

1 An electric oven is connected to a 230 V root mean square (rms) mains supply using a cable of negligible resistance.

- (a) (i) Calculate the peak-to-peak voltage of the mains supply.

peak-to-peak voltage = _____ V

(2)

- (ii) The resistance of the heating element in the oven at its working temperature is 12 Ω .

Calculate the power dissipated by the heating element in the oven.

Give your answer to an appropriate number of significant figures.

power = _____ W

(3)

- (b) In practice the resistance of the cable connecting the oven to the mains supply is not negligible. Each of the **two** wires connecting the heating element to the mains electricity supply has a length of 3.15 m. Each metre of wire has a resistance of 0.0150 Ω .

- (i) Explain why the rms voltage across the heating element in the oven will be less than 230 V.

(2)

- (ii) Calculate the rms voltage across the heating element in the oven when it is at its working temperature.

rms voltage = _____ V

(3)

- (iii) Calculate the average power wasted in the cable due to the heating effect of the electric current.

average power = _____ W

(2)

- (iv) State **two** reasons why it is important that the cable has a low resistance.

1. _____

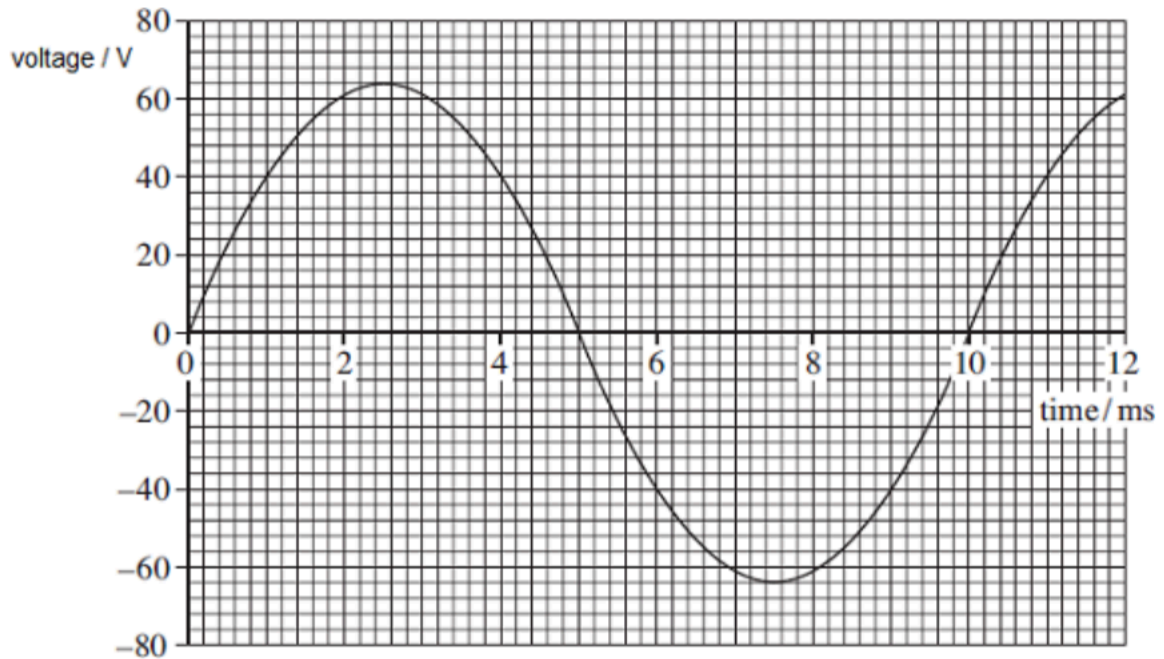
2. _____

(2)

(Total 14 marks)

2

The graph below shows how a sinusoidal alternating voltage varies with time when connected across a resistor, R.



- (a) (i) State the peak-to-peak voltage.

peak-to-peak voltage _____ V

(1)

- (ii) State the peak voltage.

peak voltage _____ V

(1)

- (iii) Calculate the root mean square (rms) value of the alternating voltage.

rms voltage _____ V

(2)

(iv) Calculate the frequency of the alternating voltage. State an appropriate unit.

frequency _____ unit _____

(3)

- (b) On the graph above draw a line to show the dc voltage that gives the same rate of energy dissipation in R as produced by the alternating waveform.

(2)

- (c) An oscilloscope has a screen of eight vertical and ten horizontal divisions. Describe how you would use the oscilloscope to display the alternating waveform in the graph above so that two complete cycles are visible.

(3)

(Total 12 marks)

3

An oscilloscope is used to investigate various voltage sources. In order to do this a voltage source is connected to the y-input and the time base is switched off. **Figure 1** below shows the screen of the oscilloscope when the y-input is not connected to a voltage source.

Figure 1

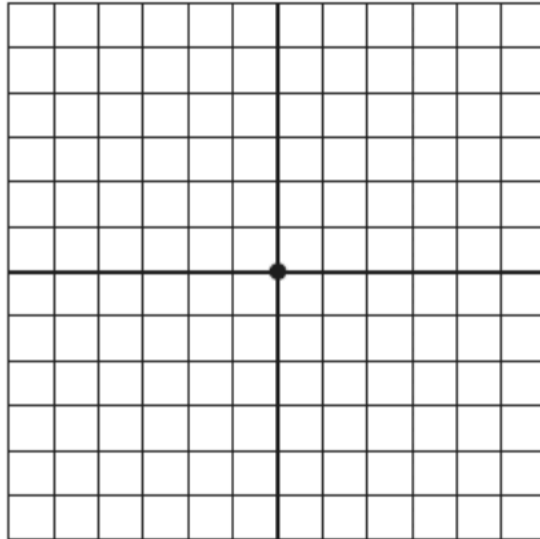
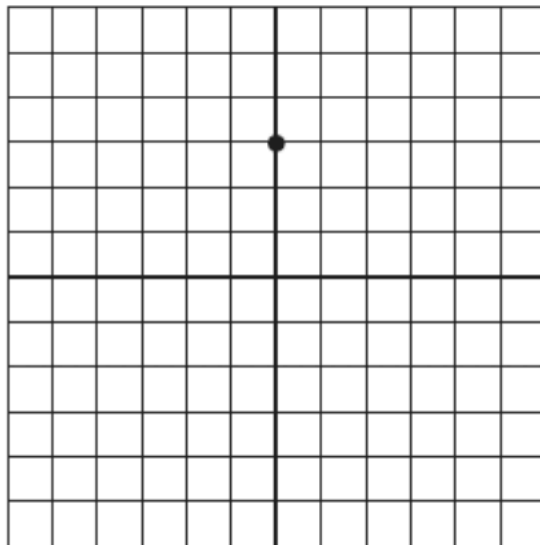
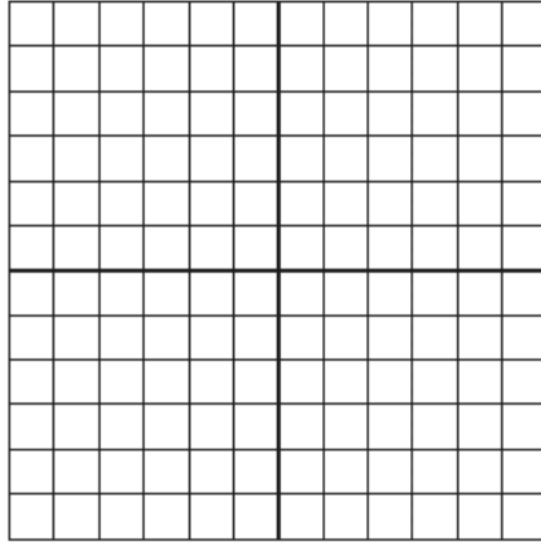


Figure 2 shows the screen when a 1.5V cell is connected to the y-input.

Figure 2



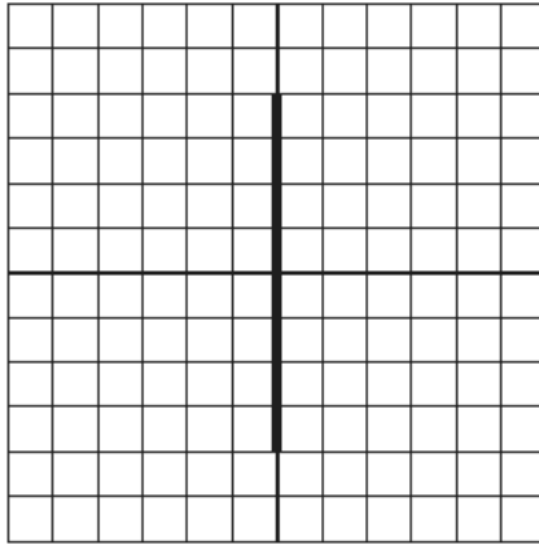
- (a) On the grid below show the appearance of the screen if the y-input is connected to a 2.5V dc supply.



(1)

- (b) The y-input is now connected to a sinusoidal ac voltage supply and the screen is shown in **Figure 3**.

Figure 3



- (i) Explain why a vertical line is now seen on the screen.

(2)

- (ii) Calculate the peak-to-peak voltage of the ac supply.

answer = _____ V

(2)

- (iii) Calculate the root mean square voltage of the supply.

answer = _____ V

(2)

(Total 7 marks)

4

Domestic users in the United Kingdom are supplied with mains electricity at a *root mean square voltage* of 230V.

- (a) State what is meant by root mean square voltage.

(1)

- (b) (i) Calculate the peak value of the supply voltage.

answer = _____ V

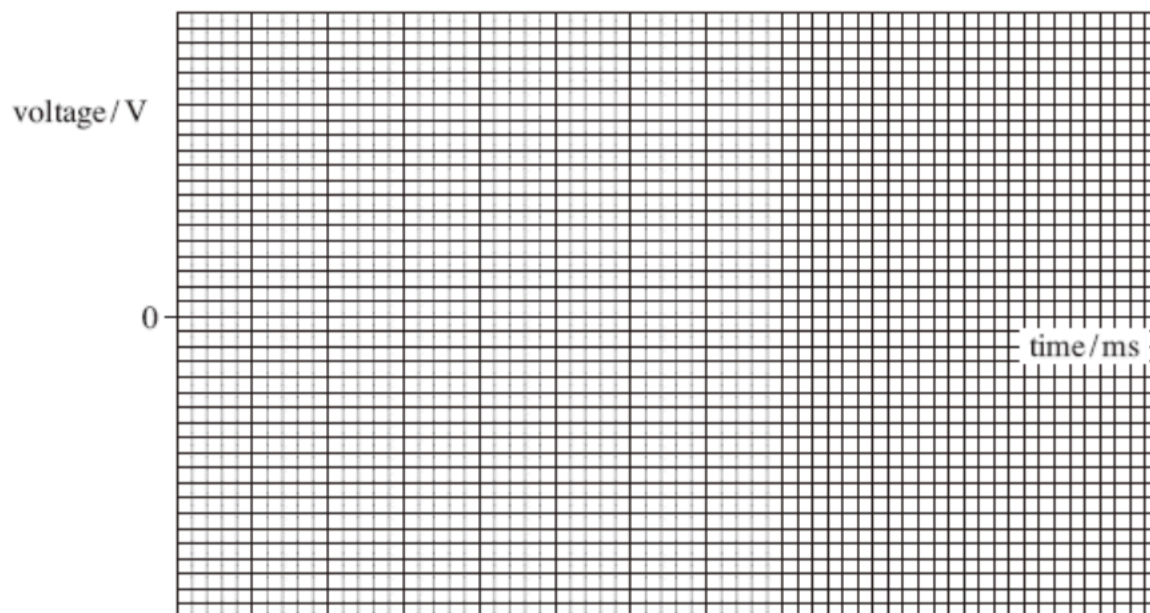
(2)

- (ii) Calculate the average power dissipated in a lamp connected to the mains supply when the rms current is 0.26 A.

answer = _____ W

(1)

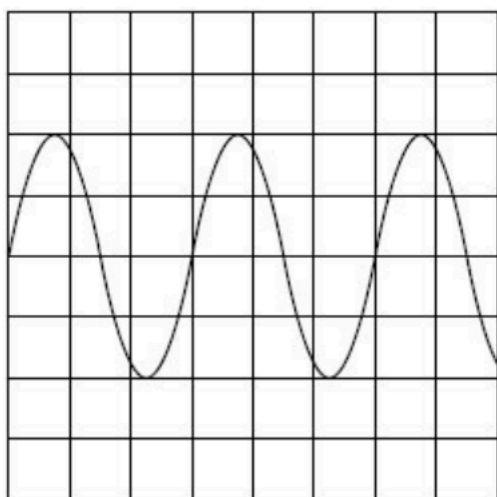
- (c) The frequency of the voltage supply is 50 Hz. On the axes below draw the waveform of the supplied voltage labelling the axes with appropriate values.



(4)

(Total 8 marks)

- 5** An alternating current (ac) source is connected to a resistor to form a complete circuit. The trace obtained on an oscilloscope connected across the resistor is shown in the diagram below.



The oscilloscope settings are: Y gain 5.0 V per division
time base 2.0 ms per division.

- (i) Calculate the peak voltage of the ac source.

answer = _____ V

(1)

(ii) Calculate the rms voltage.

answer = _____ V

(1)

(iii) Calculate the time period of the ac signal.

answer = _____ ms

(1)

(iv) Calculate the frequency of the ac signal.

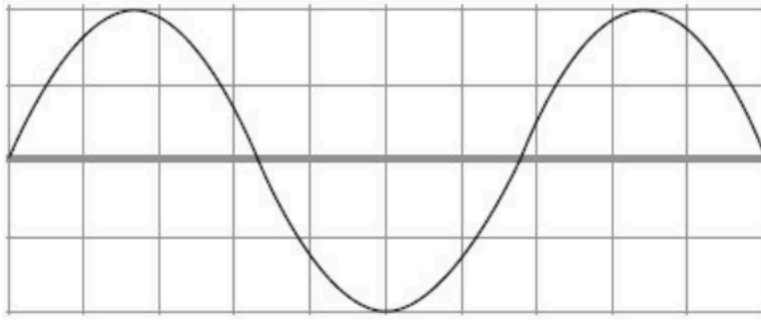
answer = _____ Hz

(2)

(Total 5 marks)

6

The diagram below shows an ac waveform that is displayed on an oscilloscope screen.



The time base of the oscilloscope is set at 1.5 ms per division and the y-gain at 1.5 V per division.

(a) For the ac waveform shown,

(i) Calculate the frequency

answer _____ Hz

(3)

(ii) Calculate the peak voltage

answer _____ V

(2)

(iii) the rms voltage

answer _____ V

- (b) State and explain the effect on the oscilloscope trace if the time base is switched off.

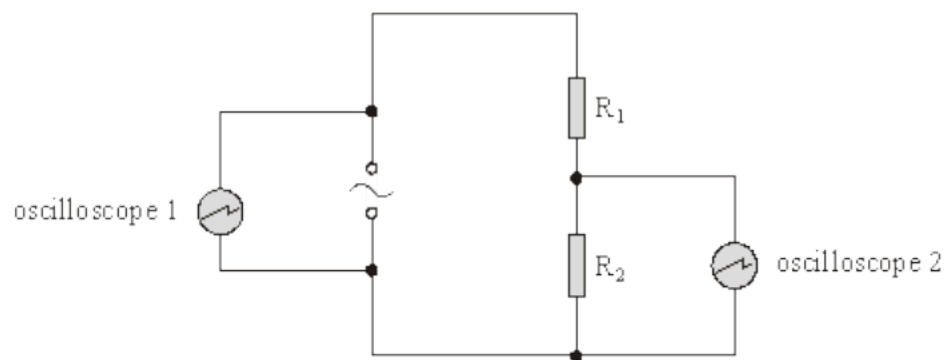
(2)

(Total 9 marks)

7

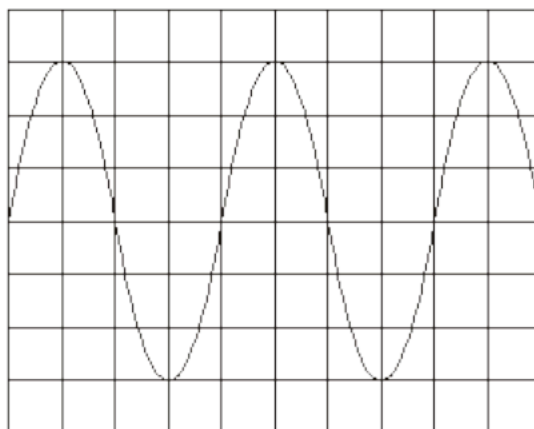
The circuit in **Figure 1** shows a sinusoidal ac source connected to two resistors, R_1 and R_2 , which form a potential divider. Oscilloscope 1 is connected across the source and oscilloscope 2 is connected across R_2 .

Figure 1



- (a) **Figure 2** shows the trace obtained on the screen of oscilloscope 1. The time base of the oscilloscope is set at 10 m/s per division and the voltage sensitivity at 15 V per division.

Figure 2



For the ac source, calculate

- (i) the frequency,

- (ii) the rms voltage.

(4)

- (b) The resistors have the following values: $R_1 = 450 \, \Omega$ and $R_2 = 90 \, \Omega$. Calculate

- (i) the rms current in the circuit,

- (ii) the rms voltage across R_2 .

(2)

- (c) Oscilloscope 2 is used to check the calculated value of the voltage across R_2 . The screen of oscilloscope 2 is identical to that of oscilloscope 1 and both are set to the same time base. Oscilloscope 2 has the following range for voltage sensitivity: 1 V per div., 5 V per div., 10 V per div. and 15 V per div. State which voltage sensitivity would give the most suitable trace. Explain the reasons for your choice.

(3)

(Total 9 marks)

8

An oscilloscope is connected to a sinusoidal ac source as shown in **Figure 1**. The frequency and the voltage output of the ac source can be varied.

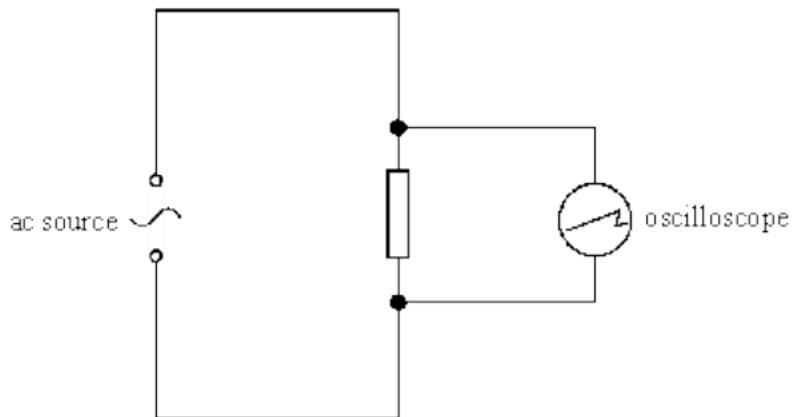


Figure 1

At a certain frequency the ac signal has an rms output of 7.1 V. **Figure 2** shows the trace obtained on the screen of the oscilloscope when one horizontal division corresponded to a time of 5.0 ms.

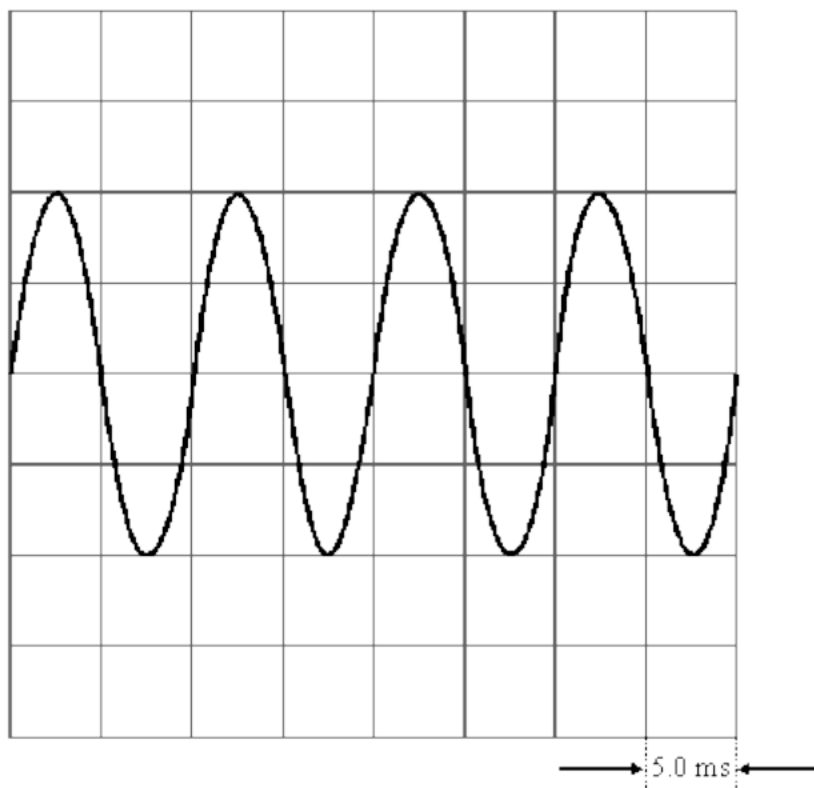


Figure 2

(a) Calculate, for the signal shown in **Figure 2**,

(i) the peak voltage,

(ii) the frequency.

- (b) The voltage output and frequency of the signal are now changed so that the peak voltage is 80 V and the frequency is 200 Hz.

State which **two** controls on the oscilloscope have to be altered so that **four** full cycles again appear on the screen but the peak to peak distance occupies the **full** screen.

Determine the values at which these two controls have to be set.

control 1: _____

value of the setting: _____

control 2: _____

value of setting: _____

(5)

(Total 8 marks)

9

A sinusoidal alternating voltage source of frequency 500 Hz is connected to a resistor of resistance $2.0 \text{ k}\Omega$ and an oscilloscope, as shown in **Figure 1**.

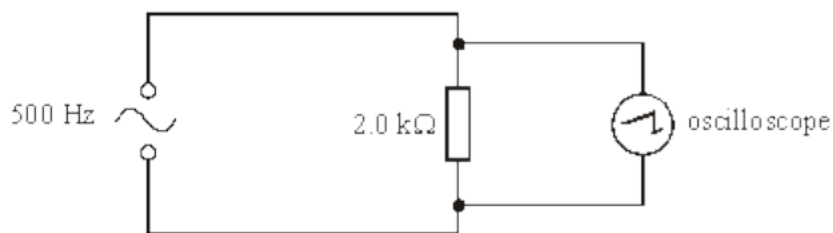


Figure 1

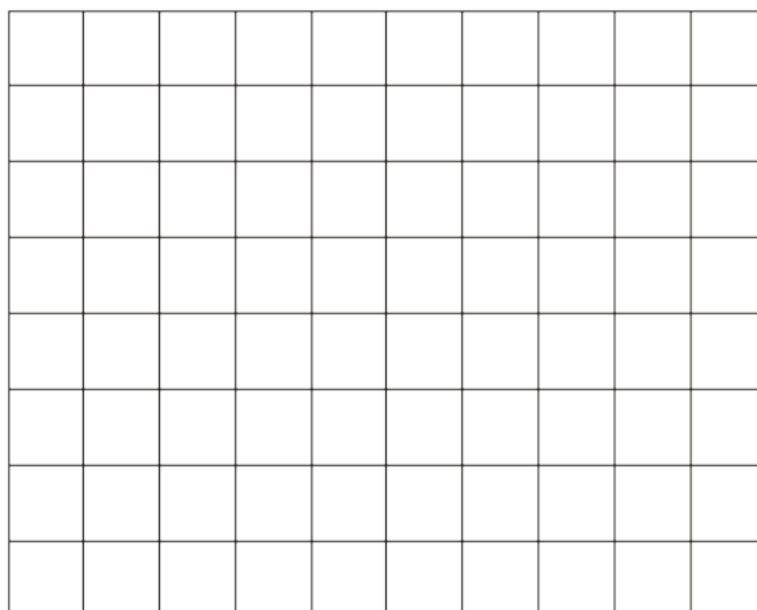
- (a) The rms current through the resistor is 5.3 mA. Calculate the peak voltage across the resistor.

(2)

(b) The settings on the oscilloscope are

timebase: $250\ \mu\text{s}$ per division,
voltage sensitivity: $5.0\ \text{V}$ per division.

Draw on the grid, which represents the screen of the oscilloscope, the trace that would be seen.



(4)
(Total 6 marks)

10

- (a) The circuit shown in **Figure 1** may be used to determine the internal resistance of a battery. An oscilloscope is connected across the battery as shown. **Figure 2** represents the screen of the oscilloscope.

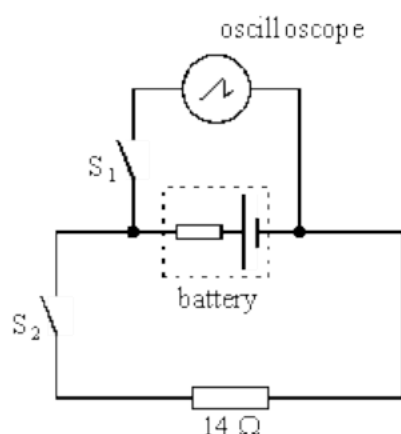


Figure 1

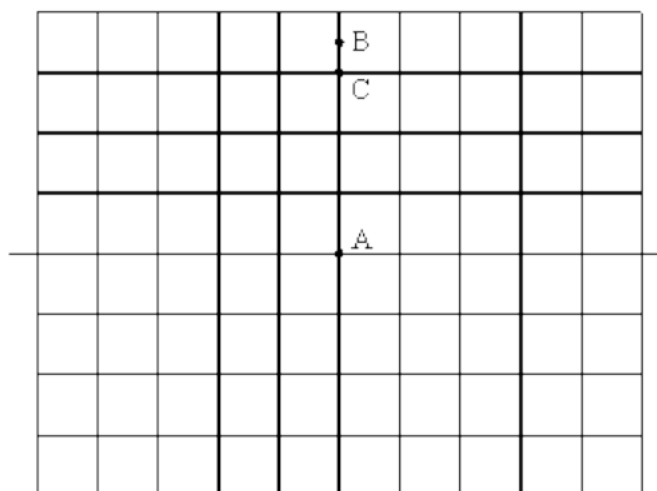


Figure 2

The time base of the oscilloscope is switched off throughout the experiment. Initially the switches S_1 and S_2 are both open. Under these conditions the spot on the oscilloscope screen is at A.

- (i) Switch S_1 is now closed, with S_2 remaining open. The spot moves to B. State what the deflection AB represents.

- (ii) Switch S_1 is kept closed and S_2 is also closed. The spot moves to C. State what the deflection AC represents.

- (iii) The vertical sensitivity of the oscilloscope is 0.50 V div^{-1} . Calculate the current through the 14Ω resistor with both switches closed.

- (iv) Hence, calculate the internal resistance of the battery.

(b) The oscilloscope is now connected to an alternating voltage source of rms value 3.5 V.

(i) Calculate the peak value of the alternating voltage.

(ii) Draw on **Figure 3** what you would expect to see on the oscilloscope screen, if the time base is still switched off and the voltage sensitivity is altered to 2.0 V div^{-1} .

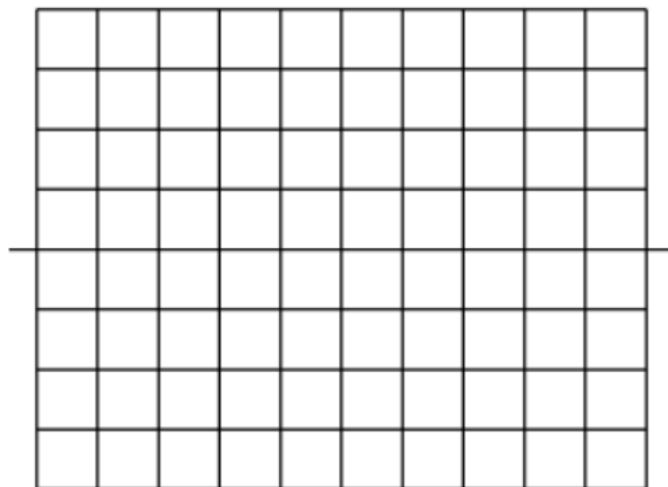


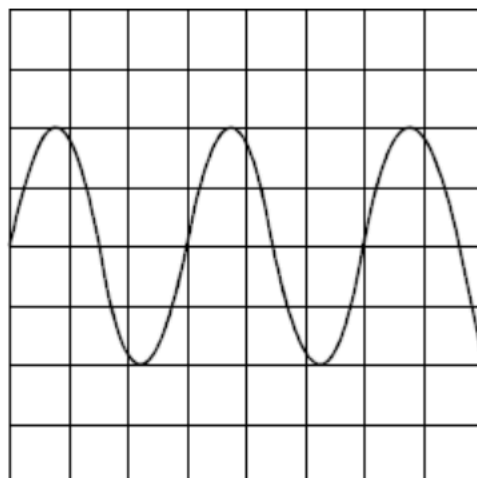
Figure 3

(3)

(Total 9 marks)

11

An alternating current (a.c.) source is connected to a resistor to form a complete circuit. The trace obtained on an oscilloscope connected across the resistor is shown.



The oscilloscope settings are: Y sensitivity $4.0 \text{ V per division}$,
time base $1.0 \text{ ms per division}$.

- (a) Determine the peak voltage of the a.c. source.

- (b) Hence calculate the r.m.s. voltage.

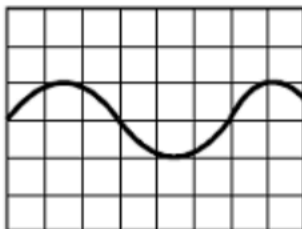
- (c) Determine the time period of the a.c. signal.

- (d) Hence calculate the frequency of the a.c. signal.

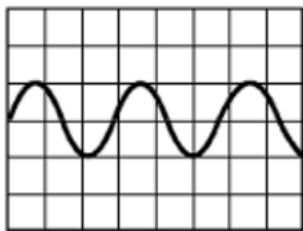
(Total 4 marks)

12

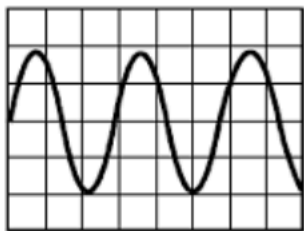
The diagram below shows the waveform obtained when the output of an alternator is connected to a cathode ray oscilloscope.



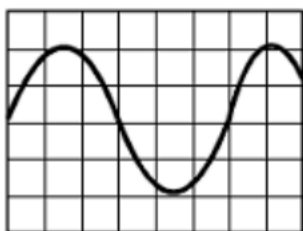
Which one of the following best represents the output when the speed of rotation of the generator is doubled and no adjustment is made to the oscilloscope?



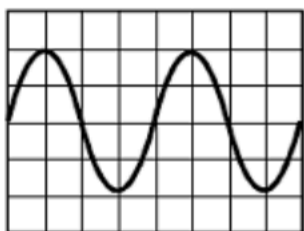
A



B



C



D

(Total 1 mark)

13

- (a) Calculate the length of copper wire that has a diameter of $1.6 \times 10^{-3} \text{ m}$ and a resistance of 25Ω .

resistivity of copper = $1.7 \times 10^{-8} \Omega \text{ m}$

Length of wire _____

(3)

- (b) The resistance of copper wire is **not** zero. Explain why this fact leads to the use of alternating current rather than direct current when transmitting electrical energy.

(3)

(Total 6 marks)

Mark schemes

1

- (a) (i) $230 \times \sqrt{2} = 325 \text{ (V)} \checkmark$
 $(2 \times 325 =) 650 \text{ to } 651 \text{ V } \checkmark$

*allow doubling their incorrect peak voltage (162.6×2) by use of $\sqrt{2}$
 2 as an attempt to find peak-to-peak for 1 mark but not just 2×230*

2

- (ii) (use of $P = V^2/R$)

$$P = 230^2/12 \checkmark$$

$$P = 4.4 \times 10^3 \text{ (W)} \checkmark \text{ cao}$$

2 sig. figs. Incorrect answer must be supported by working $\checkmark$

Allow their incorrect answer (a)(i)² $\div$ 12

Or $325^2 \div 12$ as a use of for 1 mark

Alternative

For first mark

$$I = \frac{V}{R} \text{ **and** } P = VI \text{ allowing their incorrect answer}$$

(a)(i) or 325 as sub for V for 1 mark

Answers 8.8 kW (325V) and 35 kW (650V)

3

- (b) (i) there is a pd / voltage across the cable $\checkmark$
 pd / voltage across cooker is 230 V minus this pd / voltage $\checkmark$
 2nd mark depends on 1st mark in all

The current is lower due to the resistance of cable / The current is lower as circuit resistance increases $\checkmark$

pd across oven is lower since $V = I \times \text{Resistance of element}$ $\checkmark$

or

Resistance of the cable is in series with element $\checkmark$

Voltage splits (in ratio) across these resistances $\checkmark$

2

- (ii) resistance of cable = $2 \times 3.15 \times 0.0150 = 0.0945 \checkmark$

Allow power 10 error here

$$V = \frac{12}{12 + R_{\text{cable}}} \times 230 \checkmark$$

$$\text{Or } I = \frac{230}{12 + R_{\text{cable}}} \text{ and } V = \left(\frac{230}{12 + R_{\text{cable}}} \right) \times 12$$

$$= 228 \text{ V } \checkmark \text{ cao}$$

Allow their incorrect R_{cable} correctly substituted for 2nd marking

3

- (iii) 230 – their (b) (ii) or 19 (A) quoted for current or equivalent seen in equation (230 / 12.0945) ✓

(P =) 34.2 to 42.3(W) ✓ correct working

ecf as $P = (230 - (b)(ii))^2 / \text{their } R_{\text{cable}}$

2

- (iv) minimise power loss / maximise efficiency of oven / ensure element gets as hot as possible ✓

avoid overheating / fires ✓

not just to carry a large current / larger pd across element

Either order

2

[14]

2

- (a) (i) 128 V ✓

1

- (ii) 64 V

CE from (i)

1

- (iii) $V_{\text{rms}} = 64 / \sqrt{2} \checkmark = 45.3 \text{ V} \checkmark$

CE from (ii)

2

- (iv) frequency = $1 / 0.01 \checkmark = 100 \checkmark \text{ Hz} \checkmark$

*do not accept kHz for unit mark unless correct for candidate value
if use 10 s instead of 10 ms then can score second two marks*

3

- (b) horizontal line ✓

through y = 45 (44 – 48) x = 0 ✓

CE from (a)(iii) + / - half square

straight line must extend to at least to 6.0 ms

2

- (c) connect to y-input ✓

adjust / change time base ✓

so that each division is 2.0 ms OR 20 ms across screen ✓

reference to y-gain / sensitivity ✓

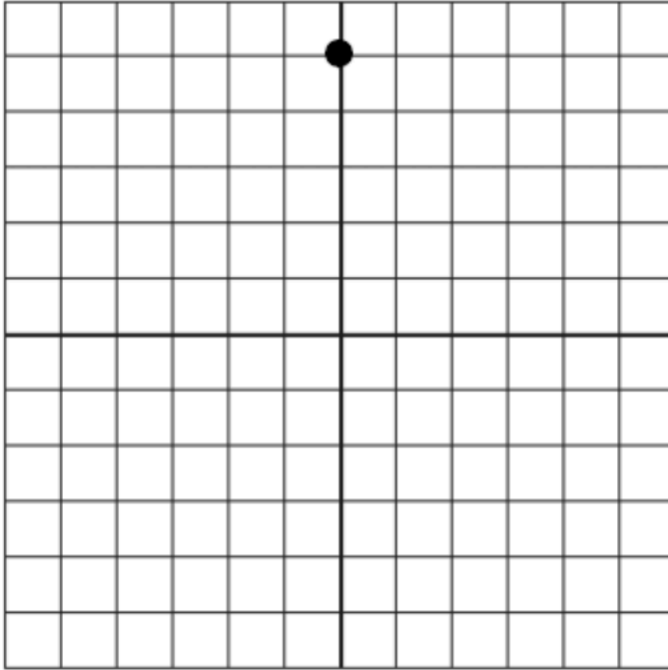
if inappropriate numbers quoted for y gain then lose last mark

3max

[12]

3

(a)



1

- (b) (i) the **voltage reverse/changes** direction/sign ✓

this makes **the spot** move up and down **or** correct
 explanation of lack of horizontal movement ✓

2

- (ii) length of line = 8 divisions

$$\text{peak to peak} = 8 \times 0.5 = 4.0 \text{ V} \checkmark \checkmark$$

2

- (iii) (peak = 2.0 V)

$$\text{rms} = 2.0/\sqrt{2} = 1.4 \text{ V} \checkmark$$

2

[7]**4**

- (a) the square root of the mean of the squares of all the values of the
 voltage in one cycle **(1)**

or the equivalent dc/steady/constant voltage that produces the same
heating effect/power (1)

1

- (b) (i) peak voltage = $230 \times \sqrt{2}$ **(1)**

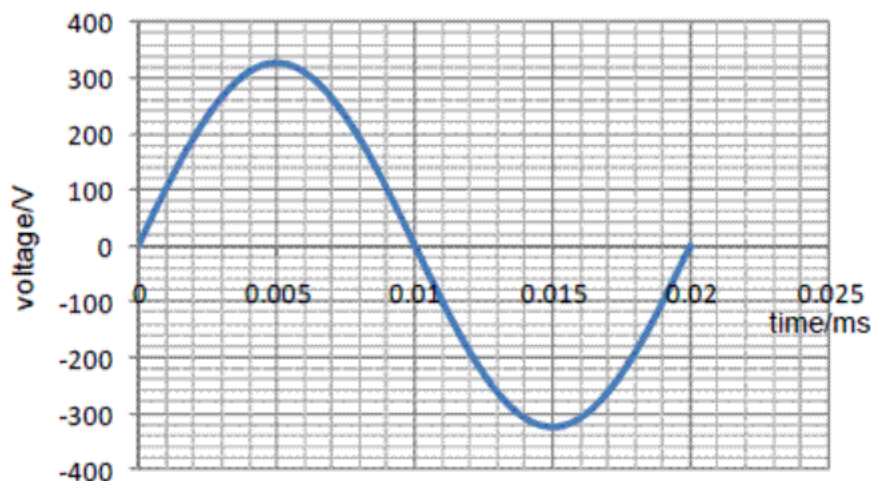
$$\text{peak voltage} = 325 \text{ V (or } 324 \text{ V) (1)}$$

2

- (ii) average power = $230 \times 0.26 = 60 \text{ W (1)}$

1

(c)



shape and symmetrical with consistent values of x at $y = 0$ and consistent $y_{\max}$ (must be at least one cycle) (1)

appropriate scale y-axis (1)

correct peak values (to within one 2 mm square) (1)

correct period (accept 0.02 or 20) (1)

4

[8]

5

(i) 10.0 (V) (1)

1

(ii) $V_{\text{rms}} = 10.0/\sqrt{2} = 7.1$ (V) (1)

1

(iii) time period = $3 \times 2 = 6$ (ms) (1)

1

(iv) frequency = $1/0.006$ or $1/6$ (1)

frequency = 167 (1) (Hz)

2

[5]

6

(a) (i) use of 1.5 cycles (1)

conversion to time eg time for 1.5 cycles = $10 \times 1.5 = 15$ ms (1)

calculation of frequency eg frequency = $1 / 0.010 = 100 \pm 3$ Hz (1)

(ii) peak voltage = 1.5×2 (1) = 3.0 V (1)

(iii) rms voltage = $3.0/\sqrt{2}$ (1) (ce from (a) (i))

rms voltage = 2.12 V (1)

7

- (b) vertical line is formed **(1)**
 of length equal to twice the peak voltage **(1)**
 because trace no longer moves horizontally
 or spot moves **just** up and down **(1)**

max 2

[9]

7

- (a) (i) $T = 40(\text{ms})$ **(1)**

$$f\left(\frac{1}{T}\right) = 25 \text{ Hz} \text{ (1)}$$

(allow C.E. for value of T)

- (ii) peak voltage $(= 3 \times 15) = 45 \text{ (V)}$ **(1)**

$$\text{rms voltage} = \frac{45}{\sqrt{2}} = 32 \text{ V} \text{ (1)}$$

(31.8 V)

4

- (b) (i) $I_{\text{rms}} = \frac{31.8}{540} = 59 \text{ mA}$ **(1)**

(58.9 mA)

(use of 32 V gives 59(.2) mA)

(allow C.E. for value of V_{rms} from (a))

- (ii) $V_{\text{rms}} = 59 \times 10^{-3} \times 90 = 5.3(1) \text{ V}$ **(1)**

(allow C.E. for value of I_{rms} from (i)) [or $V_2 = V_1 \frac{R_2}{R_1 + R_2}$]

2

- (c) $V_{\text{peak}} = 5.31 \times \sqrt{2} = 7.5(1) \text{ (V)}$ **(1)**

best choice: 5 V per division **(1)**

(allow C.E. for incorrect V_{rms} and for suitable reason)

reason: others would give too large or too small a trace **(1)**

3

[9]

8

- (a) (i) (use of $V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$ gives) $V_0 = 7.1\sqrt{2} = 10 \text{ V}$ **(1)**

- (ii) $T = 10 \text{ (ms)}$ **(1)**

$$\text{(use of } f = \frac{1}{T} \text{ gives)} f = \frac{1}{10 \times 10^{-3}} = 100 \text{ Hz} \text{ (1)}$$

3

- (b) control 1: time base **(1)** (or time period)

(use of $T = \frac{1}{f}$ gives) $T = \frac{1}{200} = 5 \times 10^{-3} \text{ (s) (1)}$

setting = 2.5 ms (div⁻¹) **(1)**

control 2: voltage sensitivity or Y-plate setting (or Y-gain) **(1)**

setting = 20 V (div⁻¹) **(1)**

5

[8]

9

- (a) ($V = IR$ gives) $V_{\text{rms}} = (5.3 \times 10^{-3} \times 2 \times 10^3) = 10.6 \text{ (V) (1)}$
 $V_0 = V_{\text{rms}} \sqrt{2} = 10.6 \sqrt{2} = 15 \text{ V (1) (14.99 V)}$
 [or calculate $I_0 (= 7.5 \text{ mA})$ and then V_0]

2

- (b) (use of $T = \frac{1}{f}$ gives) $T = \frac{1}{500} = 2 \times 10^{-3} = 2.0 \text{ (ms) (1)}$

trace to show:

correct wave shape (sinusoidal) **(1)**

correct amplitude (3 divisions) **(1)**

correct period (8 divisions) **(1)**

4

[6]

10

- (a) (i) the emf (of the battery) **(1)**
- (ii) the voltage across the battery when current flows
 [or terminal voltage or pd supplied to the circuit]
- (iii) $V = (3 \times 0.5) = 1.5 \text{ (V) (1)}$
 current = $(1.5/14) = 0.11 \text{ A (1) (0.107 A)}$
- (iv) ($\epsilon = V + Ir$ and emf = $3.5 \times 0.5 = 1.75 \text{ (V) gives}$)
 $1.75 = 1.5 + 0.107r \text{ (1)}$
 $r = 2.3 \Omega$
 [or use of $\epsilon = I(R + r)$ with $I = 0.107$ gives $r = 2.4 \Omega$
 and $I = 0.11$ gives $r = 1.9 \Omega$]
 (allow C.E. for value of I from (iii))

6

- (b) (i) peak value = $3.5\sqrt{2} = 4.9 \text{ V}$ (1)
- (ii) oscilloscope screen to show
vertical line of height 2.5 divisions above central axis (1)
and below central axis (1)

3

[9]

11

- (a) $V_0 = 8.0 \text{ V}$ (1)
- (b) $V_{\text{rms}} = 8/\sqrt{2} = 5.7 \text{ (V)}$ (1)
(allow e.c.f. from (a))
- (c) $T = 3.0 \text{ ms}$ (1)
- (d) $f = \frac{1}{T} = 330 \text{ (333) Hz}$ (1)
(allow e.c.f. from (c))

[4]

12

B

[1]

13

- (a) $R = \rho L/A$

C1

$A = 2.0 \times 10^{-6} \text{ (m}^2\text{) or } \pi(0.8 \times 10^{-3})^2$ seen in equation
(condone $\pi(1.6 \times 10^{-3})^2$ or 8.04×10^{-6} seen)

C1

$L = 2900 \text{ m, } 2940 \text{ m, } 2960 \text{ or } 3000 \text{ m}$

A1

3

- (b) resistance leads to loss of heat/energy/power
or I^2R loss or voltage drop (across cable)

B1

lower current lowers loss of heat/energy/power
or reduces voltage drop

B1

ac can be transformed (to lower transmission current)

B1

3

[6]