

# 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

**ADVANCE NOTICE**



## INSTRUCTIONS TO CANDIDATES

- Take the article away and read through it carefully. Spend some time looking up any technical terms or phrases you do not understand. You might find it helpful to try out the measurement ideas described in part 3.
- For the examination on Thursday 9 June 2016 you will be given a fresh copy of this article, together with a question paper. You will not be able to take your original copy into the examination with you.
- The values of standard physical constants will be given in the Advancing Physics Data, Formulae and Relationships booklet. Any additional data required are given in the appropriate question.

## INFORMATION FOR CANDIDATES

- Questions in Section C of paper G492/01 (Understanding Processes, Experimentation and Data Handling) will refer to this Advance Notice material and may give additional data related to it.
- Section C will be worth about 40 marks.
- Sections A and B of paper G492/01 will be worth about 60 marks, and will examine the *Understanding Processes* section of the specification.
- There will be 2 marks for quality of written communication (QWC) assessed in Sections B and C.
- This document consists of 4 pages. Any blank pages are indicated.

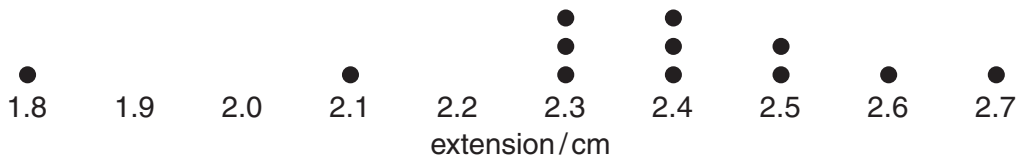
## 1 Dot plots

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  $k$ .

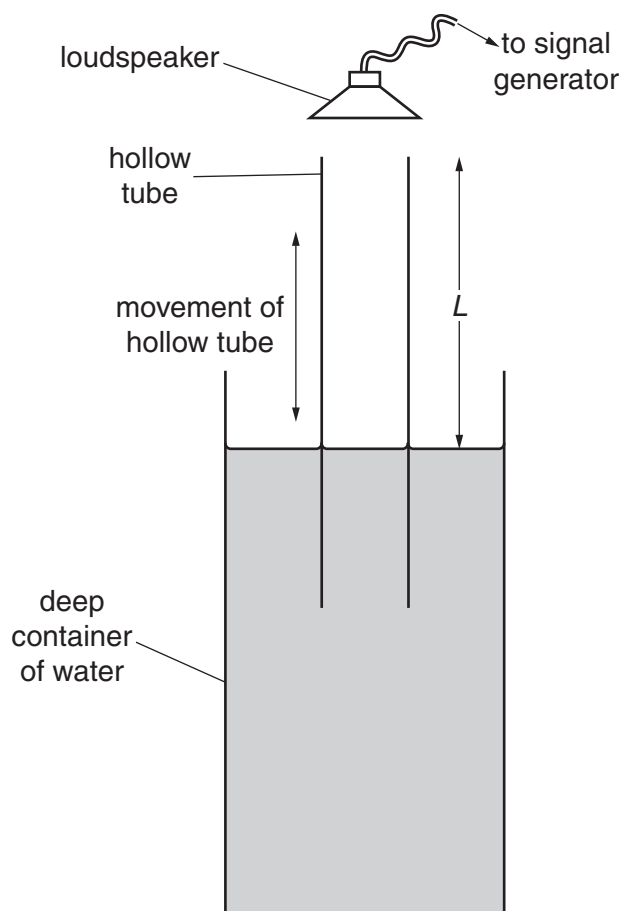
## 2 Systematic errors

**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  $-0.01\text{ A}$  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

$$L_1 + c = \frac{1}{4}\lambda. \quad (1)$$

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

$$L_2 + c = \frac{3}{4}\lambda. \quad (2)$$

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

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

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**

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