EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2021
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CIVICS GROUP	2 0 -
REGISTRATION NUMBER	

PHYSICS

Paper 4 Practical

9749/04

26 August 2021

2 hours 30 minutes

Candidates answer on the Question Paper.
Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	12
2	10
3	21
4	12
Total	55

This document consists of **18** printed pages and **2** blank pages.

BLANK PAGE

1 In this experiment, you will **investigate** the motion of an interrupted pendulum.

(a) Set up the apparatus as shown in Fig. 1.1.

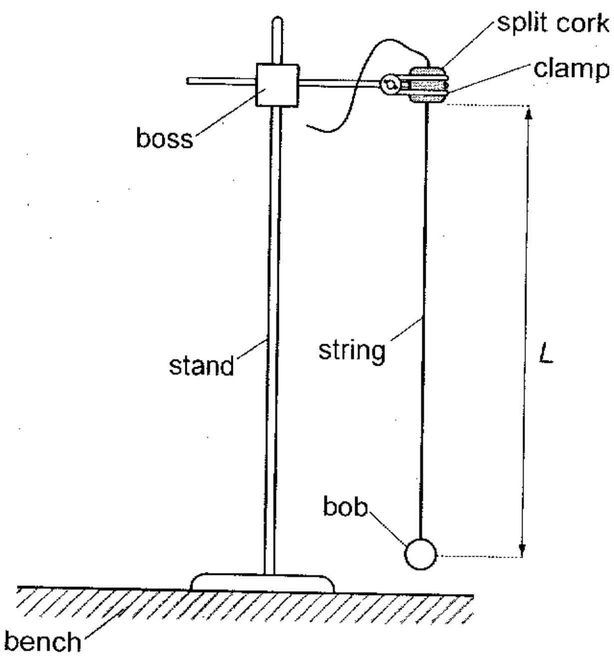


Fig. 1.1

Adjust the string in the split cork so that the distance L between the bottom of the split cork and the centre of the bob is approximately 55 cm.

Measure and record L.

L = ...

Calculate $\frac{L}{2}$.

$\frac{L}{2}$ = ...

[1]

(b) (i) Attach the other boss and clamp and the wooden rod to the stand as shown in Fig. 1.2.

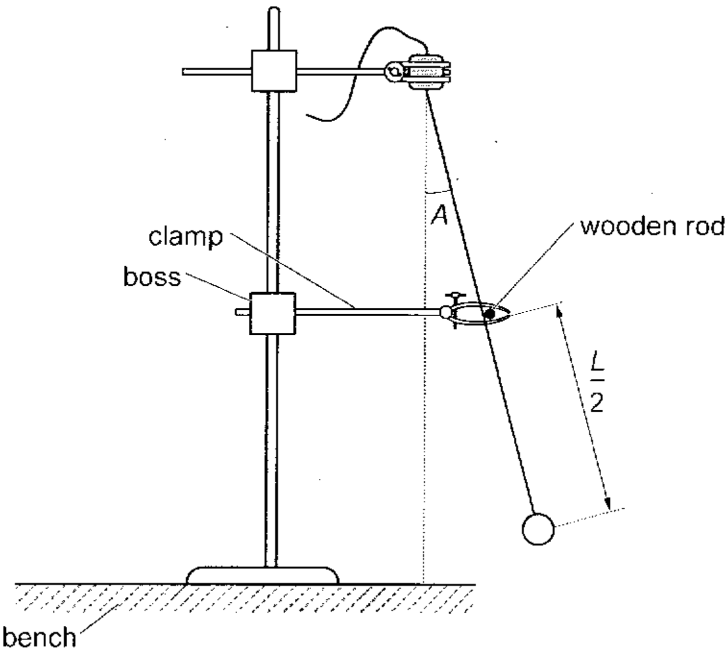


Fig. 1.2

Adjust the position of the wooden rod so that, when the string is touching the rod, the angle A between the vertical and the string is approximately 14°, as shown in Fig. 1.2.

Without changing the length of the pendulum, ensure the distance between the wooden rod and the centre of the bob is $\frac{L}{2}$.

Measure and record angle A.

A = ... [1]

(ii) Estimate the percentage uncertainty in your value of A.

percentage uncertainty = ... [1]

(c) (i) Pull the bob away from the wooden rod so that the angle between the string and the vertical is 45°, as shown in Fig. 1.3.

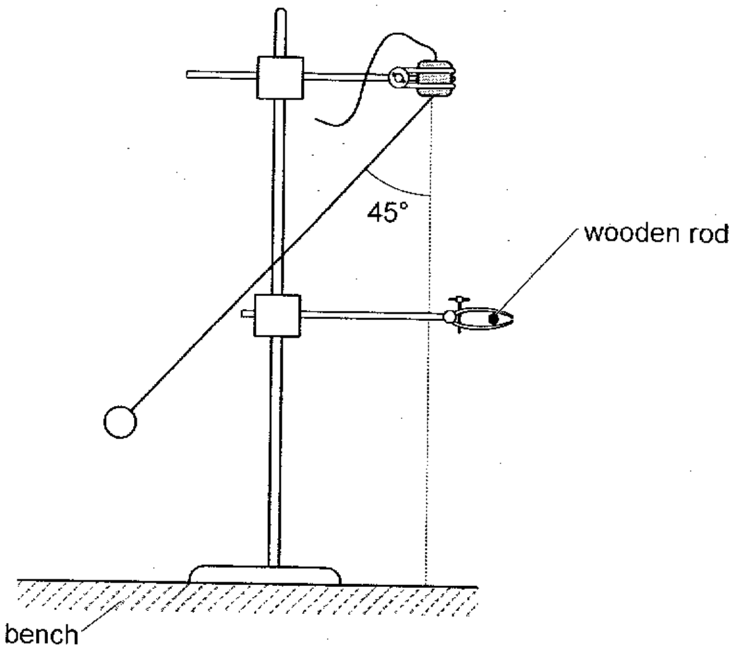


Fig. 1.3

Release the bob. The bob will oscillate and hit the wooden rod.

Determine the period T of these oscillations.

T = ... [2]

(ii) Calculate d where

$$d = \frac{\sin A}{\sin 45^\circ}.$$

d = ... [1]

(d) Move the position of the wooden rod so that angle A is approximately 28°.

Without changing the length of the pendulum, ensure the distance between the wooden rod and the centre of the bob is $\frac{L}{2}$.

Measure and record angle *A* and repeat **(c)(i)** and **(c)(ii)**.

A = ...

T = ...

d = ...

[3]

(e) It is suggested that the relationship between *T* and *d* is

$$T = k\,(d + 1.707)$$

where *k* is a constant.

(i) Using your data, calculate two values of *k*.

first value of *k* = ...

second value of *k* = ...

[1]

(ii) Justify the number of significant figures given in your values of k by comparing with the significant figures of T and $(d + 1.707)$.

....

....

.... [1]

(iii) Explain whether your results support the suggested relationship.

Justify your conclusion by referring to your answer in **(b)(ii)**.

....

....

.... [1]

[Total: 12]

2 In this experiment, you will investigate the forces on an irregularly shaped object.

(a) Position the wooden strip on the pivot as shown in Fig. 2.1 so that it is balanced.

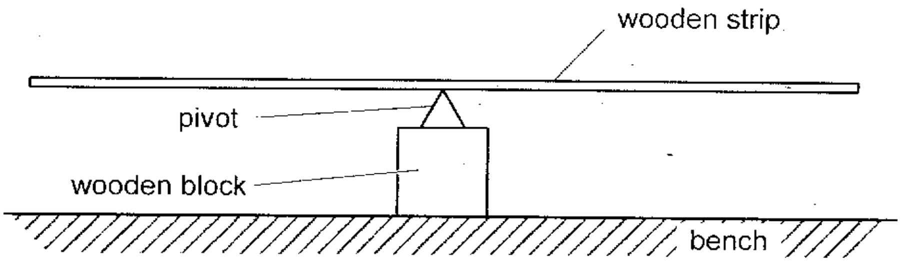


Fig. 2.1

Place the beaker under the wooden strip.
Hang the metal bob inside the beaker at a distance of 30.0 cm from the pivot, then balance the strip by placing the mass on the other side of the pivot, as shown in Fig. 2.2.

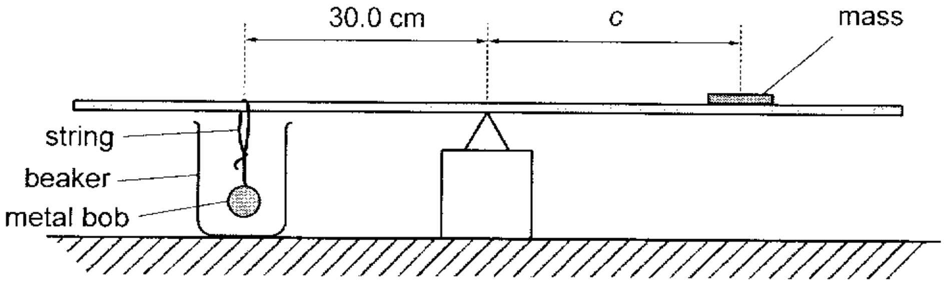


Fig. 2.2

The distance between the centre of the mass and the pivot is c.

Measure and record c.

c = ... [1]

(b) Pour water into the beaker until the metal bob is completely immersed.

Balance the strip by moving the position of the mass, as shown in Fig. 2.3.

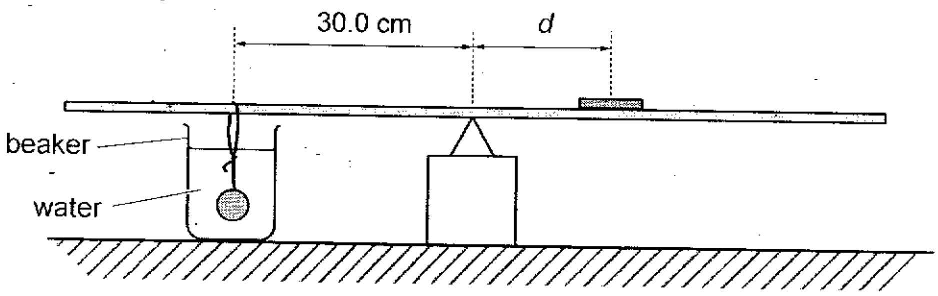


Fig. 2.3

Ensure that the metal bob is completely immersed and is not touching the bottom of the beaker.

The distance between the centre of the mass and the pivot is d.

Measure and record d.

d = ... [1]

(c) Estimate the percentage uncertainty in your value of d.

percentage uncertainty = ... [1]

(d) Theory suggest that

$$\frac{\text{density of the metal bob}}{\text{density of water}} = \frac{c}{c-d}.$$

The density of water is 1000 kg m^{-3}.

Calculate the density of the metal bob.

density of the metal bob = ... [2]

(e) **(i)** Suggest a significant source of error in this experiment.

....

....

....

....[1]

(ii) Suggest an improvement that could be made to this experiment to address the error identified in **(e)(i)**. You may suggest the use of other apparatus or a different procedure.

....

....

....

....[1]

(f) The relationship from **(d)** holds not just for water, but also for any liquid whose density is less than that of the metal bob. The modified relationship is

$$\frac{\text{density of the metal bob}}{\text{density of liquid}} = \frac{c}{c-d}.$$

You are provided with a beaker containing a liquid of unknown density that is smaller than the density of the metal bob. The density of the metal bob has already been determined in **(d)**.

Explain how you might use the existing set up to find the density of the given liquid. **You are not allowed to find the density of the given liquid by measuring its volume or mass.**

Your account should include:

- your experimental procedure
- how you determine the density of liquid using a graph

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [3]

[Total: 10]

3 In this experiment, you will investigate the resistance per unit length of a wire.

(a) **(i)** Set up the circuit as shown in Fig. 3.1.

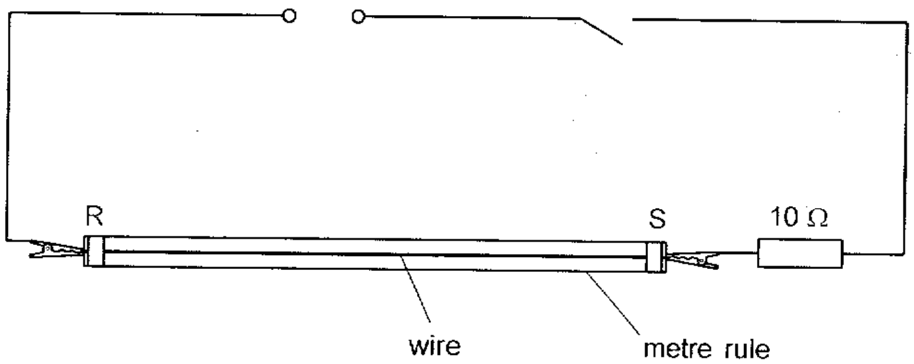


Fig. 3.1

Close the switch.

Measure and record the potential difference V_1 across the wire RS and the potential difference V_2 across the 10 Ω resistor.

Open the switch.

V_1 = ... V [1]

V_2 = ... V [1]

(ii) Use your values from **(a)(i)** to determine the resistance per unit length k_1 of wire RS.

k_1 = ... [2]

(b) **(i)** Assemble the circuit as shown in Fig. 3.2.

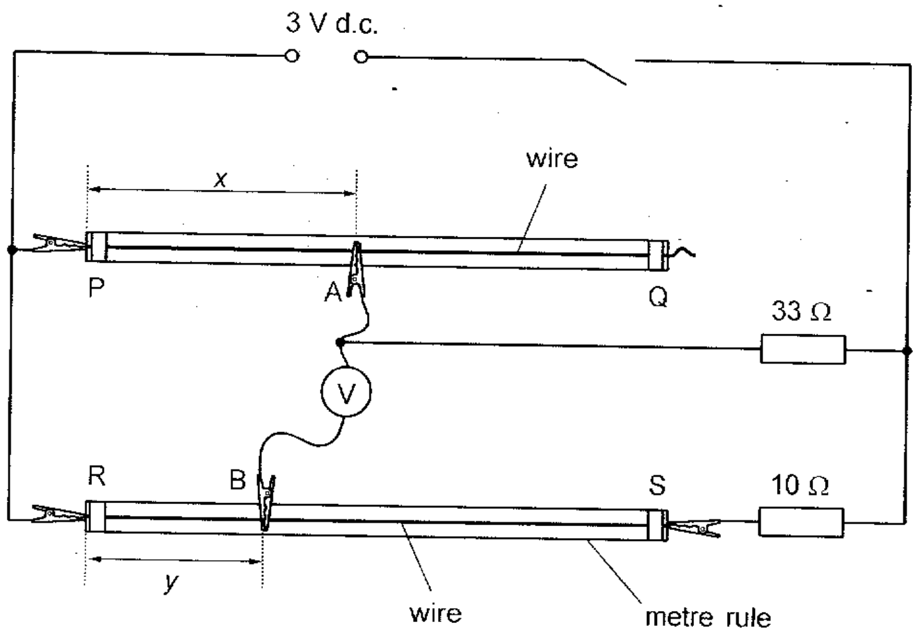


Fig. 3.2

A and B are crocodile clips.

Connect A near the midpoint of PQ.

Measure and record the length x of wire between P and A.

x = ... cm [1]

(ii) Connect B to RS. Close the switch.

Adjust the position of B until the voltmeter reading is as close as possible to zero.

Measure and record the length y of wire between R and B. Open the switch.

y = ... cm [1]

(iii) Estimate the percentage uncertainty in your value of y.

percentage uncertainty = ... [1]

(c) Change x and repeat **(b)(i)** and **(b)(ii)** until you have a suitable range of values of x and y.

Present your results clearly.

[5]

(d) The quantities x and y are related by the equation

$$\frac{1}{y} = \frac{a}{x} + b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

a = ...

b = ...

[6]

(e) Sketch a line on your graph grid to show the results you would expect if the experiment was repeated with the 33 Ω and 10 Ω resistors interchanged.

Label this line Z. [1]

(f) **(i)** Theory suggests that

$$\frac{a}{b} = \frac{33}{k_2}$$

where k_2 is the resistance per unit length of wire RS, and the constant 33 has a unit of Ω.

Calculate k_2.

k_2 = ... [1]

(ii) State whether your results for the resistance per unit length of wire RS in **(f)(i)** and **(a)(ii)** agree with each other.

Justify your conclusion by referring to your answer in **(b)(iii)**.

....

....

.... [1]

[Total: 21]

BLANK PAGE

4 The core of a particular type of nuclear reactor is cooled by pumping liquid sodium around the reactor using a magnetic pump. The principle of operation of this type of pump is based on the force experienced by the liquid when it carries a large direct current in a strong magnetic field. The direction of the force on the liquid can be found using Fleming's left hand rule.

The magnetic field is provided by two large current-carrying coils placed above and below the pipe. The electric current, magnetic field and the direction of flow of the liquid are all mutually perpendicular as shown in Fig. 4.1.

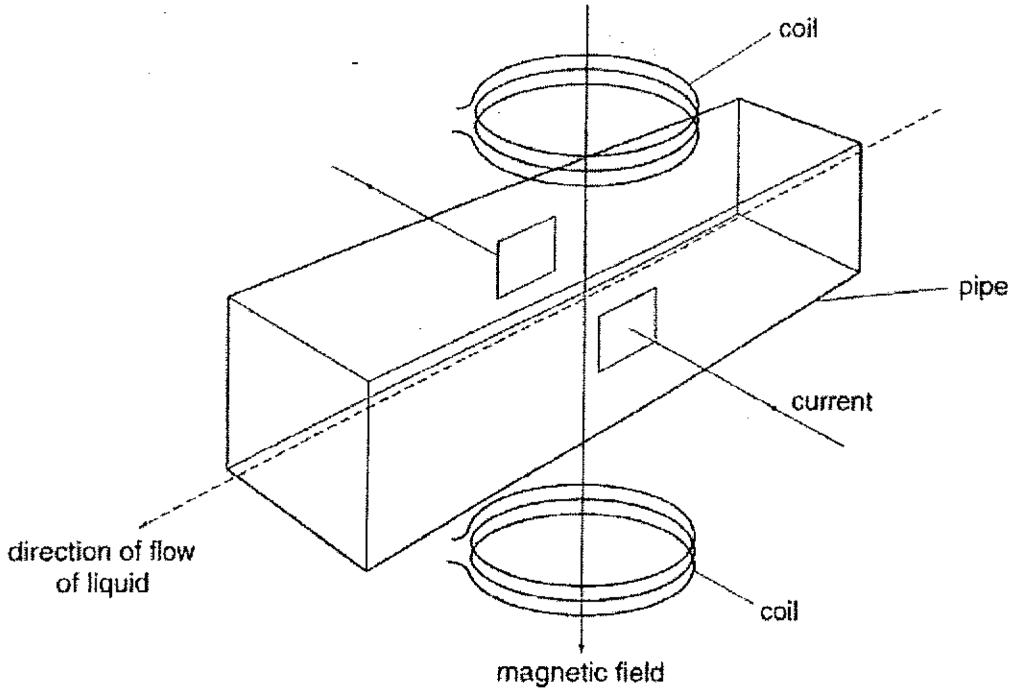


Fig 4.1

The volume flow rate R of a concentrated salt solution carrying a direct current I and flowing in a magnetic flux density B is given by the equation

$$R = kB^p I^q$$

where k, p and q are constants.

Design an experiment to determine the values of p and q.

In your account you should pay particular attention to the following:

(a) the equipment you would use
(b) the procedure to be followed
(c) how the magnetic flux density and volume flow rate are measured
(d) the control of variables
(e) any important precautions you would take which may improve the accuracy of your experiment.

Diagram

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

[12]

[Total: 12]

eunoia JUNIOR COLLEGE

2021 J2 H2 Prelim P4 Mark Scheme

Experiment 1

Question	Marking Instructions	Mark
(a)	• Repeated readings for *L*. • 50.0 cm ≤ *L* ≤ 60.0 cm • *L* recorded to correct precision (0.1 cm) and unit. • Correct calculation, s.f. and unit for *L*/2.	1
(b)(i)	• *A* is recorded to correct precision (1°) • Evidence of repeated readings and averaging for *A*. • 11° ≤ *A* ≤ 17°	1
(b)(ii)	• Successful calculation of percentage uncertainty of *A* to 2 s.f. using 2° ≤ ΔA ≤ 5° • If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown, including formula to find absolute uncertainty (1/2)(max – min).	1
(c)(i)	• Evidence of repeated measurements of *t* • *t* (>15s) is recorded with the correct precision (2 d.p.) and unit.	1
	• *Average t calculated to correct d.p.* • *T* is calculated correctly and given to the correct s.f. and unit. • 1.200 s ≤ *T* ≤ 1.600 s	1
(c)(ii)	• Correct calculation and sf of *d* with no unit.	1
(d)	• *A* is recorded to correct precision and unit (1°) • Evidence of repeated readings and averaging for *A*.	1
	• Evidence of repeated measurements of *t* and average calculated. • *t* (>15s) is recorded with the correct precision (2 d.p.) and unit. • *T* is calculated correctly and given to the correct s.f. and unit. • second value of *T* > first value of *T*	1
	• Correct calculation of *d* with no unit.	1
(e)(i)	• Correct calculation of k_1 and k_2 to 3 s.f. (or follow least s.f. of k and (d + 1.707)) with correct units.	1
(e)(ii)	• *k* follows the least s.f. of *T* and (*d* + 1.707). • Since *T* has ... sf and (*d*+1.707) has ...... sf, *k* has ..... sf.	1
(e)(iii)	• Compared percentage difference between k_1 and k_2 with the percentage uncertainty in **(b)(ii)** to support conclusion. • Conclusion depends on candidate's experimental results.	1

Total: 12 marks

Experiment 2

Question	Marking Instructions	Mark
(a)	• Repeated readings for *c*. • 15.0 cm ≤ *c* ≤ 25.0 cm • *c* recorded to correct precision (0.1 cm) and unit.	1
(b)	• Repeated readings for *d*. • *d* < *c* • *d* recorded to correct precision (0.1 cm) and unit.	1
(c)	• Successful calculation of percentage uncertainty of *d* to 2 s.f. using 2 mm ≤ Δ*d* ≤ 10 mm • If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown.	1

(d)	• Correct calculation of ρ_{bob} to correct s.f. with correct unit.
	    ○ Acceptable s.f.
	        ▪ Follow least term with least s.f. (or add one more)
	        ▪ correct use of rule: follow d.p. then s.f.
	        ▪ 3 sf (complex case)
		1

	• 6000 kg m^{-3} ≤ ρ_{bob} ≤ 11 000 kg m^{-3}	1
(e)(i)	Relevant point(s) might include: 1) One reading is not enough to draw a (valid) conclusion (not "not enough for accurate results", "few readings"). 2) Difficult to balance strip/prism moves/strip slips/strip slides/strip moves on prism. This affects the measurement of *c* and *d*. 3) Difficult to measure *c* or *d* with reason e.g. difficult to locate centre of (the) mass/parallax error. 4) Difficult to set/measure the position of the pendulum because of thick string. • Source of error must be significant. Clearly described on why and how it arises, and which variable that is being measured would be affected.	1
(e)(ii)	Relevant point(s) might include: 1) Take more readings and plot a graph or take more readings and find average of results. 2) Improved method of balancing strip e.g. groove under strip/flatten top of prism/method of fixing prism or wooden block. 3) Improved method of measuring *c* or *d* e.g. scale markings on strip/suspend mass under strip/ mass of uniform shape 4) Use thin(ner) string (allow 'thin(ner) string' only once in total). • Feasible improvement to address the sources of error stated in (e)(i). Improvement is clearly elaborated with details.	1

Question	Marking Instructions	Mark
(f)	• method to measure independent or dependent variables together with instruments used - Mark for use of ruler • mention what quantity to vary and how to vary	1
	Control of Variables: depending on what quantities are used as variables • Keep "30 cm" constant using ruler to check OR keep mass constant (by using the same slotted mass or method to check),	1
	• Linearising equation shown • Mention of plotting ……. against ……. • Mention of how density can be found from graph - Density must be made the subject if equation is used.	1

Total: 10 marks

Experiment 3

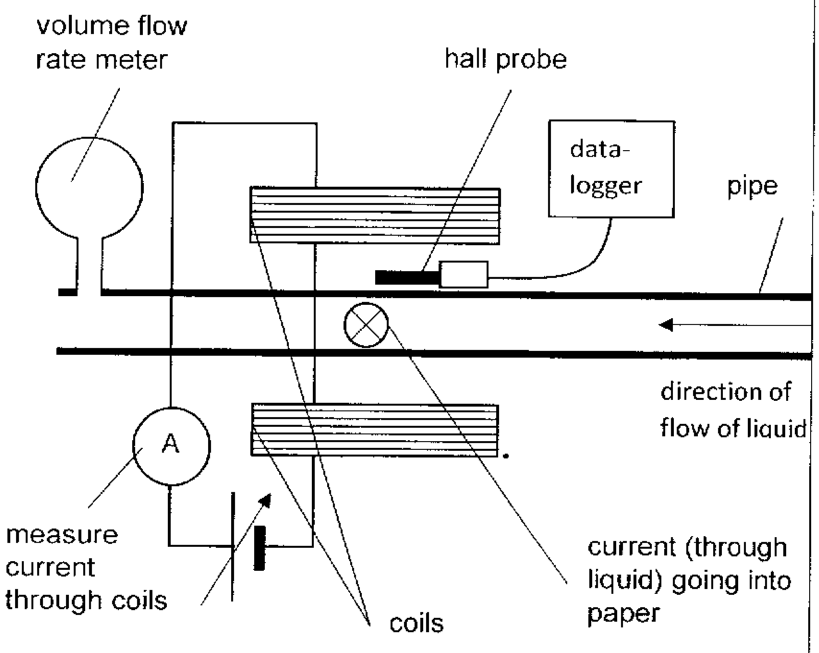
Question	Marking Instructions	Mark
(a)(i)	• Repeated readings for V_1 and V_2.	1
	• V_1 and V_2 recorded to correct precision (0.01 V)	1
(a)(ii)	• Correct calculation for resistance of wire RS. • If total p.d. across resistors is used, must be the addition of V_1 and V_2.	1
	• Correct s.f. and unit for k_1. • Mark for only s.f. and unit • Must show the length used to the correct precision and unit.	1
(b)(i)	• Repeated readings for x. • $45.0 \text{ cm} \leq x \leq 55.0 \text{ cm}$ • x recorded to correct precision (0.1 cm).	1
(b)(ii)	• Repeated readings for y. • $y < x$ • y recorded to correct precision (0.1 cm).	1
(b)(iii)	• Successful calculation of percentage uncertainty of y to 2 s.f. using $2 \text{ mm} \leq \Delta y \leq 5 \text{ mm}$ • If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working (formula and calculation) is clearly shown.	1
(c)	• At least 6 sets of readings without assistance: positive trend between x and y.	1
	• Evidence of repeated readings for y.	1
	• Correct table headings with correct units.	1
	• x and y recorded to correct precision (0.1 cm).	1
	• $\langle y \rangle$ calculated to correct d.p. , $\frac{1}{x}$ and $\frac{1}{y}$ to correct s.f.	1
(d)	• Correct linearization with statement clearly presented.	1

Question	Marking Instructions	Mark
	• The hypotenuse of the gradient triangle must be at least half the length of the drawn line. Both read-offs must be accurate to half a small square. • Gradient triangle must be shown and drawn using dotted lines • Gradient coordinates must be shown on graph • All read-offs must be accurate to half a small square (including y-intercept) • Gradient calculated correctly to 3 s.f. (or follow least s.f.) and *a* presented with no unit. • Accept dropping of trailing zeros for read-off	1
	• y-intercept calculated correctly to 3 s.f. and *b* presented with correct units (cm^{-1}). • Accept dropping of trailing zeros for read-off	1
	<u>Graph: Layout</u> • *Scales*: must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. All observations must be plotted. Awkward scales (e.g. 3:10) are not allowed. Accept only 1, 2, 5 only (every 10 small sq) • *Labels*: Scales to be labelled no more than 4 cm apart. • Axes must be labelled with the quantity (and units) which is being plotted.	1
	<u>Plotting of points</u> • All observations must be plotted to an accuracy of half a small square. • Penalize if additional plotted point not shown in table, for e.g. gradient coordinates or points in sketching the new graph marked by x	1
	<u>Graph: Best Fit Line</u> • Judge by balance of trend points about the candidate's line. There must be an even distribution of points either side of the line along the full length. Line must not be kinked. (Allow only one anomaly)	1
(e)	• Line *Z* below existing line in graph. • No marks if label Z is absent.	1
(f)(i)	• Correct calculation, s.f. and unit for k_2.	1
(f)(ii)	• Compared percentage difference between k_1 and k_2 with the percentage uncertainty in **(b)(iii)** to support conclusion. • Denominator should be minimum k value • Conclusion depends on candidate's experimental results.	1

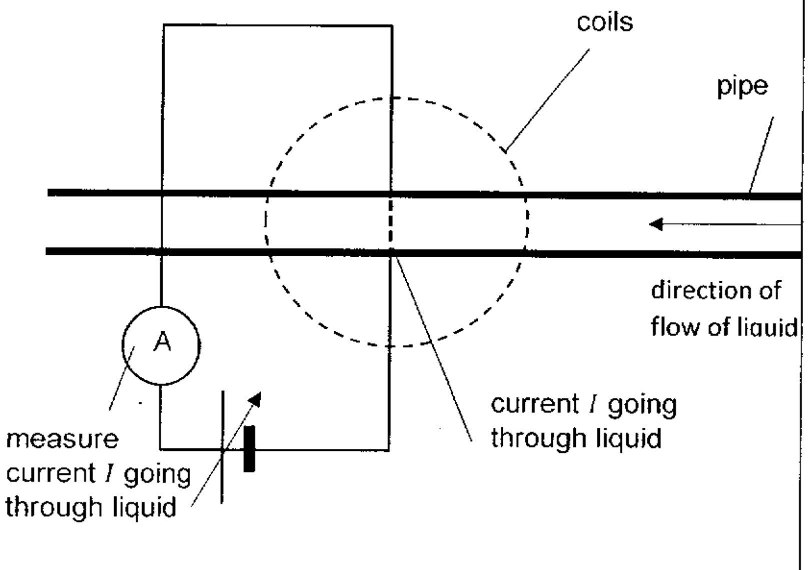
Total: 21 marks

Experiment 4

Section	Description	Marks
Diagram	• Placement: Diagram showing **hall probe** between coils and **volume flow rate meter** on pipe. (Alternatively, gaussmeter/magnetic field sensor connected to a datalogger) • Connection: Coil or Circuit is connected to a variable power supply/power supply connected in series with a rheostat.	1 1



Side view



Top view

Procedure	*Independent Variable* Measure current I using an ammeter (connected in series with the wire and power supply - can be awarded if this is shown clearly in the diagram). Measure magnetic flux density B using a hall probe connected to a datalogger/voltmeter/CRO.	1 1
	Dependent Variable Measure the volume flow rate R of the concentrated salt solution using a volume flow rate meter	1
	Repeat RUN #1 Vary I by adjusting the variable power supply while keeping B constant. RUN#2 Vary B by adjusting the current flowing through the coil by varying the power of the variable power supply connected in series to the coil while keeping I constant.	1 1
Analysis	RUN#1 Plot a graph of $\lg R$ against $\lg I$ q = gradient	1
	RUN #2 Plot a graph of $\lg R$ against $\lg B$ p = gradient	1
Control of Variables	• Keep the (internal) diameter/**volume** of the pipe constant so as to keep the effects of resistive forces from the pipe constant. • Keep the temperature/density/**concentration** of the salt solution constant. • Distance between coil and pipe constant by measuring using metre rule so that flux density is constant.	Any two of these points 2
Additional Details	• Adjust the hall probe until a maximum reading is achieved. Record this as B **OR** Hall probe should be placed at right angles to direction of magnetic field/plane of coil. • Reasoned method to keep Hall probe in constant orientation {e.g. use of set square, fix to rule, optical bench or equivalent) • Repeat each experiment for the same value of B and reverse the current/Hall probe and average • Method to calibrate Hall probe using a known field. • Method to keep concentration of liquid constant. • Close the switch for the circuit with the direct current and wait until the flow rate stabilises before taking the reading. • Choose a suitable range of current to be supplied (either to B-field or through the solution) such that the percentage uncertainty of the reading of the volume flow rate is minimized.	

	• Align the plane of the coils to a set square placed against a vertical plumbline to ensure that the coils are parallel to each other. • Use a set square placed against the pipe and against the wire to ensure that the current is running perpendicular to the flow of the solution. • Place the whole closed pipe of concentrated salt solution on a horizontal surface so that the flow of liquid is solely driven by the current supplied. Check by placing a spirit level along the pipe. • Linearising equation: $\lg R = \lg k + p \lg B + q \lg I$ • Setup away from other magnetic sources to prevent interferfence	
Safety	• Wear thermal-insulating gloves when adjusting coils as they may become hot. • Accept wear insulating/rubber gloves, reason being electric shock • Switch off current to the coil when not in use to prevent overheating.	Any one 1

Total: 12 marks