Centre Number

Candidate Number

ADVANCED
General Certificate of Education
2023

Physics

Assessment Unit A2 3A
assessing
Practical Techniques and Data Analysis

APH31

[APH31]
FRIDAY 12 MAY, MORNING

1 hour.

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Write your answers in the spaces provided in this question paper.
Answer **both** questions.
The Supervisor will tell you the order in which you are to answer the questions. Not more than 28 minutes are to be spent in answering each question, and after 26 minutes you must stop using the apparatus in Questions 1 and 2 so that it can be re-arranged for the next candidate. At the end of the 28 minute period you will be instructed to move to the station for the next question. At the end of the Test a 4 minute period will be provided for you to complete your answer to any question, but you will not have access to the apparatus during this time.

The total mark for this paper is 40.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use an electronic calculator.

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

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1 In this experiment you will investigate the oscillations of a pendulum whose motion is obstructed by the metal rod of a clamp.

Aims

The aims of this experiment are to:
- measure the period of oscillation as the position of the rod is changed;
- analyse the results and plot a linear graph;
- use the results to find a value for the acceleration of free fall.

Apparatus

You are provided with a pendulum suspended from a cork attached to a retort stand. The length L of the pendulum is set at 70.0 cm and **should not be changed during the experiment**. A second clamp is attached to the retort stand so that the rod of the clamp obstructs the motion of the pendulum as it swings, as shown in **Fig. 1.1**.
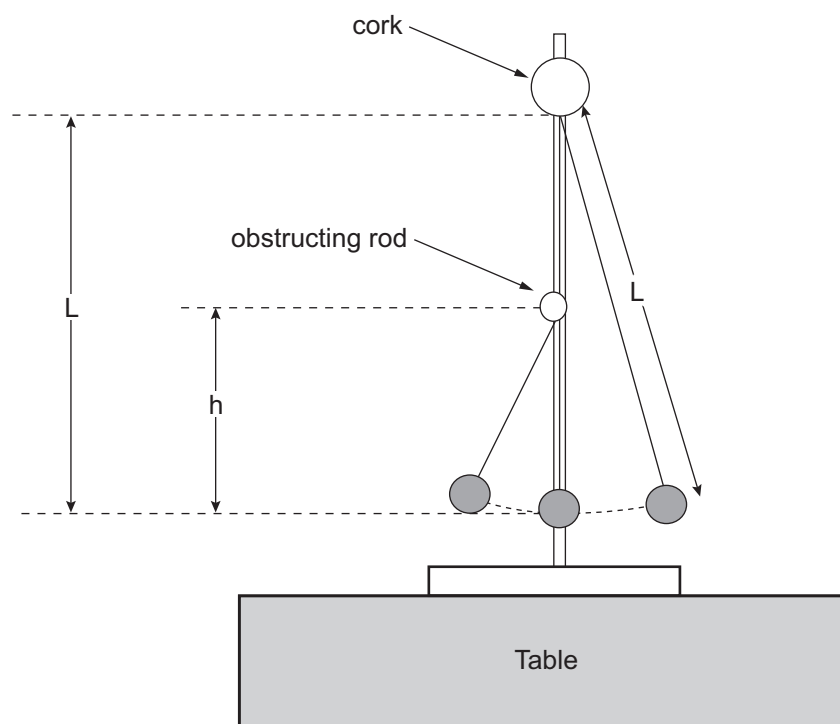
A stopclock and metre rule are also provided.

Fig. 1.1

Procedure

(a) h is the distance between the position of the rod and the centre of the pendulum, as shown in **Fig 1.1**. Adjust h to a value of about 10cm. You can change h by moving the boss holding the obstructing rod, but the length L of the pendulum must not be altered.

Displace and release the pendulum so that it swings to and fro with a small amplitude, with the string of the pendulum hitting into the obstructing rod on each oscillation.

Take readings to allow you to determine an accurate value for the period of oscillation T.

Record all your results in **Table 1.1** adding any extra headings required.

Repeat the procedure until you have five sets of corresponding values of h and T for heights in the range from 10 cm to 50 cm, at approximately 10 cm intervals.

Table 1.1

h / cm		T / s	

[5]

Theory

Theory suggests that the relationship between T and h is given by **Equation 1.1**.

$$T = \frac{\pi}{\sqrt{g}}(\sqrt{h} + \sqrt{L})$$ **Equation 1.1**

where g is the acceleration of free fall and L is the length of the pendulum.

(b) Show that a graph of T against $\sqrt{h}$ will result in a straight line from which the value of g could be determined.

[2]

(c) (i) To draw the graph, it is necessary to calculate additional quantities from your results. Complete the final blank column of **Table 1.1** with an appropriate heading and values. [3]

(ii) Plot a graph of T against $\sqrt{h}$ on the grid of **Fig. 1.2** and draw the best fit straight line for the points plotted. [5]
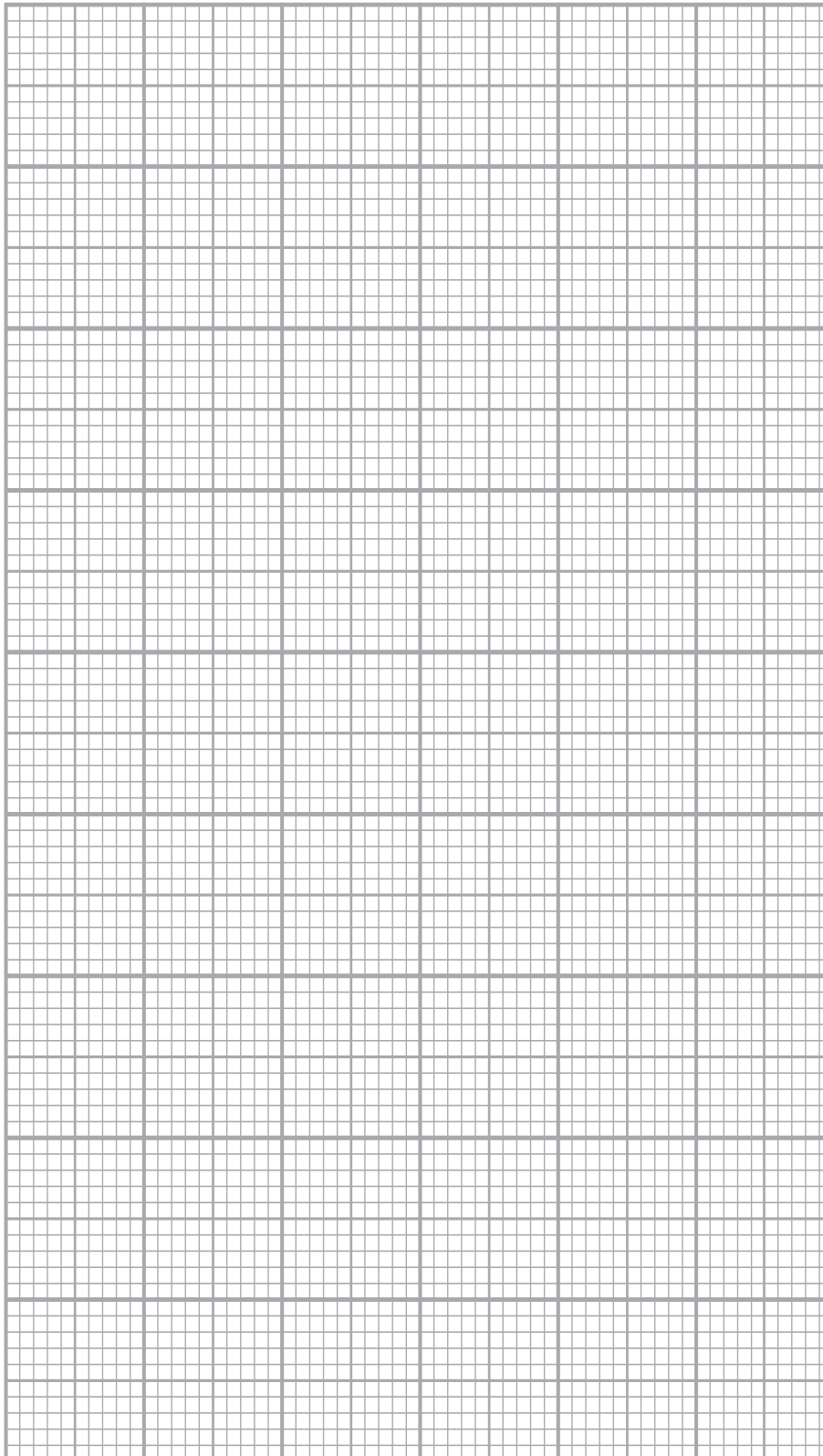
Fig. 1.2

(d) (i) Calculate the gradient of your graph.

Gradient = _____ [2]

(ii) Use the value of the gradient from part **(i)** to obtain a value for g in $cm\,s^{-2}$.

g = _____ $cm\,s^{-2}$ [2]

(iii) Calculate the percentage difference between your experimentally determined value of g and the accepted value of g, $981\,cm\,s^{-2}$.

Percentage difference = _____ % [1]

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(Questions continue overleaf)

2 In this experiment you will investigate how a capacitor discharges through two resistors connected in parallel.

Aims

The aims of this experiment are to:
- determine the time constant for the circuit as the resistance of one of the resistors is changed;
- analyse the results and plot a linear graph;
- use the results to determine the resistance of a fixed resistor.

Apparatus

You are provided with the circuit shown in **Fig. 2.1** and a stopclock.
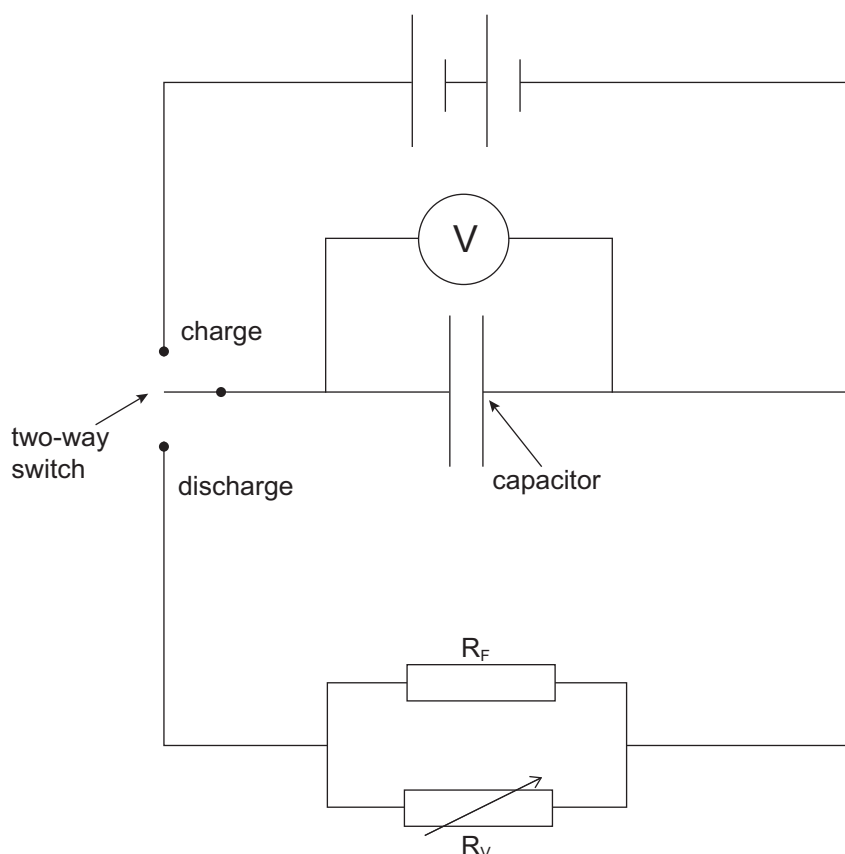

Fig. 2.1

The resistance of the variable resistor R_V can be changed by turning the dial on the box to known values of resistance. The fixed resistor R_F is connected in parallel.

The two-way switch can be moved into the upper position, labelled 'charge', to charge the capacitor and into the lower position, labelled 'discharge', to discharge the capacitor through the two resistors.

Procedure

(a) (i) Place the two-way switch to the position marked 'charge'. Record the initial voltage V_0 from the voltmeter.

$V_0 =$ _____ V

The time constant τ of a capacitor-resistor network is defined as the time taken for the voltage across the capacitor to fall to 0.37 of its initial value.
Calculate $0.37 \times V_0$ and record this value of the voltage V.

$V =$ _____ V   [2]

(ii) Turn the dial on the resistor box so that the $10\,k\Omega$ resistor is selected.
Move the two-way switch to the discharge position and, at the same time, start the stopclock.
Stop the stopclock when the voltage across the capacitor drops to V, $0.37 \times V_0$, as calculated in **(i)**.
Record this value of τ in the second column in **Table 2.1**.
Repeat the procedure to get a more accurate value for τ when $R_V = 10\,k\Omega$.

Repeat the experiment for **four** other R_V values from those that are available on your resistor box **and** are shown in **Table 2.1**.

Table 2.1

R_V / kΩ	τ / s			$\dfrac{1}{R_V}$ / $(\times 10^{-2}\,k\Omega^{-1})$	$\dfrac{1}{\tau}$ / s^{-1}
	1	**2**	**Ave**		
6.80				14.7	
10.0				10.0	
22.0				4.55	
33.0				3.03	
47.0				2.13	
100				1.00	
220				0.455	

[4]

Theory

The total resistance R_T of the variable and fixed resistor combined in parallel is given by **Equation 2.1**.

$$\frac{1}{R_T} = \frac{1}{R_V} + \frac{1}{R_F}$$ **Equation 2.1**

The total resistance, capacitance and time constant are related by **Equation 2.2**.

$$\tau = R_T\, C$$ **Equation 2.2**

(b) (i) Show that these two equations can be combined to form **Equation 2.3**.

$$\frac{1}{R_V} = C\frac{1}{\tau} - \frac{1}{R_F}$$ **Equation 2.3**

[2]

(ii) A graph of $1/R_V$ against $1/\tau$ will be a straight line graph. State how the capacitance C can be determined from the graph.

_____ [1]

(c) (i) In order to draw the graph, the values of $1/R_V$ and $1/\tau$ must be calculated. The values of $1/R_V$ have already been calculated for you in the third column of **Table 2.1**. Complete the final blank column in **Table 2.1** with values for $1/\tau$ to 3 decimal places.   [2]

(ii) Choose a scale for the x-axis, plot the graph of $1/R_V$ against $1/\tau$ on the grid of **Fig. 2.2** and draw the best fit straight line for the points plotted.   [4]
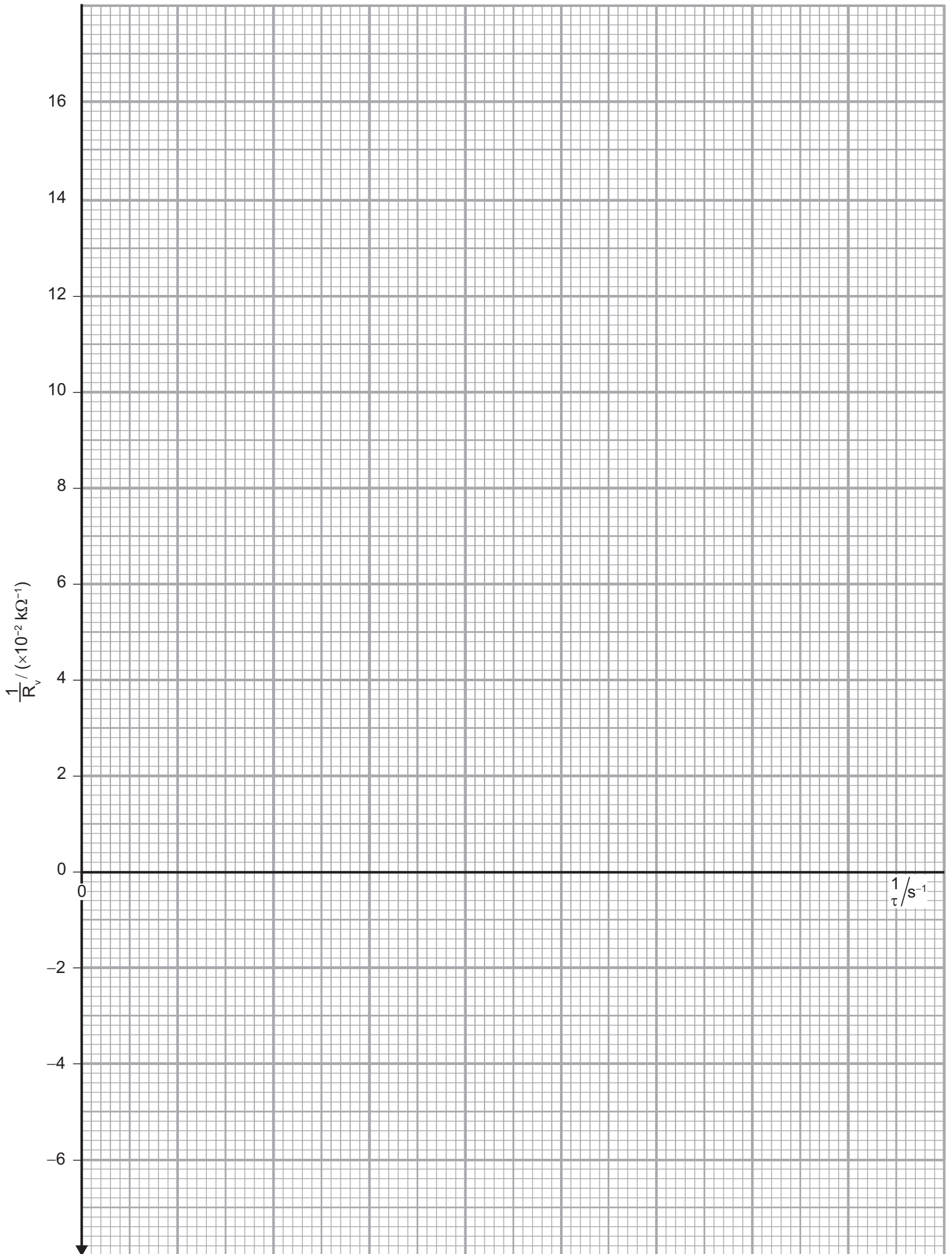
Fig. 2.2

(d) Use your graph to obtain a value for the fixed resistance, R_F. Include an appropriate unit for R_F.

$R_F =$ _____

Unit of $R_F =$ _____   [5]

THIS IS THE END OF THE QUESTION PAPER

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Physics

Assessment Unit A2 3A

Practical Techniques and Data Analysis

[APH31]
FRIDAY 12 MAY, MORNING

APPARATUS
AND
MATERIALS
LIST

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

CONFIDENTIAL

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

Information about the apparatus and materials required for this assessment must NOT be communicated to students. If apparatus/materials have their serial code and/or manufacturer specified then it is essential that centres use this exact apparatus/material.

On receipt of this APPARATUS AND MATERIALS LIST, centres must contact Gavin Gray, ggray@ccea.org.uk immediately if they have difficulty in sourcing the specified apparatus or materials.

Teachers will be given detailed instructions for setting up the experiment in the *Confidential Instructions for Physics Practical Test*, to which they will have confidential access from April 2023.

Teachers will have confidential access to a copy of the experimental test 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 **two** experimental tests (40 marks). The duration of the assessment is 1 hour.

The apparatus in the following list will allow for **one experiment** to be set up for the practical test which makes up questions 1–2. In other words, each set of apparatus (as listed on **page 3**) will accommodate two candidates when doing the circus of experiments.

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

Friday 12th May 2023 Physics A2 3A (APH31)

(Main Session) **9.15 am–10.15 am**
(First Alternative) **10.30 am–11.30 am**
(Second Alternative) **11.45 am–12.45 pm**
(Third Alternative) **1.15 pm–2.15 pm**
(Fourth Alternative) **2.30 pm–3.30 pm**

One set of apparatus for A2 3A (APH31) will therefore be sufficient for ten candidates on **Friday 12th May** if the Main Session and all four alternatives are used. A laboratory may contain one, two, three or more sets of apparatus. This means that two, four, six, eight or more candidates can be accommodated in the same session. **To maintain the confidentiality of details of the practical tests, candidates entered for any of the alternative sessions must be segregated within the centre so that there can be no contact with candidates who have taken an earlier test in any centre.**

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

Question 1

Requirements

- Pendulum bob, string and split cork
- Retort stand (height at least 75 cm)
- Clamp and boss × 2
- Stopclock to 0.01 s
- Metre rule
- G clamp

Question 2

Requirements

- 1000 µF capacitor
- 22 kΩ resistor
- Masking tape
- Variable Power Supply to supply 5V D.C.
- Resistance substitution box with 10 kΩ, 22 kΩ, 47 kΩ, 100 kΩ and 220 kΩ values. E.g. Philip Harris B8H27234
- Digital Voltmeter 0–20 V to 0.01 V
- Connecting leads (approx. 9)
- Stopclock to 0.01s
- Component holders × 2
- Sticky labels
- Two way switch

Physics

Assessment Unit A2 3A

Practical Techniques and Data Analysis

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CONFIDENTIAL
INSTRUCTIONS

1 Confidential Instructions

These instructions will give detailed guidance on setting up and testing the apparatus and materials to be used. **Again, information contained within the Confidential Instructions must not be relayed to candidates under any circumstances**. If at this point, centres find that the testing process produces results different to those specified in the Confidential Instructions, they must contact the CCEA Science Officer (ggray@ccea.org.uk) immediately.

2 Final Apparatus Testing

The practical assessment question paper will be made available to the Head of Physics **two** working days before the timetabled starting time so that teachers and technicians can carry out a final test on the experiments. If on checking the apparatus gives unexpected results, the CCEA Physics Subject Officer should be contacted immediately (ggray@ccea.org.uk), if the problem cannot be resolved. Then the centre must e-mail the CCEA Physics Subject Officer stating the centre name and number, the specific nature of the problem and the range of anomalous results produced. CCEA will respond by acknowledging receipt of the e-mail. If you do not receive a response within 24 hours, please contact the CCEA Physics Subject Officer by telephone (028 90261200) to confirm that CCEA has received your e-mail.

3 Practical Assessment A2 3A

The A2 3A Practical Techniques Assessment is a test of practical skills comprised of 2 experimental tests. The duration of the assessment is 1 hour. Some of this time will be set aside for supervisors to re-set the apparatus ready for the next candidates. The assessment should be run as a circus of experiments with candidates moving to the next experiment at the designated time. The assessment should be timed as follows:

Questions	Time
Q1 (practical test)	26 minutes
Changeover and practical write-up	2 minutes
Q2 (practical test)	26 minutes
Changeover and practical write-up	2 minutes
End of test write-up	4 minutes

At the end of the 26 minute period, candidates must stop using the apparatus. During each 2 minute changeover period candidates may continue with their write up, however they will not have access to the apparatus. At the end of the test a 4 minute period is provided to complete their answer to any question, but will not have access to the apparatus.

4 After the Practical Assessments

When the individual exam sessions have finished, please return the A2 3A practical scripts together with the corresponding advice notes to the examinations officer (EO). We will collect these by the day after the examination. If we don't, please contact us immediately to arrange another time for collection.

Where the centre finds that a candidate may have been disadvantaged because the apparatus did not function as intended, the supervising teachers should make a report to the EO. The EO will forward the confidential report on the issue and the candidates affected to the centre support section at CCEA for special consideration. Candidates should be identified by their examination number.

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

Question 1

Requirements
- Pendulum bob, string and split cork
- Retort stand (height at least 75 cm)
- Clamp and boss × 2
- Stopclock to 0.01 s
- Metre rule
- G clamp

Preparation

Clamp the retort stand to the desk using the G clamp. Tie the pendulum bob to the end of the string. Thread the pendulum string through the split cork. Position the split cork in the jaws of the clamp. Set the length of the pendulum to be 0.700 m. Position the second boss and clamp so that the rod of the clamp obstructs the path of the pendulum at a height of approx. 5 cm above the centre of mass of the bob as shown in the diagram in **Fig 1.1**.
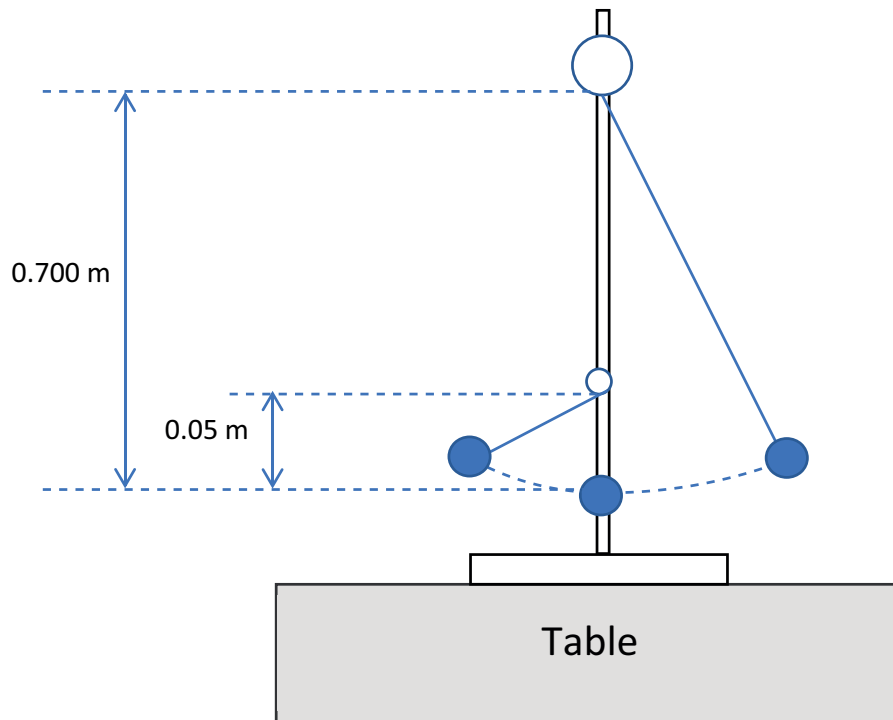

Fig 1.1

Place the stopclock and metre rule beside the pendulum

Action at Changeover

Ensure the length of the pendulum is 0.700 m, return the position of the rod to 5 cm above the centre of mass of the bob. Zero stopclock.

Question 2

Requirements

- 1000 μF capacitor
- 22 kΩ resistor
- Masking tape
- Variable Power Supply to supply at least 5V D.C.
- Resistance substitution box with 10 kΩ, 22 kΩ, 47 kΩ, 100 kΩ and 220 kΩ values.
  E.g. Philip Harris B8H27234
  OR
  Resistance selector box with 6.8 kΩ, 10 kΩ, 33 kΩ, 47 kΩ and 100 kΩ values, e.g. SLS Lascells PY3110
- Digital Voltmeter 0–20 V to 0.01 V DC
- Connecting leads (approx. 9)
- Stopclock to 0.01 s
- Component holders × 2
- Sticky labels
- Two way switch

Preparation

Wrap both the capacitor and the 22 kΩ resistor in masking tape so that the values of the capacitance and resistance cannot be seen. Place the capacitor and resistor into the component holders and label them 'capacitor' and 'R_F'. Label the resistance substitution box as 'R_V'. Set up the circuit as shown in **Fig 2.1**.
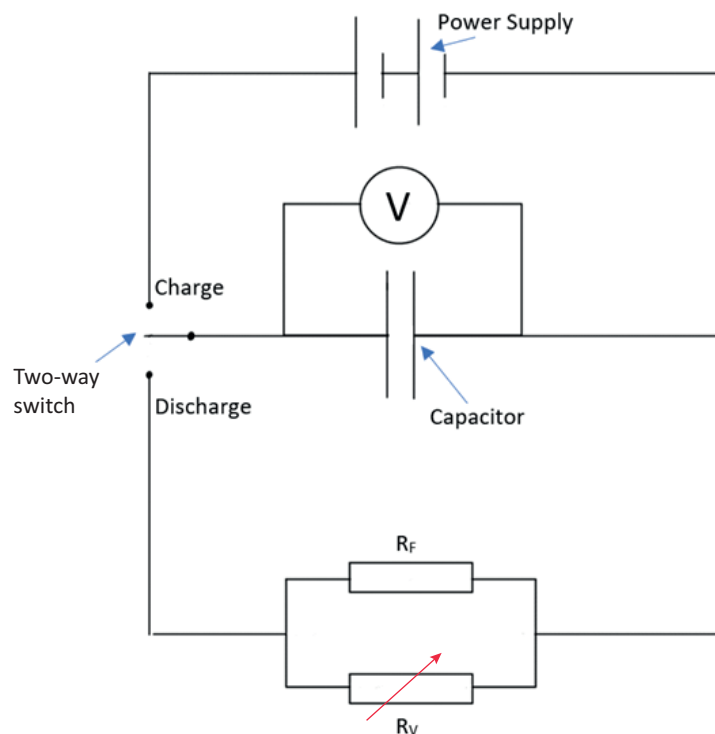

Fig 2.1

Place a label on the two-way switch with the words 'charge' and 'discharge' on it to indicate the correct positions. Turn the two way switch to the charged position and turn the dial on the variable power supply until the voltmeter reads approximately 5V. Place a label stating 'do not touch' onto the dial of the power supply.

Turn the dial on the resistance substitution box to 10 kΩ.

Action at Changeover

Ensure the circuit is as shown in **Fig 2.1**. Place the two-way switch into the charged position and check the voltmeter reads approximately 5V. Turn the dial on the resistance substitution box to 10 kΩ. Reset the stopclock to zero.