HCI P4

Suggested Mark Schemes and Markers' Comments

Qn 1 Mark Scheme and Markers' Comments

Question	Answer	Marks
1 (a) (i)	**PDO** Repeat measurements of x and find average. **MMO** Value of x to the appropriate precision (i.e. 2 d.p. in cm) with unit.	1 1
1 (a) (ii)	**ACE** Percentage uncertainty in x calculated correctly using sensible value of Δx (absolute uncertainty of x) (accepted range of Δx is 0.5 mm to 2.0 mm) to indicate unevenness of surface rather than precision of vernier caliper.	1
1 (b) (i)	**MMO** Value of d to the nearest 0.1 mm with unit. (accepted range of small hole is between 0.50 cm and 0.80 cm)	1
1 (b) (ii)	**ACE** Calculation of A in suitable units with same or one more significant figure than d.	1
1 (c) (v)	**ACE** Estimation of m using ratio of x values and 100 g with unit.	1
1 (d)	**ACE** Correct calculation of time taken for 5 g with unit.	1
1 (e)	**MMO** Measurement of d for big hole. (accepted range of big hole is between 0.70 cm and 1.00 cm) **ACE** Calculation of A. **PDO** Values of d to appropriate precision and A to appropriate number of significant figures with units. **PDO** Flow rate R with appropriate units, e.g. g s^{-1}. **ACE** Determination of constant of proportionality. (i.e $k = R / A$) **ACE** Draw conclusion based on stated criterion e.g. not obeyed because more than 20% difference in values of k.	6
1 (f)	**ACE** Investigate flow of pepper with hole size. Use smaller holes. Investigate flow of pepper with number of holes. Use more than one hole of this size.	2
	Total	15

Qn 2 Mark Scheme and Markers' Comments

Question	Answer	Marks
2 (a) (ii)	**MMO** Value of y_0 to the appropriate precision with unit.	1
2 (a) (vi)	**ACE** Calculation of $(y - y_0)$ in suitable units to an appropriate decimal place (maintain same d.p. as y_0 and y).	1
2 (a) (vii)	**ACE** Percentage uncertainty in $(y - y_0)$ calculated correctly using sensible value of $\Delta(y - y_0)$ (absolute uncertainty of $y - y_0$). (accepted range of $\Delta(y - y_0)$ is 2 mm to 6 mm)	1
2 (c) (i)	**MMO** y_0 and y for both masses on Ruler A **ACE** Calculation of $(y - y_0)$ and percentage change of $(y-y_0)$. **PDO** Values of y_0 to appropriate precision and $(y - y_0)$ to appropriate number of decimal places with units.	2
2 (c) (ii)	**ACE** Draw conclusion based on comparison of the percentage change and percentage uncertainty.	1
2 (d) (i)	**ACE** Relevant points (with appropriate elaboration) might include: • difficulty in judging whether metre rule B, that is clamped, is vertical • uncertainty in reading y and y_0 due to the thickness of rule or parallax error as rule B is a small distance from rule A.	1
2 (d) (ii)	**ACE** Relevant points (with appropriate elaboration) might include: • use spirit level to check that metre rule B is vertical. • attach needle as a pointer at the end of rule A.	1
	Total	8

Qn 3 Mark Scheme and Markers' Comments

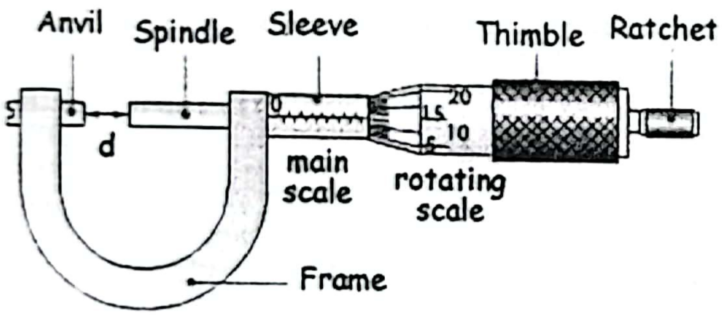
Measurements

3 (a) (i)

Value for d in the range 0.17 mm ≤ d ≤ 0.21 mm, with unit.

Accept: 0.00019 m, 0.019 cm

Reject: 0.190 mm



3 (c) (ii)

Value for V_1 range 0.300 V ≤ V_1 ≤ 0.600 V

Value for V_2 range 0.200 V ≤ V_2 ≤ 0.400 V

V_1 larger than V_2 by 0.1 V

Tabulation

3 (d)

Data (2 marks)

Deduct 1 mark if only 5 sets tabulated.

Deduct 2 mark if 4 or less sets tabulated.

Deduct 1 mark per column of nonsensical data collected.

Deduct 1 marks if minor assistance rendered.

Deduct 2 marks if major assistance rendered.

Heading (1 mark)

Units must be presented.

Penalise broken table

Range of IV (1 mark)

$\Delta l \geq 25$ cm.

Decimal Place (1 mark)

l to nearest 1 mm

V_1 and V_2 to the nearest 0.001 V.

Significant Figure (1 mark)

V_1/V_2, the number of s.f. should be correct.

Calculation (1 mark)

All V_1/V_2 calculated correctly.

Penalise rounding off error.

Graph

3 (e)

Scale
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.
Scales must be chosen so that plotted points occupy at least half the graph grid in both *x* and *y* directions.
Axes must be labelled (with units if any).

Plots
All observations must be plotted to an accuracy of half a small square or less.
Penalise student who used x to mark a grad point.

BFL
There must be a fair scatter of points either side of the line.
Penalise student who identified anomalous point(s) wrongly.
Student must have at least 5 non-anomalous data points to be awarded the BFL mark.
The data points show no trend at all, the BFL mark is forfeited.

Linearising equation

Gradient – the hypotenuse must be greater than half the length of the drawn line. Read-offs must be accurate to within half a small square.

y-intercept is calculated from $y = mx + c$ using a point on the line.
Or
y-intercept must be read off to the nearest half small square accuracy

P and Q
Values of *P* and *Q* calculated correctly with units.

Analysis

3 (f)
There is no anomalous data as no data point deviates substantially from the linear trend set by the other data points. All data points are closely and evenly scattered about the best fit line.
Or
(X,Y) is a anomalous point because it deviates significantly from the linear trend set by the other data points.

3 (g) Working (substitution) must be presented.
ρ in range 3×10^{-7} to $7\times10^{-7}\,\Omega$ m. (4.9×10^{-7} is the theoretical answer)

3 (h) (i) Sources of errors
Uncertainty in determining the position of L and M | Uncertainty in measurement of / because of considerable thickness of crocodile clips.

3 (h) (ii) Improvements
1. replace the crocodile clips with jockeys

Qn 4 Mark Scheme and Markers' Comments

	Marks	Marking Points
Diagram	3	• Strain gauge stuck in correct orientation to cylinder (can be credited in procedure) • Cylinder with mass on top and resting on platform/table-top and not floating • Electrical circuit correctly drawn.
Variables	4	V1. How to vary compression 10 times (load different masses) V2. How to measure the mass and calculate force ($\Delta F = mg$) (or use force meter) V3. How to measure resistance V4. How to measure ΔR (before and after loading)
Analysis	1	A1. What graph to plot and how to obtain n
Reliability	3	Any good further design details, some of these might be: R1, R2 and R3 • Control! Keep temperature constant, monitor with a thermometer • Preliminary experiments to determine suitable range of masses to obtain observable/meaningful results • Way to apply compressive force uniformly over the cross-section of cylinder • Repeat measurement of mass/ resistance and take average to reduce random error. • After each unloading, check that the resistance value returns to the original value, otherwise some permanent deformation might have taken place and the load might have been excessive for the experiment
Safety	1	Any relevant safety precaution S1 e.g.: • Wear goggles in case concrete cracks • Reasonable measure to prevent cylinder/ heavy masses from toppling • Wear gloves to prevent getting burnt by hot wires (for those using power source)
Total	12	

Analysing the Question

Back ground Info

4 Concrete is widely used for construction and its manufacture contributes 5% to the world's carbon dioxide (CO_2) production. One way of reducing the amount of CO_2 produced could be to use less cement in the production of concrete.

A company is producing concrete with low cement content and wishes to see how the material behaves under a compressive force. A compressive force applied to a concrete object will reduce the length of the object in the direction of the force very slightly.

The reduction in length of the object is to be measured using a strain gauge.

When a wire has its length changed, its resistance changes. A strain gauge cons… wire as shown in Fig. 4.1.

Intro to new instrument. Read carefully!

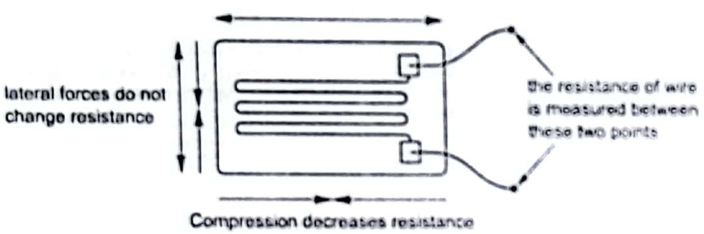


Fig. 4.1

The gauge consists of a wire wound backwards and forwards and embedded in thin plastic. The plastic is then bonded firmly to the specimen being investigated.

The relation between change in resistance ΔR and change in force ΔF is ← **Need to define ΔR and ΔF**

$$\Delta R = k(\Delta F)^n$$ ← **Relation given, no need to hypothesize**

where k and n are constants.

You are provided with some heavy masses, a low voltage power supply and other equipment usually found in a Physics laboratory. **Can't assume normal slotted mass!** **Safe, won't get electrocuted!**

Design an experiment to determine the value of n for compressive forces applied to a small concrete cylinder along its axis. **TASK OBJECTIVE!!**

You should draw a labelled diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment you would use,

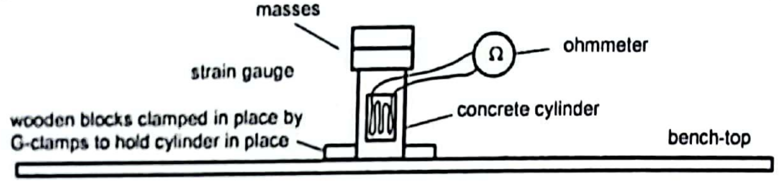
(b) the procedure to be followed,

(c) how the compressive force and change in resistance are measured. **Important hints!**

(d) the control of variables,

(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram



1. Set up the apparatus as shown. Adhere the strain gauge to the cylinder using in the orientation shown.
2. Conduct the experiment in a temperature controlled room. Monitor temperature with a thermometer.
3. Before loading the cylinder, measure the resistance R_1 using an ohmmeter.
4. Load the cylinder evenly across its cross section by placing the mass centrally on the cylinder.
5. Calculate the compressive force using $\Delta F = mg$, where m is measured with an electronic mass balance.
6. Measure the new resistance R_2, and calculate $\Delta R = R_2 - R_1$
7. **Repeat steps 3 to 6 until a total of 10 sets of data have been collected.**
8. $\Delta R = k(\Delta F)^n$
   $\lg \Delta R = \lg k + n \lg(\Delta F)$

   Plot lg ΔF against lg ΔR to obtain a straight line and determine the gradient of the line which is the numerical value for n.

Additional details
1. Conduct preliminary experiments to determine suitable range of masses to obtain observable differences.
2. After each unloading, check that the resistance returns to its original value. Otherwise the load might have been too much, and has caused permanent deformation.
3. Repeat for each load, average the readings to check for reproducibility/reduce random error.

Safety
1. Wear safety goggles to protect eyes in case concrete cracks and fragments flies off as projectiles.
2. Wedge the cylinder tightly on opposite sides using G-clamps to secure it and prevent possible toppling.

Alternative setup
*Find resistance using $R = V/I$