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General Certificate of Education
Advanced Level Examination
June 2010

Physics
(Specifications A and B)

PHA6/B6/X

Unit 6 Investigative and Practical Skills in A2 Physics
Route X Externally Marked Practical Assignment (EMPA)

Section A Task 1

For this paper you must have:
- a calculator
- a pencil
- a ruler.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for Section A Task 1 is 15.

Section A Task 1

Follow the instructions given below.

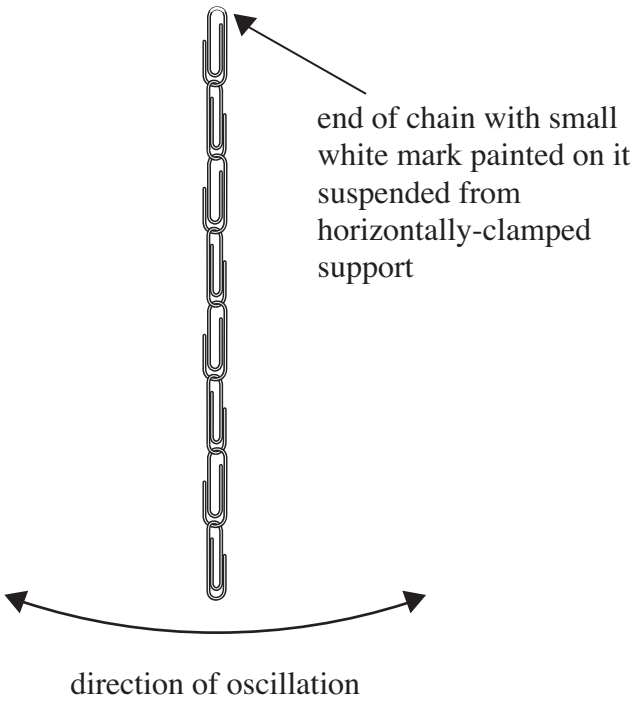
Answer **all** the questions in the spaces provided.

No description of the experiment is required.

1 You are to investigate the small-amplitude oscillations of a chain, suspended from one end, in a vertical plane.

1 (a) You are provided with three short chains, each consisting of eight paper clips joined together. One end of each chain has a small white mark painted on it to show the end from which it should be suspended. Suspend one chain from the horizontally-clamped support so that the chain hangs freely in a vertical plane. The white mark should be at the point of suspension of this chain.
Displace the lower end then release the chain so that it performs small-amplitude oscillations in a vertical plane, as shown in **Figure 1**.

Figure 1



1 (a) (i) Make and record suitable measurements to calculate the period, T_1, of the oscillations of this chain. You should use a fiducial mark to assist in making these measurements.

.....

.....

T_1 = ...

1 (a) (ii) Connect one of the other chains to the lower end of the suspended chain, thereby doubling the number of inter-connected paper clips.
The white mark on the lower chain should be at the point of suspension to the upper chain. Repeating the procedure as before, make and record suitable measurements to calculate the period, T_2, of the oscillations of this chain.

.....

.....

.....

T_2 = ...

1 (a) (iii) Connect the remaining chain to the lower end of the suspended chain, thereby suspending all the paper clips in a single chain.
The white mark on the lower chain should be at the point of suspension to the upper chain. Repeating the procedure as before, make and record suitable measurements to calculate the period, T_3, of the oscillations of this chain.

.....

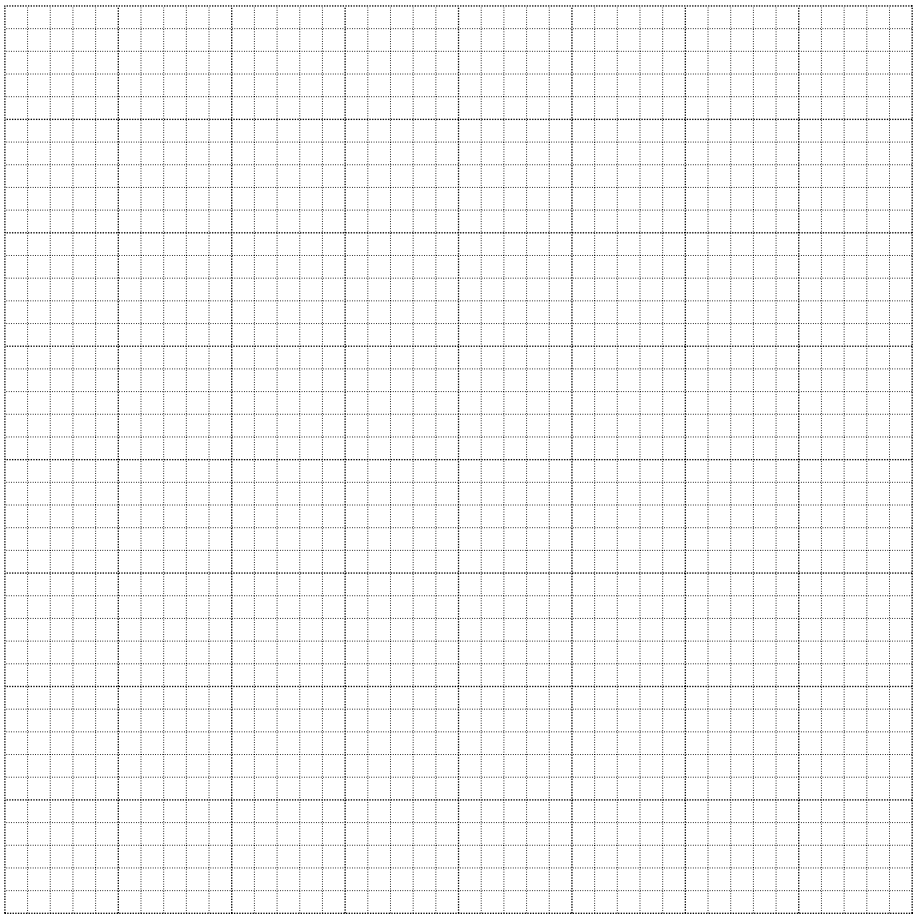
.....

T_3 = ...

(3 marks)

Question 1 continues on the next page

1 (b) It is suggested that n, the number of suspended paper clips is related to T, the period of the paper clip chain by an expression of the form $n \propto T^x$ where x is an integer.
With the aid of the grid provided or otherwise, use the results that you obtained in part (a) to determine the value of x.



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x = ...

(4 marks)

1 (c) A student claims that T can be calculated in the same manner as the period of a simple pendulum of length equal to that of the chain.
Show that the student's claim is false.

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(2 marks)

9

Turn over for the next question

2 You are provided with two identical pendulums coupled to each other by thread from which four paper clips have been suspended.

2 (a) Displace the bob of the left-hand pendulum about 5 cm leftwards, keeping the string in the vertical plane defined by the rest position of the pendulums.
Release the bob and observe the subsequent motion of both pendulums; you will see that the amplitude of the left-hand pendulum gradually decreases and the amplitude of the right-hand pendulum increases.
After a certain time has elapsed, the left-hand pendulum briefly comes to rest and the right-hand pendulum swings with maximum amplitude, then the transfer of energy between the pendulums reverses until the right-hand pendulum is once again at rest and the left-hand pendulum swings with maximum amplitude.

Make suitable measurements to calculate the time, τ, for the amplitude of either pendulum to increase from zero to a maximum and then fall to zero again.
Labels, on which you may write, have been placed on the edge of the bench to assist you in making these measurements.

.....

.....

τ = ...

(1 mark)

2 (b) It is suggested that τ may be inversely proportional to the number of paper clips suspended from the thread.

2 (b) (i) Make measurements to calculate τ with five paper clips suspended from the thread.

.....

.....

τ = ...

2 (b) (ii) Make additional measurements to calculate τ with six paper clips suspended from the thread.

.....

.....

τ = ...

2 (b) (iii) Explain whether your results from parts (a) and (b) show that τ is inversely proportional to the number of paper clips suspended from the thread.

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(4 marks)

2 (c) Explain **one** difficulty that might be encountered if you were to make measurements to determine τ with **less than** four paper clips suspended from the thread.

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(1 mark)

6

END OF QUESTIONS

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Physics PHA6/B6/X

(Specifications A and B)

Unit 6 Investigative and Practical Skills in A2 Physics
Route X Externally Marked Practical Assignment (EMPA)

Section A Task 2

For this paper you must have:
- a calculator
- a pencil
- a ruler.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for Section A Task 2 is 16.

Section A Task 2

Follow the instructions given below.

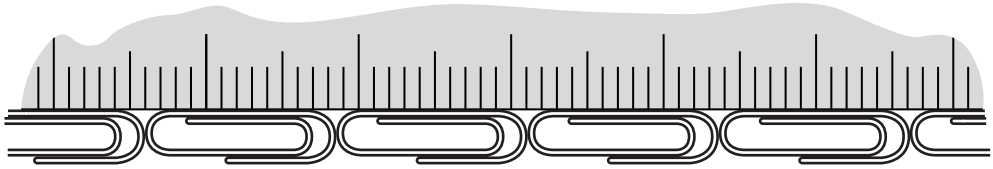
Answer **all** the questions in the spaces provided.

No description of the experiment is required.

In this experiment you are to make measurements on a chain of paper clips, supported at each end, which hangs in equilibrium in a vertical plane above the bench.

1 (a) You are provided with a number of **unconnected** paper clips.
Place a metre ruler on the bench with the graduations uppermost and lay some paper clips against the edge of the ruler so they are aligned in a single row, each paper clip touching the next without overlapping, as shown in **Figure 2.**

Figure 2



Make suitable measurements to determine the mean length, c, of one paper clip.

.....

.....

c = ...

(1 mark)

1 (b) Using the micrometer screw gauge, make suitable measurements to determine the diameter, d, of the wire from which the paper clips have been formed.

.....

.....

d = ...

(1 mark)

1 (c) Adjust the height of the horizontally clamped supports until these are **close to the top** of the stands and the top surface of each is the **same vertical distance** above the bench. Position one metre of paper tape parallel to the edge of the bench, about 20 cm from the edge. Fix this down to the bench with Sellotape.

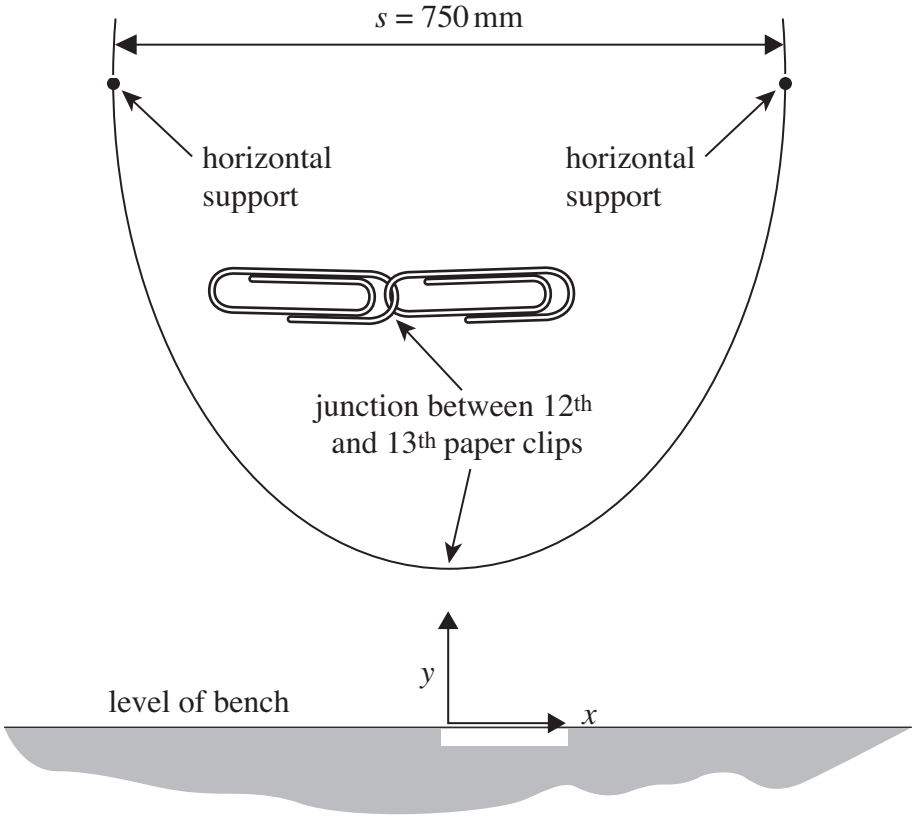
You are also provided with a chain of 24 paper clips.
Suspend one end of the chain from one horizontally-clamped support and the other end from the second horizontally-clamped support, so that the full length of the chain hangs in equilibrium in a vertical plane above the bench.
Adjust the positions of the stands to which the horizontal supports are clamped until the chain lies directly above the length of paper tape and the **horizontal distance**, *s*, between the ends of the paper clip chain is 750 mm.

Mark on the tape the point **directly below** the centre of the chain.

Using the additional apparatus provided, measure and record values of *x* and *y*, which are the horizontal and vertical distances respectively, from the point marked on the paper tape to junctions between paper clips in the chain, as shown in **Figure 3**.
Take sufficient readings of *x* and *y* to define the shape of the chain from the **centre to the right-hand end** of the chain.

Record all your measurements and observations on **page 4**.

Figure 3



Question 1 continues on the next page

Measurements and observations.

(6 marks)

1 (d) Plot, on the grid opposite, a graph of y on the vertical axis and x on the horizontal axis.

(8 marks)

16

END OF QUESTIONS

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Physics
(Specifications A and B)

PHA6/B6/X

Unit 6 Investigative and Practical Skills in A2 Physics
Route X Externally Marked Practical Assignment (EMPA)

Section B

For this paper you must have:
- a calculator
- a pencil
- a ruler
- a small plane mirror
- your completed Section A Task 2 question paper/ answer booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for Section B is 24.

Section B

Answer **all** the questions in the spaces provided.

The time allowed is 1 hour 15 minutes.

You will need to refer to the work you did in Section A Task 2 when answering these questions.

1 In part (a) and part (b) of Section A Task 2 you obtained measurements to determine the mean length, c, of one paper clip, and d, the diameter of the wire from which the paper clips have been formed.

It can be shown that L, the length of the paper clip chain used in part (c) of Section A Task 2, when laid out flat, is given by

$$L = nc - 2d(n - 1),$$

where n = number of paper clips in the chain.

1 (a) Evaluate L.

.....

.....

.....

L = ...

(2 marks)

1 (b) A student suggests that because d is much less than c, the length of the chain can be safely estimated by calculating nc.
The student calculates the percentage difference between the calculated value of nc and the true value of L, for different values of n.
The student's results are shown in **Table 1**.

Table 1

n	percentage difference
1	0.00
2	2.17
4	3.28
8	3.85
16	4.14
32	4.28
64	4.35

1 (b) (i) Explain why the percentage difference increases as n increases.

.....

.....

.....

.....

1 (b) (ii) The student suggests that the percentage difference tends towards a constant value when n becomes very large. Explain with reference to the data in **Table 1**, why the student's suggestion might be correct.

.....

.....

.....

.....

.....

1 (b) (iii) A different student decides that calculating nc is an acceptable method of estimating L, providing that the percentage difference is less than 4%.
Suggest how the student could use the data in **Table 1** to determine the **largest** value of n that meets this condition and explain what the student should do so this value of n is determined accurately.
You should illustrate your answer with a sketch.

.....

.....

.....

.....

.....

(5 marks)

7

2 A student performs the experiment using apparatus identical to that which you used.
The student records the position of **every junction** between paper clips in the chain, starting at the centre of the chain where the 12^{th} and 13^{th} paper clips are joined, and finishing where the 24^{th} paper clip meets the horizontal support at the right-hand end of the chain.

Using all the data measured, the student uses a computer to produce the graph, shown in **Figure 4**.

2 (a) Use **Figure 4** to determine the gradient, G, at the junction **between the 18^{th} and 19^{th} paper clips**. You are provided with a small plane mirror which you may use to assist you in answering the question.

.....

.....

G = ...

(2 marks)

2 (b) The student calculates the length of the chain, L, and measures the horizontal distance, s, between the ends of the paper clip chain.
The student's results are $L = 1.17$ m and $s = 0.756$ m.

Using your result for G and the student's values for L and s, evaluate

2 (b) (i) p, where $p = \dfrac{L}{4G}$,

.....

.....

2 (b) (ii) q, where $q = \dfrac{s}{2p}$.

.....

.....

(1 mark)

2 (c) The sag, r, is the vertical distance between the point of suspension and the bottom of the chain.

Evaluate r, where $r = \dfrac{p}{2}(e^{q} + e^{-q} - 2)$.

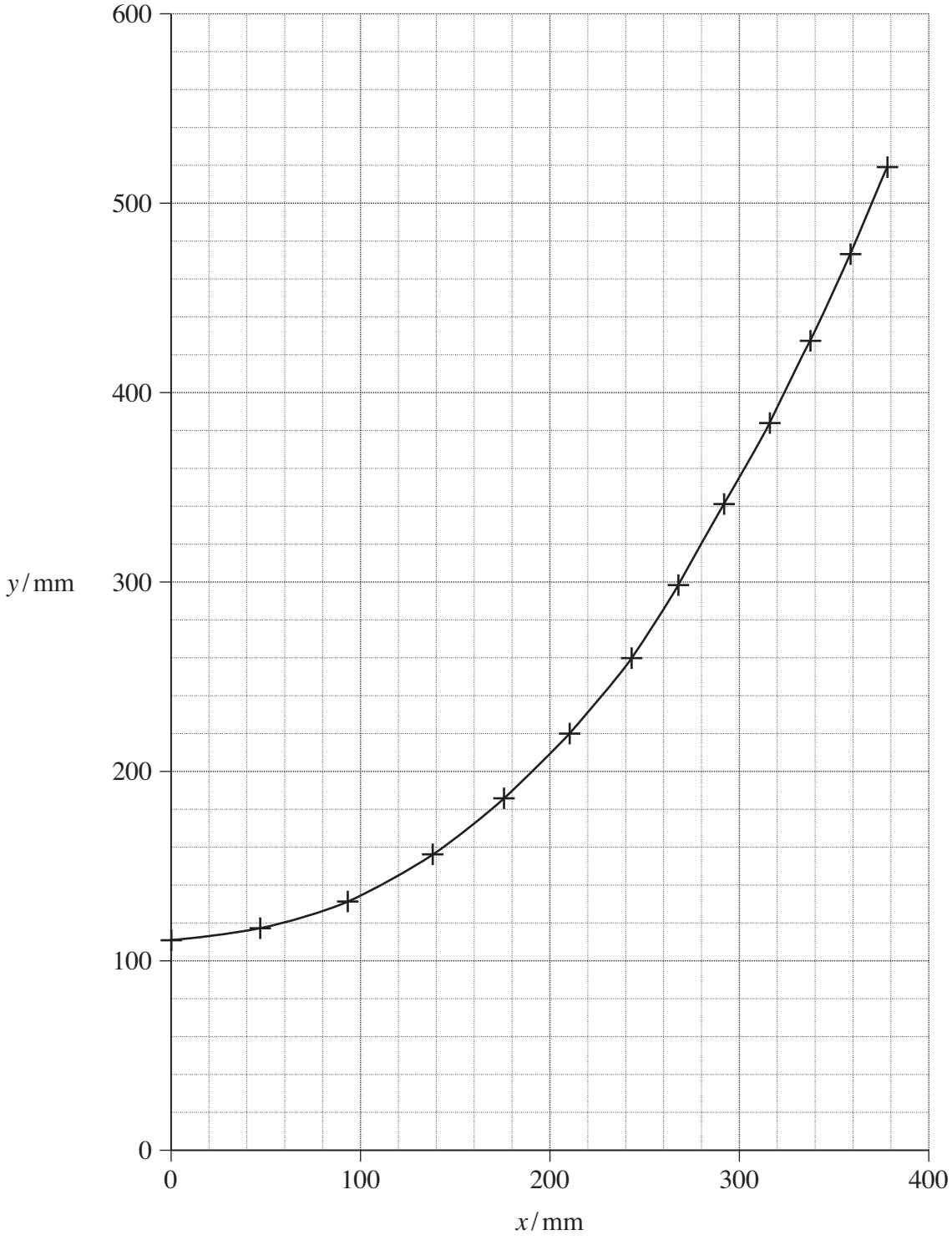
.....

.....

(2 marks)

5

Figure 4



Turn over for the next question

3 In Section A Task 1 you measured the period, T, of an oscillating chain of paper clips.

3 (i) Make a sketch to show how you used a fiducial mark (reference point) to reduce the uncertainty in your values of T.

3 (ii) Explain why you positioned the fiducial mark in the position shown in the sketch.

.....

.....

.....

(2 marks)

2

4 In Section A Task 1 you investigated the motion of coupled pendulums, measuring the time, τ, for the amplitude of either pendulum to increase from zero to a maximum and then fall to zero again. A student performs this experiment and measures four values of τ with three, five and then seven paper clips suspended from the thread.
The student's results are shown in **Table 2**.

Table 2

n	τ_1 / s	τ_2 / s	τ_3 / s	τ_4 / s	mean τ / s	uncertainty / s	percentage uncertainty
3	112.8	111.2	115.8	114.3			
5	67.3	69.9	64.2	66.2			
7	44.8	49.1	48.7	47.9			

4 (a) Complete the relevant column of **Table 2** to show the mean value of τ for $n = 3$, $n = 5$ and $n = 7$.

(1 mark)

4 (b) (i) Calculate the uncertainty in the mean values of τ for $n = 3$, $n = 5$ and $n = 7$; show the results of these calculations in the relevant column of **Table 2**.

4 (b) (ii) Use your results to calculate the percentage uncertainty in the mean values of τ for $n = 3$, $n = 5$ and $n = 7$; show the results of these calculations in the relevant column of **Table 2**.

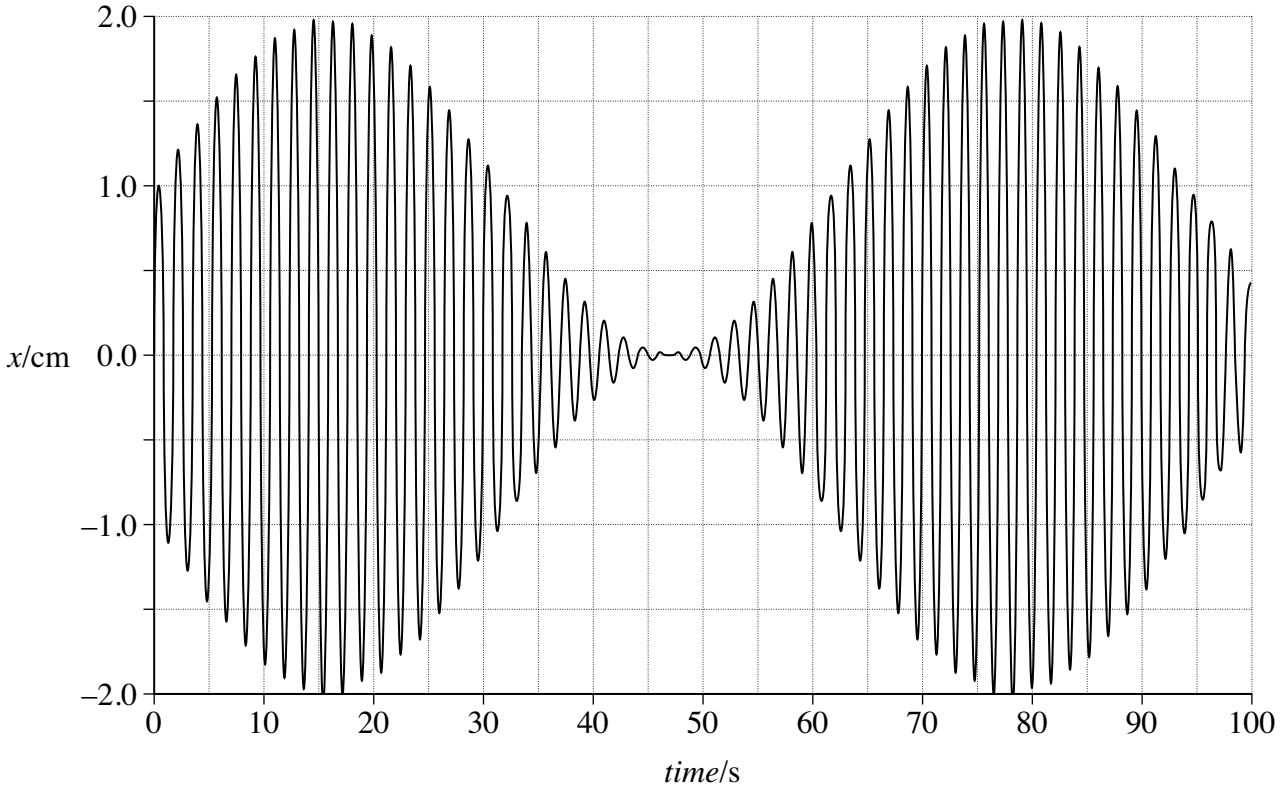
(2 marks)

Use this space for any working.

Question 4 continues on the next page

4 (c) A student uses a motion sensor connected to a data logger to investigate the motion of one of the coupled pendulums.
Data about the displacement, x, of the pendulum bob is recorded over an interval of 100 seconds and then displayed graphically, as shown in **Figure 5**.

Figure 5



4 (c) (i) Use **Figure 5** to estimate τ for these coupled pendulums.

.....

.....

τ = ...

4 (c) (ii) Determine the period of the pendulum's motion represented in **Figure 5**.

.....

.....

period = ...

(3 marks)

4 (d) State and explain **two** advantages of using a data logging technique to produce the data in an experiment such as this, compared with the method which you were required to use in Section A Task 1.

advantage 1

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advantage 2

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(4 marks)

10

END OF QUESTIONS

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