OCR
Oxford Cambridge and RSA

Thursday 9 June 2016 – Afternoon

AS GCE PHYSICS B (ADVANCING PHYSICS)

G492/01 Understanding Processes / Experimentation and Data Handling

Duration: 2 hours

INSERT

INSTRUCTIONS TO CANDIDATES

- This Insert contains the material required to answer the questions in Section C.

INFORMATION FOR CANDIDATES

- This document consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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1 Dot plots

When a force F is applied to a spring, the extension x is related to the force F acting on the spring according to the relationship

$$F = kx$$

where k is the spring constant.

In a simple experiment the extension of a spring is measured with a ruler when a standard laboratory mass of 1 kg is attached. The experiment is repeated ten more times. The results, presented as a simple dot plot, are shown in Fig. 1.

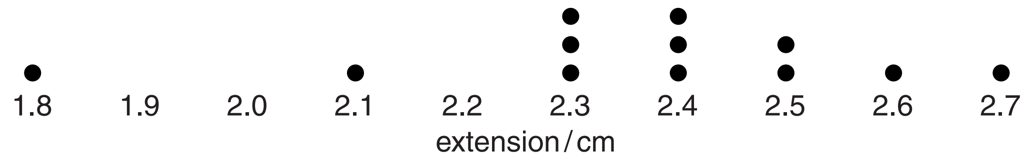

Fig. 1

With a dot plot you can look at the distribution and range of values in a set of data to find the mean and its uncertainty. The spread of the data, which is half the range, gives a useful estimate of the uncertainty.

It is useful to have a rough rule of thumb to identify whether a particular value is so far from the mean that it might be suspected to be an outlier, and so should be investigated further. One such rule is to identify as a possible outlier any value that lies more than twice the spread above or below the mean, temporarily excluding the suspected value from the calculation of mean and spread.

The uncertainty in the extension x can be used to determine an uncertainty in the final calculated value of the spring constant k.

2 Systematic errors

Systematic errors can arise from experimental procedures or from the measuring instruments themselves. They are reproducible inaccuracies that are consistently in the same direction. Unlike random uncertainties, systematic errors cannot be detected or reduced by increasing the number of observations. Two examples are a measuring tape becoming stretched over years of use giving false readings, and a **zero error** on an instrument making all readings too large or small by a set amount, such as an ammeter that reads –0.01 A when there is no current.

Understanding the impact of the systematic error in terms of the direction of the error is also important. If a systematic error is suspected in one variable, it is important to think about whether this error would make the final result too large or too small.

3 Measuring the speed of sound

You may wish to try this at school with the appropriate health and safety procedures.

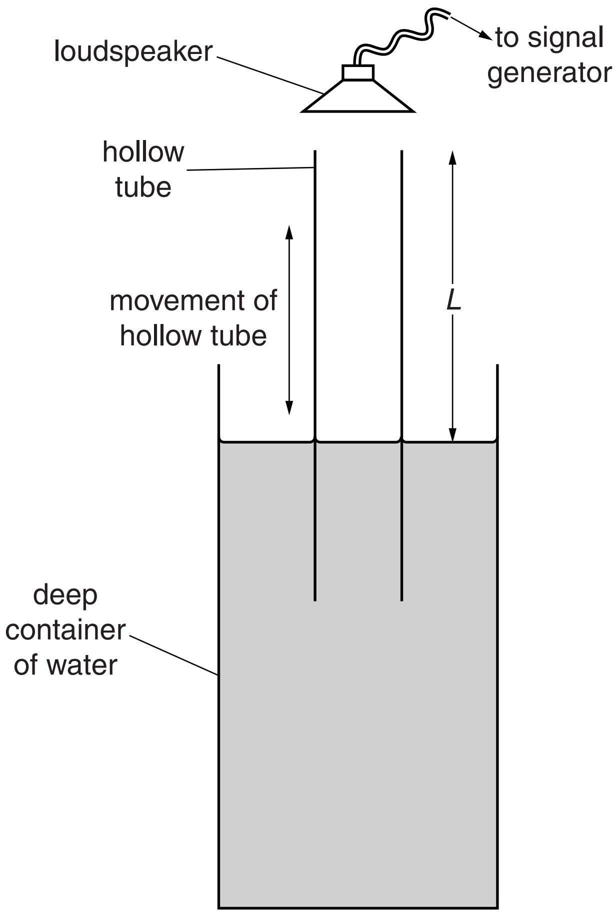

Fig. 2

A loudspeaker connected to a signal generator is mounted above the top of the hollow tube as shown in Fig. 2 and sound waves travel down the tube. The tube is slowly moved up in the water, altering its length, until a resonance is heard. At this point there is a standing wave in the tube with a displacement node at the bottom and a displacement antinode at the top.

A systematic error exists in the experiment because the antinode is not at the open end of the tube, but a small distance beyond it. This is known as the end correction c and it depends on the diameter of the tube.

The shortest value of L at which the resonance is heard, L_1, is given by

$$L_1 + c = \tfrac{1}{4}\lambda. \qquad (1)$$

Raising the tube further, another standing wave is formed when the length of the tube above the water level is L_2, where

$$L_2 + c = \tfrac{3}{4}\lambda. \qquad (2)$$

The L_2 resonance is quieter than the L_1 resonance so making the measurement of L_2 more difficult.

The two equations can be combined to give

$$L_2 - L_1 = \tfrac{1}{2}\lambda$$

which removes the need to measure or know the value for the end correction c.

The frequencies used in the experiment need to be carefully matched to the length of the hollow tube and the depth of the container of water. A graph of $(L_2 - L_1)$ against $\frac{1}{f}$ is the most reliable way of calculating the speed of sound from these results. Signal generators now produce very stable and accurately determined frequencies. Therefore the largest uncertainty in the value obtained for the speed of sound comes from the uncertainty in determining the resonant lengths L_1 and L_2.

END OF ARTICLE