

AS Level Physics B
H157/02 Physics in depth

Question Set 7

1 This question is about the standing waves that produce the musical notes in string instruments.

(a) A double bass is a large musical instrument with four strings of the same vibrating length L but different thicknesses. Notes are produced by moving a bow perpendicular to the string (**Fig. 1.1**).

This question considers only the thickest string of the double bass, which produces the lowest notes.

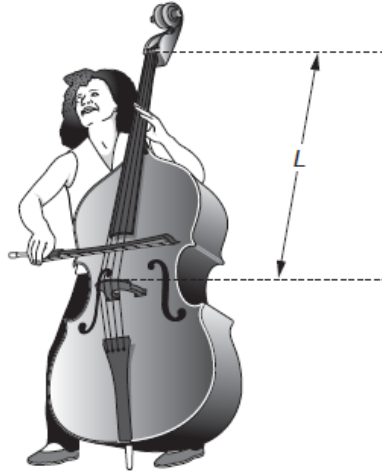


Fig. 1.1

(i) The length $L = 0.980\text{m}$ and the frequency f_0 of the fundamental note produced by the thickest string is 41.2Hz . Show that the waves travelling along the string have a speed of less than 100ms^{-1} . [2]

(ii) A player can produce a harmonic (a note of higher frequency) by touching the string **lightly** at a certain point to make the string vibrate with zero amplitude at that point. This point must be a whole fraction of L from one end of the string, e.g. one-half, one-third, etc. of the way along.

The player produces a note of frequency f about 200Hz on this thickest string by touching it at a distance x of about 20cm from one end.

Using appropriate scientific terms, explain why this higher frequency is produced, and calculate the values of x and f to an appropriate number of significant figures.

$x = \dots\dots\dots\text{cm}$ $f = \dots\dots\dots\text{Hz}$ [4]

- (iii) The fundamental frequency f_0 of the note produced by a vibrating string of length L is given by the equation

$$f_0 = \frac{1}{2L} \sqrt{\frac{T}{\rho A}}$$

where T is the tension of the string, A its cross-sectional area and ρ the density of the material of which it is made.

Calculate the diameter of the thickest string, which has a tension of 290 N and a mean density of 8100 kg m^{-3} .

diameter = m **[3]**

- (b) A bass guitar (**Fig. 1.2**) has four strings that produce notes of the same frequencies as the four strings of the double bass. The strings are not played with a bow like a double bass. They are pulled perpendicular to the string and released (plucked) just as on an ordinary guitar.

As in part (a), part (b) considers only the thickest string of the instrument

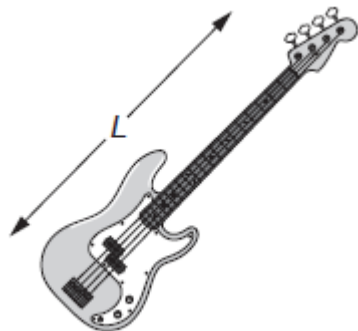


Fig. 1.2

- (i) Use the equation given in (a)(iii) to show that, for strings producing the same fundamental frequency f_0 ,

$$\rho A \propto \frac{T}{L^2}.$$

Show your working clearly and explain your reasoning

[2]

- (ii) The thickest string on the bass guitar is 0.86 m long and is at a tension of 190 N.

You can assume that this string has the same mean density as a double bass string, which is 0.98 m long and is at a tension of 290 N.

By considering the ratio $\frac{T}{L^2}$ for the thickest strings on each instrument,

discuss how the two strings will differ, and how plucking a double bass string would feel different from plucking a bass guitar string of the same fundamental frequency. You may include calculations in your answer.

[3]

[Question total: 14]

2

Two students, Alice and Bob, are using a diffraction grating to determine the wavelength of light emitted by a light-emitting diode (LED).

Bob places a ruler a distance x behind the grating and Alice observes the positions on the ruler corresponding to the straight-through beam (**A**) and the first-order diffracted beams (**B** and **C**), as shown in **Fig. 2.1**.

y_1 and y_2 are the observed values of y , the displacement on the ruler of **C** and **B** from **A**.

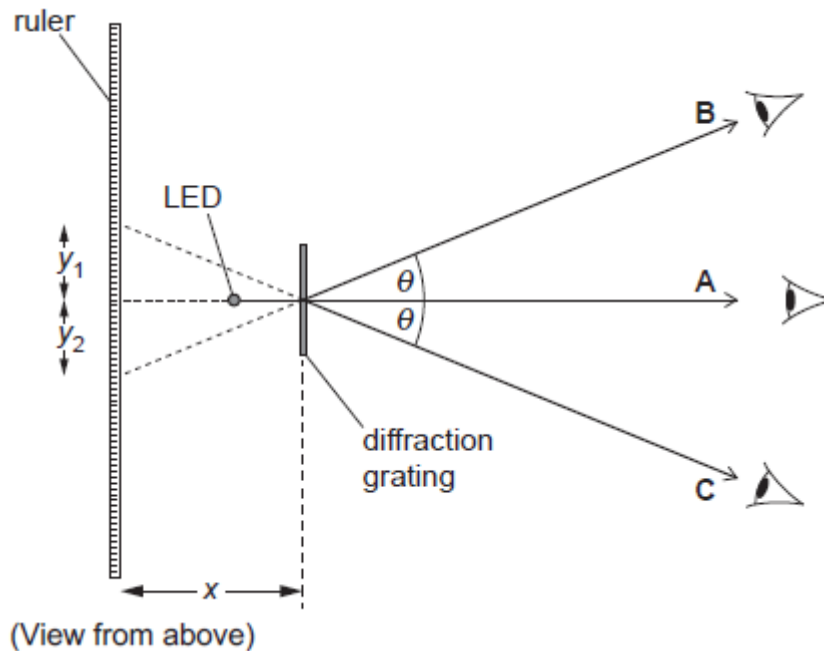


Fig. 2.1

(a) By measuring the distances y_1 and y_2 , Alice and Bob intend to find the angle θ of first-order diffraction maximum.

(i) For this LED, Alice and Bob obtain the following data for the first-order maximum.

Use the table to calculate the mean value of y and its uncertainty.

mean = cm
uncertainty = cm **[3]**

(ii) Explain why repeating the measurements at least three times is good experimental practice. **[2]**

(iii) Describe how Alice and Bob could use the values obtained in part **(a)(i)** to find the mean frequency of the light from the LED. You do not need to do any calculations. **[3]**

- (b) * Repeating the experiment for different LEDs, Bob used their data to plot the graph of Fig. 2.2.

The values of E , the minimum energy needed to emit a photon, were obtained by measuring the minimum p.d. that would allow the LED in question to emit light. The gradient of the best-fit straight line should be the Planck constant, h .

Bob's analysis is shown on the graph of Fig. 2.2 and in the box following.

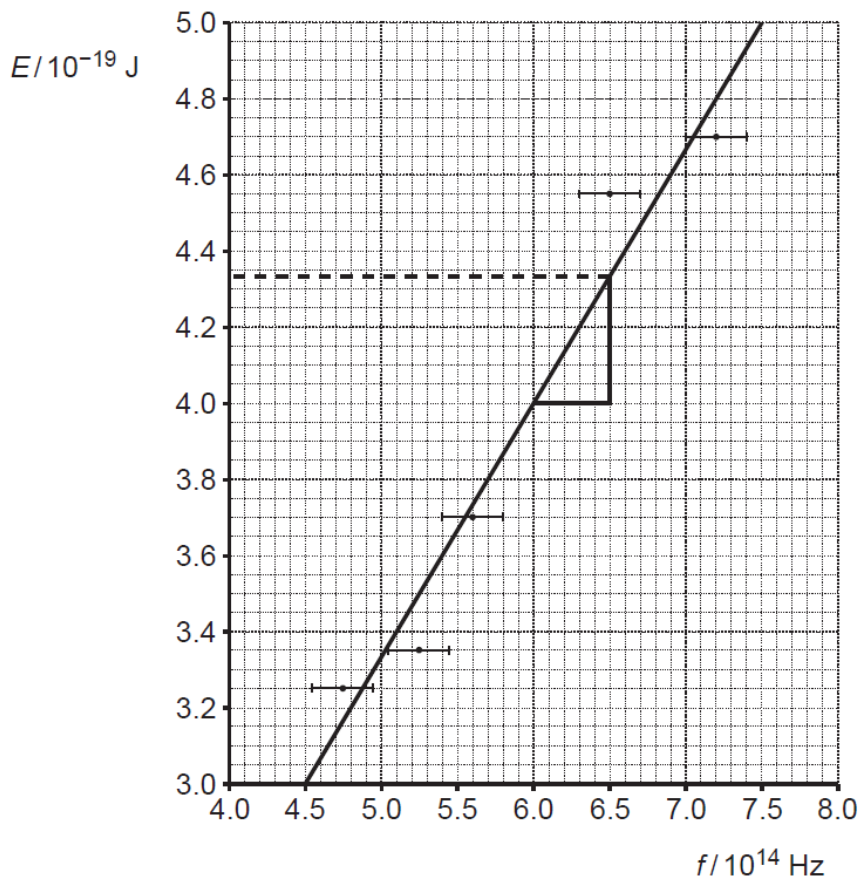


Fig. 2.2

Evaluate his analysis of the data from the experiment.

$$h = \text{gradient} = \frac{4.33 \times 10^{-19} - 4.0 \times 10^{-19}}{0.5 \times 10^{14}} = 6.6 \times 10^{-34} \text{ J s .}$$

This is exactly the same as the data book, so the experiment worked well.

[6]

[Question total: 14]

Total Marks for Question Set 7: 28



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