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90520

905200

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

For Supervisor's use only

Level 3 Physics, 2010

90520 Demonstrate understanding of wave systems

Credits: Four
9.30 am Tuesday 23 November 2010

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

Make sure you have the Resource Booklet L3-PHYSR.

You should answer ALL the questions in this booklet.

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

For each 'describe' or 'explain' question, the answer should be written or drawn clearly with all logic fully explained.

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 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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All formulae are provided in the separate Resource Booklet L3-PHYSR.

QUESTION ONE: STEAM WHISTLE

Data to use:

speed of sound in dry air at 20°C = 343 m s^{-1}

speed of sound in steam at 200°C at a pressure of 7 MPa = 523 m s^{-1}

Steam-powered trains use loud whistles for signals. The whistles work like pipes that are closed at one end. Instead of air, steam from the boiler makes the sound.

One such whistle acts as a pipe closed at one end, with a length of 0.180 m. It produces a sound with many overtones (harmonics).

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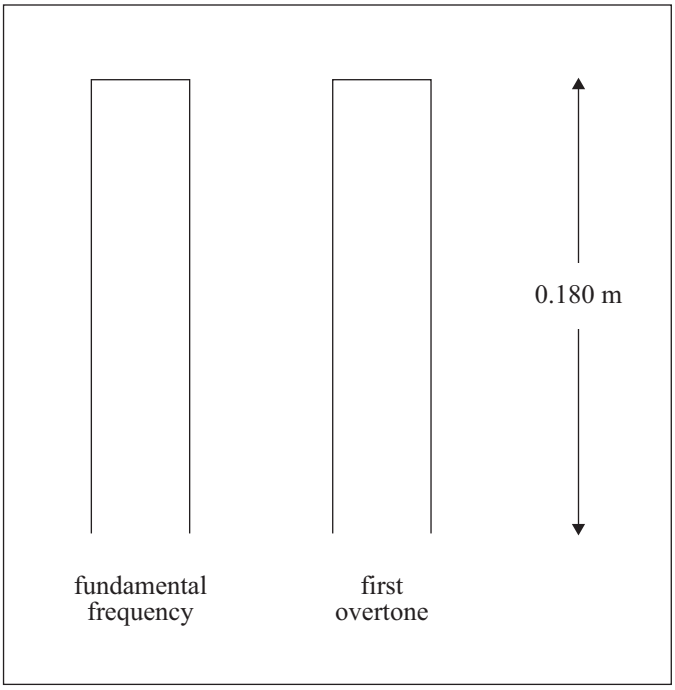
http://www.steam-whistles.com/photos/index.4.jpg

(a) Label the diagrams (right) to show the positions of displacement nodes (N) and antinodes (A) of the standing waves that are set up in the pipe when it vibrates

(i) at its fundamental frequency (1st harmonic)

(ii) with its first overtone (3rd harmonic).



(b) In this part of the question assume that the whistle is full of steam at 200°C, at a pressure of 7 MPa, and surrounded by dry air at 20°C.

Calculate the frequency of the fundamental (1st harmonic).

_____

_____

frequency of the fundamental = _____

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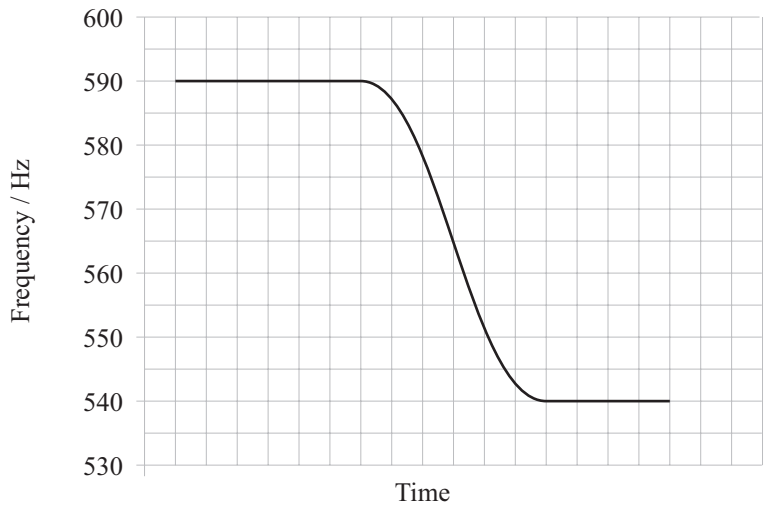
(c) The whistle is initially full of dry air at 20°C. It is blown with a jet of steam and as it whistles it is gradually filled with steam, changing the sound of the whistle.

Describe what you might expect to hear and explain any changes.

(d) A different train passes a student at a steady speed, sounding its whistle with a full jet of steam. The frequency of the fundamental, measured by the stationary student, changes as shown.



By calculating the true frequency of the whistle, or otherwise, show that the speed of the train is 15.2 m s^{-1}.

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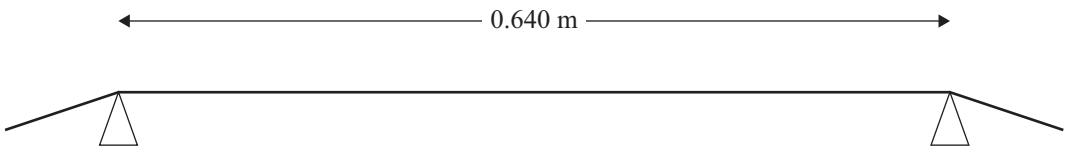
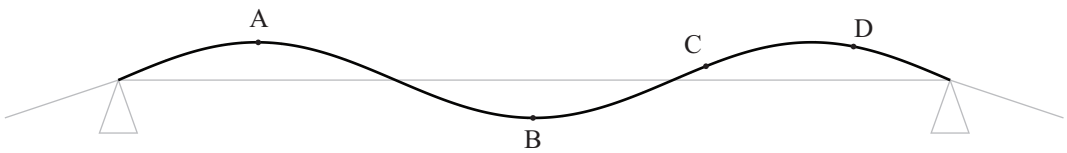
QUESTION TWO: TUNING A GUITAR

The 'A' string on a guitar has a weight and a tension which means that waves travel along the string at 563 m s^{-1}. The length of the string that is free to vibrate is 0.640 m.



(a) Show that the fundamental frequency (1st harmonic) of the string is 440 Hz.

(b) The diagram shows the shape of the string at one moment while it is oscillating in a standing wave at the frequency of its second overtone (3rd harmonic). Particles in the string at A, B, C and D are all oscillating with simple harmonic motion.



(i) Compare the phase difference and amplitude of the particles of string at antinodes A and B.

(ii) Compare the phase difference and amplitude of particles of string at C and D.

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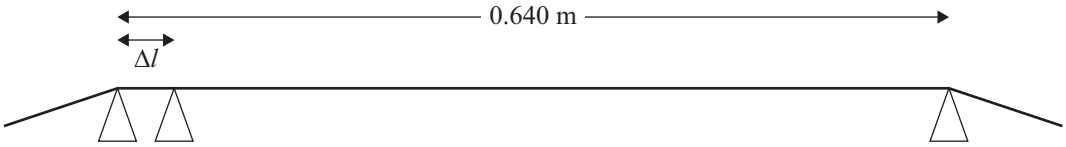
(c) On a second guitar, an identical 'A' string, with the same tension and weight, is tuned to the same frequency. Without changing the tension, this second string is shortened by Δl. When both strings are plucked to sound their fundamental frequency, beats are detected at a frequency of 20 Hz.



Calculate the change in length, Δl, of the second string.

Δl _____

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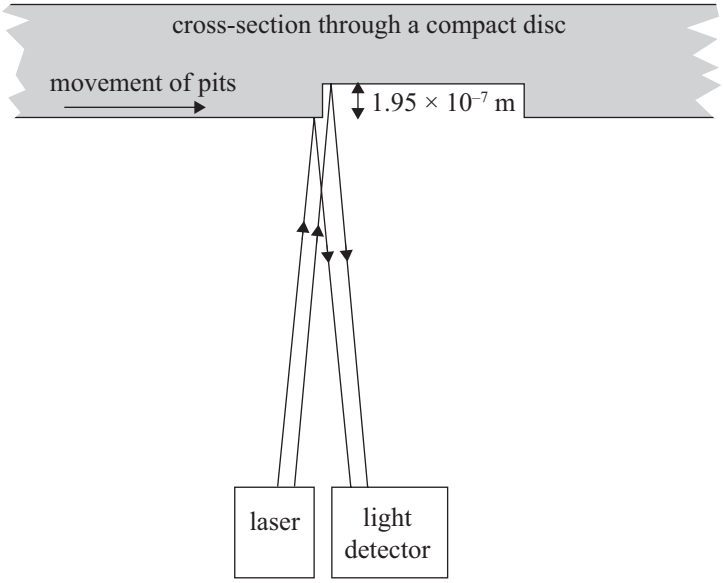
QUESTION THREE: CD SPECTRUM

A compact disc (CD) is read with a laser light of wavelength 7.80×10^{-7} m.

The recorded surface, on the bottom of the CD, has pits in it, which are 1.95×10^{-7} m deep.

The CD rotates, moving the pits over a laser beam and varying the intensity of the reflected light.

Consider a beam consisting of just two rays of light which reflect off the bottom of the CD.



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http://stereophile.com/images/archivesart/Magicfig1.jpg

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CD surface (electron microscope photo).

www.faqs.org/photo-dict/photofiles/list/1593/10620cd_player.jpg

(a) Explain how the intensity of the detected beam depends on whether the reflected rays are in phase or out of phase with each other when they arrive at the detector.

(b) The movement of the pits makes the intensity of the reflected beam vary between high and low so the detector receives a digital signal.

Explain why the pits are made exactly 1.95×10^{-7} m deep.

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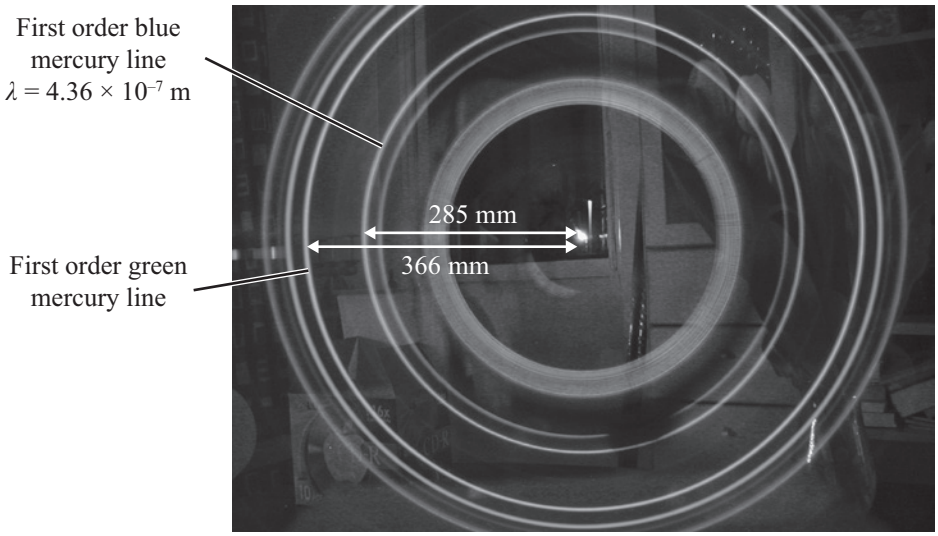
The pits on a CD are in lines along one long spiral track. The tracks are essentially circles, 1.60×10^{-6} m apart.

A teacher uses a CD to make a transparent plastic disc with this track pattern to use as a diffraction grating. He photographs a street lamp through the disc and obtains the picture below.



http://commons.wikimedia.org/wiki/File:Compact-Disc-spectrum-Mercury.jpg

(c) Show that the first order blue mercury line ($\lambda = 4.36 \times 10^{-7}$ m) occurs at a diffraction angle of 15.8°.

(d) Use the distances marked on the photograph to calculate the wavelength of the first order green mercury line.

wavelength = _____

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

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