Uncertainties Homework

1. A car accelerates uniformly from rest from a point A and is timed over the distance AB as shown in Figure 1.

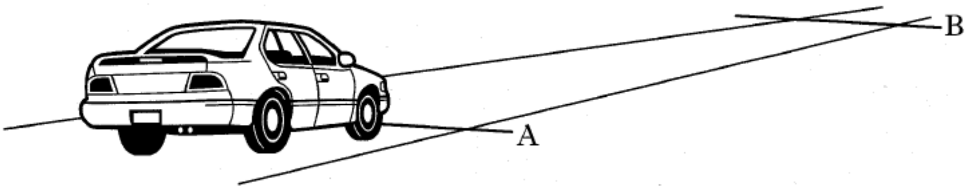

Figure 1

The results are as follows:

distance travelled, AB = (100 ± 1) m

time taken = (8·0 ± 0·4) s.

(*a*) Calculate:

(i) the acceleration of the car;

(ii) the percentage uncertainty in the acceleration.

8. (*a*) A student investigating the force on a current-carrying conductor placed perpendicularly to a uniform magnetic field obtains the following readings.

Length of conductor	= (0·050 ± 0·001) m				
Current	= (2·50 ± 0·01) A				
Force readings	3·8 mN	3·4 mN	3·3 mN	3·7 mN	3·3 mN

(i) Calculate the magnetic induction B, in Tesla, using the equation $F = BIl$.

(ii) Calculate the **absolute** uncertainty in this value.

(iii) Suggest **one** improvement that would reduce the uncertainty in the value obtained for the magnetic induction. **Justify your answer**.

Graphical Analysis Homework

1. A student constructs a simple air-insulated capacitor using two parallel metal plates, each of area A, separated by a distance d. The plates are separated using small insulating spacers as shown in Figure 15A.

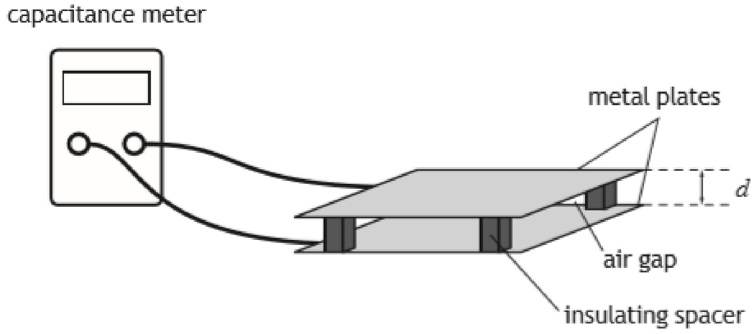

Figure 15A

The capacitance C of the capacitor is given by

$$C = \varepsilon_0 \frac{A}{d}$$

The student investigates how the capacitance depends on the separation of the plates. The student uses a capacitance meter to measure the capacitance for different plate separations. The plate separation is measured using a ruler.

The results are used to plot the graph shown in Figure 15B.

The area of each metal plate is $9{\cdot}0 \times 10^{-2}\ \text{m}^2$.

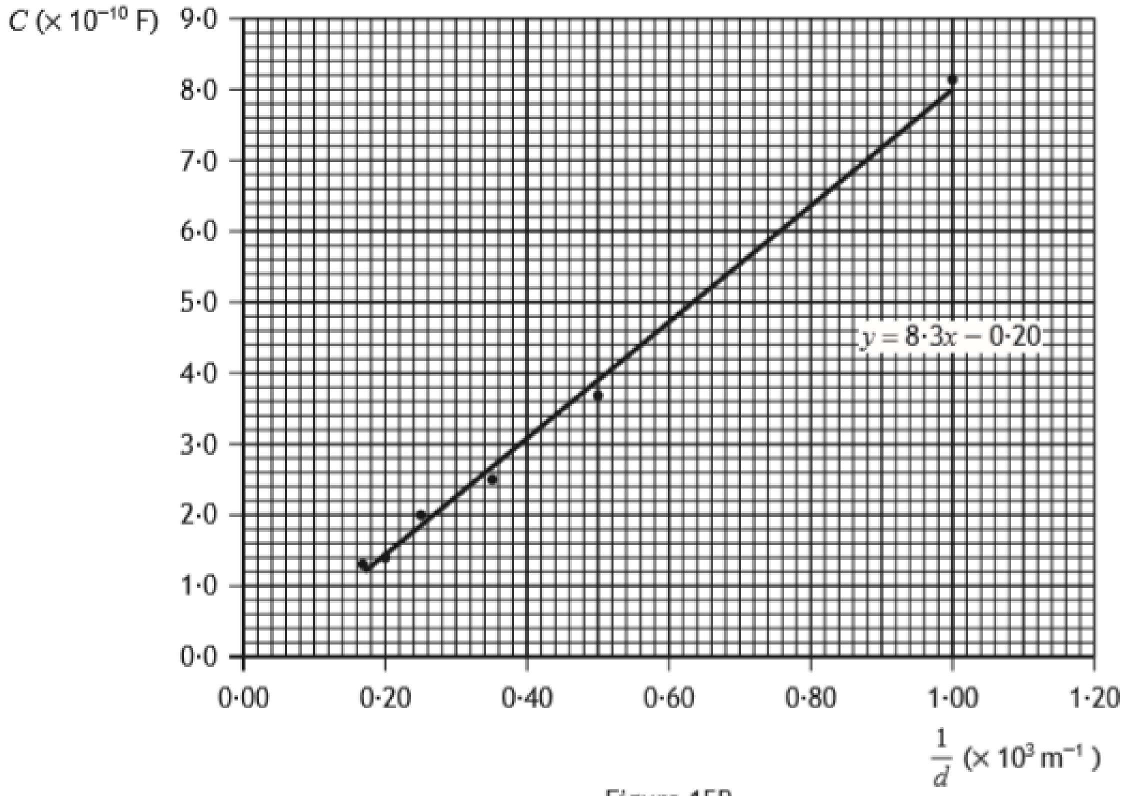

Figure 15B

1. **(continued)**

(a) Use information from the graph to determine a value for ε_o, the permittivity of free space. **3**

(b) The best fit line on the graph does not pass through the origin as theory predicts.

Suggest a reason for this. **1**

2. A student carries out an experiment to determine Young's modulus for a wire. The experimental set up is shown in Figure 19.

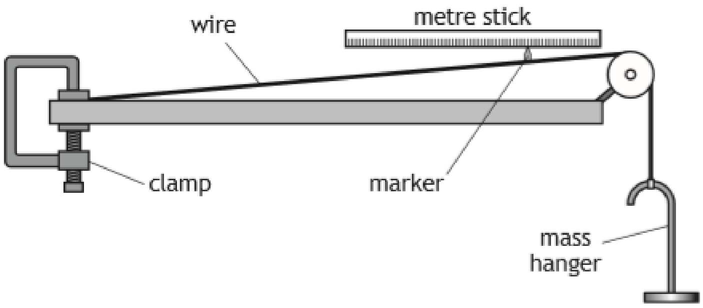

Figure 19

Young's modulus E can be determined by applying the formula

$$E = \frac{FL_0}{A_0 \Delta L}.$$

Where

F = forces applied
L_0 = distance from clamp to marker
ΔL = length of extension wire
A_0 = original cross-sectional area of wire

The student attaches a mass hanger to the wire and fixes a marker on the wire at a distance of 2·00 m from the clamp. Masses are added to the hanger and the extension of the wire is measured by noting the distance moved by the marker along the metre stick.

The masses are removed and the experiment repeated.

The length of the wire is measured using a tape measure.
The diameter of the wire is measured using a micrometer.

An extract from the student's workbook is shown.

Uncertainties: Combined scale and calibration

tape measure	± 5 mm
metre stick	± 1 mm
balance	± 0·1 kg
micrometer	± 0·01 mm

2. (continued)

mass (kg)	*force* (N)	*wire extension* (mm)			E ($\times 10^9$ N m^{-2})
		1	2	mean	
0·8	7·84	3	3	3	69
1·2	11·76	4	5	4·5	69
1·6	15·68	5	5	5	83
2·0	19·6	7	7	7	74
2·4	23·52	8	9	8·5	73

wire diameter = 0·31 mm area = $7·6 \times 10^{-8}$ m^2
distance from clamp to marker = 2·00 m

conclusion — the mean value of E is 74×10^9 N m^{-2}.

(a) The student realises that calculating the mean for the individual measurements of E is an inappropriate method for estimating Young's modulus for the wire.

On square ruled paper* draw a graph the student could use to determine a value for Young's modulus for the wire. 3

(b) Use information from your graph to determine a value for Young's modulus for the wire.

The uncertainty in your value is *not* required. 3

(6)

*graph paper is attached which you can print OR use any you have available. If you have no graph paper, sketch the graph as best you can.