90520

905200

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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Physics, 2008

90520 Demonstrate understanding of wave systems

Credits: Four
9.30 am Tuesday 25 November 2008

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 numerical answers, full working must be shown. The answer should be given with an SI unit to an appropriate number of significant figures.

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

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 2–10 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 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 (all criteria within a column are met)		

You are advised to spend 35 minutes answering the questions in this booklet.

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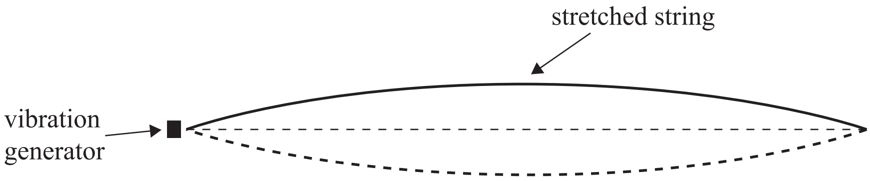
You may find the following formulae useful.

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

QUESTION ONE: STANDING WAVES

Speed of sound in air = 3.40×10^2 m s^{-1}

When a guitar string is plucked, a standing wave is set up. Standing waves can be demonstrated in the laboratory by vibrating **one end** of a stretched elastic string with the other end fixed. The end that is vibrated can also be considered fixed, because the vibration generator oscillates with very low amplitude.



(a) The vibration generator is set at a frequency of 35 Hz. When the string is stretched to a length of 1.2 m, a 1st harmonic (fundamental) standing wave is produced.

Calculate the speed of the wave in the string.

speed = ____________

The string is fixed at this length and the frequency of the generator is increased until the 3rd harmonic (2nd overtone) standing wave is produced.

(b) Calculate the new frequency of the generator.

frequency = ____________

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(c) How does this increase in frequency change the wavelength of the wave on the string, and by what factor?

With the generator still set at the **higher** frequency (producing the 3rd harmonic), the string is **tightened**, keeping the length the same, and the standing wave disappears.

(d) Explain why a standing wave does not occur when the string is tightened.

(e) The string is now stretched, and when its length reaches 1.8 m, a 2nd harmonic (1st overtone) standing wave is produced by the vibration generator, which is still at the higher setting.

Calculate the new speed of the wave.

speed = ______________

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QUESTION TWO: DOPPLER EFFECT

Speed of sound in air = 3.40×10^{2} m s^{-1}

A teacher swings a siren on the end of a string in a **horizontal** circle. The diagram below shows the situation viewed from **above**.

The siren is emitting a note of frequency 287 Hz.

(a) When the siren is in position A, it is travelling **towards** the student. The frequency the student hears **is greater than** 287 Hz.

Explain this increase in frequency.

(b) The apparent frequency the student hears when the siren is at position A is 304 Hz.

Calculate the speed of the siren.
You may assume that the distance between the student and the teacher is great enough for the siren to be considered to be moving **directly** towards the student at this position.

speed = ______________

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(c) Although the siren is moving, the teacher hears the true frequency of 287 Hz.

Explain why.

(d) The teacher now gets two identical sirens and sets them both to generate sound waves at a frequency of 287 Hz. She attempts to demonstrate beats to the student by moving one of the sirens away from the student at a steady speed.

Calculate the speed at which the teacher must move the siren, in order to generate beats with a frequency of 5.0 Hz.

speed = ______________

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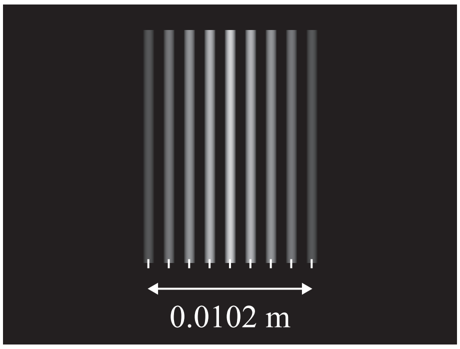
QUESTION THREE: INTERFERENCE

Interference techniques can be used in the quality control of the weaving process used to manufacture fabrics. This can be demonstrated in the laboratory by shining a narrow beam of laser light through a piece of fine gauze. The gaps between the woven threads of the gauze create multiple point sources of light and these interfere to produce a pattern of bright spots on a screen.

A student uses the vertical threads to make a diffraction grating and shines light from a laser through the threads to form a pattern of fringes on a screen, as shown below.



The grating is 2.14 m from the screen and the distance between the two outside bright lines is measured to be 0.0102 m. The wavelength of the laser light is 6.3×10^{-7} m. The student marks the lines on the screen.

(a) Calculate the average distance between two adjacent bright lines. Give your answer to the correct number of significant figures.

average distance = ______________________

(b) Calculate the spacing of the threads.

thread spacing = ______________________

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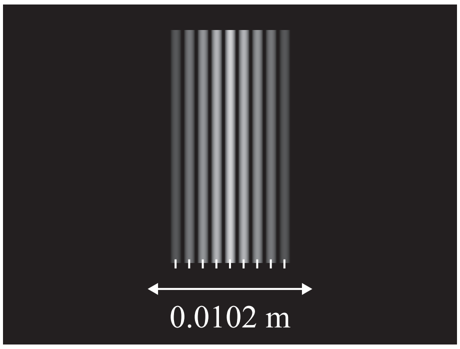
(c) The threads that produced the pattern in the diagram on the opposite page are replaced with a new set of threads and the pattern shown in the diagram below is obtained.



Explain what this would tell you about the spacing of the threads in the new gauze.

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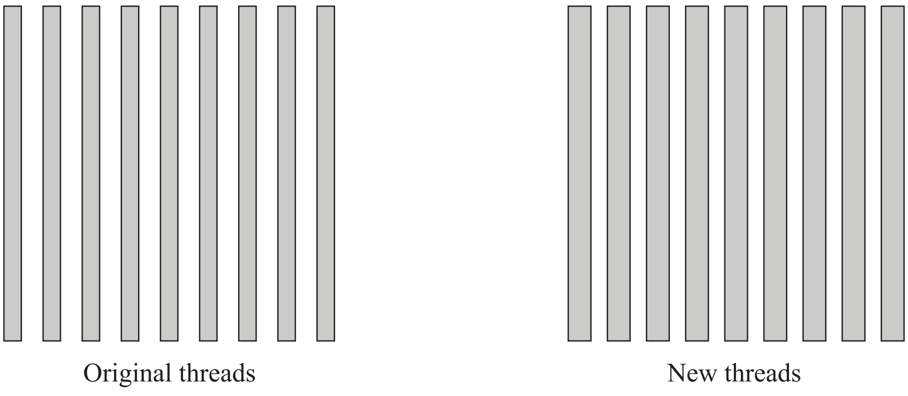
(d) The original threads are now replaced with **thicker** threads, with the same spacing as the original threads. The new interference pattern is in some ways the same, but in other ways it is different.

Explain how the thicker threads will affect the pattern on the screen, and what will be unchanged.



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(e) Light from a red laser (wavelength 6.70×10^{-7} m) is shone at a new diffraction grating. The light forms a pattern showing nine bright fringes spread across a distance of 4.0 cm. When the laser is replaced with a green laser, the interference pattern shows nine fringes spread out over a distance of 3.2 cm.

Calculate the wavelength of the green laser.

wavelength = ______________

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

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