Rewarding Learning

ADVANCED
General Certificate of Education
2015

Centre Number

Candidate Number

Physics

Assessment Unit A2 3
Practical Techniques
Session 1

AY231

[AY231]

WEDNESDAY 6 MAY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Turn to page 2 for further Instructions and Information.

For Examiner's use only		
Question Number	Marks	Remark
1		
2		
3		
Total Marks		

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions in this booklet. Rough work and calculations must also be done in this booklet. Except where instructed, do not describe the apparatus or experimental procedures.
The Supervisor will tell you the order in which you are to answer the questions. Not more than 30 minutes are to be spent in answering each question. You may be told to start with the experimental tests in Section A, or with the single question in Section B.
Section A consists of two experimental tests. A 28-minute period is allocated for you to use the apparatus. Two minutes is allocated to the supervisor to prepare the station for the next candidate. At the end of the 30-minute period you will be instructed to move to the area set aside for your next question. Section B consists of one question in which you will be tested on aspects of planning and design.

INFORMATION FOR CANDIDATES

The total mark for this paper is 60.
All questions carry 20 marks each.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each part question.
You may use an electronic calculator.

Section A

1 In this experiment you will use a signal generator to establish resonance on a tensioned metal wire and from the results determine relationships between the variables in the experiment and the physical dimensions of the wire.

The aims of this experiment are:

- to measure the diameter of the wire
- to obtain data on how the resonant frequency varies with the suspended mass
- to use the results to plot a linear log-log graph
- to use the graph to determine the relationship between the suspended mass and the resonant frequency

(a) Measuring diameter of the wire

The apparatus consists of a length of wire fixed at one end, the other end passes over a pulley and supports suspended masses on a hanger. The wire is connected to a signal generator from points outside the length between the fixed end and the pulley. The wire passes through a magnetic field at a point halfway between the fixed end and the pulley. A frequency meter measures the a.c. frequency of the transverse wire wave. This arrangement, illustrated in **Fig. 1.1**, has been set up for you.

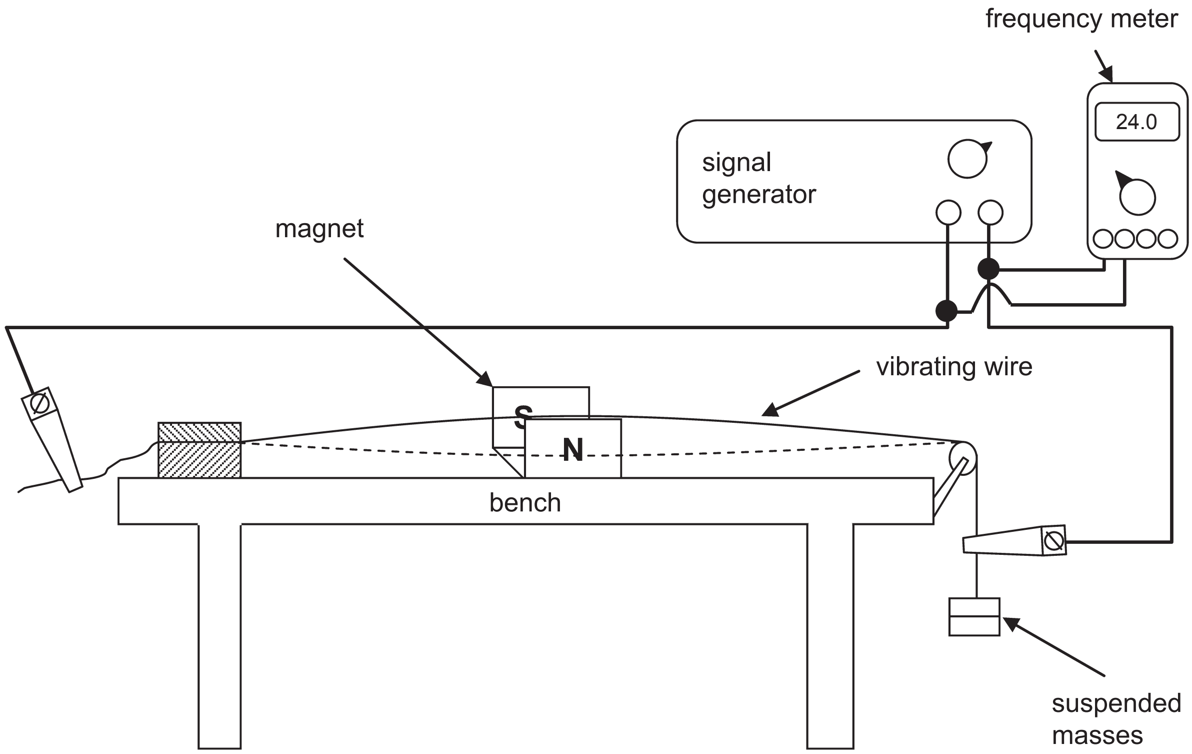

Fig. 1.1

Determine a **reliable** value for the diameter, d, of the wire.

d = ____________________ [2]

Examiner Only	
Marks	Remark

Examiner Only: Marks | Remark

(b) Obtaining the data

(i) For the suspended mass of 0.10 kg, use the signal generator to increase the frequency of the transverse wire wave until the first position of resonance (the fundamental) is obtained. Record this frequency in column 2 of **Table 1.1**.

Now, increase the suspended mass by 0.10 kg to 0.20 kg and use the signal generator to increase the frequency of the transverse wire wave until the new fundamental is obtained. Record the frequency of the transverse wire wave in column 2 of **Table 1.1**.

Continue this procedure until the resonant frequencies have been found for the suspended masses 0.30 kg, 0.40 kg and 0.50 kg.

[1]

(ii) Now, decrease the suspended mass by 0.10 kg to 0.40 kg and use the signal generator to decrease the frequency of the transverse wire wave until the fundamental is obtained. Record the frequency of the transverse wire wave in column 3 of **Table 1.1**.

Continue this procedure until the resonant frequencies have been found for the suspended masses 0.30 kg, 0.20 kg and 0.10 kg.

[1]

Table 1.1

1	2	3	4	5	6
Suspended mass m/kg	Resonant frequency f/Hz			lg_{10}(f/Hz)	lg_{10}(m/kg)
	Increasing	Decreasing	Average		
0.10					
0.20					
0.30					
0.40					
0.50					

Examiner Only	
Marks	Remark

(iii) Calculate the average resonant frequency for each suspended mass from 0.10 kg to 0.40 kg; insert your answer in column 4 of **Table 1.1**. Also, in the space below state whether the resonant frequency data is reliable or not reliable giving a reason for your statement.

____

____

____ [2]

(iv) In column 5 of **Table 1.1** insert the values for the logarithm to base 10 of the average resonant frequency for each suspended mass from 0.10 kg to 0.40 kg and also the single value for the 0.50 kg suspended mass. Logarithm values should be given to **two decimal places**.

[1]

(v) In column 6 of **Table 1.1** insert the values for the logarithm to base 10 of the suspended masses from 0.10 kg to 0.50 kg. Logarithm values should be given to **two decimal places**.

[1]

(c) Drawing the graph

On the graph grid of **Fig. 1.2**, plot the graph lg_{10}(m/kg) against lg_{10}(f/Hz). The logarithm to base 10 of the suspended mass is already scaled, scale the *x*-axis, plot the five points and draw a linear best fit line.

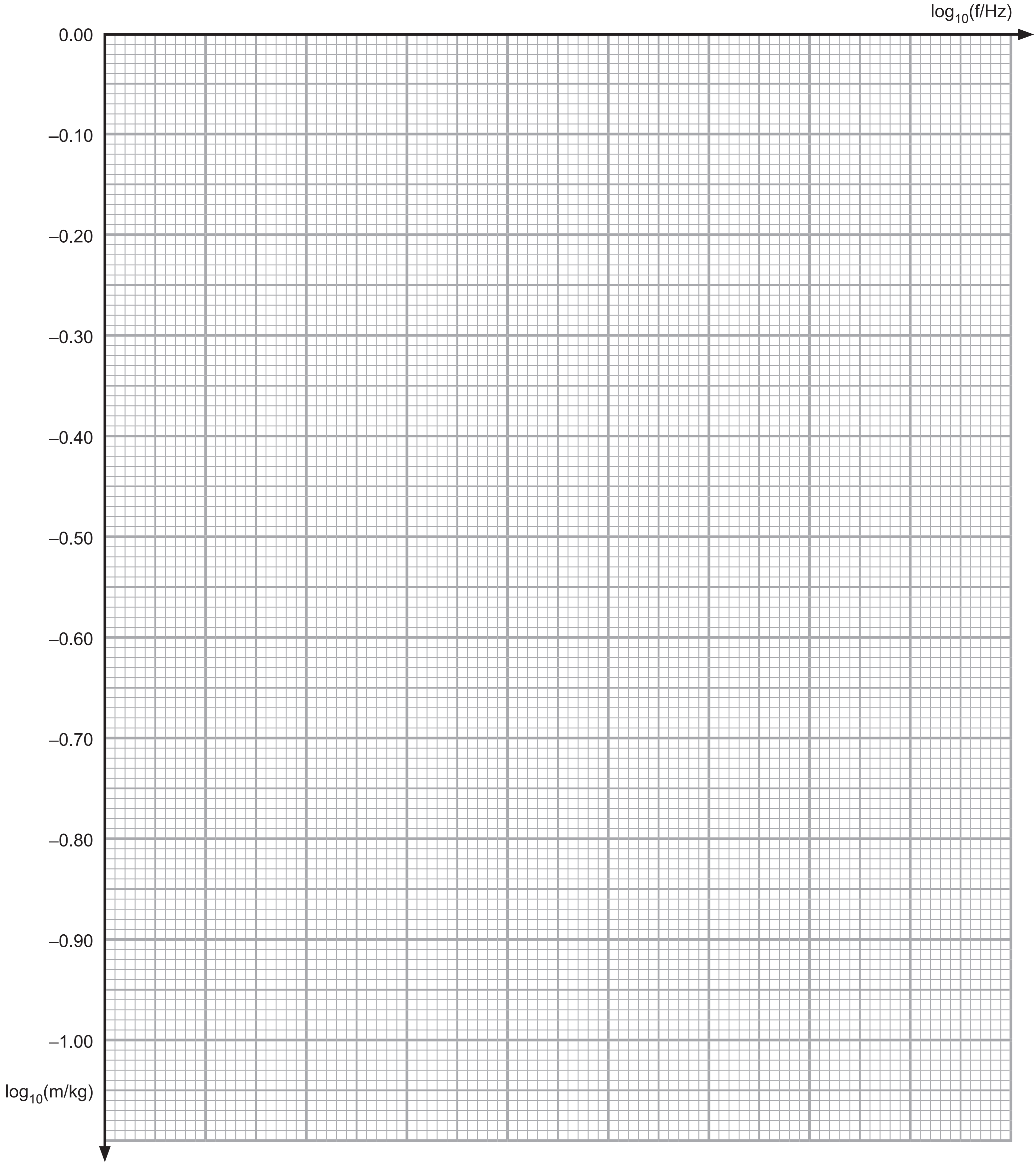

Fig. 1.2

[3]

Examiner Only	
Marks	Remark

(d) Determining the relationship between the suspended mass and the resonant frequency of the wire wave

The relationship between the suspended mass, *m*, and the resonant frequency of the transverse wire wave, *f*, is of the form shown in **Equation 1.1** where k and n are constants.

$$m = kf^n \qquad \textbf{Equation 1.1}$$

(i) Determine the gradient of the best-fit line drawn in **Fig. 1.2**.

Gradient = ____________________ [3]

(ii) Determine the magnitude of n, state your answer to **one** significant figure.

n = ____________________ [1]

Theory indicates that constant k depends upon the density of the material from which the wire is made, ρ, the diameter of the wire, d, the length of the wire from the fixed end to the pulley, L, and the acceleration of free fall, g. The precise nature of the relationship is given by **Equation 1.2**.

$$k = \frac{\pi \rho d^2 L^2}{g} \qquad \textbf{Equation 1.2}$$

The wire used in the experiment was constantan which has a density of 8.9×10^3 kg m^{-3} and a length L = 1.2 m. The acceleration of free fall may be taken as 9.8 m s^{-2}.

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(iii) Use data collected in part **(a)**, **Equation 1.2** and the information given to evaluate the theoretical value for k.

Theoretical value for k = ____________________ kg s^2 [2]

(iv) Use your graph to determine a practical value for k.

Practical value for k = ____________________ kg s^2 [3]

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2 In this experiment you will determine the periodic time of an oscillating piece of card and from the results determine relationships between the variables in the experiment and the physical characteristics of the oscillating card.

The aims of this experiment are:

- to obtain length, L, and periodic time data for an oscillating rectangular piece of card
- to draw a graph to show how the periodic time varies as the dimensions of the card vary
- to establish the aspect ratio that results in the minimum periodic time
- to draw a linear graph and use it to determine the acceleration of free fall

(a) Measuring the periodic time of the oscillating card

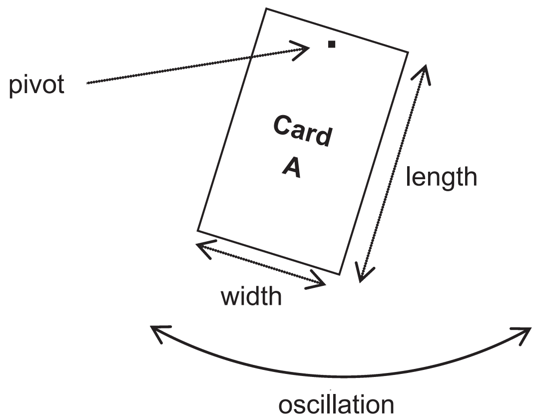

Fig. 2.1

(i) 1. Measure the length of Card A, see **Fig. 2.1**, and input the value into column 2 of **Table 2.1**.
2. Slip the small hole in Card A over the pin attached to the cork in the retort stand clamp.
3. Start the card oscillating by displacing it to one side.*
4. Determine a value for the periodic time, T, of the oscillating card and record your values in columns 3, 4 and 5 of **Table 2.1**.
5. Replace the Card A with that labelled Card B.
6. Measure the length of Card B and input the value into column 2 of **Table 2.1**.
7. Determine the periodic time of this new card by inputting data to columns 3, 4 and 5 of **Table 2.1**.
8. Continue the process with Cards C, D, E and F, determining the periodic time of each until columns 1–5 of **Table 2.1** are complete.

* Smaller cards may require larger displacements

Note: Small wobbles as the cards oscillate may be ignored.

Table 2.1

1	2	3	4	5	6	7	8
Card	L/ mm	No. of oscillations, N	Time for N oscillations/s	T/s	c		
A							
B							
C							
D							
E							
F							

[5]

(ii) Comment on difficulties in obtaining the timing data for the different lengths of the oscillating card.

____

____

____ [2]

(iii) The Aspect Ratio, c, of the card is found by dividing the length of the card by its width. The card you have been experimenting on has a width of **1.00×10^{-1} m**. Complete column 6 in **Table 2.1** by calculating the aspect ratio to an appropriate number of significant figures. [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(b) (i) Graph of periodic time against aspect ratio for the card

Complete **Fig. 2.2** by plotting the periodic time, T, of each oscillating card against its aspect ratio, c, and drawing an appropriate best-fit curve.

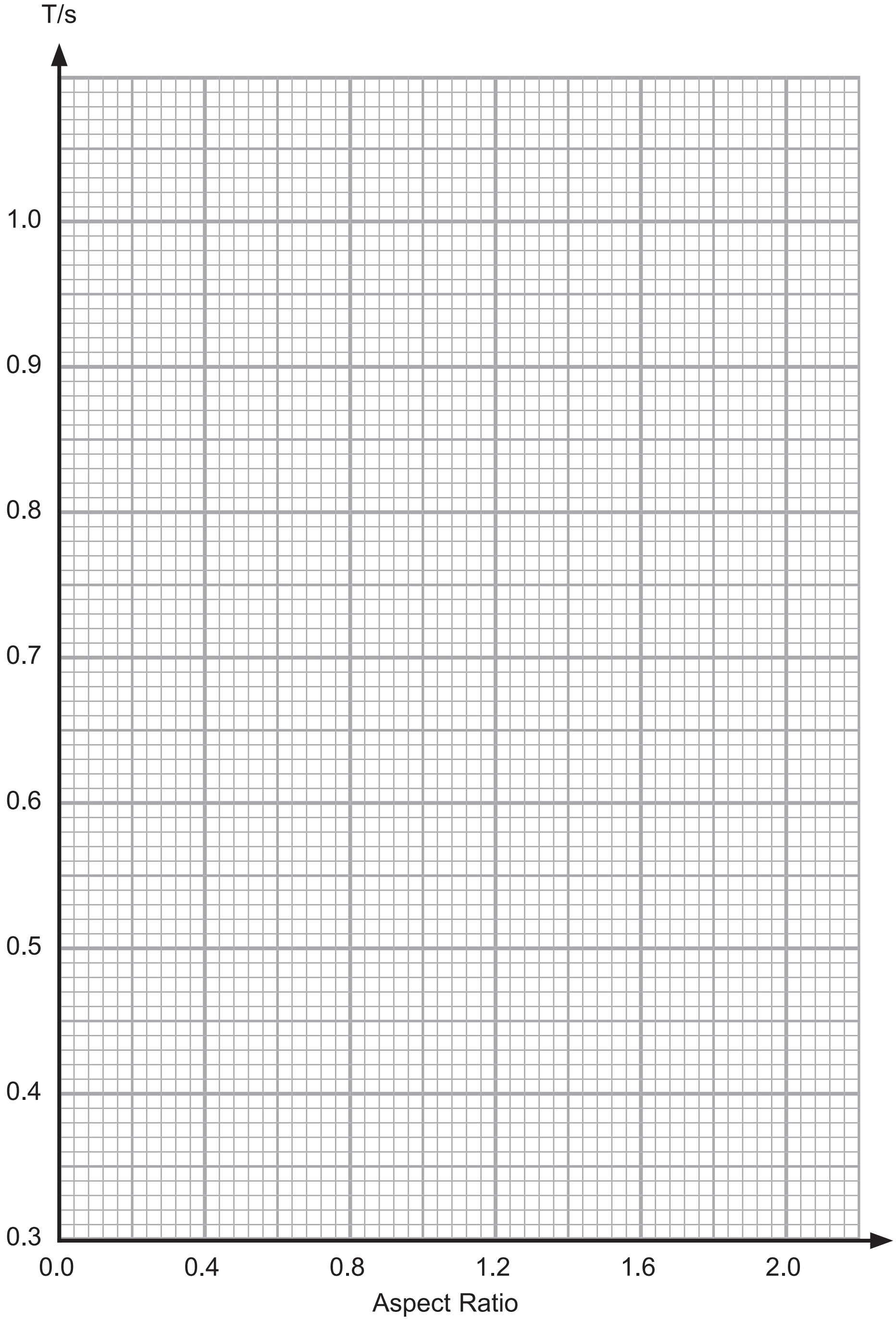

Fig. 2.2

[2]

(ii) Use the curve on **Fig. 2.2** to determine the aspect ratio that leads to the minimum periodic time of the oscillating card.

Aspect ratio, c = ____________________ [1]

Examiner Only	
Marks	Remark

(c) Determination of the acceleration of free fall, g, from a linear graph

Equation 2.1 represents the theoretical relationship for the best-fit curve in **Fig. 2.2**.

$$T = 2\pi\sqrt{k\left(4c + \frac{1}{c}\right)} \qquad \textbf{Equation 2.1}$$

Where k is a constant.

Analysis of **Equation 2.1** indicates that a graph of T^2 against $\left(4c + \frac{1}{c}\right)$ should result in a linear graph.

(i) Head columns 7 and 8 of **Table 2.1** appropriately and calculate the data required to draw this graph.

[3]

(ii) Plot the points and draw the best-fit straight line on **Fig. 2.3**. [2]

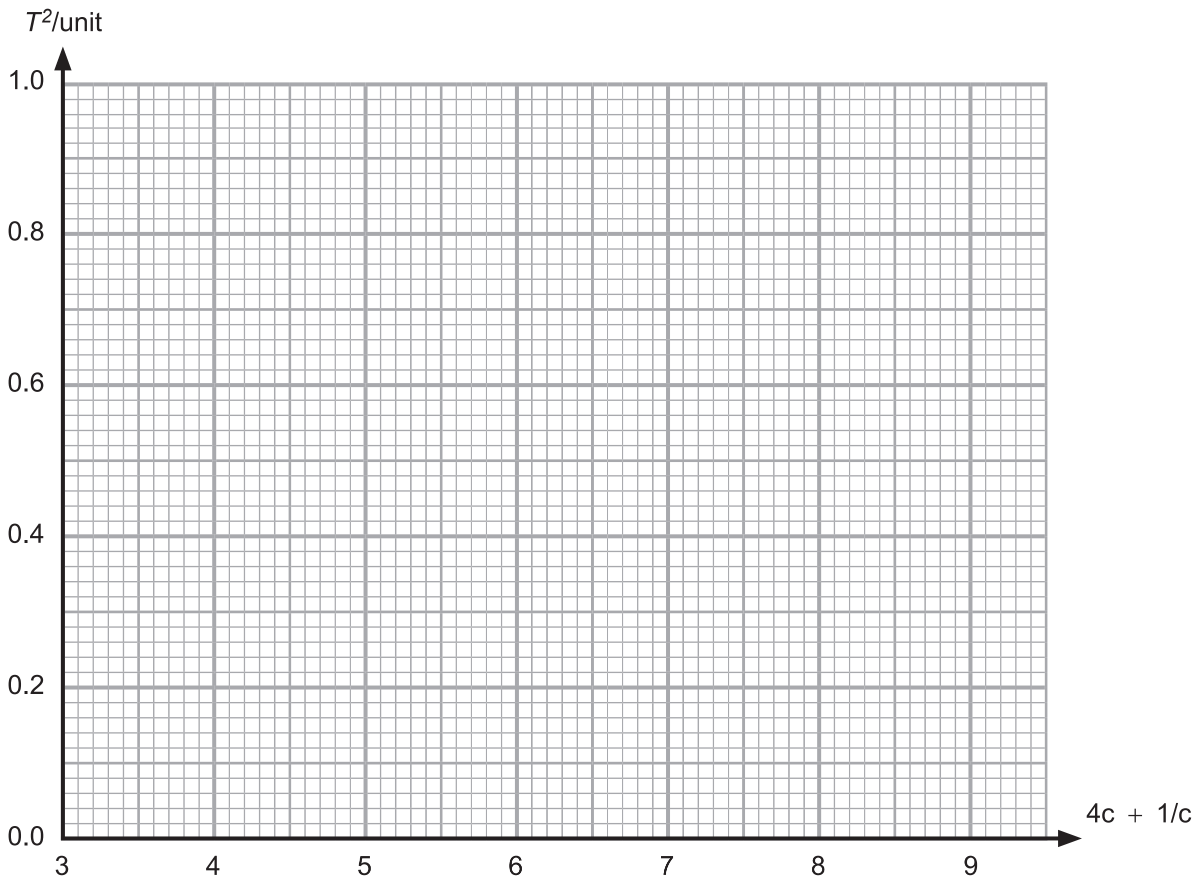

Fig. 2.3

Examiner Only	
Marks	Remark

(iii) In **Equation 2.1**, constant $k = \dfrac{0.017}{g}$.

Use this information and the graph drawn in **Fig. 2.3** to determine a value for the acceleration of free fall, g.

g = ____________________ $m\,s^{-2}$ [3]

Section B

3 In this question you are to plan an experiment to verify the Joule Law of Heating given in the form of **Equation 3.1**.

$$\Delta\theta = kI^2 \qquad \textbf{Equation 3.1}$$

Where $\Delta\theta$ is the change in temperature, I is the current and k is a constant.

Fig. 3.1 is a graph of the experimental results for the temperature change, $\Delta\theta$, in a sample of water against the square of the current, I^2, through a constantan heating coil of wire immersed in the water. The software package used to draw the graph has included the equation for the trend line.

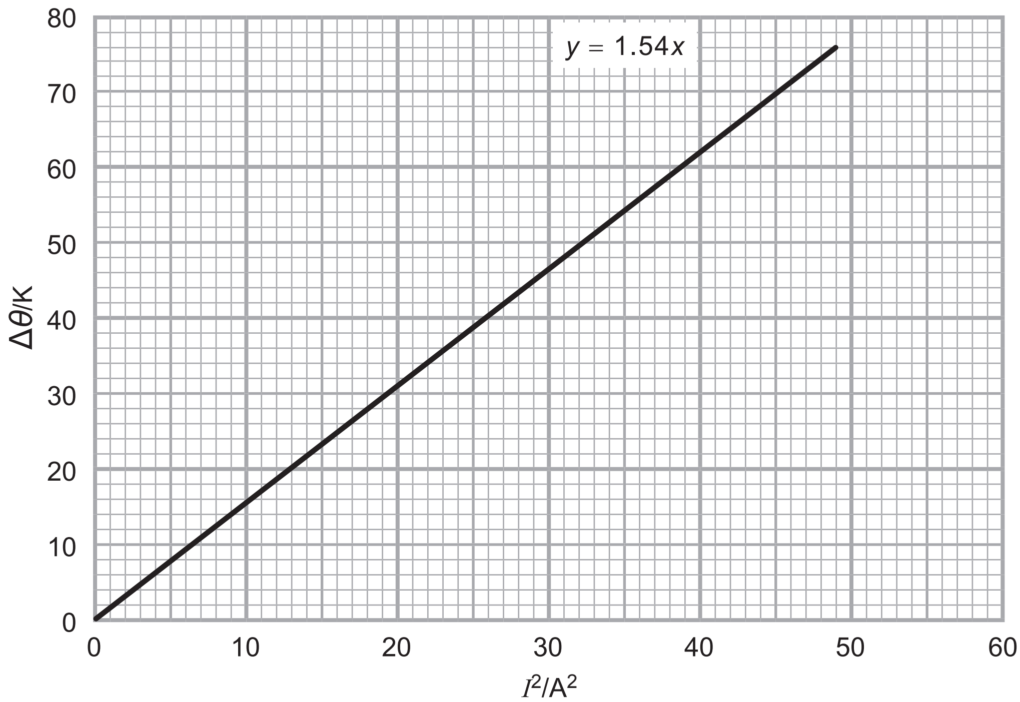

Fig. 3.1

Examiner Only	
Marks	Remark

(a) **(i)** Does the graph in **Fig. 3.1** verify the Joule Law of Heating? Explain your answer.

____

____

____ [2]

(ii) Suggest a reason why the graph does not extend beyond a temperature change of 75 K.

____

____ [1]

(b) In the space below, draw a fully labelled diagram of an experimental arrangement that would facilitate the taking of results that would allow a graph similar to that shown in **Fig. 3.1** to be drawn. Remember to include any measuring instruments required.

[6]

Examiner Only

Marks	Remark

(c) (i) Outline how the experiment should be conducted in order to obtain the data required to draw a graph similar to that given in **Fig. 3.1**.

[4]

(ii) Describe any strategies required to promote the taking of accurate measurements.

[2]

Examiner Only	
Marks	Remark

Constant k is defined in **Equation 3.2**.

$$k = \frac{Rt}{mc + 41} \qquad \textbf{Equation 3.2}$$

Where: R is the resistance of the coil, t is the time for which the water is heated, m is the mass of water heated and c is the specific heat capacity of the water.

(d) Describe how a value for the resistance of the coil could be determined.

____

____

____

____

____

____ [2]

In the experiment $R = 1.80\,\Omega$, $m = 0.0741\,\text{kg}$ and $c = 4190\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$.

(e) Calculate the time, in minutes, for which the samples were heated.

Time = ____________________ minutes [3]

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Physics

Assessment Unit A2 3
Practical Techniques
Sessions 1 and 2

[AY231] [AY232]
WEDNESDAY 6 AND THURSDAY 7 MAY

CONFIDENTIAL INSTRUCTIONS TO TEACHERS

CONFIDENTIAL INSTRUCTIONS FOR PHYSICS A2 PRACTICAL TEST

Confidentiality

To maintain the integrity of the Test, no question papers or any material pertaining to the Test should be publicly released until after the final session.

General

The Practical Test will contain three compulsory questions, of which two are 30-minute experimental tests and the third is a 30-minute question testing Planning and Design. The total time allowed is 1 hour 30 minutes. The order in which candidates are to take the questions is to be decided by the Supervisor. Candidates will have access to the apparatus in the experimental tests for 28 minutes each, the final two minutes being reserved for adjustment of the apparatus by the Supervisor. The question paper includes spaces for answers; candidates will write their answers in the Question/Answer booklet.

Question 1 (Same for Sessions 1 and 2)

Preparation

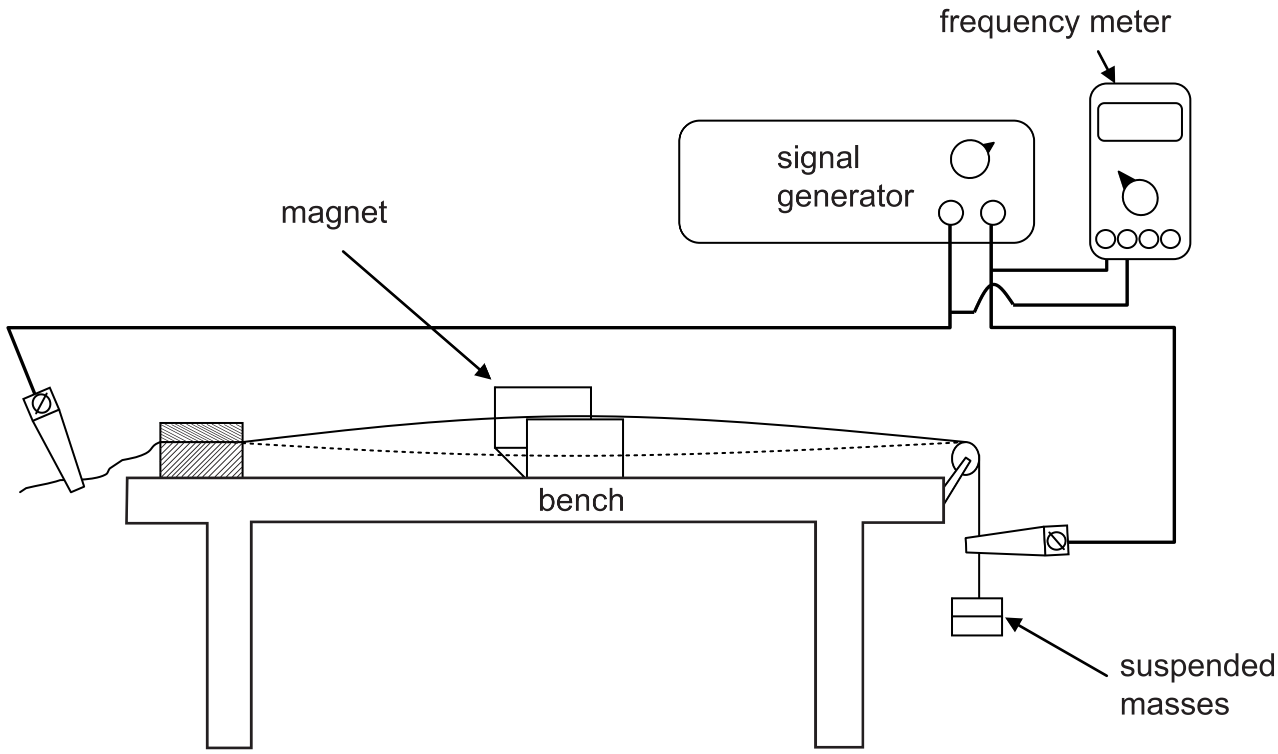

Fig. 1.1

Cut a 1.6 m length of 32 swg constantan wire. (1.2 m Session 2)
Secure the wire at one end of a bench using the G-clamp and the wooden blocks; clamp the wire so about 20 cm sticks out the back.
Double the other end of the wire over on itself and twist it tightly to form a secure loop.

Place the wire over the bench pulley so that the length of wire between block and pulley is 1.2 m (0.8m Session 2) and hook the 100 g mass holder onto the loop at the end of the wire.

Attach the magnadur magnets to the inside surfaces of the yoke so that **opposite** poles face each other.
Place the magnets at the midway point between the wooden block and the bench pulley with the wire inside the magnetic field.

Attach the output terminals of the signal generator to the ends of the constantan wire, see **Fig. 1.1**.

A frequency meter is attached to the output terminals of the signal generator.

Test: With a suspended mass of 300 g a single loop (fundamental) standing wave pattern should be observed at a frequency of approximately 30 Hz. (50 Hz Session 2)

Before the Examination

Arrange the apparatus so that:

- Only the 100 g mass holder is suspended from the wire.
- Ensure the magnetic poles attract.
- Ensure the magnet is at the approx. half distance.
- Ensure the micrometer is closed.
- Ensure the signal generator is set to accommodate the range 5 Hz–50 Hz (5 Hz–70 Hz Session 2) and the control knob is at the lowest frequency for the range.

Action at changeover

Arrange the apparatus as Before the Examination.

Information required by Examiners

None

Question 2 (Same for Sessions 1 and 2)

Preparation

Take the A4 card and cut it into rectangles (with sizes in mm) measuring:

200 × 100	Label this card 'Card A'
100 × 100	Label this card 'Card B'
60 × 100	Label this card 'Card C'
40 × 100	Label this card 'Card D'
30 × 100	Label this card 'Card E'
20 × 100	Label this card 'Card F'

In each card, punch a small hole just large enough for it to fit over the head of the optical pin, 1 mm from one of the 100 mm sides and on the **centre line**; see **Fig. 2.1**.

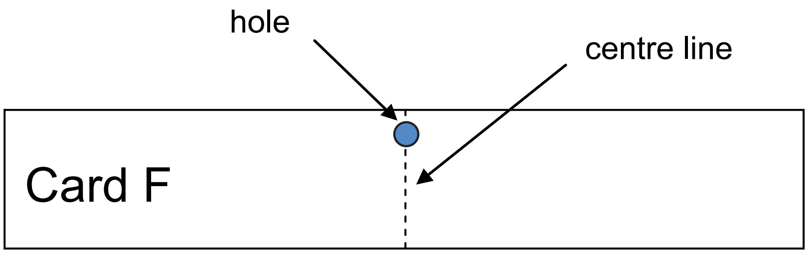

Fig. 2.1

Insert an optical pin into a flat face on the cork so that it is secure and is perpendicular to the face of the cork.

Secure the cork in the jaws of a clamp attached about 60 cm above the surface of the desk using the retort stand.

Test that the hole is large enough to allow the card to swing freely.

Before the Examination

Place all six cards on the bench, in size order, with their labels visible.

Reset the stopwatch to zero.

Action at changeover

Place all six cards on the bench, in size order, with their labels visible. Check the holes for damage and replace if necessary.

Reset the stopwatch to zero.

Information required by Examiners

None

Question 3

No equipment is required for this question.

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2015

Physics

Assessment Unit A2 3
Practical Techniques
Sessions 1 and 2

[AY231] [AY232]
WEDNESDAY 6 AND THURSDAY 7 MAY

APPARATUS
AND
MATERIALS
LIST

A2 PHYSICS UNIT 3 (A2 3)
APPARATUS AND MATERIALS REQUIRED FOR PRACTICAL ASSESSMENTS

CONFIDENTIAL

Information about the apparatus and materials required for the A2 Practical Assessments **must not** be communicated to candidates sitting the examination.

This document gives preliminary information on the apparatus and materials required for the A2 Practical Assessments.

Teachers will be given detailed instructions for setting up the experiments in the *Confidential Instructions for Physics (A2) Practical Tests*, to which they will have confidential access from March 2015.

Teachers will have confidential access to a copy of the experimental tests two working days (48 hours) before the start of the assessment.

The A2 3 Practical Techniques Assessment is a test of practical skills consisting of Section A and Section B. Section A comprises 2 experimental tests (40 marks) and Section B consists of one question which tests aspects of planning and design (20 marks). The duration of the assessment is 1 hour 30 minutes. Some of this time will be set aside for supervisors to re-set apparatus for the next candidates. In each of the experimental tests (Q1 and Q2), candidates must stop using the apparatus after 28 minutes. At the end of each 28 minute period, a changeover time of 2 minutes will be set aside for the supervisor to re-set the apparatus for the next candidates. During the changeover periods, candidates may write-up anything they have not completed, however they will not have access to the apparatus. Candidates will move on to the next question after 30 minutes. The time allocation for **question 3** (planning and design) is 30 minutes. As the time allocation for each question is effectively the same, the supervisor can decide in which order the candidates should attempt the questions.

The apparatus in the following list will allow for **one experiment** to be set up for each of the practical tests which make up **questions 1 and 2**. In other words, each set of apparatus (as listed on page 4) will accommodate three candidates.

The apparatus can be used for alternative sessions according to the following schedule:

6 May 2015 Physics A2 3A (AY231)

(Main Session) **9.15 am–10.45 am**
(First Alternative) **11.00 am–12.30 pm**
(Second Alternative) **1.15 pm–2.45 pm**
(Third Alternative) **3.00 pm–4.30 pm**

7 May 2015 Physics A2 3B (AY232)

(Main Session) **9.15 am–10.45 am**
(First Alternative) **11.00 am–12.30 pm**
(Second Alternative) **1.15 pm–2.45 pm**
(Third Alternative) **3.00 pm–4.30 pm**

One set of apparatus for A2 3A (AY231) will therefore be sufficient for twelve candidates on **6 May** if the Main Session and all three alternatives are used. Similarly, one set of apparatus for A2 3B (AY232) will be sufficient for twelve candidates on **7 May** if the Main Session and all three alternatives are used. A laboratory may contain one, two, three or more sets of apparatus. This means that three, six, nine or more candidates can be accommodated in the same session. **When alternative sessions are used care must be taken to segregate candidates who have taken the examination from those who have still to sit the examination.**

IMPORTANT NOTICE

Centres are urged to order items needed for the Physics Practical Tests from the suppliers as soon as possible.

Question 1

Ref	Component	Session 1	Session 2
1.1	spool of 32 swg constantan wire	1	1
1.2	bench pulley	1	1
1.3	G-clamp	1	1
1.4	Wooden block (approx 20 mm high × 40 mm × 50 mm)	2	2
1.5	Face poled magnets (magnadur)	2	2
1.6	Iron yoke (for magnets)	1	1
1.7	Micrometer screwgauge	1	1
1.8	Signal generator	1	1
1.9	Digital frequency meter	1	1
1.10	Crocodile clips	2	2
1.11	4 mm connecting wires (one of which ~ 1 m)	4	4
1.12	100 g mass hanger	1	1
1.13	100 g slotted masses (compatible with 1.12)	4	4

Question 2

Ref	Component	Session 1	Session 2
2.1	380 µm (312 gsm) A4 card	2	2
2.2	Retort stand	1	1
2.3	Boss head	1	1
2.4	Clamp	1	1
2.5	Medium sized cork	1	1
2.6	Optical pin (or equivalent)	1	1
2.7	Rule to measure to ~ 300 mm to ±1 mm precision	1	1
2.8	Stopwatch/stop clock, accurate to 0.01 s	1	1

Question 3

No equipment is required for this question.