

## Teacher Resource Bank

GCE Physics

Sample A2 EMPA:

- Question Paper



## AQA Physics Sample A2 EMPA

## Centre Instructions

## Section A Task 1

Candidates are to investigate the current in a circuit containing resistors that form potential dividers.

## Question 1

**Apparatus required:**

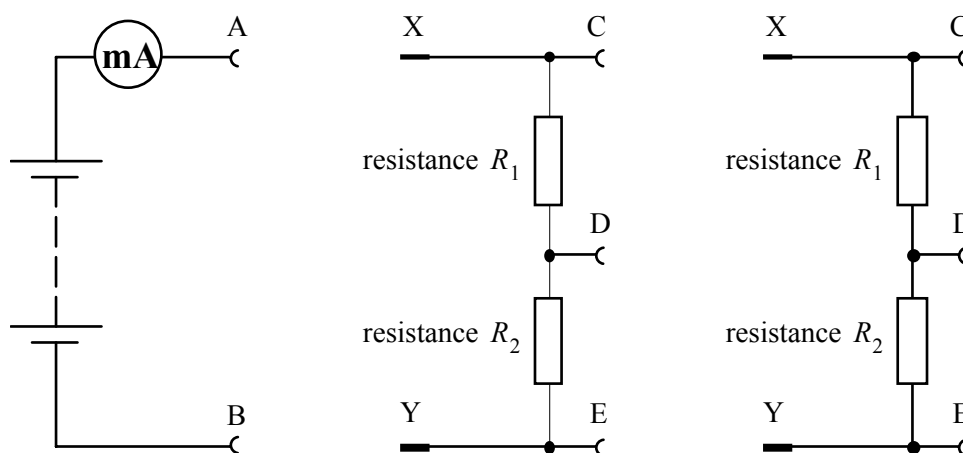
*power supply and milliammeter*

- dc power supply consisting of a series arrangement of 4 D-Type 1.5 V cells in a suitable holder (or holders) or a 5 V stabilised supply
- milliammeter capable of reading currents up to 200 mA (an inexpensive 3 ½ digit digital multi-meter will be satisfactory); this should be connected in series with the positive terminal of the dc supply
- 4 mm round sockets marked A and B to be connected to the free ends of the circuit

*potential divider circuits (2 circuits required per candidate)*

- one  $6.8\ \Omega$  resistor, carbon or metal film, at least 0.25 W (Rapid 62-0324); this resistor should have its value concealed and be labelled 'resistance  $R_1$ '
- one  $68\ \Omega$  resistor, carbon or metal film, at least 0.25 W (Rapid 62-0342); this resistor should have its value concealed and be labelled 'resistance  $R_2$ ' (component codes given are for Rapid carbon film type, packets of 100)
- 4 mm round sockets marked C, D and E and 4 mm round plugs marked X and Y are required to complete the arrangement (see below)

The circuits required for each candidate are shown below.



The Examiners require no information for this question.

## Section A Task 1

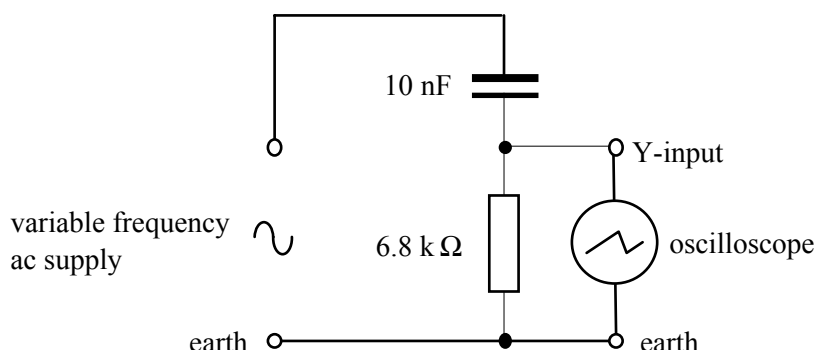
Candidates are required to use an oscilloscope to measure the frequency of an ac voltage and to measure the ac voltage across a resistor in an RC circuit.

### Question 2

#### Apparatus required for each candidate:

- audio signal generator to supply sinusoidal voltage of frequency  $850 \pm 5$  Hz with **peak to peak** voltage  $5.0 \pm 0.2$  V; this supply should have an integral power switch
- oscilloscope with variable time base and Y-voltage sensitivity; suggested settings are given below
- 10 nF capacitor, ceramic or polyester type, (Rapid 08-0230); the value of the capacitor should be concealed and the capacitor labelled 'C<sub>1</sub>'
- 4.7nF capacitor, ceramic or polyester type, (Rapid 08-0220); the value of the capacitor should be concealed and the capacitor labelled 'C<sub>2</sub>'
- one 6.8 k $\Omega$  resistor, 0.25 W or greater, carbon or metal film, (Rapid 62-0390)\*; this resistor should have its value concealed and be labelled 'R' (\*pack of 100)
- connecting wires and component holders with which candidates can assemble the circuits shown below
- mm ruler or strip of mm graph paper for measuring the traces

Supervisors should assemble the circuit so that the resistor R and the capacitor C<sub>1</sub> (10nF) are in series with the output terminals of the signal generator. Connect the earth input of the oscilloscope and the negative terminal of the signal generator should be connected to the same terminal of R, as shown below.



The generator should be set so that the output voltage is a sinusoidal waveform of frequency  $850 \pm 5$  Hz and **peak to peak** voltage  $5.0 \pm 0.2$  V. Once set to show this waveform, the controls of the signal generator should be taped over to conceal the settings; any digital read-out showing the frequency should also be concealed.

**Candidates are instructed not to adjust the output pd or the frequency of the variable frequency supply.**

The time-base of the oscilloscope should be set to  $0.2 \text{ ms div}^{-1}$  or  $0.5 \text{ ms div}^{-1}$ .

Any continuously variable time-base setting should be set to the 'calibrated' setting and may be taped over.

Once set the time-base control(s) of the oscilloscope should **not be taped over or in any other way concealed** since candidates will be required to read the settings.

**Candidates are instructed not to adjust the time base setting of the oscilloscope. If the invigilator notices that a candidate, contrary to these instructions, is changing the time base setting, the invigilator may intervene and correct the candidate's mistake.**

With the circuit assembled as shown in the diagram, the trace seen on the screen will have amplitude of about 0.8 V (1.6 V peak to peak). The Y- gain sensitivity should be adjusted so that the complete ac cycle is visible; a suitable setting will be  $2 \text{ V div}^{-1}$ .

Any continuously variable Y- gain sensitivity control should be set to the 'calibrated' setting and taped over.

Candidates should be able to vary the Y- gain sensitivity in the usual steps (e.g.  $\times 1$ ,  $\times 2$ ,  $\times 5$ ) between  $1 \text{ V div}^{-1}$  and  $10 \text{ V div}^{-1}$ .

Candidates should be able to vary the X-shift and Y- shift settings in order to position the trace at a convenient point on the screen.

Having confirmed that a suitable trace can be produced with  $C_1$  and R in series, the signal generator should be switched off and the spot on the oscilloscope focused at low brilliance.

Candidates must be able to replace  $C_1$  with  $C_2$  and then replace  $C_1$  so that it is in series with  $C_2$ .

It is not necessary to provide a set of this equipment for each candidate. In order to facilitate the use of instruments such as the oscilloscope, it may be prudent to tell some candidates to start work on Question 1 before attempting Question 2.

**Invigilators must ensure that the oscilloscope settings have been readjusted as described above and that the rest of the circuit has been returned to its initial state before allowing the next candidate to proceed.**

## Section A Task 2

Candidates are to investigate the discharge of a capacitor through different combinations of resistors.

### Apparatus required for each candidate:

- stopwatch capable of reading to 0.1 s or better

### for circuit (diagram below)

- digital voltmeter (or equivalent multimeter) capable of 0.1 V resolution or better
- dc supply with emf in range 50% to 90% of full-scale reading of available voltmeters, e.g. for 2000 mV digital meter, 1.5 V 'D-type' cell in good condition, in a suitable holder
- 15 k $\Omega$  resistor, 0.25 W or greater, metal or carbon film
- one 2200  $\mu$ F electrolytic capacitor
- 4 mm round sockets labelled 'C' and 'D' (see diagram) and lead terminated at one end with 4 mm plug, labelled 'flying lead'
- component holder fashioned from two crocodile clips fixed to short length of wood or plastic, clips to be labelled 'X' and 'Y'
- stripboard if soldered circuit is used
- means of concealment for capacitor and 15 k $\Omega$  resistor

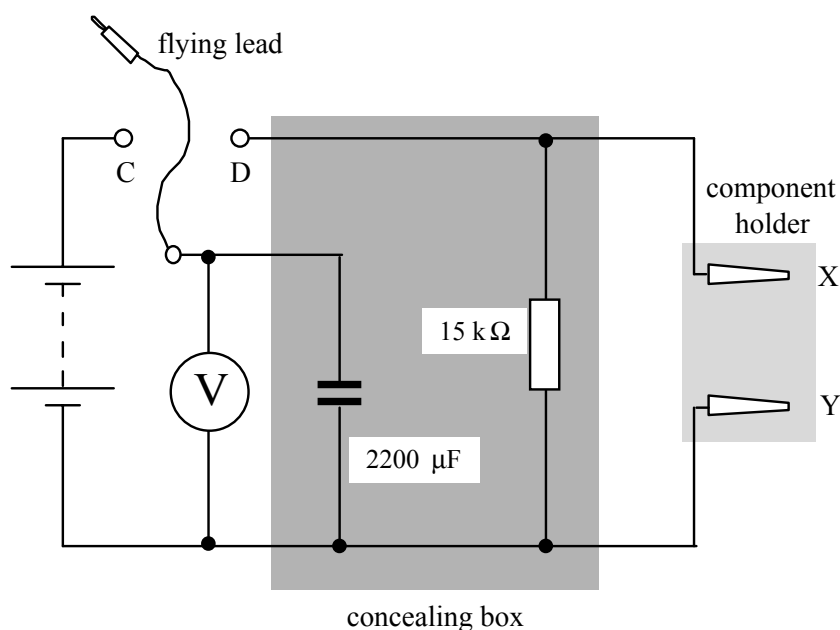
### additionally

- resistors, 0.25 W or greater, metal or carbon film, of resistance 47 k $\Omega$ , 27 k $\Omega$ , 18 k $\Omega$ , 12 k $\Omega$ , 8.2 k $\Omega$ , 6.8 k $\Omega$ : the resistor values must be clear to the candidate (it is suggested that the resistors could be fixed onto a postcard, e.g. with Sellotape, and the resistance printed alongside)

No.	Component	Rapid Code
1	15 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0398*
1	2200 $\mu$ F electrolytic capacitor, 10 V or greater	11-0320
1	47 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0410*
1	27 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0404*
1	18 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0400*
1	12 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0396*
1	8.2 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0392*
1	6.8 k $\Omega$ resistor, 0.5 W or 0.6 W metal or carbon film	62-0390*

\* per pack of 100

The supervisor should assemble the circuit shown in the diagram. The portion that is shaded should be concealed from the candidates, e.g. in a suitable box or using opaque tape.



The choice of power supply is at the discretion of the centre and rests on the type of voltmeter available.

Voltmeters should be digital and offer a resistance of at least 50 kΩ.

If multimeters are to be the attention of candidates can be drawn to the appropriate setting before the commencement of the experiment.

Testing the circuit:

Charge the capacitor by connecting the flying lead to the terminal marked 'C'. Discharge the capacitor through the 15 kΩ resistor and measure the time for the voltmeter reading to **fall by 75%**. The theoretical time obtained should be 46 s but given the tolerances of the components involved, a time in the range 40 to 55 s is acceptable. Use any of the additional resistors connected between X and Y and the time for the voltmeter reading to fall by 75% should be reduced, e.g. with 47 kΩ between X and Y the time should fall to about 35 s.

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

Surname					Other Names				
Centre Number					Candidate Number				
Candidate Signature									

Leave blank



General Certificate of Education

Advanced Level Examination

**PHYSICS**  
**Investigative and Practical Skills in A2 Physics**

**Sample Unit 6 EMPA**

**Section A Task 1**

**For this paper you must have:**

- a calculator
- a pencil and a ruler

For Examiner's Use		
		Mark
Section A Task 1		
	1	
	2	
Total (Section A Task 1)		
TOTAL		
Examiner's Initials		

**Instructions**

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

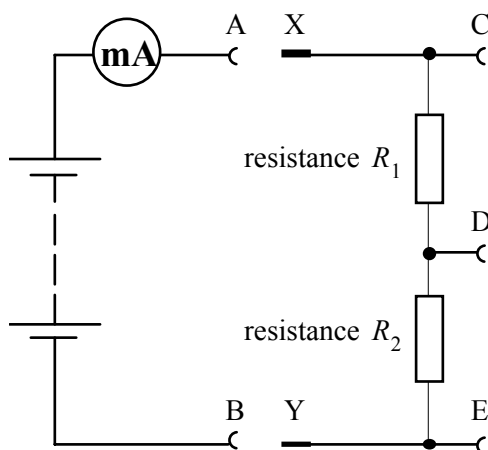
- The maximum mark for this task is 16.
- The marks for the questions are shown in brackets.

### SECTION A TASK 1

- Follow the instructions given below.
- Provide the information required in the spaces provided.
- No description of the experiment is required.

- 1 You are to investigate the current in a circuit containing resistors that form potential dividers.
- 1 (a) You are provided with two potential divider circuits, each of which has a resistor of resistance  $R_1$  in series with a resistor of resistance  $R_2$ . Each circuit is terminated with plugs X and Y; these can be used to connect a power supply and milliammeter to the potential divider. Sockets C, D and E enable the two potential dividers to be joined together to produce a more complex arrangement.
- 1 (a) (i) Connect one potential divider to the power supply by connecting plug X to socket A and connecting plug Y to socket B, as shown in **Figure 1**.

**Figure 1**



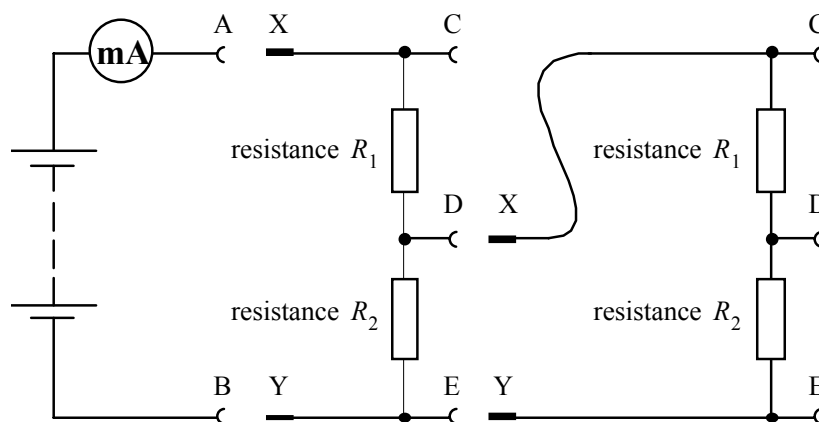
Read and record the milliammeter reading,  $I_1$ .

$I_1 = \dots\dots\dots$



- 1 (a) (i) Connect the second potential divider circuit to your circuit by making connections to sockets D and E, as shown in **Figure 2**.

**Figure 2**



Read and record the new milliammeter reading,  $I_2$ .

$I_2 =$  .....

(1 mark)

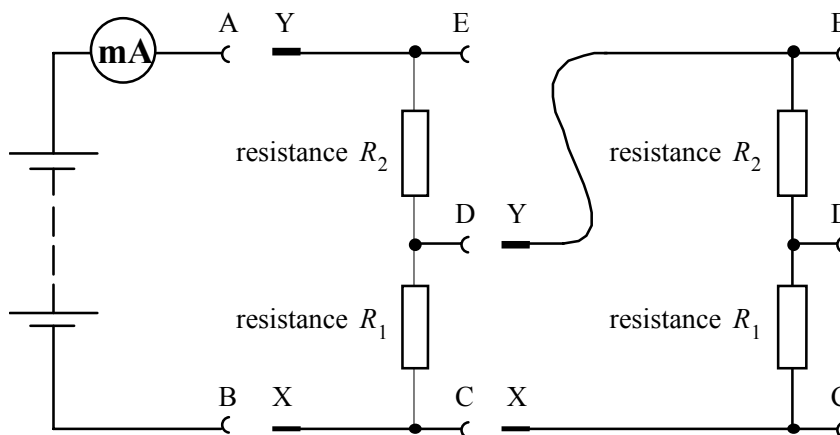
- 1 (b) Disconnect the potential divider circuits from the power supply.

Invert both potential divider circuits.

Connect the first of these to the power supply by connecting plug Y to socket A and connecting plug X to socket B.

Connect the second potential divider circuit to the first by connecting plug Y to socket D and connecting plug X to socket C, as shown in **Figure 3**.

**Figure 3**



Read and record the milliammeter readings,  $I_3$  and  $I_4$ , when one, and then both potential divider circuits are connected to the power supply.

$I_3 =$  .....

$I_4 =$  .....

(2 marks)

- 1 (c) Use your results to parts (a) and (b) to explain whether  $R_1$  or  $R_2$  is the greater resistance.

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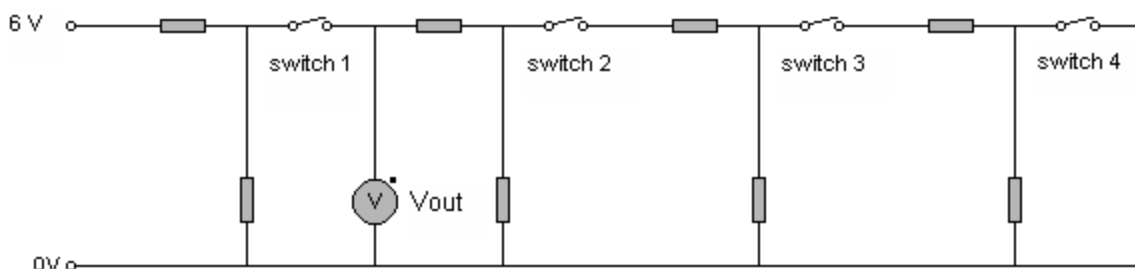
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(2 marks)

- 1 (d) A student performs a computer simulation to find out how the output voltage,  $V_{out}$ , of the first potential divider depends on  $n$ , the number of potential dividers connected together. A screenshot of the student's simulation is shown in **Figure 4**.

**Figure 4**



When (only) switch 1 is closed  $n = 1$ ; when switch 1 **and** switch 2 are closed,  $n = 2$ , etc.

When  $n = 1$ ,  $V_{out} = 4.55$  V and as  $n$  is increased,  $V_{out}$  changes by a decreasing amount. Once  $n = 10$  there is little, or no change in  $V_{out}$ .

The student's results are shown in **Table 1**.

**Table 1**

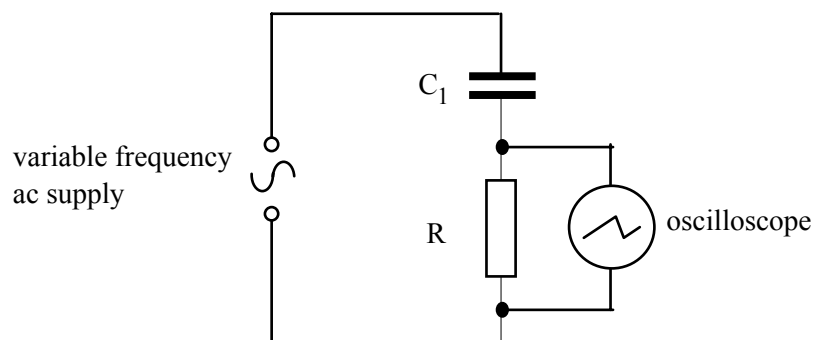
$n$	$V_{out}/V$
1	4.55
2	4.20
3	3.97
4	3.83
5	3.75
6	3.70
10	3.65
25	3.65



- 2 You are to use an oscilloscope as an ac voltmeter to measure the pd across a resistor in a circuit with different capacitors connected into it.
- 2 (a) You are provided with a circuit in which the output of a variable frequency ac supply is connected to a resistor,  $R$ , in series with a capacitor,  $C_1$ .  
**Do not adjust the output pd or the frequency of the variable frequency supply.**

An oscilloscope has been connected to display the pd across  $R$ , as shown in **Figure 5**.

**Figure 5**



**Do not adjust the time base setting of the oscilloscope.**

- 2 (a) (i) Record the setting of the time base on the oscilloscope.

.....  
 .....

- 2 (a) (ii) Switch on the variable frequency ac supply and make suitable measurements to calculate the frequency,  $f$ , of the ac voltage displayed on the oscilloscope.

.....  
 .....  
 .....  
 .....

$f =$  .....

(3 marks)

- 2 (b) (i) Measure  $V_1$ , the peak pd across R.

You may adjust the Y-shift setting and/or the Y-gain of the oscilloscope to assist you in making this measurement.

.....  
 .....

$$V_1 = \dots\dots\dots$$

- 2 (b) (ii) Switch off the variable frequency ac supply, then replace capacitor  $C_1$  with capacitor  $C_2$ . Switch on the variable frequency ac supply and measure  $V_2$ , the new peak pd across R.

.....  
 .....

$$V_2 = \dots\dots\dots$$

- 2 (b) (iii) Switch off the variable frequency ac supply then replace  $C_1$  so that it is in series with  $C_2$ . Switch on the variable frequency ac supply and measure  $V_3$ , the new peak pd across R.

.....  
 .....

$$V_3 = \dots\dots\dots$$

(2 marks)

- 2 (c) Evaluate  $\frac{V_3(V_1 + V_2)}{V_1V_2}$ .

.....  
 .....

$$\frac{V_3(V_1 + V_2)}{V_1V_2} = \dots\dots\dots$$

(2 marks)

**END OF QUESTIONS**

Surname					Other Names				
Centre Number					Candidate Number				
Candidate Signature									

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**PHYSICS**  
**Investigative and Practical Skills in A2 Physics**

**Sample Unit 6 EMPA**

**Section A Task 2**

**For this paper you must have:**

- a calculator
- a pencil and a ruler

For Examiner's Use	
	Mark
Section A Task 2	
	1
Total (Section A Task 2)	
TOTAL	
Examiner's Initials	

**Instructions**

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

- The maximum mark for this task is 16.
- The marks for the questions are shown in brackets.

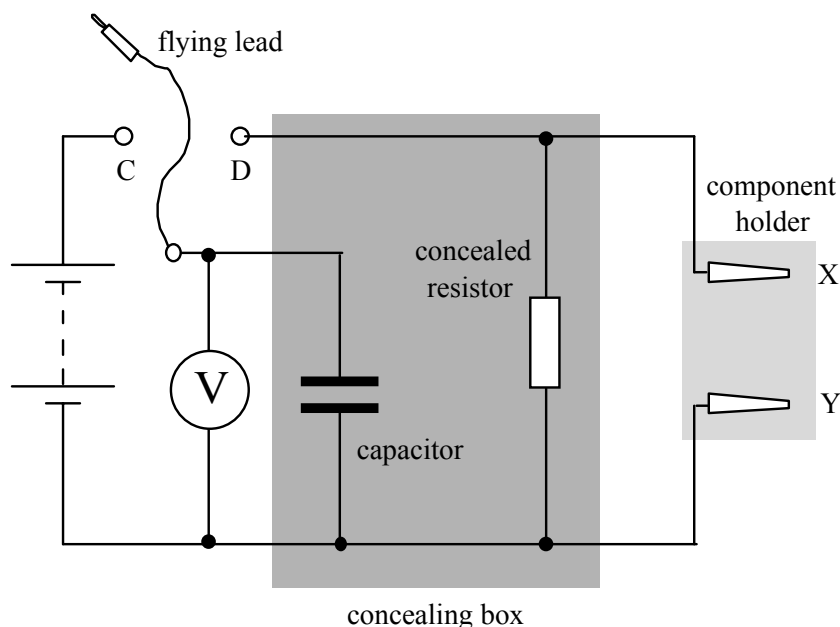
**SECTION A TASK 2**

- Follow the instructions given below.
- Provide the information required in the spaces provided.
- No description of the experiment is required.

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

- 1 You are provided with the circuit shown below, part of which is concealed, as shown by the shaded region in **Figure 6**.

**Figure 6**



- 1 (a) Charge the capacitor by connecting the flying lead to terminal C. The voltmeter will show a steady reading. Discharge the capacitor through the concealed resistor by connecting the flying lead to terminal D. The voltmeter reading will start to fall exponentially. Make suitable measurements to determine  $T_0$ , the time for the voltmeter reading to **fall to a quarter** of an initial value.

.....  
 .....

$T_0 =$  .....

(1 mark)

- 1 (b) You are also provided with six additional resistors with the following resistances:

47k $\Omega$ , 27k $\Omega$ , 18k $\Omega$ , 12k $\Omega$ , 8.2k $\Omega$ , 6.8k $\Omega$ .

Connect one of these resistors between the crocodile clips, X and Y, of the component holder.

Record the resistance,  $R$ , of the resistor connected between X and Y.

By charging and discharging the capacitor as before, measure and record the time,  $T$ , for the voltmeter reading to **fall to a quarter of an initial value**.

Repeat the procedure for each resistor in turn until you have values of  $T$  corresponding to each of the six values of  $R$ .

Record all your measurements and observations below. You should allow space to record the data you will plot on your graph. See part (c) below.

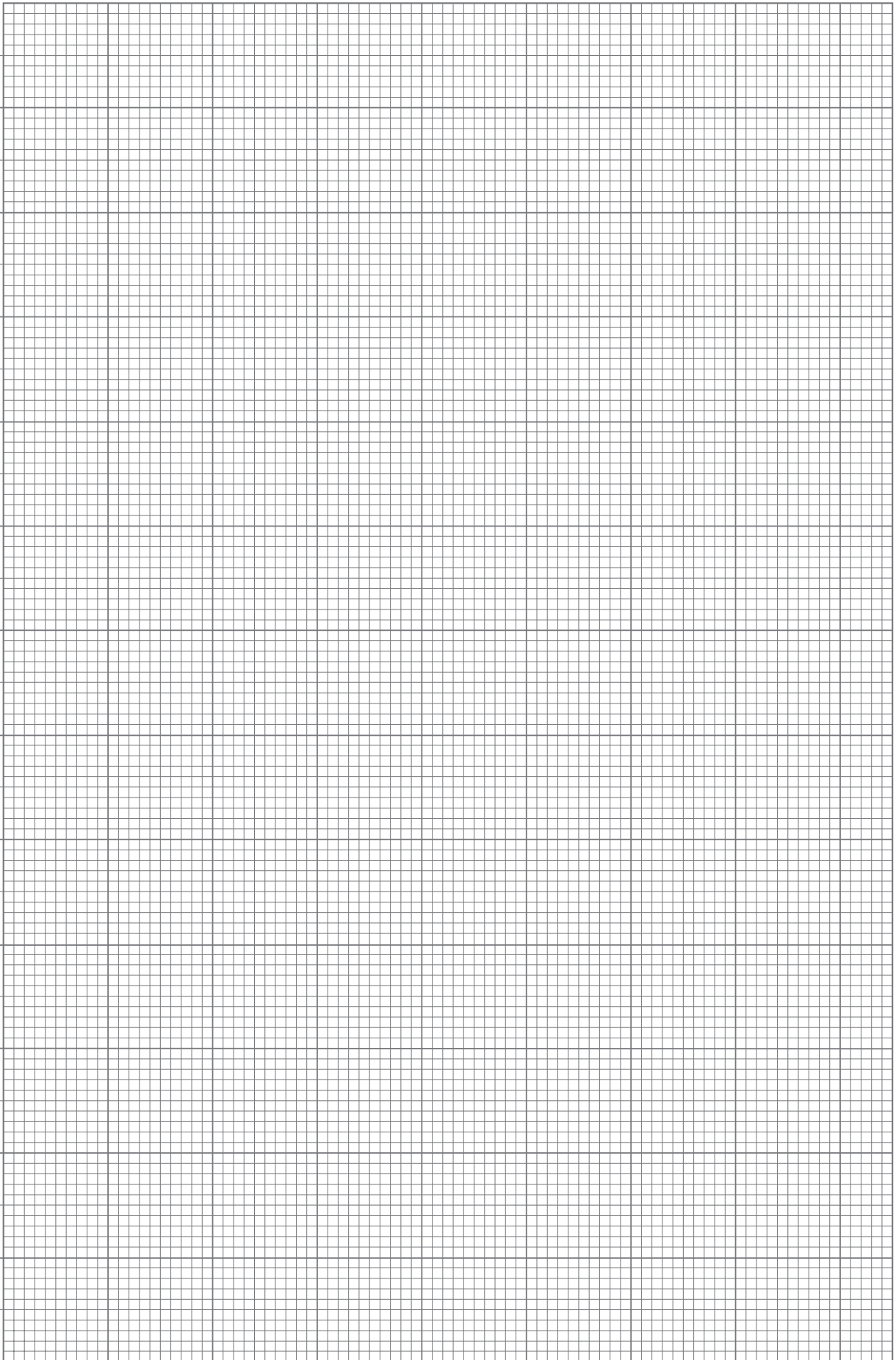
(7 marks)

- 1 (c) Plot a graph of your results with  $\frac{1}{T}$  on the vertical axis and  $\frac{1}{R}$  on the horizontal axis.

(8 marks)

**END OF QUESTIONS**





Surname					Other Names				
Centre Number					Candidate Number				
Candidate Signature									

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**PHYSICS**  
**Investigative and Practical Skills in A2 Physics**

**Sample Unit 6 EMPA**

**Section B**

Time allowed: 1 hour 15 minutes

**For this paper you must have:**

- a calculator
- a pencil and a ruler

For Examiner's Use		
		Mark
Section B	1	
	2	
	3	
	4	
Total (Section B)		
TOTAL		
Examiner's Initials		

**Instructions**

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**

- The maximum mark for this task is 23.
- The marks for the questions are shown in brackets.

**SECTION B**

- Answer all the questions in the spaces provided.
- Time allowed 1 hour 15 minutes.
- You will need to refer to the work you did in Section A Task 2 when answering these questions.

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

.....  
 .....

$G =$  ..... (2 marks)

1 (b) In Section A Task 2 part (a) you measured  $T_0$ , the time for voltmeter reading to fall a quarter of an initial value when no resistor is connected between X and Y. Evaluate  $GT_0$ .

.....  
 .....

$GT_0 =$  ..... (2 marks)

2 (a) Explain why the results for  $T$  are all smaller than the initial reading,  $T_0$ .

.....  
 .....  
 .....  
 .....  
 .....  
 .....

(2 marks)

2 (b) Justify the number of significant figures that you used in your results for  $\frac{1}{T}$ .

.....  
 .....  
 .....

(1 mark)

3 A student performs the experiment but mistakenly measures  $T_0$  and  $T$  as the time for the voltmeter reading to fall to half, rather than to a quarter of an initial value. State and explain what effect (if any) this error would have on the student's result for

3 (a)  $G$ ,

.....  
.....  
.....  
.....

3 (b)  $GT_0$ .

.....  
.....  
.....  
.....

(4 marks)

- 4 In Section A Task 1, you used an oscilloscope as an ac voltmeter to measure the pd across a resistor in a circuit with different capacitors connected into it.  
 A set of student's results for this experiment is shown in **Table 2**.  
 Note that in the student's experiment the variable frequency ac supply was set to produce a different output voltage waveform from that which you observed.

**Table 2**

measurement	$V/V$	percentage uncertainty
$V_1$	2.15	
$V_2$	1.15	
$V_3$	0.80	

The student estimates the uncertainty in each pd measurement as  $\pm 0.05\text{ V}$ .

- 4 (a) Calculate the percentage uncertainty in each measurement of pd and complete the right-hand column of **Table 2** to show the results of your calculations.

.....  
 .....  
 (1 mark)

- 4 (b) You will recall that these measurements of pd all contribute to the evaluation of  $\frac{V_3(V_1 + V_2)}{V_1V_2}$ .

- 4 (b) (i) Calculate the uncertainty in  $(V_1 + V_2)$ .

.....  
 .....  
 (1 mark)

- 4 (b) (ii) Calculate the percentage uncertainty in  $(V_1 + V_2)$ .

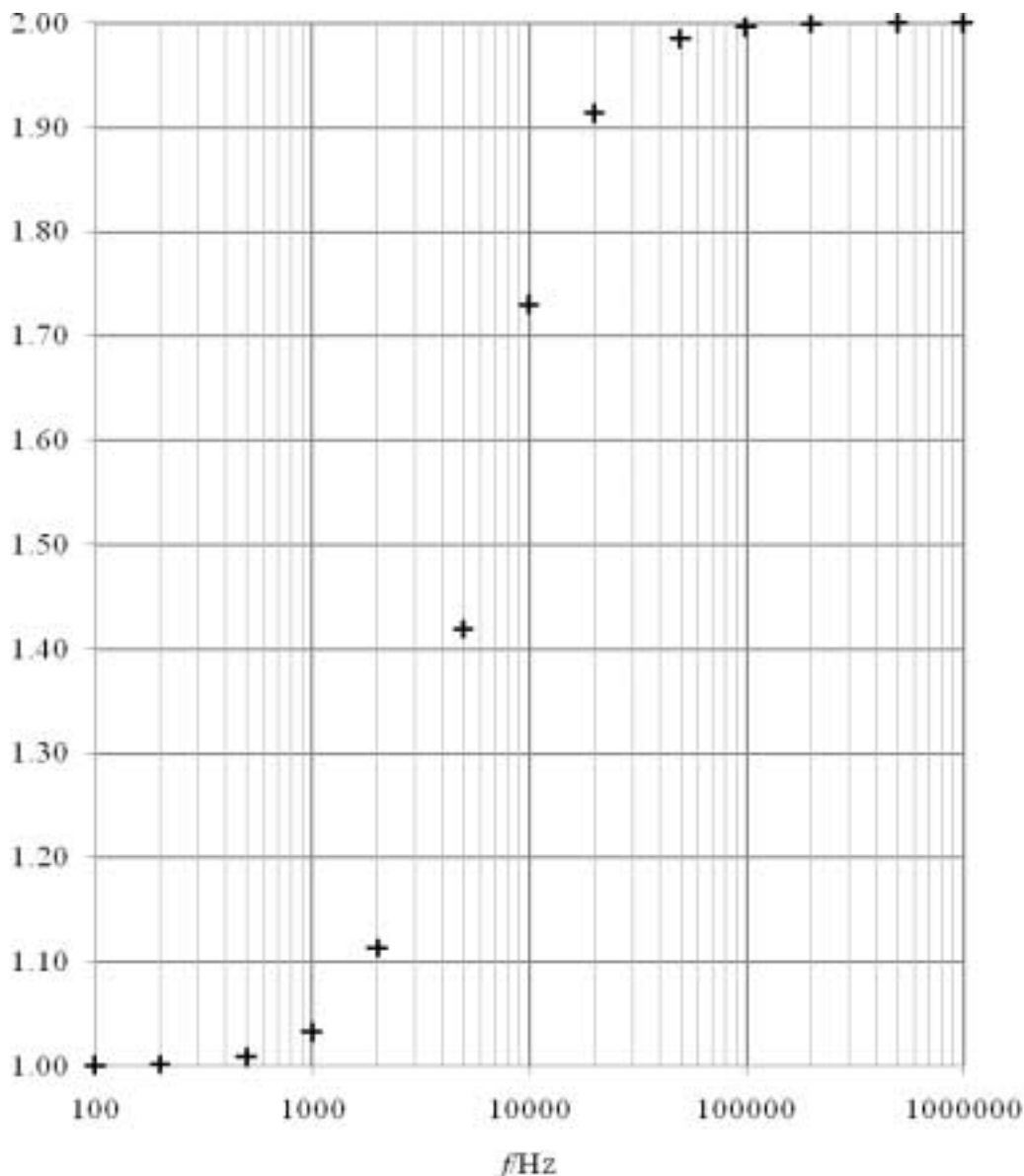
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 .....  
 (1 mark)

- 4 (b) (iii) Calculate the percentage uncertainty in  $\frac{V_3(V_1 + V_2)}{V_1V_2}$ .

.....  
 .....  
 (2 marks)

- 4 (c) A student investigates how  $\frac{V_3(V_1+V_2)}{V_1V_2}$  depends on  $f$ , the frequency of the ac supply. The student's results are displayed graphically in **Figure 7**.

**Figure 7**



Complete **Figure 7** by drawing a line of best-fit through the plotted points and then determine  $f$  when  $\frac{V_3(V_1+V_2)}{V_1V_2} = 1.50$ .

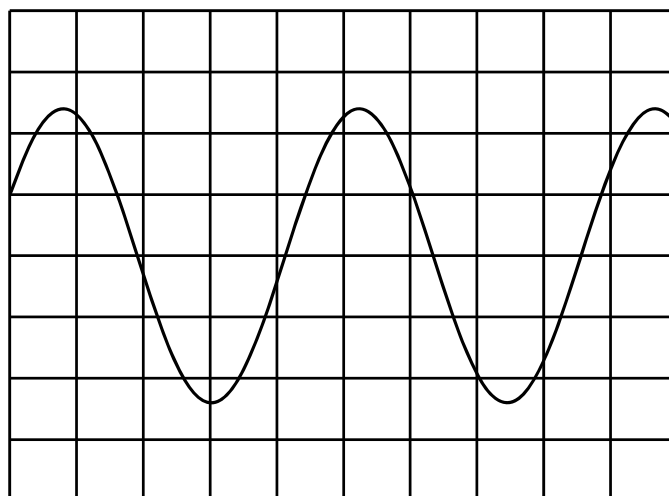
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.....

(2 marks)

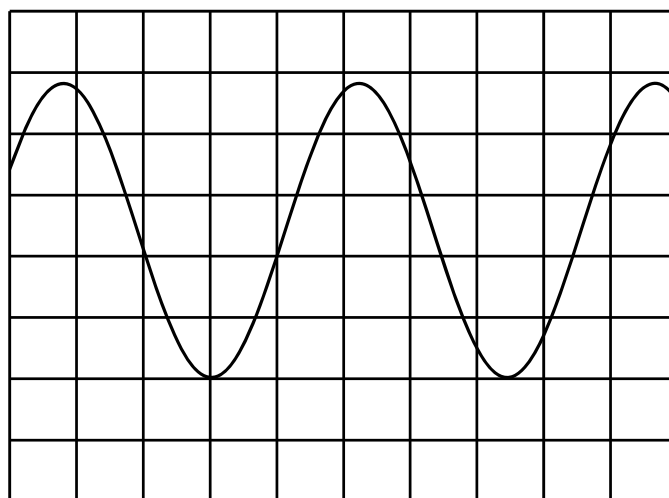
- 4 (d) When the student measure  $V_1$ , the trace displayed on the oscilloscope, is shown in **Figure 8**.

**Figure 8**



In order to reduce the uncertainty in the reading of  $V_1$ , the student adjusts a control on the oscilloscope so that the trace now appears as in **Figure 9**.

**Figure 9**



- 4 (d) (i) State the control that the student adjusted and suggest why the student decided to make this adjustment.

.....

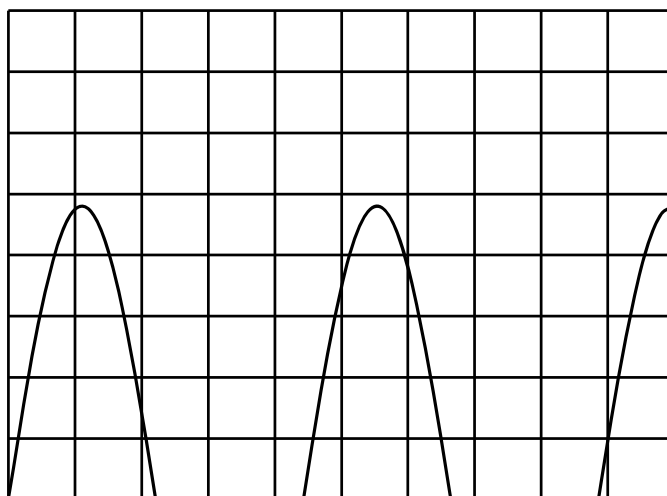
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The student makes **two** further adjustments to the controls of the oscilloscope so that the trace now appears as in **Figure 10**.

**Figure 10**



- 4 (d) (ii) State the two adjustments that the student has made.

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.....

.....

- 4 (d) (iii) Discuss whether the trace shown in **Figure 10** offers any advantage over that shown in **Figure 9** for the purposes of making an accurate measurement of  $V_1$ .

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**END OF QUESTIONS**