General Certificate of Education
Advanced Level Examination
June 2012

Physics PHA6/B6/XTN

(Specifications A and B)

Unit 6 Investigative and Practical Skills in A2 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.**

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 Part 1 and Part 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 that this requirement has been met on the front cover of the Section B written paper.

Section A: Part 1 and Part 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 teacher 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*.

Section B: EMPA written test

- The Section B EMPA written test should be taken as soon as convenient after completion of Section A.
- This test must be carried out under supervision 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 Part 2 question paper/answer booklet.
- Supervisors should ensure that candidates understand that Section A Part 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 or rest breaks.

Administration

Candidates must not bring any paper-based materials into any session or take any assessment materials away at the end of a session. Electronic and communication devices, including mobile telephones, iPods, MP3 players are **not** allowed.

Modifications

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

Absent candidates

Candidates absent for any Part of Section A should be given an opportunity to carry out the practical exercises before attempting the Section B EMPA written test. No credit can be given for any analysis done when evidence of the relevant practical work is not provided.

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

The *Supervisor's Report* provided in this document should be sent to the Examiner with the scripts. Details should be given on the *Supervisor's Report* if

- any part of the equipment provided differs significantly from that specified in these Instructions
- any help is given to candidates in the event of any failure of or difficulties with the equipment.

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.

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.
Candidates must **not** be given access to their completed 'live' EMPA. Discussion of 'live' EMPA materials is not permitted.

Submission of materials to the AQA Examiner

Once completed, each candidate's completed EMPA should be collated in candidate number order and in the following order

- Section A Part 1
- Section A Part 2
- Section B EMPA written test.

The assembled material should then be secured using a treasury tag. A copy of the Supervisor's Report should be sent with the scripts.

Section A, Part 1, Question 1
Candidates are to measure the radius of curvature of the concave surface of a spherical mirror by measuring the period of a ball bearing rolling on the mirror.

Apparatus
- one concave/convex mirror, 100 mm × 100 mm, e.g. Griffin Education XFK-200-100V
- 12 mm diameter steel sphere, e.g. Griffin Education XBX-480-030T
- beaker on which mirror can be placed with either surface uppermost and parallel to the bench; a 400 ml squat form beaker with diameter 80 mm was found suitable, e.g. Fischer Scientific FB33113
- digital stopwatch capable of reading to 0.10 s
- micrometer screw gauge capable of reading to 0.01 mm

The equipment should be placed on the bench for the candidates' use.

Candidates are allowed to make pencil marks on the mirror to assist with their measurements. Any such marks should be wiped off and any traces of grease removed from both the mirror and the steel sphere if the apparatus is to be used by a candidate following on.

The examiners require no information for this question.

Section A, Part 1, Question 2
Candidates are to measure the radius of curvature of the convex surface of a spherical mirror by measuring the period of an oscillating metre ruler placed on the top of the mirror.
The apparatus used for Question 1 is to be used again here, with the exception of the steel sphere, which is not needed.
Additional items are given in the table below.

Apparatus
- mirror (as for Question 1)
- stopwatch (as for Question 1)
- beaker (as for Question 1)
- wooden metre ruler in good condition
- the means to fashion a suitable fiducial mark, at the discretion of the Centre; this could be a horizontally clamped rod or a vertical card, supported by a bulldog clip, on which the candidates can make an appropriate mark

The equipment should be placed on the bench for the candidates' use.

It should be left to the candidates to construct the fiducial mark. The apparatus should be returned to its original state before being used again by any candidates following on.

The examiners require no information for this question.

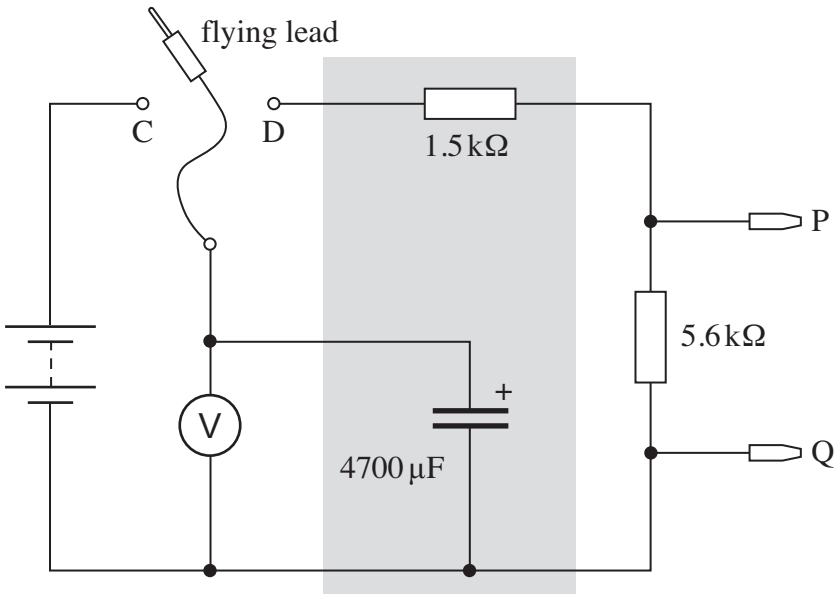
Section A, Part 2, Question 1
Candidates are to investigate the discharge of a capacitor through different combinations of resistors.

Apparatus required for each candidate:
- dc power supply, terminal pd at the discretion of the Centre; if the voltmeter is set to the 2000 mV range then one type D cell in good condition, in a suitable holder, will be adequate
- one each of the following resistors, carbon film, at least 0.25 W, Rapid references in brackets: 27 kΩ (62-0404), 12 kΩ (62-0396), 6.8 kΩ (62-0390), 3.9 kΩ (62-0384), 2.2 kΩ (62-0378), 820 Ω (62-0368); attach these with Sellotape to a postcard, printing the value of each resistor **in Ω** alongside for the candidates to see, in the manner shown in **Figure 5** of the question paper (note also that the resistance, R_0, of the resistor which is in parallel with clips P and Q, should also be printed on the card)
- digital stopwatch capable of reading to 0.10 s

for the exposed part of the circuit:
- one 5.6 kΩ resistor, carbon film, at least 0.25 W, (Rapid 62-0388); label this 'resistance = R_0'
- component holder (e.g. two mounted crocodile clips) into which the candidate will insert resistors; the clips are to be labelled 'P' and 'Q'
- digital voltmeter set to a range that will suit the power supply the Centre wishes to use; a 3½ digit LCD multi meter set to the 2000 mV range will be adequate if a 1.5 V dry cell is used
- two round sockets (Rapid 17-1920) to be labelled 'C' (leading to the positive terminal of the power supply) and 'D' (leading to the 15 kΩ resistor)
- suitable connecting leads including a flying lead connected to the positive terminal of the voltmeter, terminating with a 4 mm round plug (Rapid 17-0130)

for the concealed part of the circuit:
- one 1.5 kΩ resistor, carbon film, at least 0.25 W, (Rapid 62-0374)
- one 4700 μF electrolytic capacitor, 10 V or higher (Rapid 11-1402)
- suitable concealment for the above, e.g. ABS box or insulation tape around strip board, if this means of construction is used

The circuit to be constructed is shown below.
The components in the shaded region must be concealed from the candidates.



concealed part of the circuit shown shaded

The circuit, once constructed, may be tested as follows:

- charge the capacitor by connecting the flying lead to terminal C; the voltmeter will show a steady reading (but don't be concerned if, when the lead is removed from terminal C, the reading gradually decreases as the capacitor discharges through the voltmeter)
- connect the flying lead to terminal D so that the capacitor discharges through the concealed resistor and the resistance R_0; the voltmeter reading will be seen to fall exponentially
- the time, T_0, for the voltmeter reading to decrease by 50% should be between 15 s and 30 s
- if the process is repeated with any resistor connected between P and Q the time, T, for the voltmeter reading to decrease by 50% will be reduced; when the 820 Ω resistor is connected between P and Q the time T will be about 30% of T_0

Ensure that the six resistors are arranged correctly on the postcard and then stick these down in such a way that the candidates can remove them one at a time. Place the postcard in clear view of the candidates.

The examiners require no information for this question.

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

General Certificate of Education
Advanced Level Examination
June 2012

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, or in the case of any problem affecting a particular candidate, it should be attached to the candidate's script, before despatch to the Examiner.

Information to be provided by the Centre

Section A Part 1
Question 1 No information is required
Question 2 No information is required

Section A Part 2
Question 1 No information is required

Details of problems encountered by candidate..... candidate number .....

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Supervisor's Signature .....

Centre Number .....

Date .....

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

Section A Part 1

Follow the instructions given below.

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

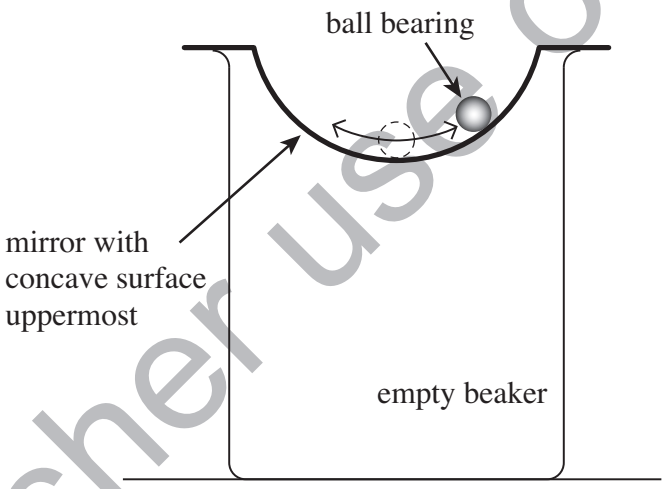
No descriptions of the experiments are required.

1 You are to measure the radius of curvature, R_1, of the concave surface of a spherical mirror by measuring the period of a ball bearing rolling on the mirror.

1 (i) Use the micrometer screw gauge to make suitable measurements to determine the radius, r, of the ball bearing.

1 (ii) Place the mirror on top of the empty beaker with the concave surface uppermost. Place the ball bearing near the edge of the mirror so that when released, the ball bearing performs oscillations about the centre of the mirror, as shown in **Figure 1**.

Figure 1



Make suitable measurements to determine the mean period, T_1, of the oscillations.
You may mark the inside of the mirror with a pencil to assist you with the measurement.

1 **(iii)** It can be shown that T_1 is given by

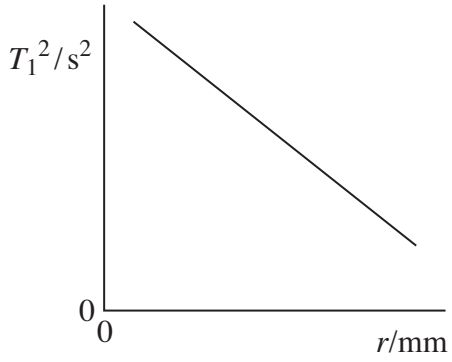
$$T_1 = 2\pi\sqrt{\frac{7(R_1 - r)}{5g}}$$

where $g = 9.81\,\text{N kg}^{-1}$.

Using your values of r and T_1, determine R_1.

1 **(iv)** A student is provided with a selection of ball bearings of different dimensions. Using each of these in turn, the student obtains values of T_1 for each corresponding value of r. The student then produces the graph of T_1^2 against r shown in **Figure 2**.

Figure 2

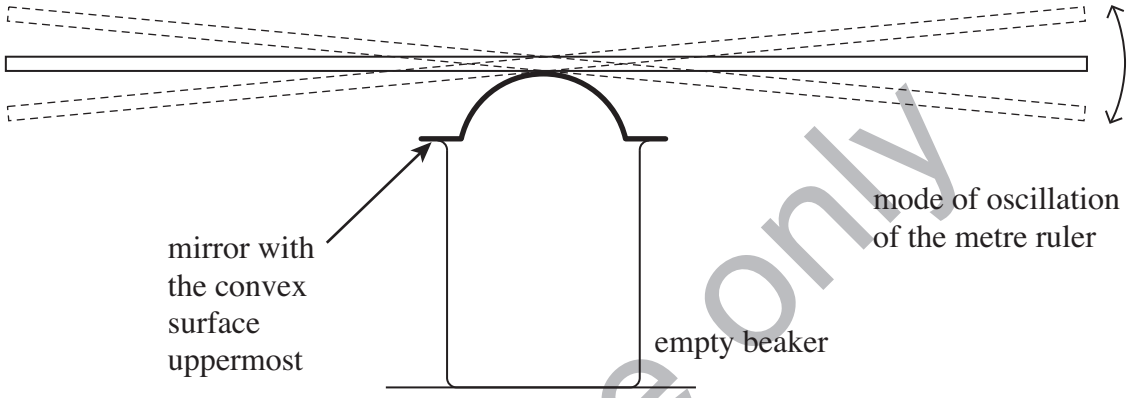


State and explain how the value of R_1 can be obtained from this graph.

2 You are to measure the radius of curvature, R_2, of the convex surface of the mirror by measuring the period of an oscillating metre ruler placed on the top of the mirror.

Place the mirror on top of the empty beaker with the convex surface uppermost. Place the metre ruler, with the graduated face uppermost, on top of the mirror so that the ruler is parallel to the surface of the bench.
Slightly depress one end of the ruler then release it so that the ruler performs small-amplitude oscillations, as shown in **Figure 3**.

Figure 3



2 **(i)** Using the additional equipment provided, assemble a suitable fiducial mark, then make suitable measurements to determine the mean period, T_2, of the oscillations.

2 **(ii)** If the thickness of the ruler is much less than its length, it can be shown that

$$R_2 \approx \frac{1}{3g}\left(\frac{x\pi}{T_2}\right)^2,$$

where x = the length of the ruler and $g = 9.81\ \text{N kg}^{-1}$.

Using your value of T_2, determine R_2.

2 **(iii)** Show with the aid of a sketch where you positioned the fiducial mark in order to reduce uncertainty in the measurement of T_2. Explain why you chose this position for the fiducial mark.

2 **(iv)** To determine T_2, a student makes five measurements of the time for 20 oscillations of the ruler.
The student's data are as follows:

$20T_2$/s	40.8	41.4	39.9	38.7	40.5

The student uses these data to determine T_2. Calculate the percentage uncertainty in the student's result.

2 **(v)** It is reasonable to assume that your result for R_2 is similar to, but **not the same**, as that obtained for R_1. Give **two** reasons why you would not expect these results to be the same.

Section A Part 2

Follow the instructions given below.

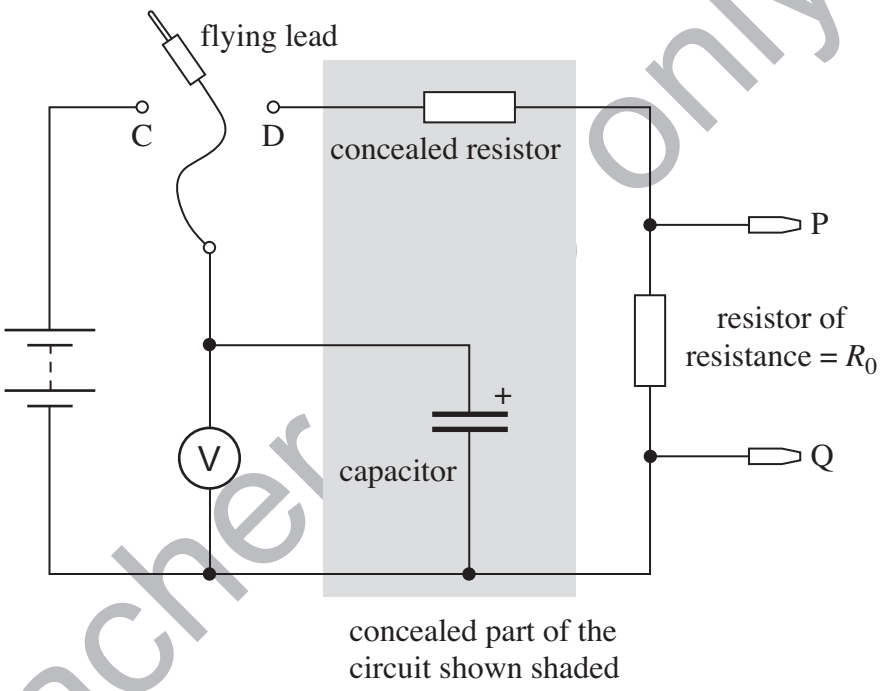
Answer **all** the questions in the spaces provided.

No description of the experiment is required.

1 In this experiment you are to investigate the discharge of a capacitor through different combinations of resistors.

You are provided with the circuit shown in **Figure 4**, part of which is concealed, as shown by the shaded region on the diagram.

Figure 4



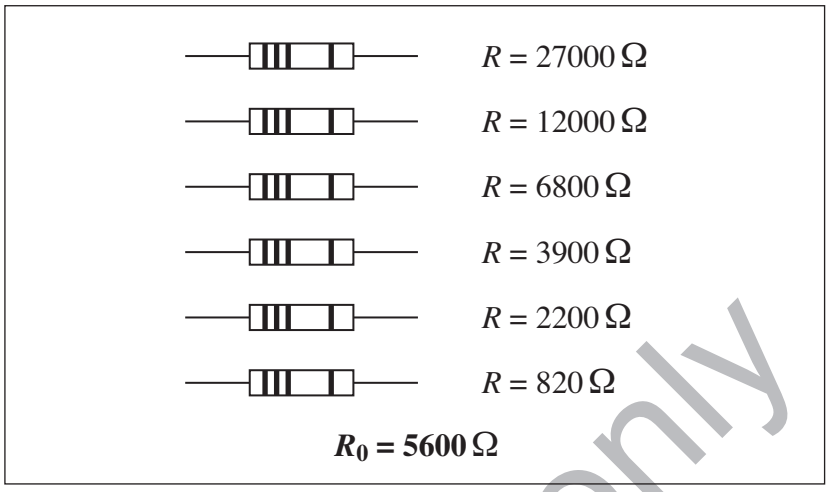
1 (a) Charge the capacitor by connecting the flying lead to terminal C.
The voltmeter will show a steady reading.

Connect the flying lead to terminal D so that the capacitor discharges through the concealed resistor and the resistance R_0.
The voltmeter reading will be seen to fall exponentially.

Make suitable measurements to determine T_0, the time for the voltmeter reading to decrease by 50%.

1 (b) You are provided with a postcard to which six resistors have been attached; the resistance, R, of each of these is printed on the card, as shown in **Figure 5**.

Figure 5



Connect the resistor with $R = 27000\ \Omega$ between clip P and clip Q so that it is in parallel with resistor R_0.

Using the same procedure for charging and then discharging the capacitor as before, make suitable measurements to obtain T, the time for the voltmeter reading to decrease by 50%.

Repeat the procedure using each resistor, in turn, between P and Q, until you have obtained values of T for all six resistors.

Record your measurements and observations below.

1 (c) Use the value of R_0 printed on the postcard to calculate values of $\frac{R}{R+R_0}$ that correspond to each of your values for T.

Record these data below.

1 (d) Plot, on the grid opposite, a graph with $\frac{R}{R+R_0}$ on the vertical axis and T on the horizontal axis.

Section B

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

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

1 (a) (i) Determine the gradient, G, of your graph of $\frac{R}{R+R_0}$ against T.

1 (a) (ii) Calculate GT_0.

1 (b) When no resistor is connected between clip P and clip Q, the time, T, for the voltmeter reading to fall by 50% = T_0.

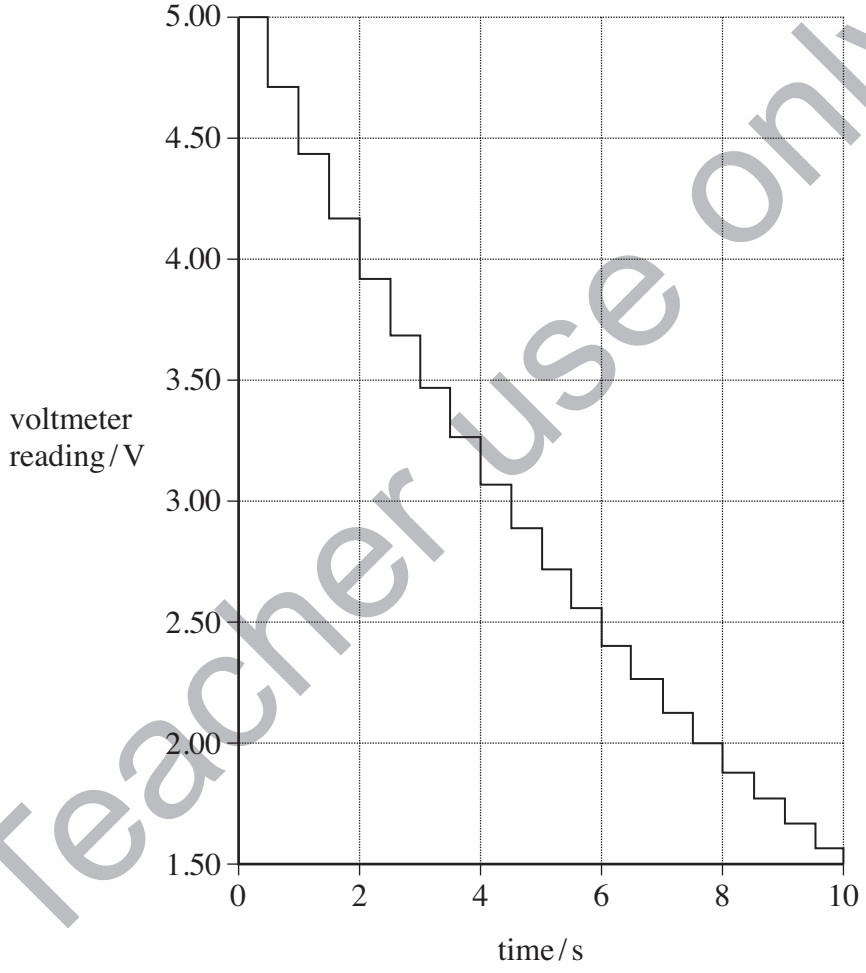
1 (b) (i) State the value of R when $T = T_0$.

1 (b) (ii) Explain how T_0 could be obtained from your graph of $\frac{R}{R+R_0}$ against T.

2 A student carried out the experiment on Section A Part 2, making measurements to determine the time, T, for the voltmeter reading to fall by 50% for different values of R, including smaller values than you used.
The digital voltmeter used by the student had certain characteristics that may have introduced uncertainty in the measurements of T.

2 (a) The first characteristic is the *sample rate*; this is the rate at which readings are transferred to the display of the meter. For the type of digital voltmeter used, a typical sample rate is 2 Hz.
Figure 6 shows how the voltmeter reading varied with time as the capacitor was discharged.

Figure 6



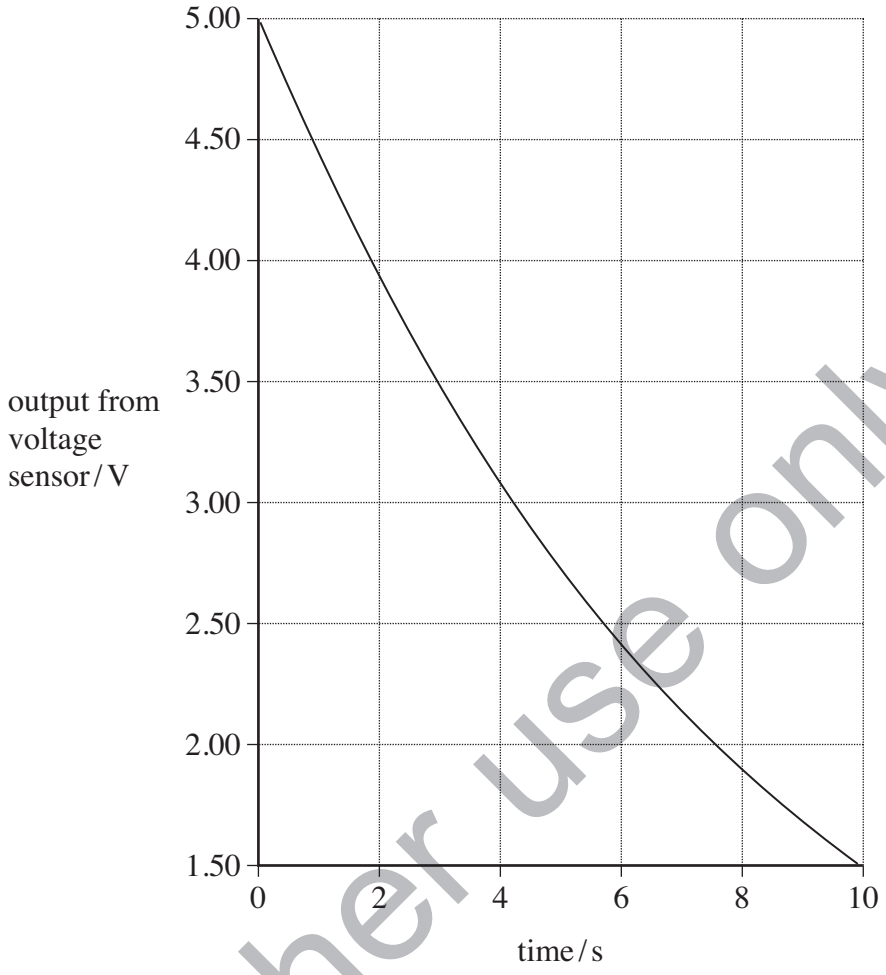
2 (a) (i) Explain how **Figure 6** shows that the sample rate of the voltmeter is 2 Hz.

2 (a) (ii) With reference to **Figure 6**, outline **one** difficulty that the student would find when measuring *T* using the readings displayed on the voltmeter.

2 (a) (iii) A teacher suggests that the student should wait until the voltmeter reading has fallen by 75% before stopping the watch.
Explain how the value of *T* can be obtained using this method and explain why the uncertainty in the result would be reduced.

A different student replaced the digital voltmeter with a voltage sensor connected to a data logger. The results of this experiment are shown in **Figure 7**.

Figure 7



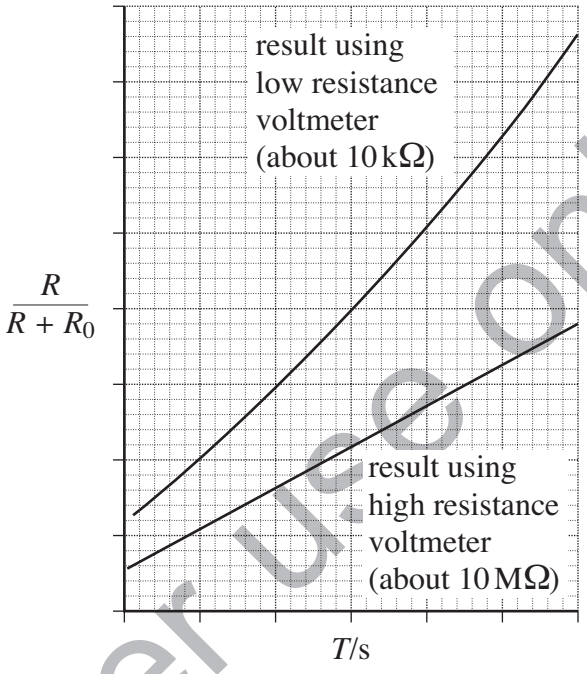
2 (a) (iv) Explain why the results displayed in **Figure 7** show a continuous curve whereas those represented in **Figure 6** show a stepped line.

2 (b) The second characteristic of the meter that affects the measurements of T is the *resistance of the voltmeter*. The voltmeter provides another conducting route through which the capacitor can discharge, effectively lowering the resistance of the circuit. This causes all the readings of T to be less than they should have been.

2 (b) (i) What type of error does this cause in your measurements for T?

Figure 8 illustrates how the resistance of the voltmeter affects the experiment.

Figure 8

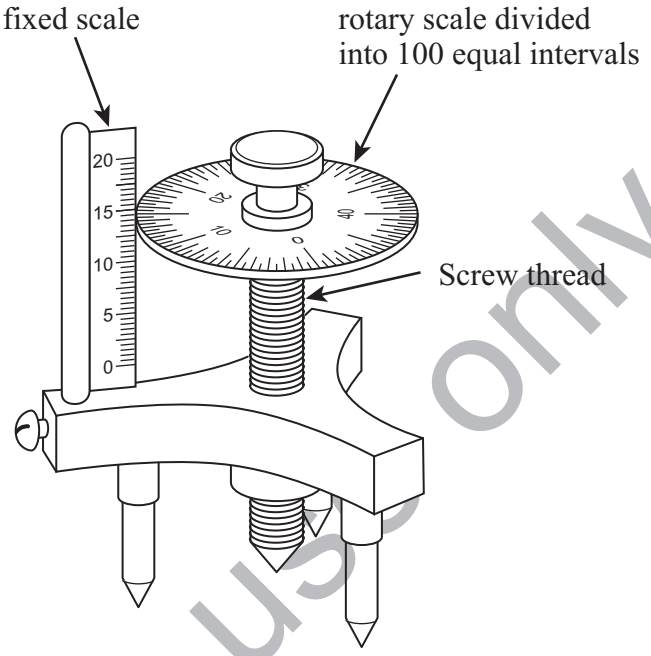


2 (b) (ii) Explain with reference to **Figure 8** whether the results of your experiment indicate that the resistance of the voltmeter you used was small enough to cause an error of this type.

3 In the experiment in Section A Part 1 you made measurements to calculate the radii of curvature of the surfaces of a spherical mirror. In order to check the accuracy of such an experiment, an instrument called a *spherometer* is used.

A spherometer is shown in **Figure 9**.

Figure 9



A spherometer, like a micrometer screw gauge, is a device in which a screw thread mechanism is used. One full rotation of the mechanism advances the screw 0.5 mm and this causes the rotary scale, which is divided into 100 equal intervals, to move vertically through one division of the fixed scale.
As with the micrometer screw gauge, the instrument is read by combining the readings from the fixed scale and the rotary scale.

3 (i) What is the precision of the spherometer?

3 **(ii)** Measurements made with a spherometer show that the radius of curvature, R_2, of the convex surface of the mirror is 84.4 mm.
Using the oscillating metre ruler method, a student calculates a value of R_2 which is 4.5% lower than the spherometer value.
Calculate the value of R_2 obtained by the student.

3 **(iii)** To calculate the radius of curvature, R_2, of the convex surface of the mirror, the student used the formula

$$R_2 \approx \frac{1}{3g}\left(\frac{x\pi}{T}\right)^2$$

in which x = the length of the ruler, $g = 9.81\,\text{N kg}^{-1}$ and T is the period of the oscillations.

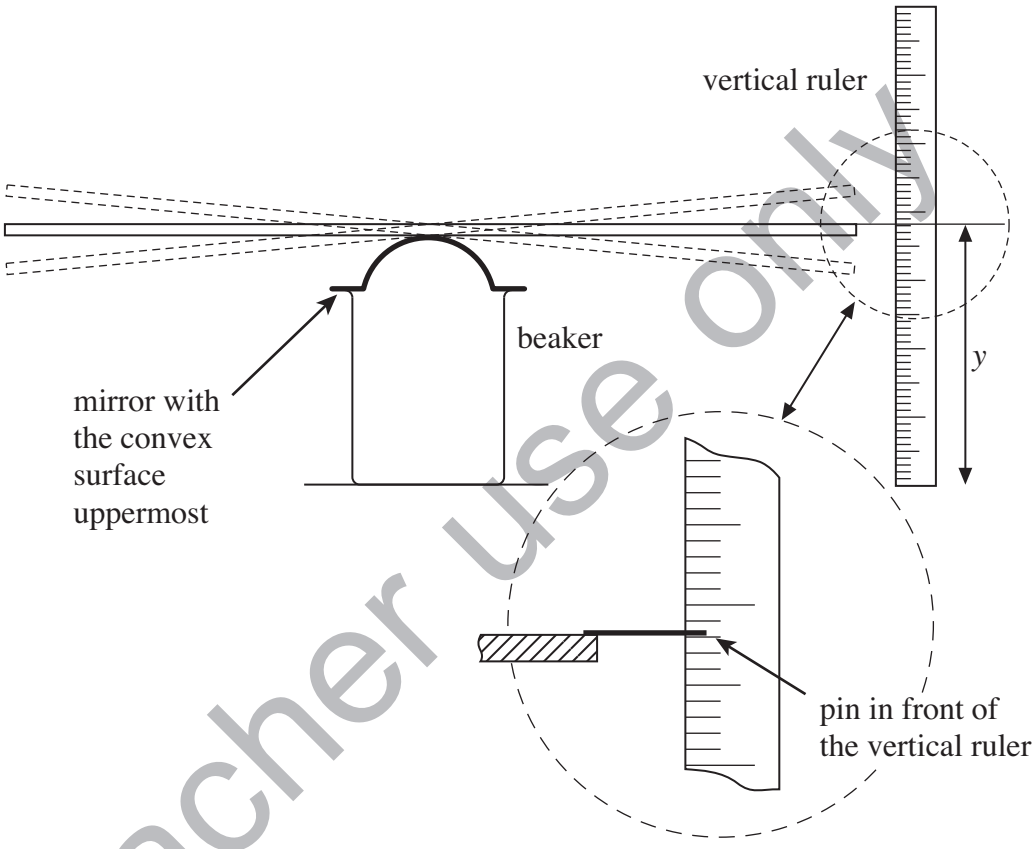
Assuming the uncertainties in x and g are negligible and the percentage uncertainty in R_2 = 4.5%, calculate the percentage uncertainty in the student's result for T.

3 **(iv)** Based on a single measurement of 10 oscillations, the student calculated that $T = 2.04\,\text{s}$.
Calculate the uncertainty in the student's measurement for the time of 10 oscillations of the ruler.

4 It is suggested to a student who is watching a metre ruler oscillating on the convex surface of a mirror that the amplitude of the oscillations decreases exponentially. The student is challenged to show whether or not this is true.

The student decides to record the motion of the ruler using a video camera. She attaches a pin to the end of the ruler and positions a vertical scale behind the tip of the pin, as shown in **Figure 10**.

Figure 10



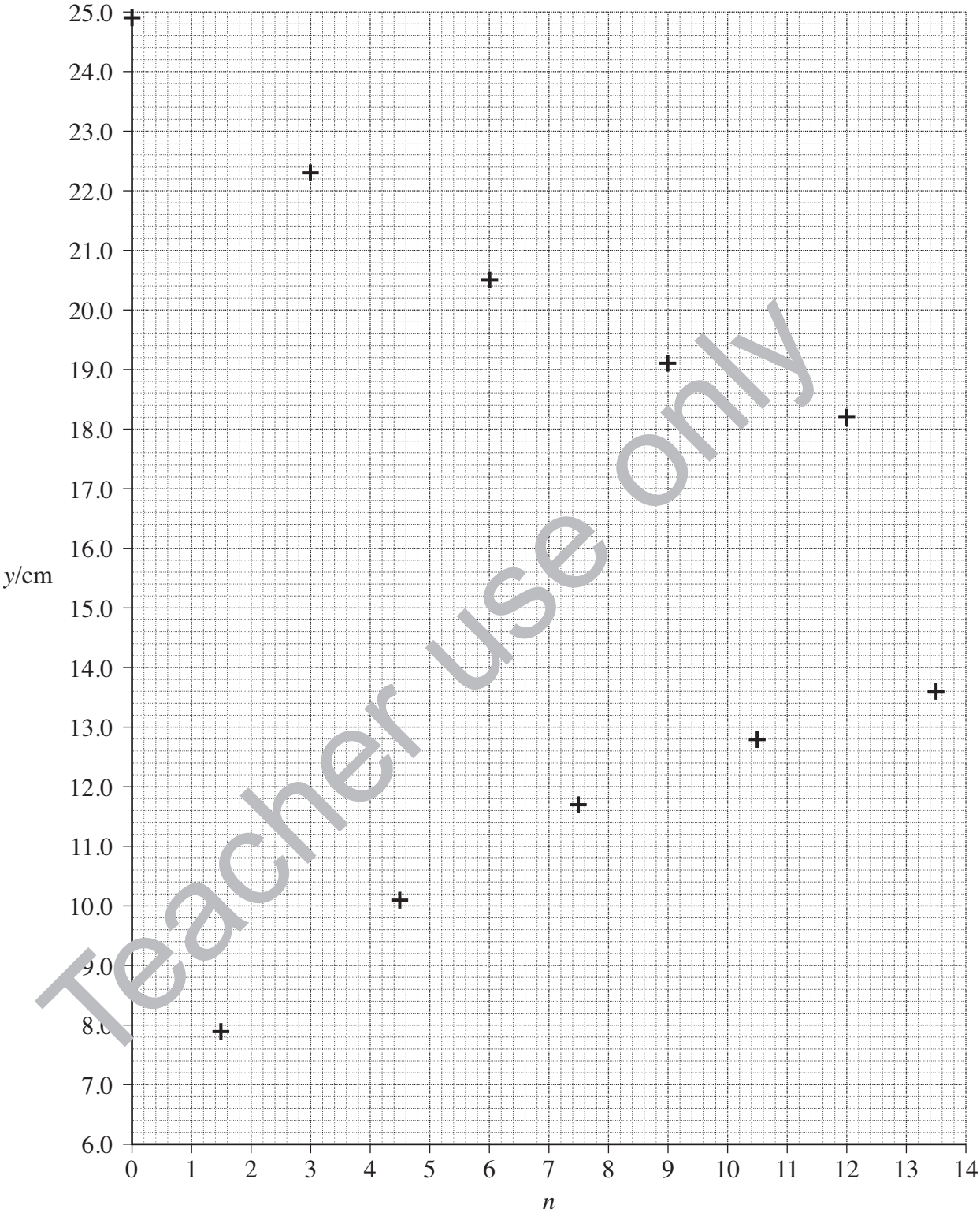
The student records the height above the bench of the tip of the pin at the top, y_t, and at the bottom, y_b, of its motion during several successive swings, n, of the ruler.

Her results are shown below.

n	0	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5
y_t/cm	24.9		22.3		20.5		19.1		18.2	
y_b/cm		7.9		10.1		11.7		12.8		13.6

4 (a) Her data points are plotted on **Figure 11**.

Figure 11



On **Figure 11** draw

(i) a line to show how y_t varies with n,

(ii) a line to show how y_b varies with n,

(iii) a line parallel to the horizontal axis to mark the position of the tip of the pin against the vertical scale when the ruler is at the equilibrium position.

4 (b) Hence or otherwise, explain whether the student's data confirms the suggestion that the amplitude of the oscillations decreases exponentially.