HWA CHONG INSTITUTION
C2 Preliminary Examination
Higher 2

A

CANDIDATE NAME		**CT GROUP**	20S
TUTOR NAME			

PHYSICS **9749/04**

Paper 4 Practical **20 Aug 2021**

Candidates answer on the Question Paper. **2 hr 30 min**

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES
This paper consists of 3 sets, namely A, B and C, as printed on the top right hand corner of each set.
Write your name and CT class and tutor's name clearly in the spaces at the top of this page.
Write your name and CT class clearly in the spaces at the top of sets B and C.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs or rough working. Do not use paperclips, highlighters, glue or correction fluid.

Answer **all** questions.

You will be allowed a maximum of one hour to work with the apparatus for Questions 1 and 2 (set A), and a maximum of one hour for Question 3 (set B). You are advised to spend approximately 30 minutes on Question 4 (set C).

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.

The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
A1	/ 15
A2	/ 6
B3	/ 22
C4	/ 12
Total	

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

1 This experiment considers the forces on a wooden cylinder.

(a) You have been provided with a wooden cylinder with a spring attached.

The distance L between the centre of the hole with the string and the end of the cylinder is shown in Fig. 1.1.

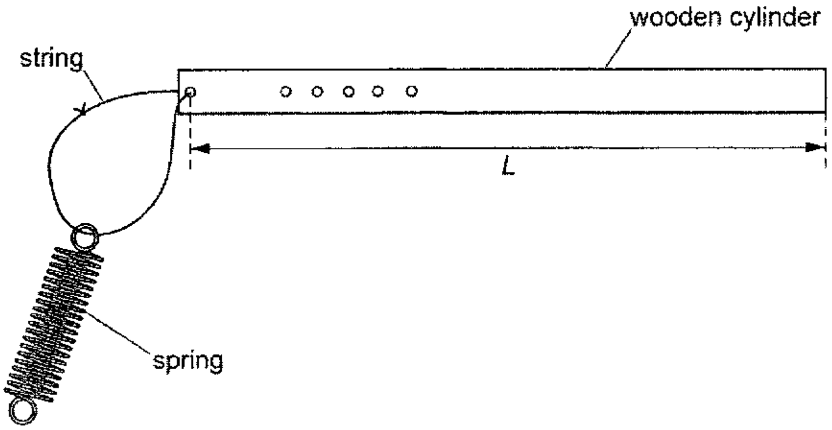


Fig. 1.1

The length of the unstretched spring is S, as shown in Fig. 1.2.

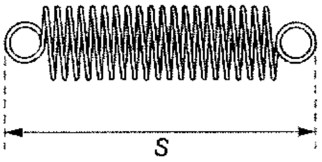


Fig. 1.2

Measure and record L and S.

L = ...

S = ...

[1]

(b) Set up the apparatus as shown in Fig. 1.3.

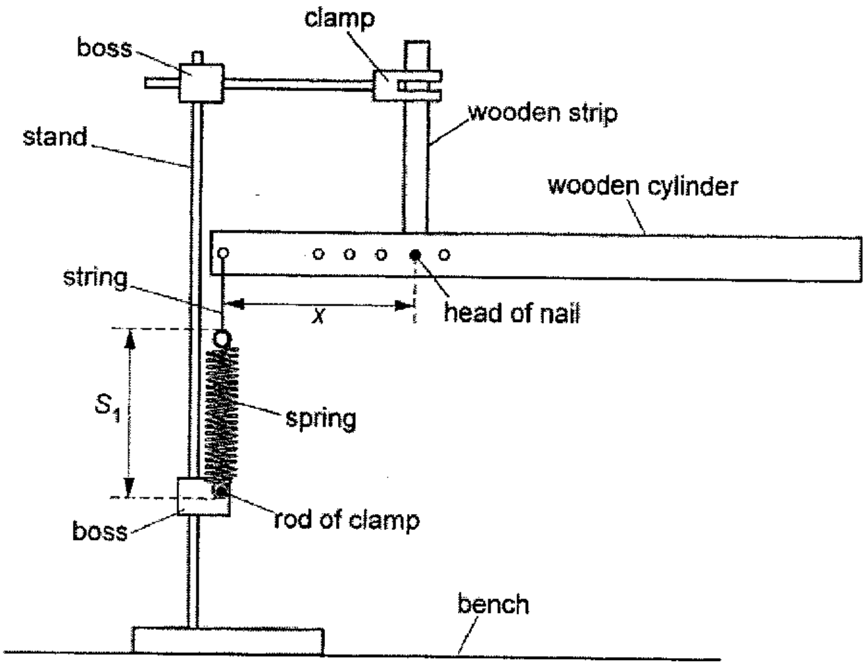


Fig. 1.3

Place the nail through one of the holes in the wooden cylinder.

Adjust the apparatus until the spring and the wooden strip are vertical and the wooden cylinder is horizontal.

The distance x between the hole with the string and the hole with the nail is shown in Fig. 1.3.

The length of the stretched spring is S_1.

(i) Measure and record x and S_1.

x = ...

S_1 = ...

[1]

(ii) Calculate e, where

$$e = S_1 - S\,.$$

e = ... [1]

(iii) Calculate n, where

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

n = ...

(c) Vary distance *x*.

Adjust the apparatus until the spring and the wooden strip are vertical and the wooden cylinder is horizontal.

Repeat **(b)(i)**, **(b)(ii)** and **(b)(iii)**.

Present your results clearly.

[3]

(d) The quantities *e* and *n* are related by the expression

$$n(e-P)=Q$$

where *P* and *Q* are constants.

(i) Draw a graph of *e* against $\dfrac{1}{n}$. [3]

(ii) Determine the gradient of the line.

gradient = ... [1]

(iii) Determine the y-intercept of the line.

y-intercept = ... [1]

(e) **(i)** Use your answers in **(d)(ii)** and **(d)(iii)** to determine values for P and Q.

P = ... cm

Q = ... cm

[1]

(ii) Theory suggests that

$$Q = \frac{Mg}{2k}$$

where g is 9.81 N kg^{-1}, M is the mass of the wooden cylinder and k is the spring constant of the spring.

Mass M is written on one end of the wooden cylinder.

Calculate k.

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

(f) Explain why, in theory, your graph should go through the point (2,0).

....

....

....

....

....[2]

[Total: 15]

2 In this experiment, you will obtain the I-V characteristic graph of a filament lamp.

(a) Connect the circuit as shown in Fig. 2.1

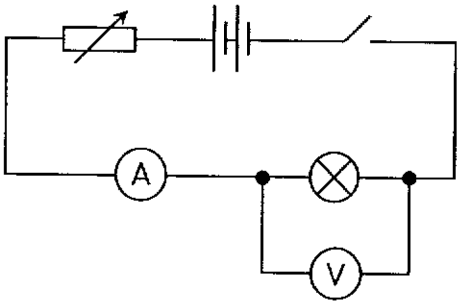


Fig. 2.1

(b) Close the switch.

Adjust the rheostat until the voltmeter reading V is about 0.5 V.

Record the ammeter reading I.

I = ...mA [1]

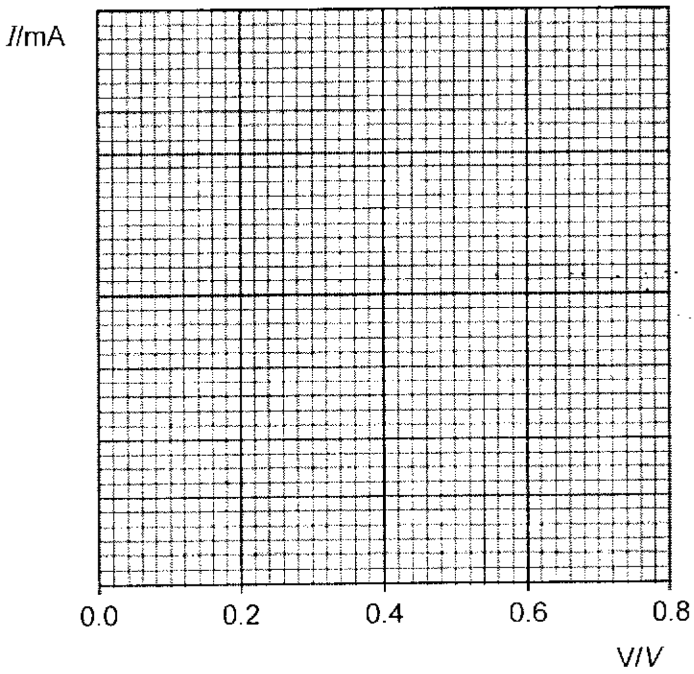
(c) **(i)** Adjust the rheostat to obtain more readings of V and I.

Tabulate your results clearly.

[2]

(ii) Plot values of I against V on the grid. The graph obtained should be a curve.

[2]



(d) Fig. 2.2 shows another circuit that may be used to vary voltage across the filament lamp.

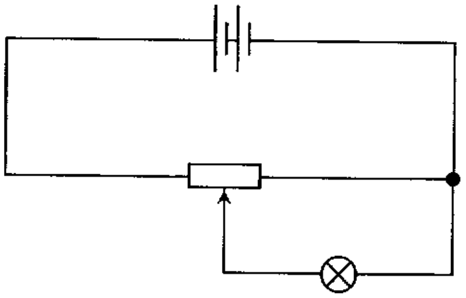


Fig. 2.2

Draw lines in Fig. 2.3 to show how the components can be connected to achieve the circuit shown in Fig. 2.2.

[1]

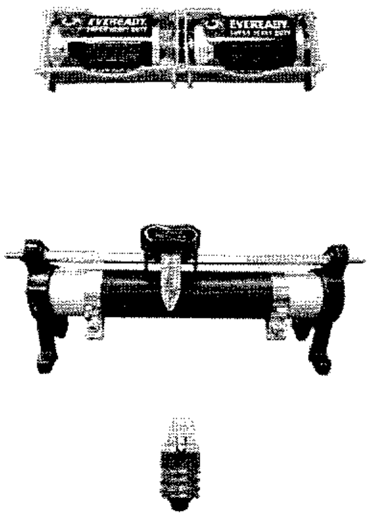


Fig 2.3

[Total: 6]

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NAME ____________________ CLASS 20S ( ) SCORE ______ **B**

3 In this experiment, you will investigate the behaviour of an oscillating system.

You have been provided with one metal wire, two pendulum bobs and a rubber band.

(a) **(i)** Use the micrometre screw gauge to measure and record the diameter *d* of the wire.

d = ... cm [1]

(ii) Use the Vernier callipers to measure and record the diameter *D* of the pendulum bob.

D = ... cm [1]

(b) **(i)** Bend the copper wire at its mid-point so that the two arms of the wire form an angle θ, as shown in Fig. 3.1. Adjust the arms so that θ is approximately 40°.

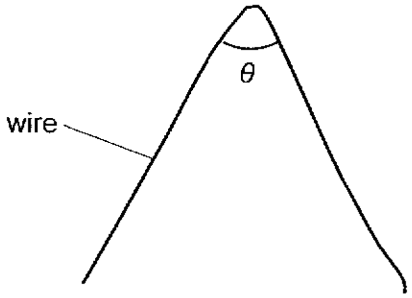

Fig. 3.1

(ii) Measure and record θ.

θ = ... ° [1]

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

percentage uncertainty in θ = ... [1]

(c) **(i)** Bend the ends of the wire to form hooks for hanging pendulum bobs and set up the apparatus as shown in Fig. 3.2.

The distance C is the distance between the top of the wire and the centre of the bob on each side of the bent wire.

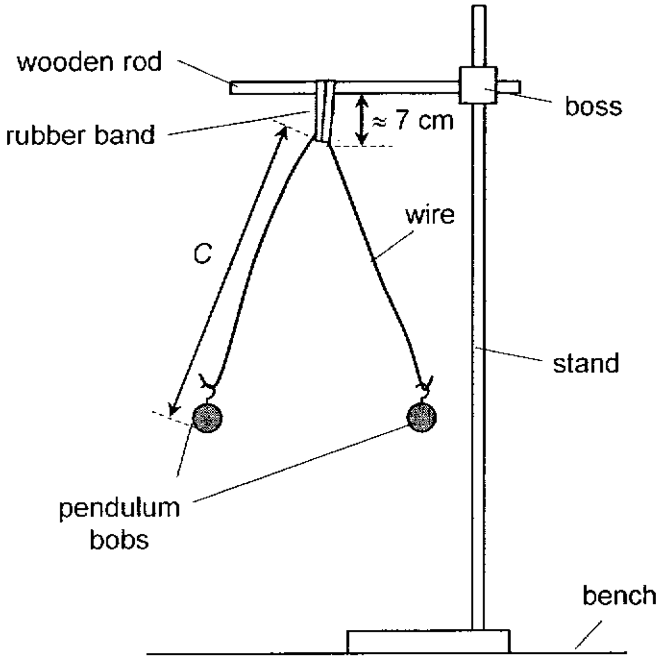

Fig. 3.2

Loop the rubber band **twice** over the wooden rod. The distance between the rod and the bottom of the band should be approximately 7 cm.

(ii) Determine C and estimate the percentage uncertainty in your value of C.

C = ...

percentage uncertainty in C = ...

[2]

(iii) Move one of the bobs so that the wire turns through approximately 90° about a **vertical axis**. Release the bob.

The wire will oscillate about a vertical axis.

Determine the period T of these oscillations.

T = ... s [2]

(d) Increase θ and repeat **(b)(ii)** and **(c)(iii)**.

θ = ... °

T = ... s

(e) It is suggested that

$$T = 2\pi C \sin(\theta / 2)\sqrt{\frac{m}{k}}$$

where k is a constant and m is the mass of each bob, with a value of 70.0 g.

(i) Use your values from **(b)(ii)**, **(c)(ii)**, **(c)(iii)** and **(d)** to determine two values of k.

Give your values of k to an appropriate number of significant figures.

first value of k = ...

second value of k = ...
[1]

(ii) Justify the number of significant figures given in your values of k.

....

....

....[1]

(iii) State whether the results of your experiment support the suggested relationship in **(e)**.

Justify your conclusion by referring to your values in **(b)(iii)** and **(c)(ii)**.

....

....

....

....[2]

(f) You are now to measure the period of oscillations at two different values of L, where L is the distance between the centres of the pendulum bobs.

The two values of L should be approximately 10 cm and 5 cm.

The value of θ must be the **same** in both cases.

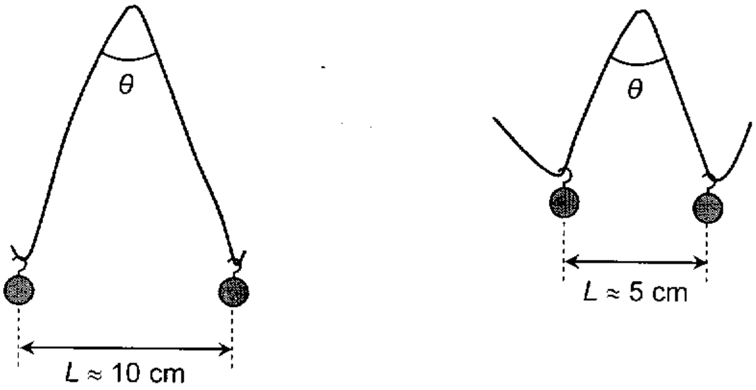

Fig. 3.3

Tabulate your results.

[3]

(g) **(i)** Suggest a significant source of error for the experiment in part **(f)**.

....

....

....[1]

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

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....[1]

(h) The behaviour of the oscillating system depends on the properties of the rubber band.

It is suggested that the period *T* is inversely proportional to the number *n* of loops in the rubber band.

(i) Explain how you would investigate this relationship using the same apparatus.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to show inverse proportionality
- why you might not have enough results to reach a valid conclusion.

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....[4]

(ii) Suggest a change to the shape of the rubber band that will improve your procedure in **(h)(i)**.

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....[1]

[Total: 22]

NAME ____________________ CLASS 20S ( ) SCORE ______ **C**

4 During earthquakes, buildings may be shaken by the seismic waves travelling in the ground beneath them. If the frequencies of the seismic waves match the resonant frequencies of the buildings, they may begin to sway back and forth, and the structural integrity of the buildings may become compromised.

Fig. 4.1 shows a horizontal spring-mass system used to study the phenomenon of resonance.

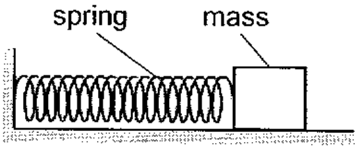

Fig. 4.1

The amplitude of oscillation A of the mass **at resonance** is thought to depend on its mass m, and the spring constant k of the spring.

With all other variables kept constant, the relation between A, m and k is

$$A = Ck^a m^b$$

where C, a and b are constant.

Design an experiment to determine the values of a and b.

You are provided with sufficient number of identical springs with the known spring constant k_0.

You are also provided with an oscillator that can vibrate the spring mass system over a large range of unknown frequencies.

You may also use any of the other equipment usually found in a Physics laboratory.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

(a) the equipment you would use,
(b) the procedure to be followed,
(c) how the frequency of vibration and the amplitude of oscillation at resonance would be measured,
(d) the control of variables,
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

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....[12]

[Total: 12]

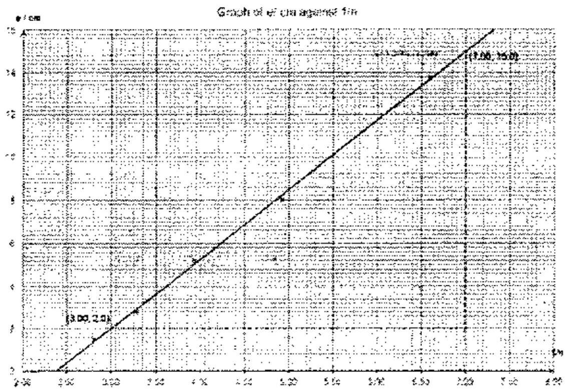
2021 C2 Preliminary Examination H2 Physics Paper 4 Mark Scheme

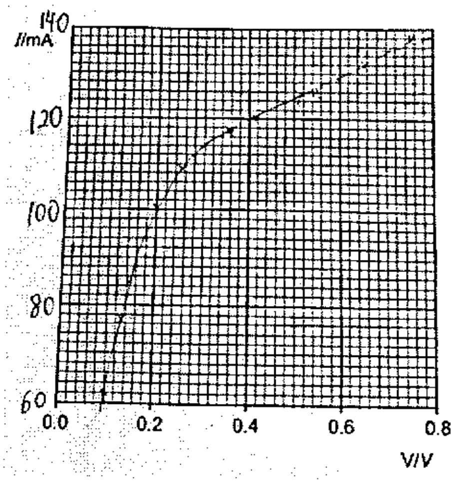
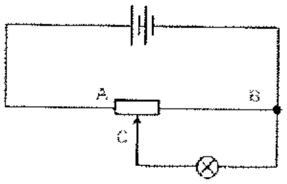
<table>
<tr><th>Qn</th><th>Answer</th><th>Mark</th><th>Checklist</th></tr>
<tr><td>1a</td><td>e.g
L = 59.0 cm
S = 5.3 cm</td><td>1</td><td>Check accuracy
<i>Accepted values:</i>
L = 59.0 ± 0.3 cm
S = 5.3 ± 0.2 cm

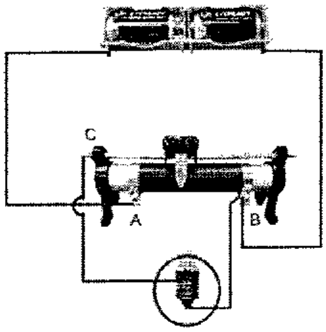
correct dp and units</td></tr>
<tr><td>bi</td><td><i>Candidate is allowed to choose any of the 5 holes to make measurements</i>
<i>e.g.</i>
x = 18.0 cm
S_1 = 8.1 cm</td><td>1</td><td>Check accuracy of x
± 0.3 cm
correct dp and units

Annotate for no repeat for S_1</td></tr>
<tr><td>bii</td><td>e.g. e = S_1 – S = 8.1 – 5.3 = 2.8 cm</td><td>1</td><td>Correct calculation and dp and units</td></tr>
<tr><td>biii</td><td><i>e.g.</i>
$n = x/L$ = 18.0 / 59.0 = 0.305</td><td>0</td><td>Correct division of the numbers</td></tr>
<tr><td>c</td><td>e.g.
1/n = L/x, S = 5.3 cm
<table>
<tr><th>x / cm</th><th>S_1 / cm</th><th>e / cm</th><th>1/ n</th></tr>
<tr><td>18.0</td><td>8.1</td><td>2.8</td><td>3.28</td></tr>
<tr><td>21.0</td><td>6.8</td><td>1.5</td><td>2.81</td></tr>
<tr><td>15.0</td><td>10.5</td><td>5.2</td><td>3.93</td></tr>
<tr><td>12.0</td><td>13.3</td><td>8.0</td><td>4.92</td></tr>
<tr><td>9.0</td><td>19.1</td><td>13.8</td><td>6.6</td></tr>
</table>
Note: (<i>n</i> column is unnecessary)</td><td>1
1
1</td><td>Correct tabulation:
Collect 5 sets of data & correct trend
Correct heading/unit
Correct dp for raw data
Correct sf for processed data
Correct computation (allow 1 slip)

*Deduct for any mistakes made in each category</td></tr>
<tr><td>di</td><td>e.g.</td><td>1
1
1</td><td>Axes quantity /unit labelled correctly
Appropriate scale chosen to spread points more than ½ available length per axis
Reject odd scales like 1: 1.5, 1:3, 1:6 etc
Correct Plots
BFL, correct judgement on anomaly</td></tr>
</table>

			
dii	e.g. $$\text{Gradient} = \frac{15.0-2.0}{7.00-3.00} = \frac{13.0}{4.00} = 3.25$$	1	Correct calculation of gradient Final sf must be correct Annotate for wrong unit stated
diii	e.g. Sub (3.00, 2.0) and Q = 3.25 into equation (1): P = 2.0 - 3.25(3.00) = -7.8	1	Correct calculation of y-intercept Final sf/dp must be correct according to the method used for y-intercept Annotate for wrong unit stated
ei	Q = gradient, P = y-intercept *e.g.* *P* = -7.8; *Q* = 3.25	1	Correct inference of *P* & *Q* from the gradient and y-intercept (sign inclusive) in the correct unit
eii	e.g. $$k = \frac{Mg}{2Q} = \frac{(0.140)(9.81)}{2(3.25\times10^{-2})} = 21.1$$	1	Correct unit conversion and calculation of *k* in the correct units
f	The point implies that when extension of the spring, e = 0, 1/*n* = 2, or *n* = ½. *n* is defined as *x*/*L*. This means that the cylinder should remain horizontal at rotational equilibrium about the pivot, where x = half the length of the cylinder.	1 1	2 key ideas: $n = \frac{1}{2}$ Rotational equilibrium – no net moment or torque
	Total	**15**	

<table>
<tr><th>Qn</th><th>Answer</th><th>Mark</th><th>Checklist</th></tr>
<tr><td>2b</td><td><i>e.g.</i>
I = 123.8 x 10^{-3} A at 0.500 V</td><td>1</td><td>Check accuracy and correct dp
accept any value that is above 100 mA with correct dp</td></tr>
<tr><td>ci</td><td>e.g.
<table>
<tr><th>V / V</th><th>I / mA</th></tr>
<tr><td>0.100</td><td>62.1</td></tr>
<tr><td>0.130</td><td>77.3</td></tr>
<tr><td>0.148</td><td>84.4</td></tr>
<tr><td>0.200</td><td>99.9</td></tr>
<tr><td>0.250</td><td>108.5</td></tr>
<tr><td>0.298</td><td>113.6</td></tr>
<tr><td>0.358</td><td>117.4</td></tr>
<tr><td>0.409</td><td>119.8</td></tr>
<tr><td>0.507</td><td>124.2</td></tr>
<tr><td>0.549</td><td>126.1</td></tr>
<tr><td>0.601</td><td>128.7</td></tr>
<tr><td>0.654</td><td>131.6</td></tr>
<tr><td>0.702</td><td>135.1</td></tr>
<tr><td>0.752</td><td>138.1</td></tr>
</table></td><td>1
1</td><td>Correct tabulation:
Column heading with units
8 sets of data
Correct dp and sf for V
ECF for <i>I</i>/mA from 2b
*Deduct 1 mark for every mistake.
Annotate if student's V column is not in V but in mV
Annotate for insufficient range of V values, at least 0.6 V</td></tr>
<tr><td>cii</td><td>
</td><td>1
1</td><td>Curve trend:
Data points plotted correctly
Appropriate y-scale
Smooth best fit and correct trend</td></tr>
<tr><td>d</td><td>
</td><td>1</td><td>Correct connections for every part of circuit</td></tr>
</table>

			
	Total	**6**	

Qn	Answer	Mark	Checklist
3ai)	**MSG** e.g. $\frac{0.150+0.150}{2}=0.150$ cm	1	Must show evidence of repeat and average. correct d.p. ± 0.005 cm accuracy
3aii)	**VC** e.g. $\frac{2.50+2.49}{2}=2.50$ cm	1	Must show evidence of repeat and average. correct d.p. ± 0.25 cm accuracy
3bii)	$\theta = 40°$	1	Correct dp. ±5°
3biii)	$\frac{\Delta\theta}{\theta}=\frac{2}{39}\times 100\%=5.1\%$	1	$\Delta\theta$ presented to 1 s.f $\Delta\theta$ between 2° and 5° Final ans to 1, 2 or 3 s.f.
3cii)	C = 26.6 cm $\frac{\Delta C}{C}=\frac{0.5}{26.6}\times 100\%=1.9\%$	1 1	C between 20 & 30 cm. C with correct dp & units. ΔC btw 2 mm to 10 mm
3ciii) and 3d)	e.g. $2T=\frac{40.6+41.4}{2}=41.0$ s $T=\frac{41.0}{3}=13.7$ s	1 1	(c)(iii) T larger than 5 s. (d) θ larger than 40° (d) T > (c)(iii) T (d) T larger than 5 s.

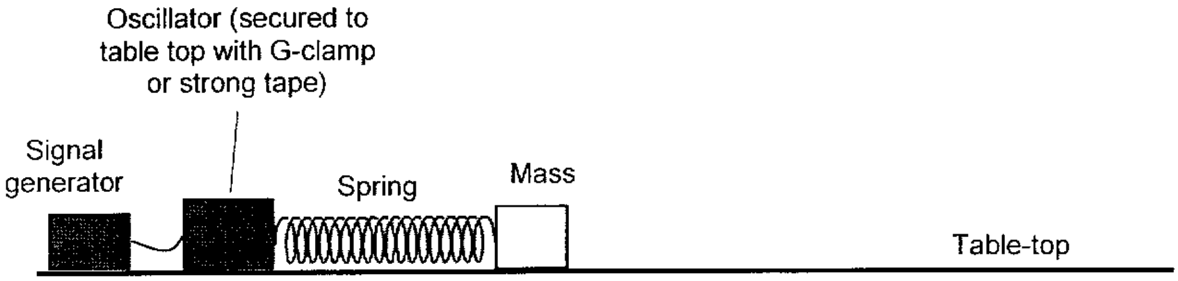
<table>
<tr>
<td>3ei)</td>
<td><i>k_1 and k_2</i>
<i>e.g.</i>
$T = 2\pi C\sin(\theta/2)\sqrt{\frac{m}{k}}$
k_1 $\quad 13.7 = 2\pi(26.5)\sqrt{\frac{70.0}{k_1}}\ \sin\left(\frac{40^\circ}{2}\right)$
$k_1 = 1.2\times10^3\ \text{cm}^2\ \text{g s}^{-2}$
k_2 $\quad 18.4 = 2\pi(26.5)\sqrt{\frac{70.0}{k_2}}\sin\left(\frac{60^\circ}{2}\right)$
$k_2 = 1.4\times10^3\ \text{cm}^2\ \text{g s}^{-2}$
<i>OR</i>
k_1 $\quad 13.7 = 2\pi(0.265)\sqrt{\frac{0.0700}{k_1}}\ \sin\left(\frac{40^\circ}{2}\right)$
$k_1 = 1.2\times10^{-4}\ \text{m}^2\ \text{kg s}^{-2}$
k_2 $\quad 18.4 = 2\pi(0.265)\sqrt{\frac{0.0700}{k_2}}\ \sin\left(\frac{60^\circ}{2}\right)$
$k_2 = 1.4\times10^{-4}\ \text{m}^2\ \text{kg s}^{-2}$</td>
<td>1</td>
<td>Substitution values shown.
Correct units matching correct substitutions.
Check calculation value.</td>
</tr>
<tr>
<td>3eii)</td>
<td>Justify s.f. of k
e.g.
<i>T</i>, <i>C</i>, <i>θ</i> and <i>m</i> have s.f. of 3, 3, 2 and 3 respectively. Both k_1 and k_2 are thus written to 2 s.f., following the least number of s.f. of <i>θ</i>.</td>
<td>1</td>
<td>Must correctly identify the number of s.f. of the quantity with the least number of s.f.
If <i>θ</i> is 3 s.f., student must also specify that <i>T, C, θ</i> and <i>m</i> are all 3 s.f. numbers.</td>
</tr>
<tr>
<td>3eiii)</td>
<td>2 Data Validation
e.g.
%difference of $k = \frac{1.4-1.2}{1.2} = 17\%$
%uncertainty of <i>C</i> and <i>θ</i>
$= 5.1\% + 1.9\% = 7\%$
Since the 2 values of <i>k</i> differ by 17%, more than the 7% uncertainty in <i>C</i> and <i>θ</i>, the results do not support the suggested relationship.</td>
<td>1
1</td>
<td>Calculation of percentage difference
Comparison with $\frac{\Delta\theta}{\theta}+\frac{\Delta C}{C}$</td>
</tr>
<tr>
<td>3f)</td>
<td>Tabulation
e.g.
<table>
<tr><th>L/cm</th><th>N</th><th>t_1/s</th><th>t_2/s</th><th>T/s</th></tr>
<tr><td>5.0</td><td>5</td><td>19.6</td><td>19.8</td><td>3.94</td></tr>
<tr><td>10.0</td><td>3</td><td>18.1</td><td>18.2</td><td>6.05</td></tr>
</table>
</td>
<td>1
1</td>
<td>Column for <i>L</i>, t_1, t_2 and <i>T</i>.
Column headings with units
Column for <i>N</i> (number of oscillations) or fixed <i>N</i> indicated.
Correct d.p. for <i>L</i>.
Consistent d.p. for <i>t</i> and t_{avg} if shown</td>
</tr>
</table>

		 1	Correct s.f. for T. Measured t > 10 s.
3g)	**Error and improvement** >It was difficult to measure L with unsteady hands holding the ruler in mid-air. <Use a retort stand to clamp the ruler. >Because the wire is so malleable, the two wire segments forming the angle are crooked. This makes the measurement of θ very subjective. <Use steel wires which are stiffer, and use pliers to bend the wires precisely (so that 2 straight wire segments form a well-defined angle).	1	Relevant significant source of error. Improvement on the error that cannot be performed during the experiment, without the additional apparatus or tools.
3hi)	**"Mini-PQ"** e.g. 1. Set up the apparatus as shown. 2. Keep θ, L and m constant. 3. Start with a single loop of rubber band, $n=1$. 4. Measure the time t taken for N oscillations. Repeat and take average. 5. Calculate the period $T=\frac{t}{N}$. 6. Repeat steps 4 and 5, each time increasing n by 1, for 10 sets of data. 7. Plot T against $\frac{1}{n}$. If relationship is valid, a straight line graph **passing through the origin** will be obtained. It may not be possible to loop the rubber band more than 4 times.	1 1 1 1	Procedure (P) Vary n, measure T Control Variable (CV): Same mass (implicit), angle and L (explitcit) Analysis (A) Plot T against $\frac{1}{n}$. Check for straight line passing through origin. Loop (L) Impossible to loop rubber band more than 4 times.
hii)	e.g. Use a longer rubber band (so that more loops can be formed).	1	• Thinner or longer or larger (diameter) or bigger rubber band • Reject triangular or circular

Q4 Mark Scheme

	Marks	Marking Points
Diagram	1	**D1** Clear, labelled diagram showing an oscillator connected to the spring, further attached to a block that can move freely, on a table-top/surface.
Variables	4	**V1** Measure *A* with metre-rule. **V2** Measure *m* with mass balance / weighing balance. **V3** Vary *k* by connecting springs in series or parallel, or cutting, or any other viable means. **V4** Two runs: 10 sets of (*m*, *A*) with constant *k* (same combination of springs), and 10 sets of (*k*, *A*) with constant / same *m*.
Analysis	2	**A1** [10 sets of (*k*, *A*) with constant *m*] Plot lg*A* vs lg*k* to obtain a straight line with gradient = *a* **A2** [10 sets of (*m*, *A*) with constant *k*] Plot lg*A* vs lg*m* to obtain a straight line with gradient = *b*.
Reliability	4	Any good further design details, some of these might be: **R1** A preliminary trial to find suitable arrangement of springs and / or masses such that the resonant frequency is in the frequency range of the oscillator. **R2** Detail of how to ascertain system is in resonance. (e.g. observe that as the frequency is slowly increased, the amplitude has increased ***and then decreased***). **R3** Formulae to calculate the spring constant of spring combinations or experiment to determine spring constant of the spring combinations. **R4** Method to ensure amplitude of oscillator is constant (e.g. measuring the actual amplitude and adjusting the amplitude). **R5** Method to measure frequency of vibrations, e.g. using a signal generator connected to the oscillator, or finding the period of a number of oscillations and taking the reciprocal of the period. **R6** Determine amplitude of mass, by measuring distance between extreme displacements and dividing by 2. **R7** Lubricating the bench, or putting the mass on a trolley with wheels to reduce damping / avoid overdamped system. **R8** Method to verify alignment of springs, mass, and oscillator (use of spirit level, protractor, set-square as relevant). **R9** Some means of securing the oscillator (e.g. with bricks, G-clamps). **R10** Use of camera for better identification of amplitude with sufficient details (e.g. play back in slow motion). **R11** Repeating of amplitude determination increasing and then decreasing the masses in case the spring's properties are changed in the course of the experiment.
Safety	1	**S1** Method to prevent injury from snapped springs and flying masses etc (e.g. boots, safety goggles).
Total	12	

Sample Solution



10 different masses, but just one spring for constant k

1. Measure mass with an electronic mass balance.
2. Turn on the signal generator and the oscillator, starting from a low frequency, which can be read off the signal generator.
3. Increase the frequency until the amplitude starts to decrease. Dial back to find the frequency that gives maximum amplitude.
4. Measure this amplitude with a metre-rule.
5. Replace the mass with a different one until 10 sets of data are obtained. Use the same spring throughout.
6. $\lg A = a \lg k + b \lg m + \lg C$. Plot $\lg A$ against $\lg m$. The gradient gives the value of b.

10 different *k*-values, but keep mass constant

7. If connected in series, the effective spring constant is $\frac{k_0}{n}$, where n is the number of springs.

   If connected in parallel, the effective spring constant is nk_0 .
8. Keeping mass constant, combine the springs in different configurations 10 times to get 10 sets of data.
9. Repeat steps 2-4 for each combination of springs.
10. Plot $\lg A$ against $\lg k$. The gradient gives the value of a.

Additional details

11. A preliminary trial could be done to find suitable arrangement of springs and/or masses such that the resonant frequency is in the frequency range of the oscillator.
12. Grease the surface the mass oscillates on to reduce friction/damping.
13. Determine the amplitude by measuring the distance between extreme displacements and dividing by 2.
14. Use a video camera to capture the oscillations. Play back in slow motion or frame by frame to better identify the maximum amplitude as read off a metre-rule placed just beside the oscillating mass.
15. Secure the oscillator to bench with a G-clamp.
16. Wear goggles to protect the eyes in case spring snaps and mass flies off.