OXFORD CAMBRIDGE AND RSA EXAMINATIONS

ADVANCED SUBSIDIARY GCE

G492

PHYSICS B (ADVANCING PHYSICS)

Unit G492: Understanding Processes / Experimentation and Data Handling

INSERT

THURSDAY 21 MAY 2009: Afternoon

DURATION: 1 hour 45 minutes

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

INSTRUCTIONS TO CANDIDATES

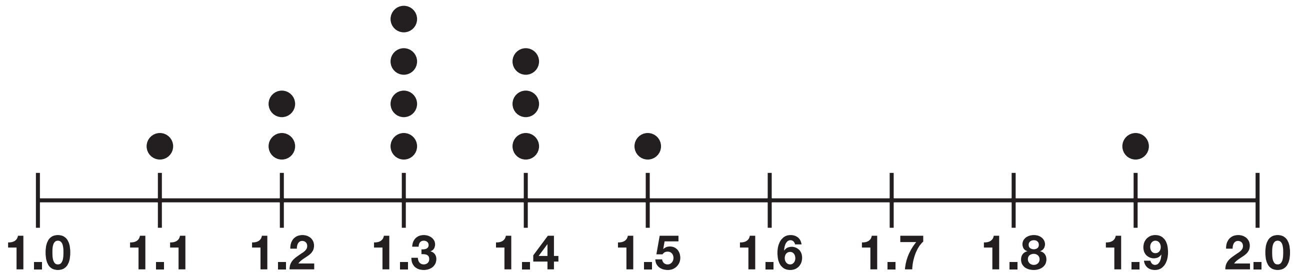
- **This insert contains the article required to answer the questions in Section C.**

READ INSTRUCTIONS OVERLEAF

DC (LEO/CGW) OV90890 11234/1

1. <u>PLOT AND LOOK</u>

When collecting data which is varying, it is a good idea to make a simple, quick plot of the values. One method is a 'dot plot', which can produce results like those in Fig. 1.



<u>FIG. 1</u>

With a dot plot, you can look at the distribution of values and identify any outliers. Excluding the outlier, you can find the <u>MEAN</u> of the distribution and the <u>SPREAD</u>, or uncertainty about the mean, which is half of the range.

This procedure gives a value of 1.3 ± 0.2 for these data. A good rule of thumb is that a value is likely to be an outlier if it lies more than 2 × spread from the mean. Here the outlier is three times the spread from the mean value which seems suspiciously far, but this does not imply that it is definitely an error.

2. HOW CAN YOU MEASURE THE DIAMETER OF AN EXTREMELY THIN WIRE IN A SCHOOL LABORATORY?

You may wish to try out these ideas in the laboratory so that you will know in advance what the difficulties might be, how the experiment works and how the data can be processed.

Making a good measurement of the diameter of extremely thin steel wire by DIRECT measurement with a micrometer is not feasible due to the limited resolution of a micrometer.

The diameter of the wire is thought to be about 10^{-4} m.

Two students were given the following practical problem to solve:

> **Determine the radius *r* of very thin steel wire by an INDIRECT method.**
>
> **Choose a method which you think can give a better measurement of the radius *r* than can be achieved with a micrometer. Aim to reduce both the uncertainty and any systematic error.**

Here is a brief description of the methods chosen by the students.

METHOD 1:

Measure the extension Δx of a length x of the steel wire under an applied force F.

Calculate the radius r from

$$\frac{F}{\pi r^2} = E\frac{\Delta x}{x}$$

where E is the Young modulus of the steel.

METHOD 2:

Measure the mass m of a length x of the steel wire.

Calculate the radius r from

$$m = \pi r^2 \rho x$$

where ρ is the density of the steel.

A book of Physical Constants gives the following values for the Young modulus E and density ρ for steel:

$$E = 2.1 \times 10^{11}\ \mathrm{Pa}$$
$$\rho = 7.8 \times 10^{3}\ \mathrm{kg\,m^{-3}}$$

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3. GALILEO, GRAVITY AND PROJECTILES

It is commonly stated that Galileo dropped heavy and light objects off the Leaning Tower of Pisa. He probably did not do this, but he most certainly did experiments to investigate gravity.
One of his experiments used the arrangement shown in Fig. 2.

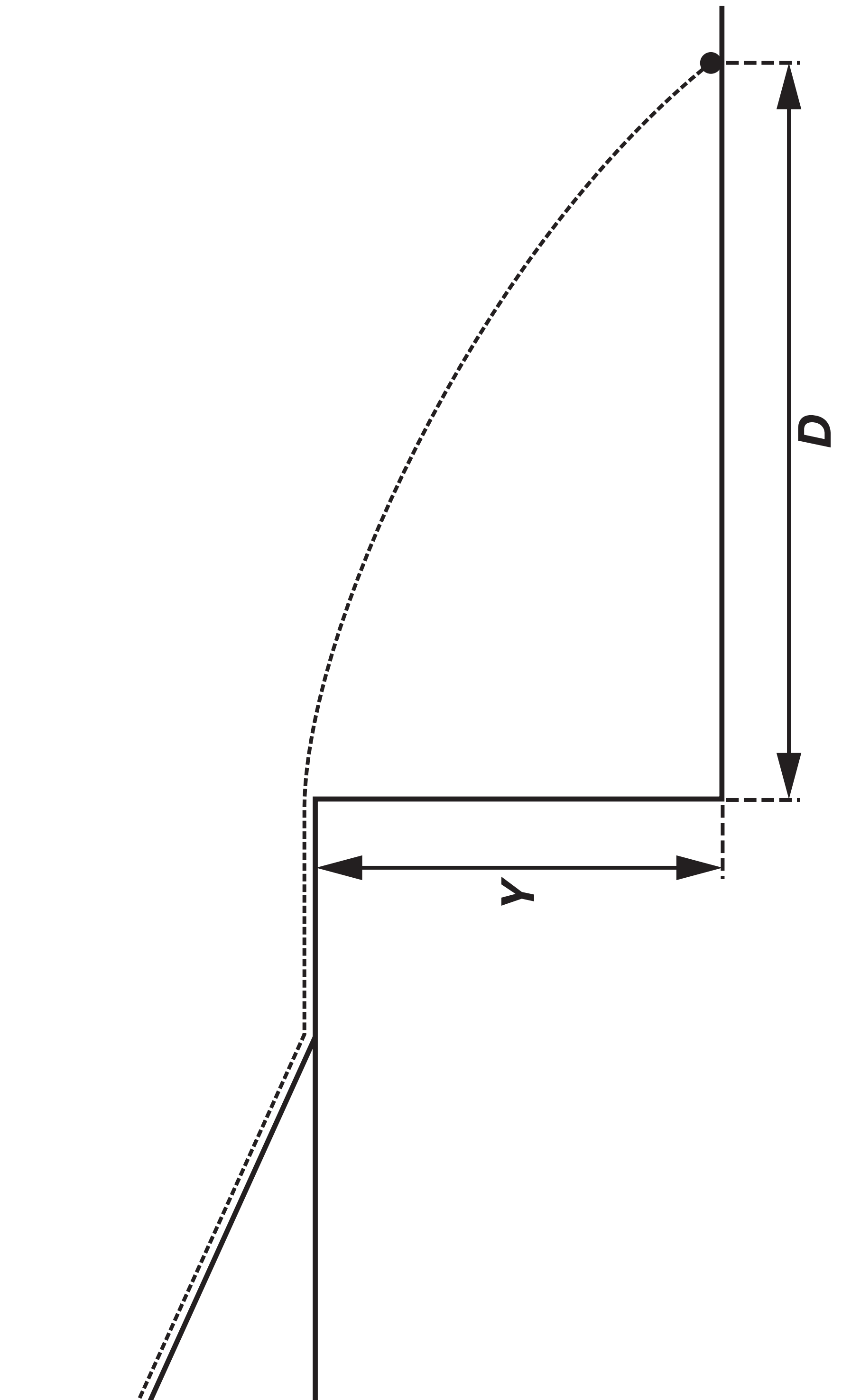

FIG. 2

A solid ball was rolled down a ramp standing on a table, starting at a height *H* above the table. The ball moved for a short distance along the table and then moved through the air, as a projectile, hitting the ground a distance *D* from the bottom of the table.

Measurement of short time intervals was difficult in 1606, when Galileo did this experiment, but measurement of distance was easy. The results he obtained, and published, were:

H / 'points'	*D* / 'points'
1000	1500
828	1340
800	1328
650	1172
300	800

The unit of distance used by Galileo was the 'point' (punto). The 'point' was not a standard unit — there were 'points' of different sizes in different Italian cities. It is thought that in Pisa, where Galileo worked, a 'point' was about 1 mm.

TRANSLATION AND ROTATION

For any object moving without rotating, the kinetic energy is given by the familiar equation

$$\text{translational kinetic energy} = \frac{1}{2}mv^2$$

where ‘translation’ means ‘moving from one place to another’.

In Galileo’s experiment, the ball is rolling, so it also has ROTATIONAL kinetic energy. For a rolling ball, roughly $\frac{1}{4}$ of the total kinetic energy is rotational kinetic energy and roughly $\frac{3}{4}$ is translational kinetic energy. This means that the horizontal velocity of the ball as it leaves the table is less than you might calculate for an object sliding down the ramp without rolling.

END OF ARTICLE

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