AQA

General Certificate of Education
Advanced Level Examination
June 2010

Physics   PHA6/B6/XTN

(Specifications A and B)

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

Instructions to Supervisors
Confidential

To be given immediately to the teacher(s) responsible for GCE Physics

Open on receipt

- **These instructions are provided to enable centres to make appropriate arrangements for the Unit 6 Externally Marked Practical Assignment (EMPA)**
- **It is the responsibility of the Examinations Officer to ensure that these *Instructions to Supervisors* are given immediately to the Supervisor of the practical examination.**

PHA6/B6/XTN

INSTRUCTIONS TO THE SUPERVISOR OF THE EXTERNALLY MARKED PRACTICAL EXAMINATION

General

Security/confidentiality

The instructions and details of the EMPA materials are strictly confidential. In no circumstances should information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.

The EMPA supplied by AQA at AS and at A2 for a given academic year must only be used in that academic year. It may be used for practice in later academic years.

Using information for any purpose beyond that permitted in this document is potentially malpractice. Guidance on malpractice is contained in the JCQ document Suspected Malpractice in Examinations and Assessments: Policies and Procedures.

The Examinations Officer should give copies of the Teacher Notes (PHA3/B3/XTN and/or PHA6/B6/XTN) to the teacher entrusted with the preparation of the examination upon receipt.

Material from AQA

For each EMPA, AQA will provide:

- *Instructions to Supervisors*
- Section A Task 1 and Task 2 question paper/answer booklets
- Section B EMPA written test papers.

Preparation/Centre responsibility

This practical assessment should be carried out after candidates have acquired the necessary skills and after the appropriate sections of the specification have been taught so that candidates are familiar with any specialist apparatus involved.

The assessment must be carried out between the dates specified by AQA.

It is the responsibility of the centre to ensure that each of the specified practical activities works with the materials provided to the candidates.

The assessment and management of risks are the responsibility of the centre.

Practical Skills Verification (PSV)

Candidates must undertake the five practical activities specified, in order for them to demonstrate in the EMPA that they can use apparatus appropriate to the teaching of Physics at this level. In doing so, candidates will be familiar with the equipment and skills they will use in the EMPA. The teacher must confirm on the *Candidate Record Form* that this requirement has been met.

Section A: Task 1 and Task 2

- Candidates should work individually and be supervised throughout. They should not discuss their work with other candidates at any stage.
- The work can be carried out in normal timetabled lessons and at a time convenient to the centre. Teachers will be in the best position to judge how many sessions are appropriate for candidates in their own centre.
- The candidates' work must be handed to the teacher at the end of each practical session and kept securely until the next stage of assessment.
- There is no specified time limit for these tasks, however candidates should be informed by the Supervisor of the expected timescale and timetable arrangements involved in carrying out the EMPA. Candidates must also be instructed that all readings must be entered in the question paper/answer booklet provided and all working must be shown. **Scrap paper must not be used.**

Sharing equipment / working in groups

Candidates are to work individually. Where resources mean that equipment has to be shared, the teachers should ensure that the candidates complete the tasks individually. Where appropriate, spare sets of apparatus should be prepared to ensure that time is not lost due to any failure of equipment.

Centres may choose to provide sufficient sets of apparatus for the candidates to work on Section A in a circus format with some candidates completing the questions in reverse order. In such cases the changeover should be carefully supervised and the apparatus returned to its original state before being used again.

Practical sessions

Before the start of the test the apparatus and materials for each candidate should be arranged, ready for use, on the bench. The apparatus should not be assembled unless a specific instruction to do so is made in these Instructions.

If a candidate is unable to perform any experiment, or is performing an experiment incorrectly, or is carrying out some unsafe procedure, the supervisor is expected to give the minimum help required to enable the candidate to proceed. In such instances the *Supervisor's Report* should be completed with the candidate's name and number, reporting to the Examiner the nature and extent of the assistance given. No help may be given to proceed with the analysis of their experimental data.

Any failure of equipment which, in the opinion of the Supervisor, may have disadvantaged any candidate should be detailed on the *Supervisor's Report*.

Turn over ▶

Section B: EMPA written test

- The Section B EMPA written test should be taken as soon as convenient after completion of Section A.
- The test must be carried out under controlled conditions and must be completed in a single uninterrupted session.
- When carrying out the Section B EMPA written test, candidates should be provided with their completed copy of Section A Task 2 question paper/answer booklet.
- Supervisors should ensure that candidates understand that Section A Task 2 is for reference only and they must not make any written alterations to this previous work while undertaking Section B.
- The duration of the Section B EMPA written test is 1 hour 15 minutes except where candidates have been granted additional time.

Administration

Candidates must not bring any paper-based materials into any session or take any assessment materials away at the end of a session. Mobile phones or other communication devices are not allowed.

Modifications

The equipment requirements for the experimental tasks are indicated on these Instructions. Centres are at liberty to make any reasonable minor modificiations to the apparatus which may be required for the successful working of the experiment but it is advisable to discuss these with the Assessment Advisor or with AQA. A written explanation of any such modification must be given in the *Supervisor's Report*.

Absent candidates

Candidates absent for any of the Section A Tasks should be given an opportunity to carry out the tasks before attempting the Section B EMPA written test. In extreme circumstances, when such arrangements are not possible, the teacher can supply a candidate with class data. In this case, there will be no evidence for Task 1 or Task 2, so no marks can be awarded for Section A.

Redrafting

Candidates may make only one attempt at a particular EMPA and redrafting is **not** permitted at any stage during the EMPA.

The Supervisor's Report

Details to be given on the *Supervisor's Report* (page 19) should explain

- any part of the equipment provided that differs significantly from that specified in these Instructions
- any help given to candidates in those circumstances given on page 3.

Supervisors must also include any numerical data that is specified in the Instructions. This may involve the Supervisor performing an experiment before the test and collecting certain data. Such data should be given to the uncertainty indicated.

Note that the Examiners may rely heavily on such data in order to make a fair assessment of a candidate's work.

Security of assignments

Candidates' scripts and any other relevant materials, printed or otherwise, should be collected and removed to a secure location at the end of each session. Under no circumstances should candidates be allowed to remove question papers from the examination room.

Once completed, each candidate's EMPA should be collated in the following order:
- Section A Task 1
- Section A Task 2
- Section B EMPA written test.

The assembled material should then be secured using a treasury tag.

Completed EMPAs are to be treated in the same manner as other completed scripts and should be kept under secure conditions before their despatch to the Examiner.

Submission of materials to the AQA Examiner

By the specified deadline centres should assemble and then despatch the following materials:
- collated candidates' scripts, in candidate number order
- the *Supervisor's Report* (page 19 of these Instructions)
- a completed *Candidate Record Form* for each candidate, arranged in candidate number order
- a completed *Centre Declaration Sheet*.

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

Question 1

> **Apparatus**
> - 24 steel paper clips, round ends, length 50 mm, width at widest point about 10 mm, of uniform quality; these should be **formed into three short chains**, each consisting of eight inter-connected paper clips with the paper clips arranged in the same way, i.e. the end with the larger diameter bend should always be linked to an end with a smaller diameter bend; mark the end of each chain with the larger diameter bend with a small blob of Tipp-Ex correction fluid or white paint
> - retort stand of height at least 600 mm, fitted with a boss near the top
> - strong nail or small screwdriver to be clamped horizontally; this provides the means of supporting the end of the chain
> - digital stopwatch capable of reading to 0.01 s
> - suitable means of providing a fiducial mark, e.g. additional stand with pointer, at the Centre's discretion

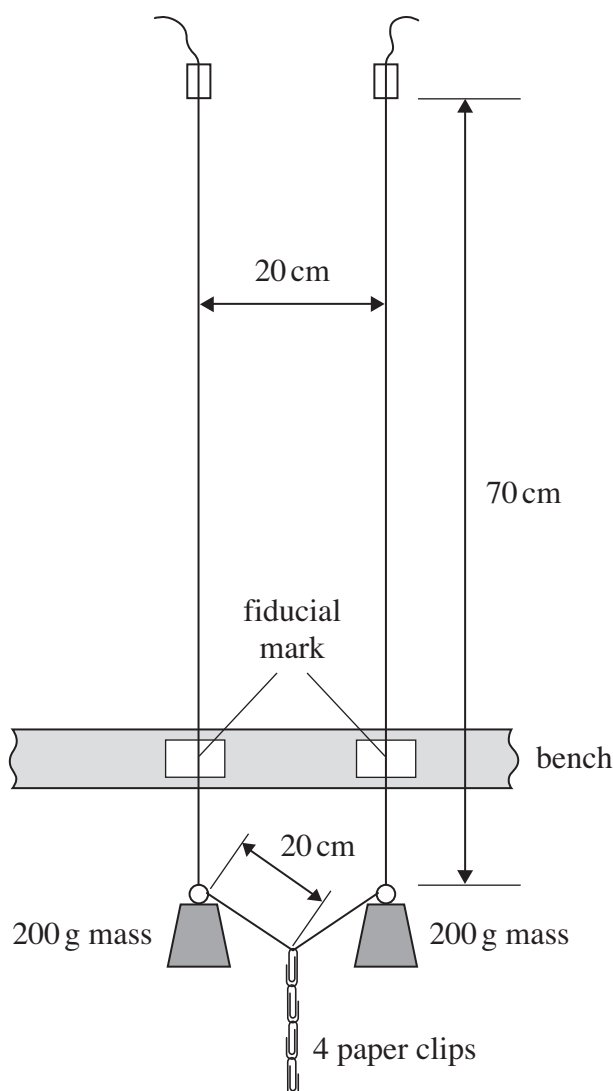**The Examiners require no information for this question.**

Question 2
Candidates are required to observe the motion of, and measure the time for energy transfer between, two coupled pendulums.

> **Apparatus**
> - two 200 g masses
> - two equal lengths of strong thread about 80 cm long
> - two retort stands of height at least 600 mm, each fitted with a boss and clamp near the top
> - four small squares of this wood or similar, to provide well-defined points of suspension for the pendulums
> - one length of strong thread about 45 cm long
> - the candidates will require 6 **unconnected** steel paper clips of same type specified above, e.g. round ends, length 50 mm, width at widest point about 10 mm, of uniform quality
> - digital stopwatch capable of reading to 0.01 s
> - labels, to be fixed to the edge of the bench (as shown in the diagram opposite) on which candidates may make fiducial marks

Supervisors should set up two identical coupled pendulums as shown in the diagram opposite.

The pendulums should hang clear of the bench. Labels, on which candidates may make fiducial marks, should be made on the edge of the bench, as shown in the diagram. Ensure that fresh labels are provided for any candidate reusing the apparatus.

The pendulums, 20.0 cm apart, each of length 70.0 cm, should be adjusted so that their periods of oscillation are identical. The masses should then be joined by a single length (approximately 40 cm) of thread. A chain of four paper clips should be suspended from the centre of the thread, as shown above.

One pendulum should be displaced about 5 cm from its equilibrium position in the plane of the diagram, whilst the other is held in its equilibrium position. Both should then be released simultaneously and the time for the transfer of motion, from one to the other, **and back again**, should be measured.

Trials have shown that this time may be between one and two minutes.

For the system described above, Examiners require the period for the transfer of motion from one pendulum to the other and back again, when one mass is displaced by 5 cm while the other is held at rest and then both are released simultaneously (to ± 2 s).

Turn over ▶

Section A Task 2
Candidates are to make measurements on a chain, supported at each end, which hangs in equilibrium in a vertical plane.

Question 1

> **Apparatus**
> - steel paper clips of the type specified for Section A Task 1, e.g. round ends, length 50 mm, width at widest point about 10 mm, of uniform quality; the candidates will require between 12 and 15 **unconnected** paper clips for part (a) – these can be placed on a piece of A4 card with the label 'for part (a)' printed on it
>   for part (c), the candidates will also require a **chain of 24 interconnected clips**; these should be joined, along the length of the chain, in the same way, i.e. an end with the larger diameter bend should always be linked to an end with a smaller diameter bend – this chain can be placed on a piece of A4 card with the label 'for part (c)' printed on it
> - micrometer screw gauge, capable of reading to 0.01 mm
> - metre ruler
> - about one metre of (paper) ticker tape and short pieces of Sellotape with which to fix the ticker tape down on to the bench
> - set-square
> - two retort stands of height at least 600 mm, each fitted with a boss near the top
> - two strong nails or small screwdrivers to be clamped horizontally; these provide the means of supporting the end of the chain

Place all this apparatus on the bench beforehand. No prior assembly required.

Examiners require the mean length of the chains of 24 interconnected paper clips that the students will use, to ± 5 mm.
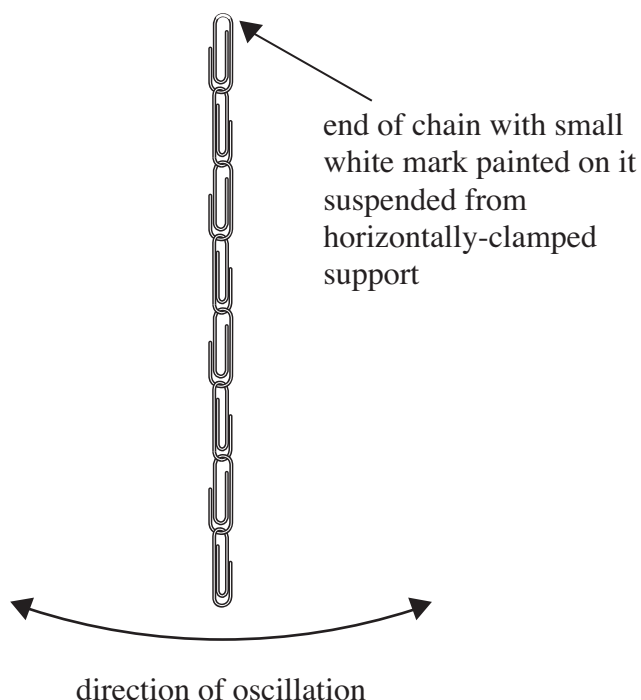

Section B

> **Apparatus**
> - small plane mirror

The mirror may be used to assist candidates in making their gradient determinations.

Note that when completing Section B of the test candidates should be provided with their completed copy of Section A Task 2, whereas candidates' copies of Section A Task 1 should **not** be made available to them.

Section A   Task 1

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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

end of chain with small
white mark painted on it
suspended from
horizontally-clamped
support

direction of oscillation

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.

Turn over ▶

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.

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.

(3 marks)

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.

(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.

(2 marks)

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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.

(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.

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

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.

(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.
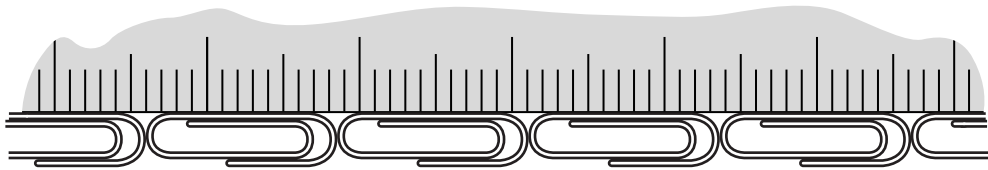
(1 mark)

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END OF QUESTIONS

Section A   Task 2

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.

(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.

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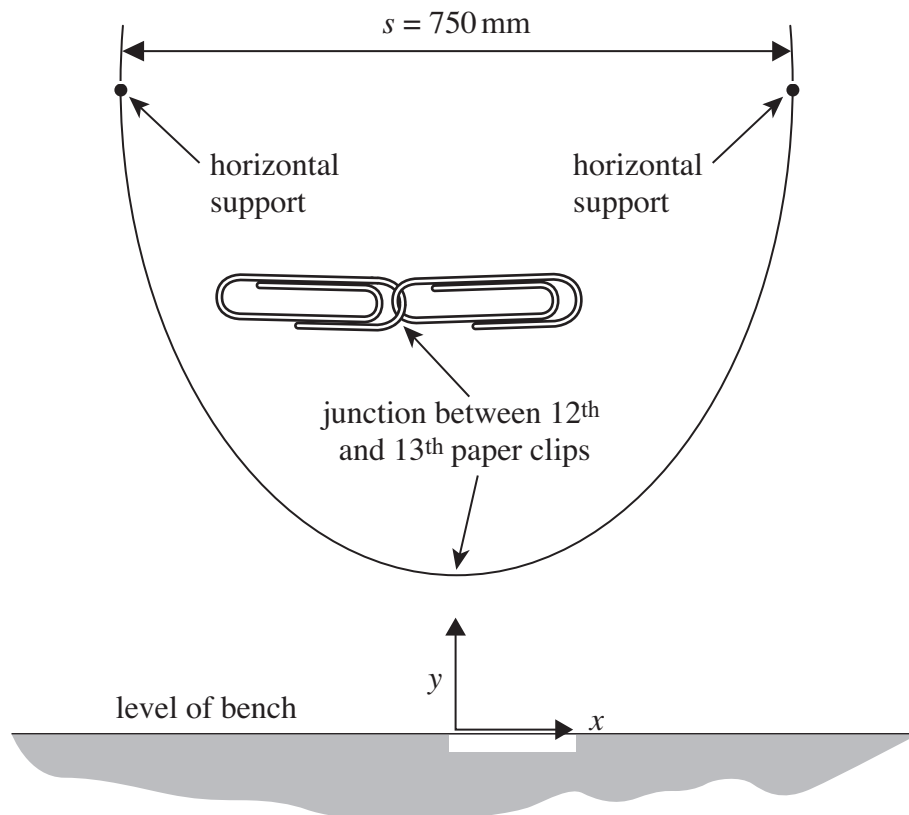
Mark on the tape the point **directly below** the centre of the chain.

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.

Figure 3

Turn over ▶

*Do not write
outside the
box*

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)

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END OF QUESTIONS

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Section B

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

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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. *(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.

Turn over ▶

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)

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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 12th and 13th paper clips are joined, and finishing where the 24th 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 18th and 19th paper clips**. You are provided with a small plane mirror which you may use to assist you in answering the question. *(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 $L = 1.17\,\text{m}$ and $s = 0.756\,\text{m}$.

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)*

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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)

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.
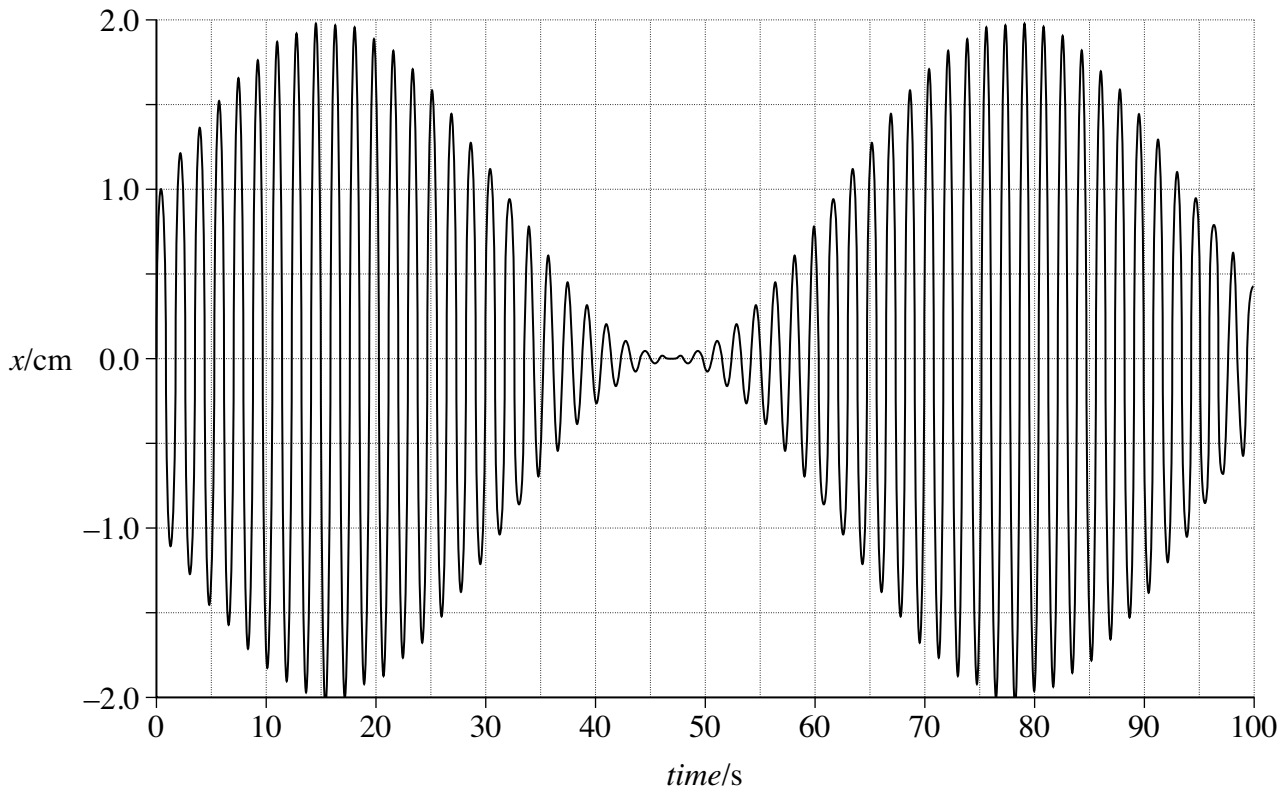The student's results are shown in **Table 2**.

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)

2

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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.

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

(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.

(4 marks)

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END OF QUESTIONS

General Certificate of Education
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Advanced Level Examination

AQA

PHYSICS (SPECIFICATIONS A AND B) PHA6/B6/XTN
Unit 6

SUPERVISOR'S REPORT

When completed by the Supervisor, this Report must be attached firmly to the attendance list, before despatch to the Examiner.

Information to be provided by the centre.

Section A Task 1
Question 1   The Examiners require no information for this question.

Question 2(a)   Examiners require the period for the transfer of motion (see page 7).

Section A Task 2
Question 1   Examiners require the length of the chains of 24 interconnected paper clips that the students will use, to ± 5 mm.

Supervisor's Signature ....

Centre Number ....

Date ....

Centres may make copies of this Supervisor's Report for attachment to individual scripts where necessary.