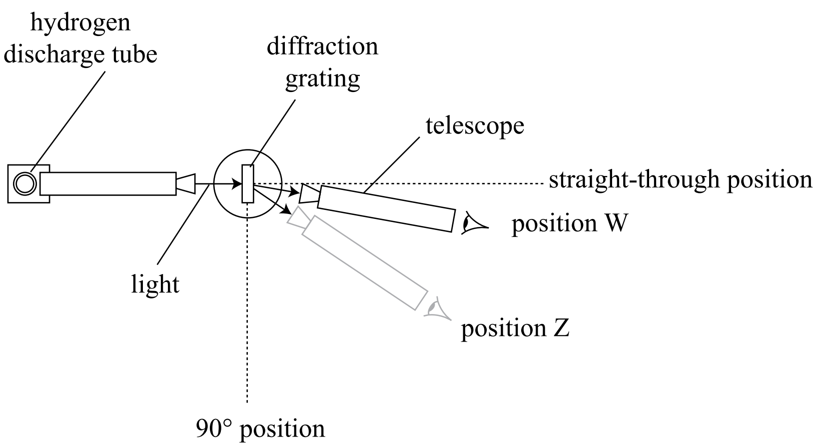
Assessor's use only

Assessor's use only

QUESTION TWO: EMISSION SPECTRA

When a high voltage electrical discharge is applied to hydrogen at low pressures, light is emitted. This light is passed through a diffraction grating that has 6.1×10^3 lines per cm, and a spectrum of coloured lines is viewed through the telescope of a spectrometer. There are several different order spectra that can be viewed. Each order is made up of 4 coloured lines; red, green / blue, purple and violet.

The following is a diagram of a spectrometer from above, showing how the telescope rotates about the position of the diffraction grating.



As the telescope is rotated from W to Z, each of the 4 lines of the first order spectrum is seen in turn.

(a) Explain which colour line would be seen first as the telescope rotates from W to Z.

(b) Show that the spacing of the slits in the diffraction grating is 1.6×10^{-6} m.

Assessor's use only

(c) The wavelength of the green / blue line is 4.86×10^{-7} m. Calculate the diffraction angle for this line in the first order spectrum.

angle = ______

(d) There are also several higher order spectra observed for hydrogen. It was found that the 3rd order purple line coincides with the 2nd order red line. If the angle for the red line in the 1st order spectrum is 23.5°, calculate the wavelength of the purple line.

wavelength = ______

(e) The diffraction grating was replaced with one that had **half** as many lines per cm. When the spectrometer telescope was rotated from the straight-through position to the 90° position, in order to see all the orders of hydrogen spectra, ONE difference that was seen was that the lines in the spectra were closer together than before. TWO **other** differences were seen. Assuming there is no change in the amount of light transmitted, describe and explain BOTH of the other two differences.

Assessor's use only

The atoms of hydrogen in a discharge tube are in rapid motion in random directions. Although each may emit a well-defined frequency, in practice the light received by the detector is a **band** of frequencies.

(f) Using the Doppler effect, explain why this happens.

The expected frequency of the violet line is 7.32×10^{14} Hz. Analysis of the violet band of light received by the detector showed that light of frequency 7.36×10^{14} Hz was also present.

(g) Calculate the component of the velocity, in the direction of the spectrometer, of the hydrogen atoms that produced the frequency 7.36×10^{14} Hz. The speed of light is 3.00×10^{8} m s^{-1}. Ignore any relativistic effects.

velocity = ____________________

Extra paper for continuation of answers if required.
Clearly number the question.

Assessor's use only

Question number