# OXFORD CAMBRIDGE AND RSA EXAMINATIONS

**AS GCE**

# G492

# PHYSICS B (ADVANCING PHYSICS)

## Unit G492: Understanding Processes / Experimentation and Data Handling

## INSERT

**FRIDAY 20 JANUARY 2012: Morning**

**DURATION: 2 hours**

**SUITABLE FOR VISUALLY IMPAIRED CANDIDATES**

**OCR SUPPLIED MATERIALS:**

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

**OTHER MATERIALS REQUIRED:**

**Do not send this Insert for marking; it should be retained in the centre or destroyed.**

DC (NH/SW) 12MEP01217 57801

## 1. DOT PLOTS

**When collecting data which is liable to some variation, for example using a stopwatch to time an event, it is good practice to make a simple, quick plot of the values. One method is a *dot plot*, which can produce results like those in Fig. 1.**

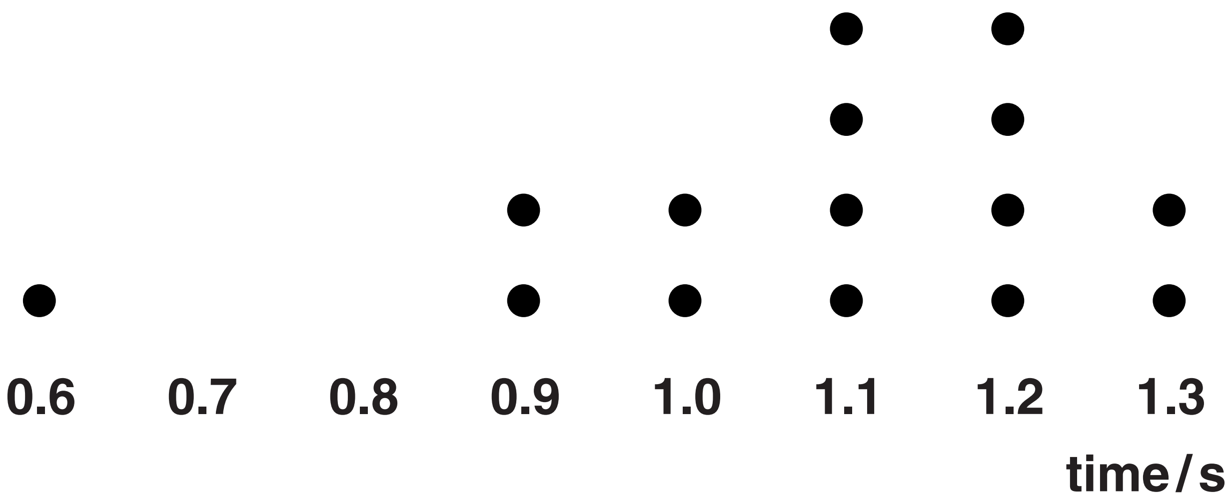


**Fig. 1**

**With a dot plot, you can look at the distribution of values and identify possible outliers. Excluding the outlier, you can find the MEAN of the distribution and the SPREAD, or UNCERTAINTY about the mean, which is half of the range.**

**As the outlying reading of 0.6 s in Fig. 1 is more than twice the spread from the mean of the remaining measurements, it is significantly different, and should be investigated further. Measuring time with a stopwatch is subject to both systematic error and uncertainty, and it would be important to consider how this variation could have arisen.**

## 2. MEASURING *g* BY FREEFALL

**A direct measurement of *g*, the acceleration due to gravity, can be made by timing an object in freefall. An example of the method using standard school equipment is shown in Fig. 2. The break-to-start and break-to-stop contacts are connected to an electronic timer.**

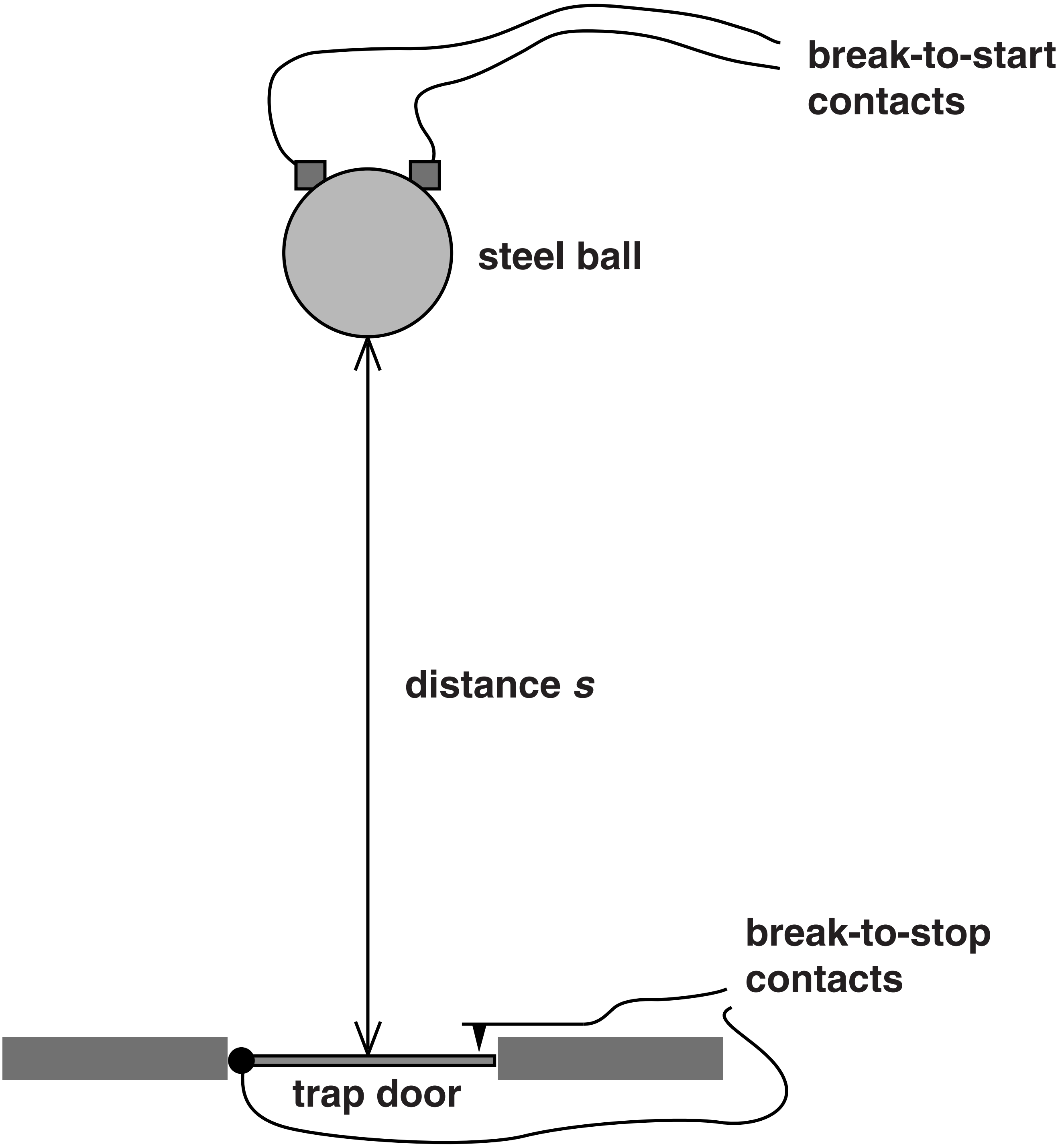


**Fig. 2**

**As the steel ball bearing is released, the electronic timer starts. The ball falls a distance *s* before it hits a hinged metal 'trap door'. The trap door opens, breaks the circuit and stops the timer. The time *t* can be measured to the nearest 0.01 of a second and the distance *s* is measured with a tape measure to the nearest centimetre. This procedure can be repeated to give a mean time *t* for this value of *s*.**

**The values of *t* and *s* can be substituted into the equation $s = ut + \frac{1}{2}at^2$ to find the acceleration. However, it is best not to rely upon the mean time *t* for one particular distance *s*. A more accurate and reliable value for *g* can be obtained by taking measurements at different values of *s* and then plotting a suitable straight line graph. Such a graph may also reveal any systematic errors in the experiment.**

**A set of readings obtained in this way is given in the table below.**

| ***s*/m** | **MEAN *t*/s** |
|---|---|
| **0.40** | **0.27** |
| **0.50** | **0.31** |
| **0.60** | **0.34** |
| **0.70** | **0.38** |
| **0.80** | **0.41** |
| **0.90** | **0.43** |
| **1.00** | **0.45** |
| **1.20** | **0.50** |

## 3. CAN WE MEASURE THE SIZE OF ATOMS?

**The English physicist Lord Rayleigh (Fig. 3) won the Nobel Prize in 1904. He made an estimate of the size of an atom by measuring the maximum spread of a tiny drop of olive oil placed on a clean water surface. Lord Rayleigh knew that the oil molecule consisted of chains of atoms. He expected the oil to spread until it was one molecule thick and could not spread any more. Chemical knowledge about the nature of olive oil suggested that the oil molecules stand on end, with one end at the water surface. His estimate has since been verified with alternative measurements.**

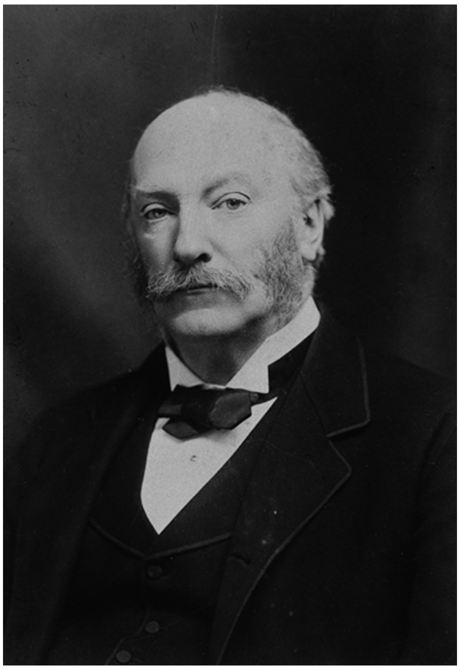

**Fig. 3**

**This intriguing experiment is easily recreated in the classroom. In this experiment a very small drop of oil is placed into a tray of water. The oil spreads out on top of the water. It is straightforward to measure this 'patch' of oil and using various assumptions it is possible to calculate a value for the approximate length of an oil molecule.**

**This classic experiment can be set up as shown below in Fig. 4.**

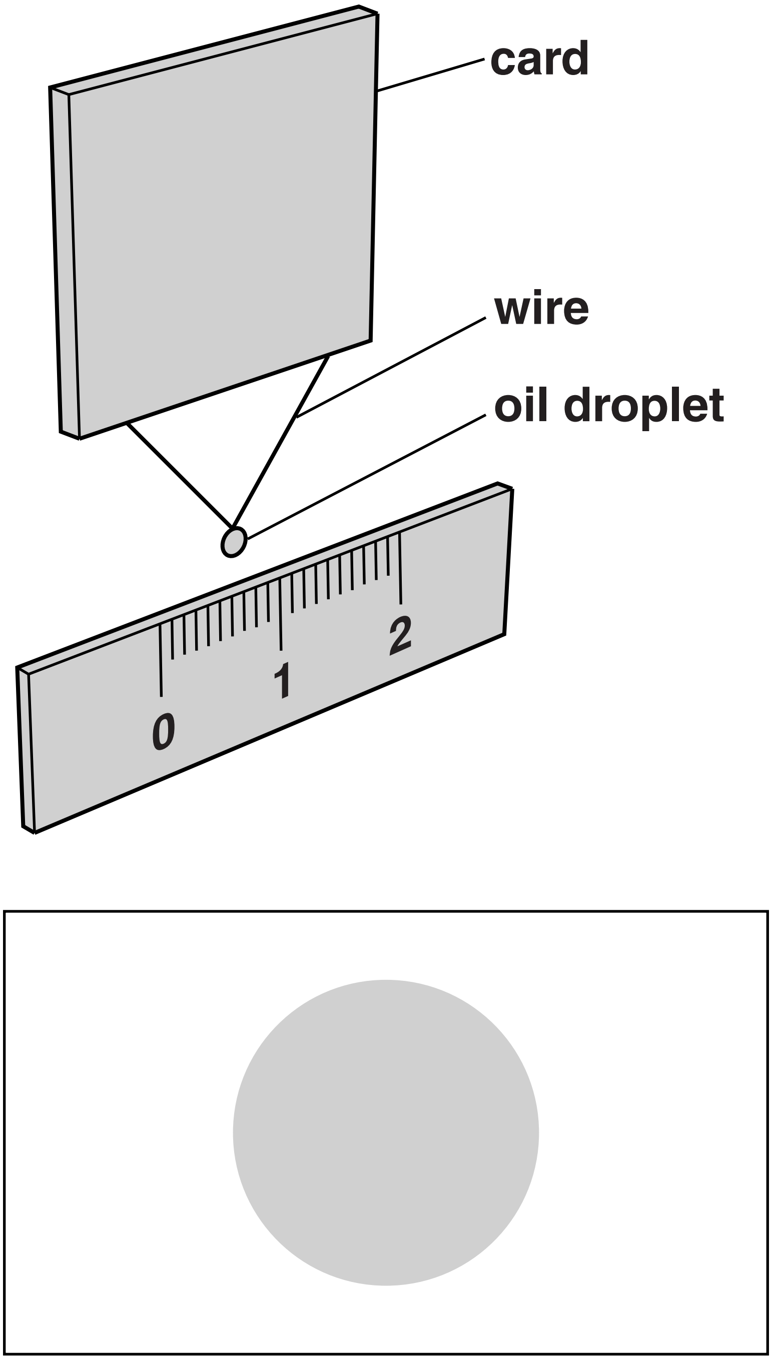


**Fig. 4**

**A large tray filled with clean water is lightly dusted with a very fine white powder. A loop of very thin wire, mounted onto card, is dipped into olive oil and removed to form a very small droplet of the oil. The diameter of the droplet can be measured by placing it against a finely graded rule and viewing it through a magnifying glass. Ideally the diameter will be about 0.5 mm, with a likely uncertainty of ± 0.1 mm. When this droplet of oil is placed onto the water it spreads out across the surface in a roughly circular fashion. This can be seen as the powder is pushed back leaving a central clear patch. The diameter of this circular patch, typically of the order of about 100 mm, can be measured with a ruler to within 5 mm. The following calculations can be made to give a value of the approximate size (diameter) of an atom to a reasonable order of magnitude.**

**Volume of oil droplet $V = \frac{4}{3}\pi r^3$ where $r$ = radius of oil droplet.**

**The volume of the drop of oil stays the same when it spreads out on the surface of the water and the area of the circular patch, $A = \pi R^2$, where $R$ = radius of patch. This allows the thickness of the circular patch to be calculated.**

**The oil spreads out as far as it can until the patch is 1 molecule thick. Dividing the volume of the oil drop by the area of the patch will give a value for the length of a molecule. The olive oil molecule is known to have a length equal to 12 atom diameters. The value for the length of the molecule divided by 12 will give a reasonable estimate for the size of an atom.**

**END OF ARTICLE**