Anglo-Chinese Junior College
Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **9749/04**
Paper 4 Practical
5 August 2021
2 hours 30 mins

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

READ THESE INSTRUCTIONS FIRST

Write your name and index 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 the appropriate units.

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

Shift
Laboratory

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.

For Examiners' use only	
1	/ 9
2	/ 13
3	/ 21
4	/ 12
Total	/ 55

For Examiner's Use

1 In this experiment, you will investigate the equilibrium of a metre rule.

(a) (i) You have been provided with a metre rule with two springs attached. The distance between one end of the metre rule and the string is L, as shown in Fig. 1.1.

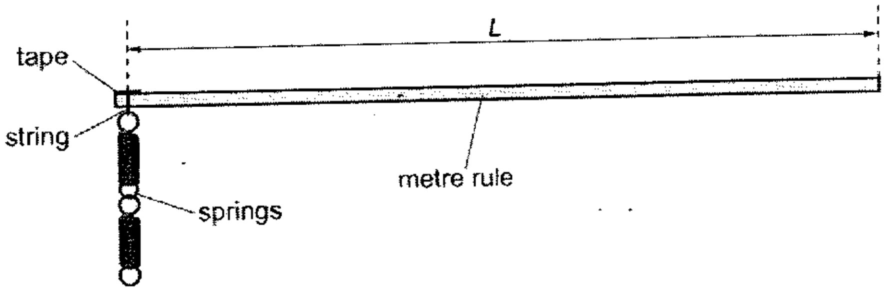

Fig. 1.1

Measure and record L.

L = ... [1]

(ii) Calculate $\frac{L}{n}$ where $n = 3$.

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

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(b) **(i)** Set up the apparatus as shown in Fig. 1.2.

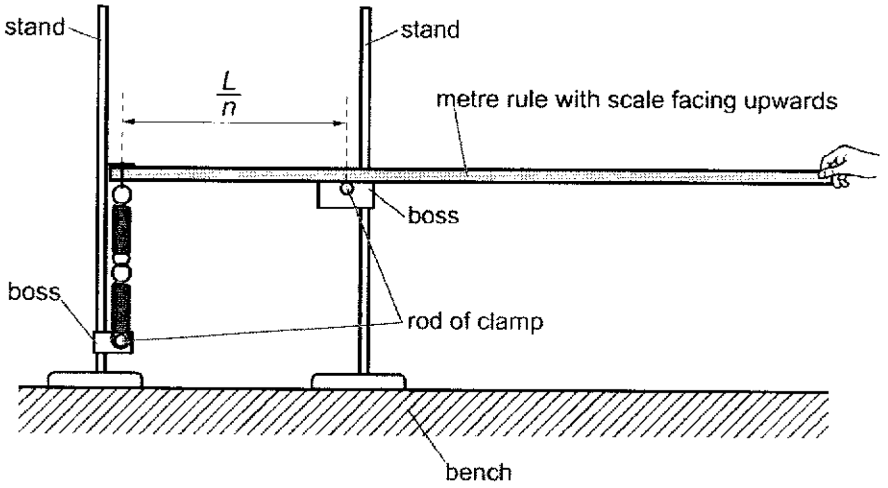

Fig. 1.2

Adjust the apparatus until the horizontal distance between the centres of the rods of the clamps is equal to your value of $\frac{L}{n}$.

Adjust the heights of the bosses so that the rule is horizontal and the springs are vertical and **unstretched** when the rule is held in position.

Gradually release the rule by lowering your hand. The rule will tilt.

The angle between the rule and the horizontal is θ, as shown in Fig. 1.3.

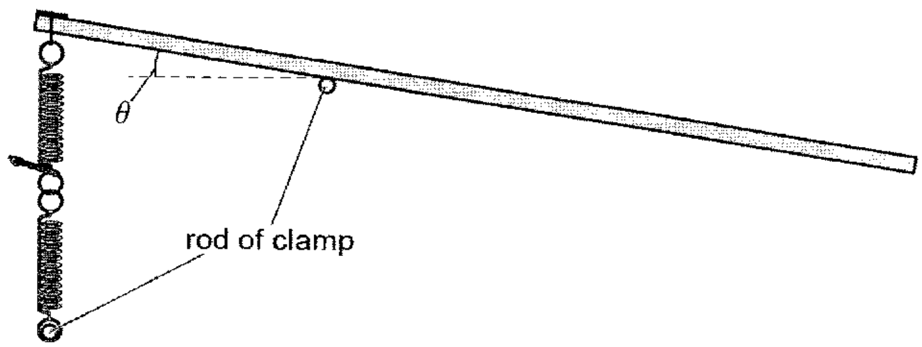

Fig.1.3

Measure and record θ.

θ = ... [1]

[Turn over

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

percentage uncertainty in θ = ... [1]

(c) The quantities θ and n are related by the equation

$$\sin\theta = C\,(0.5\,n^2 - n)$$

where C is a constant.

(i) Calculate C.

C = ... [1]

(ii) If you were to repeat this experiment with increasing values of n, describe the graph that you would plot and how you would determine C.

....

....

....

.... [2]

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(d) Theory suggests that

$$C = \frac{Mg}{kL}$$

where

M is the mass of the metre rule given on the card
k is the spring constant of the spring system
$g = 9.81\ \text{m s}^{-2}$

Use your value of C to determine a value for k.

k = ... N m^{-1} [1]

(e) The actual value of k is $25.0\ \text{N m}^{-1}$.

Comment on the accuracy of your result found in **(d)**.

....

....

.... [2]

[Total: 9]

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For Examiner's Use

2 In this experiment, you will investigate a potential divider circuit.

(a) (i) You have been provided with a wooden strip with some wire connected between two nails. Set up the circuit as shown in Fig. 2.1.

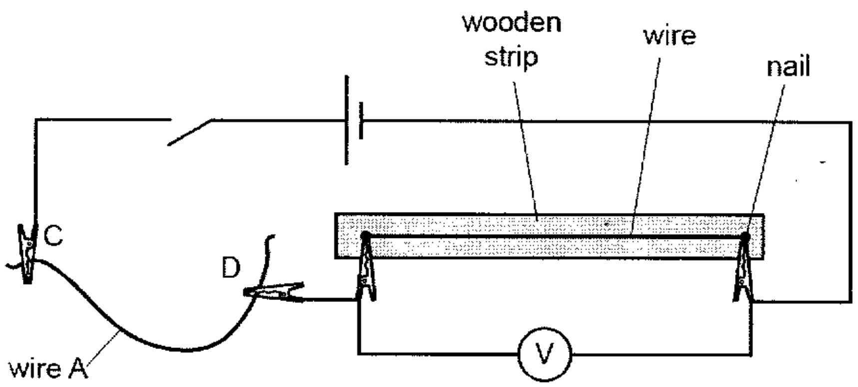

Fig. 2.1

C and D are crocodile clips. Place the clips wire A so that the length x of the wire between C and D is equal to the length of wire between the two nails.

Measure and record x.

x = ... [1]

(ii) Close the switch. Record the voltmeter reading V.

V = ...

[Turn over

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(b) Vary *x* using the same wire A throughout. Repeat **(a)**.

Present your results clearly.

[5]

(c) It is suggested that the relationship between V and x is

$$\frac{1}{V}=\frac{x}{kE}+\frac{1}{E}$$

where k is a constant and E is the electromotive force (e.m.f.) of the cell.

Plot a suitable graph to determine the value for k.

k = ... [6]

(d) Without taking further readings, sketch a line on your graph grid to show the results you would expect if the experiment was repeated with a cell that has a larger e.m.f.

Label this line **W**.

[1]

[Total: 13]

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3 In this experiment, you will investigate the amplitude of oscillations of a mass suspended from a spring.

(a) **(i)** Setup the apparatus as shown in Fig. 3.1.

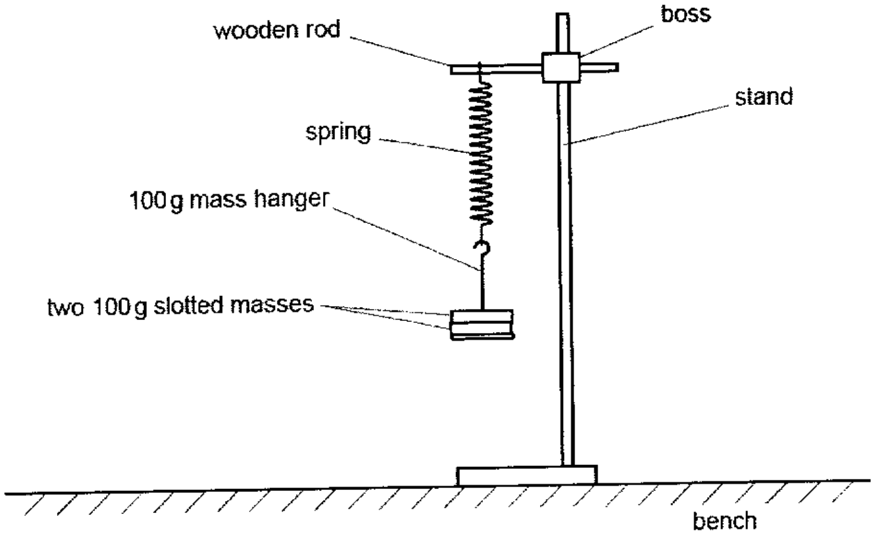

Fig. 3.1

Pull the mass hanger and slotted masses down through a short distance. Release them so that they oscillate vertically.

Measure and determine the period T of the oscillations.

T = ... s [1]

(ii) Calculate the spring constant k using

$$k = \frac{4\pi^2 M}{T^2}$$

where M = 0.300 kg.

k = ... N m^{-1} [1]

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(b) Slide the two 100 g slotted masses to the top of the mass hanger as shown in Fig. 3.2.

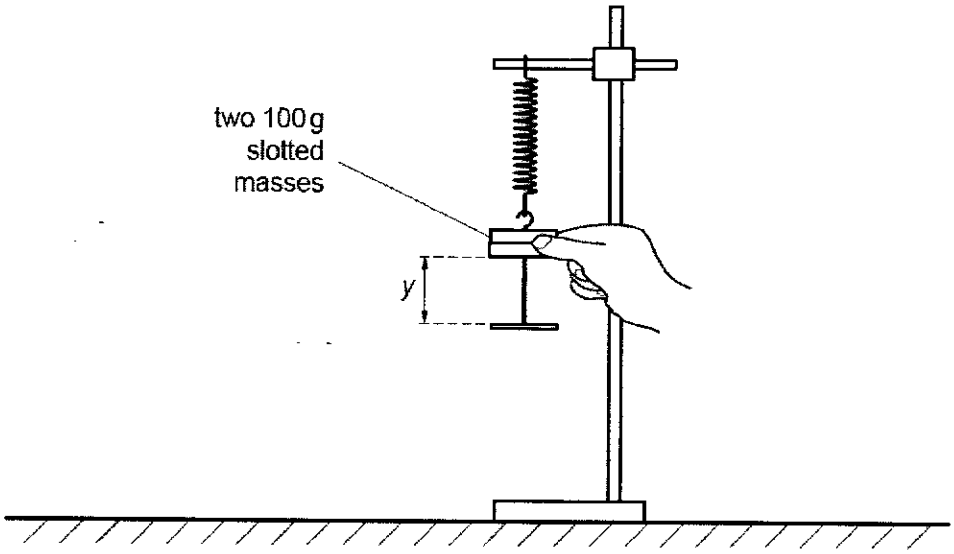

Fig. 3.2

The height of the slotted masses above the base of the mass hanger is *y*, as shown in Fig. 3.2.

Measure and record *y*.

y = ... m [1]

(c) Drop the two 100 g slotted masses. The masses and the mass hanger will oscillate vertically, as shown in Fig. 3.3.

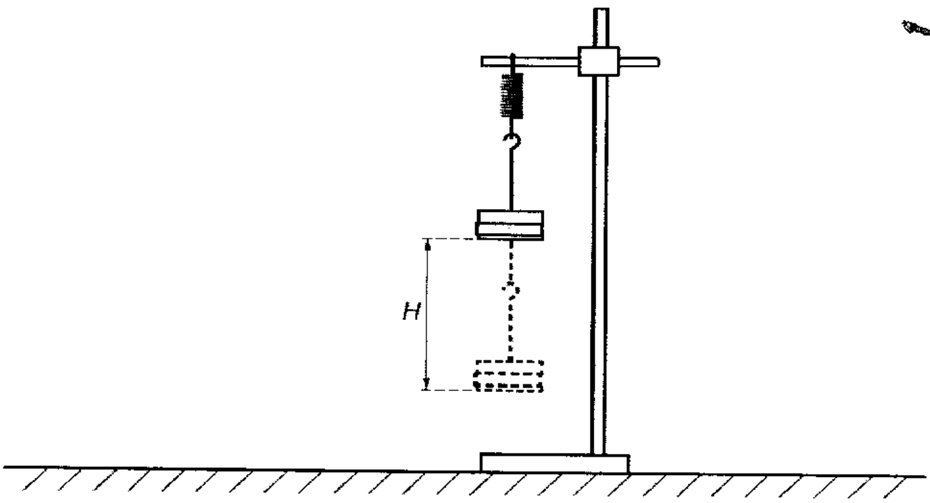

Fig. 3.3

For Examiner's Use

The distance between the lowest and highest positions of the oscillating mass hanger is H, as shown in Fig. 3.3.

Measure and record H.

H = ... m [2]

(d) Estimate the percentage uncertainty in your values of H.

percentage uncertainty in H = ... [1]

(e) Repeat **(b)** and **(c)** but this time sliding the two slotted masses approximately half-way up the mass hanger.

y = ... m

H = ... m
[2]

(f) **(i)** Suggest one significant source of uncertainty in this experiment.

....

....

....[1]

(ii) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in **(f)(i)**.

You may suggest the use of other apparatus or a different procedure.

....

....

....[1]

For Examiner's Use

(g) It is suggested that the relationship between H and y is

$$H = c\sqrt{y}$$

where c is a constant.

(i) Using your data from **(b)**, **(c)** and **(e)**, calculate two values of c.

first value of c = ...

second value of c = ...

[1]

(ii) Justify the number of significant figures you have given for your values of c.

....

....

....[1]

(iii) Explain whether your results in **(g)(i)** support the suggested relationship.

....

....

....[1]

[Turn over

For Examiner's Use

(h) A circular card, as shown in Fig. 3.4, is now attached to the base of the slotted masses in Fig. 3.1. A student wants to determine if the diameter of the card is proportional to the period of the oscillations of the new setup.

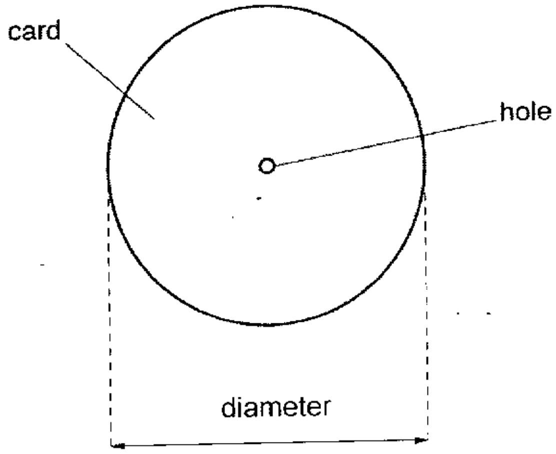

Fig. 3.4

Plan an investigation to verify if the student's hypothesis is true. You will be provided with several cards of varying diameters.

You may suggest the use of any additional apparatus commonly found in a school laboratory. Your answer should include a diagram and your experimental procedure.

....

....

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.... [4]

For Examiner's Use

(j) You will now investigate the motion of mass suspended from springs

Set up the apparatus as shown in Fig. 3.5.

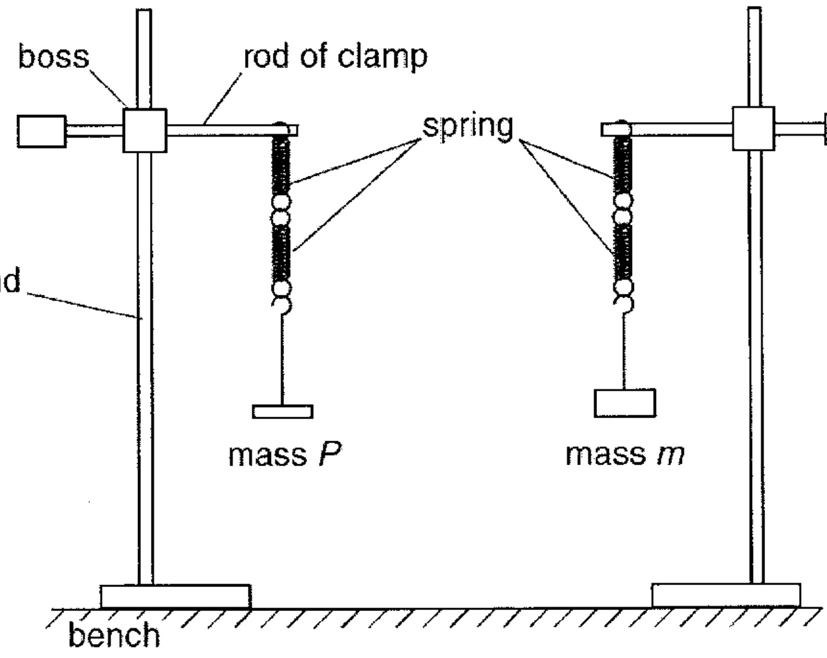

Fig. 3.5

The mass *P* must be 200 g **and must remain constant throughout the experiment**.
The mass *m* should be 250 g.

(i) Pull both masses down through a short distance. Release both masses at the same time.
Start the stopwatch when the masses are back in step and reach the lowest point together for the first time.

Measure and record the time *t* for the masses to reach the lowest point together for the sixth time.

t = ... [1]

[Turn over

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(ii) Repeat **(j)(i)** for at least two more values of m in the range of 250 g to 300 g.

Tabulate these results. Include the results from **(j)(i)**.

[2]

(iii) Comment on the trend in your results.

....

....

....[1]

[Total: 21]

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4 An experiment is carried out to investigate the rate of flow of water through a horizontal tube.

The rate of flow of water per unit time F (volume per unit time) through a tube depends on several variables, such as the pressure difference across the tube, viscosity of the liquid, the length of the tube and the radius of the tube.

A metal container with a hole at the side where a narrow horizontal tube can be secured to it with the use of a stopper as shown in Fig 4.1. h is the difference in height between the centre of the hole on the container and the water level while l is the length of the tube. The metal container can be continuously supplied with water from a tap.

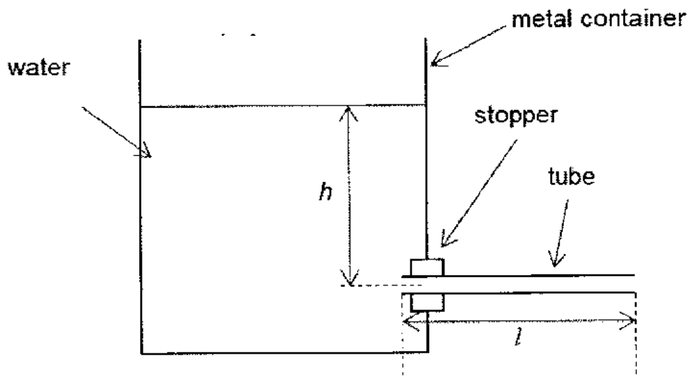


Fig 4.1

It is suggested that the relationship between F, h and l is

$$F = \frac{k\, d^4\, h^n}{l^m}$$

where d is the diameter of the tube and k, n and m are constants.

Design an experiment to determine the values of n and m.

You are provided with tubes of various lengths.

You should draw a diagram showing 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 rate of flow and the depth of the water are measured
(d) how the data would be analysed
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

For Examiner's Use

Diagram

For Examiner's Use

For Examiner's Use

[12]

[Total: 12 marks]

Annotations used in marking
BOD - Benefit of doubt
ECF - Error carried forward
POT - Powers of ten error
TE - Transfer error
CE - Calculation error
XP - Wrong physics
ENG - Generally bad english, phrasing and expression
PP - Poor presentation of answers
Note: For POT and TE, we can award the M mark, not the A mark.

Question

Q1	
(a)(i)	Value of L to the nearest mm in the range of 98.5−99.5 cm with unit
(b)(i)	Measurement of θ to the nearest degree with unit.
(b)(ii)	Percentage uncertainty in θ based on absolute uncertainty in the range of 2°−5°. Absolute uncertainty to 1 s.f. Correct method of calculation to obtain percentage uncertainty. Percentage uncertainty to 1 or 2 s.f.
(c)(i)	C calculated correctly with appropriate units. Show working with correct substitution of values.
(c)(ii)	Plot straight line graph of sin θ against $(\frac{n^2}{2} - n)$.
	Gradient = C
(d)	Value of k correctly calculated and with appropriate units k in the range of 15−30 N m^{-1}
(e)	Compare k from (d) together to uncertainty of θ with the actual value of k
	Correct conclustion based on result

[Total: 9 marks]

Q2	
(a)(i)	Value of x in the range of 48.0–52.0 cm with unit and correct decimal place.
(b)	Six sets of readings of x and V Range >= 35 cm
	Correct column headings Each column heading must contain a quantity, a unit and a separating mark where appropriate
	Correct decimal place of raw values for x and V.
	Correct significant figures for the calculated values of $\frac{1}{V}$ and correct calculation of $\frac{1}{V}$.
(c)	(Graph) 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 the x and y directions. Axes must be labelled with the quantity which is being plotted.
	(Graph) All observations to be plotted. Work to an accuracy of at least half a small square.
	(Graph) Line of best fit – even distribution of points on both sides of the line. Anomalous point should be circled and labelled on the graph. (minimum must circle it)
	Points used to calculate the gradient must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square and indicated on graph. Calculation of gradient must be accurate.
	y-intercept read off accurately with correct precision, OR, calculated accurately from y = mx + c using one point on the line. Check for sf if calculated (ecf for wrong gradient) Check for dp if read off graph

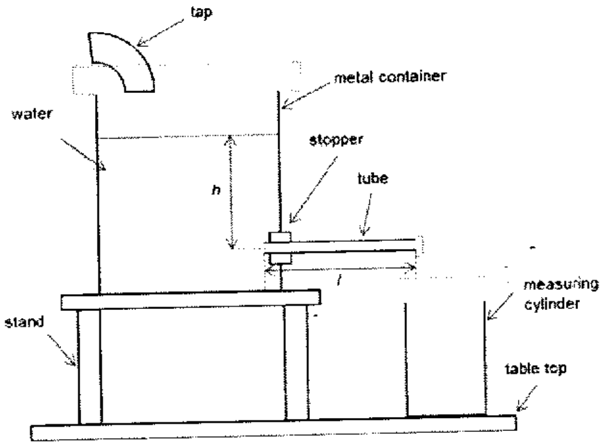
	Determine *k* by associating $\frac{1}{kE}$ = gradient and $\frac{1}{E}$ = y-intercept. Solve for *k*. Check for correct calculation. Check for units of *k*.
(d)	For a plot of 1/V against x, when *E* is larger, the gradient is smaller and the vertical intercept is smaller.

[Total: 13 marks]

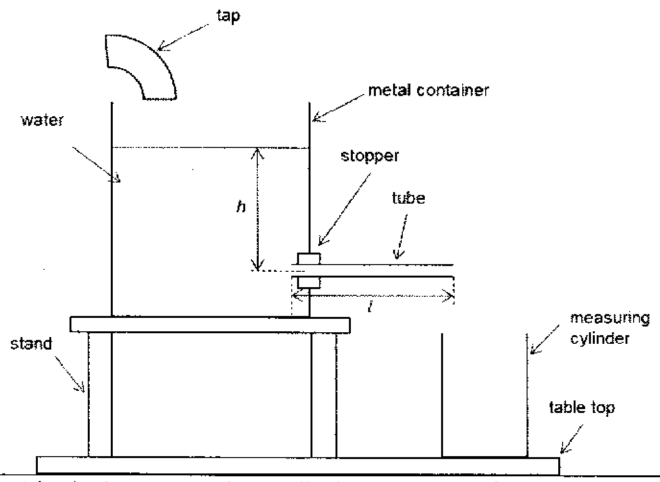
Q3	
(a)(i)	Repeated readings for N oscillations. Time taken for N oscillations, t ≥ 20.00 s $T = \frac{t}{N}$ Value of T in the range 0.50 to 1.00 s.
(a)(ii)	Correct calculation of k.
(b)	Value of y to nearest 0.001 m and in range 0.090 to 0.130 m.
(c)	Value for H calculated using the readings for the highest and lowest points.
	Evidence of repeated readings of H.
(d)	Percentage uncertainty based on absolute uncertainty of at least 0.6 cm to 4 cm. Show correct method of calculation to obtain percentage uncertainty. Answer must be given to 1 or 2 sf.
(e)	Second set of y and H recorded. y within 10% of half the value in **(b)**
	second H < first H
(f)(i)	The highest and lowest positions are difficult to determine since the mass is moving too fast. The readings for the highest and lowest positions are read off by the experimenter using the metre rule. Hence H is inaccurate.
(f)(ii)	Use a datalogger connected to a motion sensor and place the motion sensor facing the base of the mass hanger. From the graph obtained using the datalogger, determine H difference between the lowest and highest points.
(g)(i)	Both values of c correctly calculated. Units for c Given to 2 or 3 sf (depending on sf of H and y)
(g)(ii)	Follows the least sf between H and y Which quantity to follow – H or y (or both have the same sf)
(g)(iii)	(1) Find percentage difference in $k = (c_{larger} - c_{smaller}) / c_{smaller} \times 100$ %. (2) Find percentage uncertainty in c. Since $\frac{\Delta H}{H}$ was calculated in (d), it is assumed that $\frac{\Delta H}{H}$ is a good approximation for the uncertainty of c. (3) If percentage difference in c > percentage uncertainty in c, experiment results do not support the relationship. If percentage difference in c < percentage uncertainty in c, experiment results support the relationship.

(h)	**Diagram (1 m)**
	Fully labelled diagram: Card attached to the base on the mass hanger using blue tac modified from Fig. 3.1. Ensure card in centralized.
	Basic Procedure (1 m)
	Vary the diameter of the card attached. Ensure the card's diameter is equal to or larger than the base of the mass hanger.
	Measurement (1 m)
	Measure the diameter of the cards. Repeat measurement by rotating card. Use metre rule to measure the diameter.
	Analysis (1 m)
	Plot a graph of lg *T* vs lg *d* and determine if the gradient is close to 1. Otherwise not directly proportional.
(j)(i)	20.0 s ≤ t ≤ 40.0 s. Express to with correct unit and to 1 or 2 d.p with repeated reading.
(j)(ii)	Correct d.p. and column headings for t and m.
	3 sets of data including the result from (j)(i) with full range from 250g to 300g and repeated readings for t.
(j)(iii)	Based on the three sets of data shown, as m increases t decreases.

[Total: 21 marks]

4	Suggested solution
	
	1. Setup the apparatus as shown above 2. Measure the inner diameter of the tube using a vernier calipers. Ensure only tubes with the same diameter is used for the experiment 3. Ensure the tube is horizontal by measuring the distance between 2 different points on the tube to the table top and ensuring they are the same 4. Measure the length of the tube *l* using a metre rule 5. Place a towel below the measuring cylinder to capture any spillage 6. Switch on the tap and let the water flow into the metal container. Adjust the flow of the water such that the height of the water in the metal container remains the same. 7. Measure the height of the water from the centre of the tube *h* using a metre rule 8. Place a measuring cylinder below the tube to collect the water. Start the stop watch at the same time. 9. Stop the stopwatch after the measuring cylinder is about three quarter full. Record down the time and read of the volume of the water collected from the measuring cylinder. Determine the flow rate *F* by dividing the volume of water collected by time 10. Repeat the experiment step 7 and 9 to get a repeated value for the flow rate. 11. By adjusting the flow of water using the tap, obtain 6 more different values of *h*. Repeat experiment step 7 to 10 to obtain the respectively flow rate. The same tube has to be used for all different *h* to ensure *l* remains constant 12. Using the equation $F = \frac{k\,d^4\,h^n}{l^m}$, $\ln F = \ln(\frac{k\,d^4}{l^m}) + n\ln(h)$, plot a straight line of ln *F* against ln *h* where *n* is the gradient and $\ln(\frac{k\,d^4}{l^m})$ is the vertical intercept 13. By using tubes to different length, obtain 6 more different values of *l*. Repeat experiment step 7 to 10 to obtain the respectively flow rate. Ensure the height of the water is the same for all different *l* to ensure *h* remains constant. Ensure only tubes with the same diameter as the earlier experiments are used

	14. Using the equation $F = \frac{k\ d^4\ h^n}{l^m}$, $\ln F = \ln(k\ d^4\ h^n) - m\ln(l)$, plot a straight line of ln F against ln l where $-m$ is the gradient and $\ln F = \ln(k\ d^4\ h^n)$ is the vertical intercept

	Mark scheme	
	Diagram (1 m)	
		
	Diagram must include measuring cylinder, source of running water	**D1**
	Basic procedure (3 m)	
	Adjust the length of the tube (by using tube of different length) while keeping height constant	**B1**
	Adjust the height of the water level (by adjust the flow rate of the tap) while keeping length constant	**B1**
	Collect and measure the volume of water and the time taken for the collection and show equation F = Q / t	**B1**
	Measurement (2m)	
	Measure the length of the tube using a metre rule OR Measure the depth of the water level using a metre rule	**M1**
	Measure the flow rate using a measuring cylinder <u>and</u> stop watch	**M1**
	Control of Variables (1 m)	
	Radius of the tube must be kept constant by using tube of the same diameter	**C1**
	Analysis (2 m)	
	$F = \frac{k\ d^4\ h^n}{l^m}$ $\ln F = \ln(k\ d^4\ h^n) - m\ln(l)$ when varying length, Plot a straight line of $\ln F$ against $\ln(l)$ where $-m$ is the gradient and $\ln(k\ d^4\ h^n)$ is the vertical intercept	**A1**

	$F = \frac{k\ d^4\ h^n}{l^m}$ $\omega = kr^x m^y$ $\ln F = \ln(\frac{k\ d^4}{l^m}) + n\ln(h)$ when varying height of the water level, Plot a straight line of $\ln F$ against $\ln(h)$ where n is the gradient and $\ln(\frac{k\ d^4}{l^m})$ is the vertical intercept	**A1**
	Further Details (max 2 m)	
	Indicate location of metre rule inside the container when measuring height	**F1**
	Method to ensure tube is horizontal (eg, measure and ensure the distance from 2 ends of the tube to the table is the same)	**F1**
	Method to measure *h* accurately from the centre of the hole (eg, measure diameter of hole, add half of diameter to the distance from the top of the hole to the water level)	**F1**
	Repeated reading for the measurement of flow rate	**F1**
	Adjust flow of water such that flow rate of water from tap is equal to *F* in order to keep *h* constant	**F1**
	Measure the diameter of the tube using vernier callipers (to ensure the radius of the tube is the same)	**F1**
	Safety (1 m)	
	Usage of tank / sink / cloth to prevent spillage onto the table	**S1**