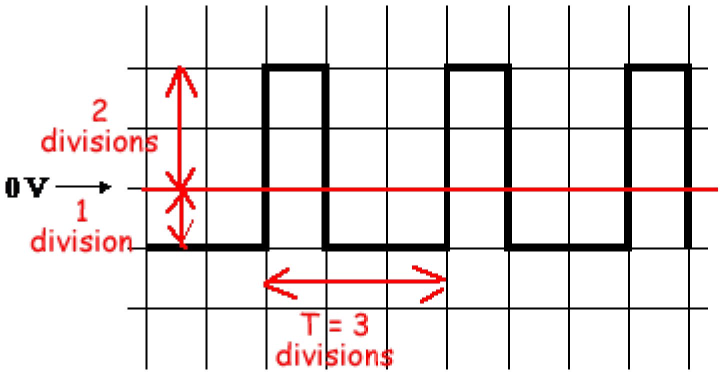
Q1. The diagram shows a trace on the screen of an oscilloscope. The Y-sensitivity of the oscilloscope is set at 5.0 V per division and the time base is set at 0.50 ms per division.



(a) For the trace, determine

(i) the maximum positive value of potential difference,

2 divisions at 5.0 V per division = 10V **(1 mark)**

(ii) the maximum negative value of potential difference,

1 division at 5.0 V per division = 5.0V **(1 mark)**

(iii) the frequency of the signal.

Time period T = 3 divisions at 0.50 ms per division = 1.5 ms = 1.5×10^{-3}s **(1 mark)**

Frequency = 1/T = $1/(1.5 \times 10^{-3})$ = 670 Hz **(1 mark)**

(4)

(b) The trace shows the variation in the potential difference across a 100Ω resistor. Calculate the energy dissipated in the resistor

$E = IVt,\ P = IV,\ P = I^2R$

$R = \frac{V}{I}$

(i) for the first 1.00 ms,

Voltage is 5V for the 1.00 ms

P=IV but I=V/R so P $=V^2/R$

Therefore in one second you would have 25/100 = 0.25 J of energy dissipated **(1 mark)**

So in 1.00 ms you would have 0.25×10^{-3}J of energy dissipated **(1 mark)**

(ii) between 1.00 ms and 1.50 ms,

Voltage is 10V for the 0.50 ms

P=IV but I=V/R so P $=V^2/R$

In one second you would have 100/100 J =1J of energy dissipated **(1 mark)**

So in 0.50 ms you would have 0.50×10^{-3}J of energy dissipated **(1 mark)**

(iii) in one cycle,

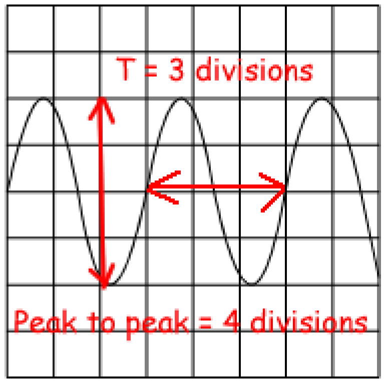
$(0.25 + 0.50) \times 10^{-3}$J = 0.75×10^{-3}J of energy dissipated **(1 mark)**

(iv) in one second.

0.75×10^{-3}J/1.5×10^{-3}s = 0.5 J of energy dissipated **(1 mark)**

(5 MAX)
(Total 9 marks)

Q2. 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 4.0V per division,
time base 1.0 ms per division.

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

Peak to peak is 4 divisions – peak voltage = 2 divisions at 4.0V per division = 8.0V

(ii) Hence calculate the r.m.s. voltage.

$$I_{rms} = \frac{I_o}{\sqrt{2}} \qquad V_{rms} = \frac{V_o}{\sqrt{2}}$$

= 8.0/(root 2) = 5.7 V

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

T = 3 divisions at 1.0 ms per division = 3.0×10^{-3} s

(iv) Hence calculate the frequency of the a.c. signal.

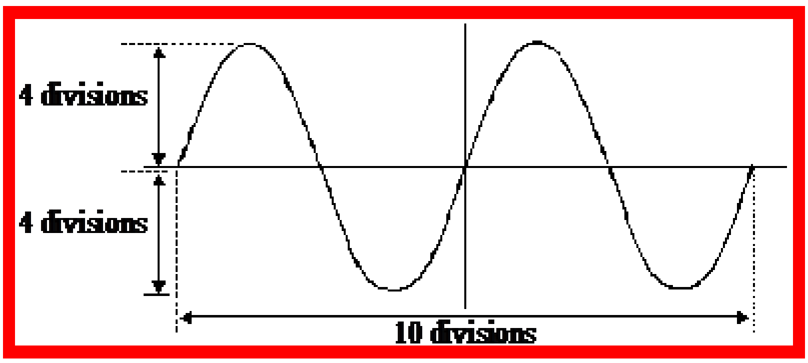
f=1/T = 1/(3.0×10^{-3}) = 330 Hz

(4)

(Total 4 marks)

Q3. A cathode ray oscilloscope is used to study the waveform of a sinusoidal alternating voltage of frequency 100 Hz and peak voltage 2.0 V. If the time base is set to 2.0 ms div^{-1} and the voltage sensitivity is 0.5 V div^{-1}, draw, in a copy of the grid on the right, the trace you would expect to see on the screen.

If the frequency is 100 Hz the period T is 1/f = 10^{-2} s = 10×10^{-3} s = 5 divisions. Therefore 10 squares will have two full traces across them.
Peak voltage is 2.0 V – so peak to peak will be 4.0V – 8 divisions. Therefore the height of the whole trace will be 8 divisions

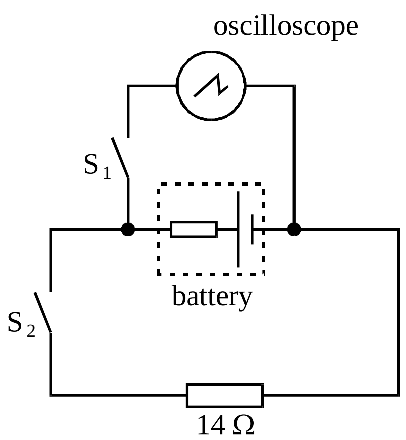


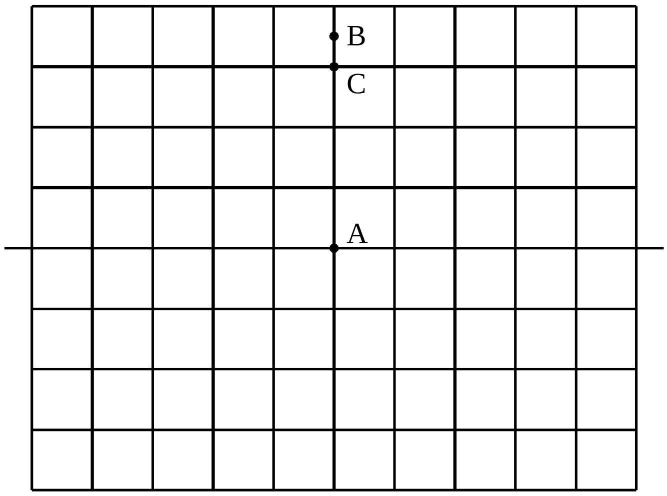
Shape must be of a sinusoidal wave (line gradient must be changing and distance between crests and troughs symmetric) **(1 mark)** correct amplitude **(1 mark)** calculation of time period shown or implied **(2 marks)** two cycles drawn **(1 mark)** (allow e.c.f. if incorrect time period *calculated*)

On the grid – in pencil - draw a centre line – then (in pencil) mark the zero positions and peaks (positive and negative) then sketch in the curve. In the exam then go over that in black biro when you are happy it is correct!

(Total 4 MAX marks)

Q4. (a) The circuit shown below may be used to determine the internal resistance of a battery. An oscilloscope is connected across the battery as shown. The grid represents the screen of the oscilloscope.





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.

No current flows in the circuit so the voltmeter reads the EMF of the battery **(1 mark)** which is 3.5 divisions

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

The current is now flowing through the external circuit and the internal resistance so the voltmeter reads the external circuit (or terminal) potential difference **(1 mark)** which is 3.0 divisions.

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

$R = \frac{V}{I}$

V = 3.0 x 0.50V = 1.50V **(1 mark)**
R = 14Ω

I = V/R = 1.50/14 = 0.11A **(1 mark)**

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

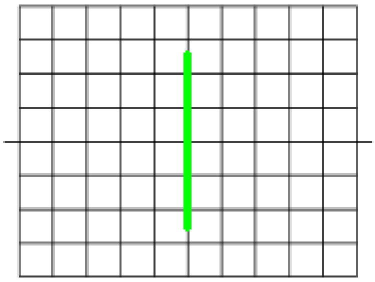
$\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

ε = 3.5 x 0.50V = 1.75V **(1 mark)**
ε = IR + Ir = V +Ir
1.75 = 1.5 + 0.11r
0.25/0.11 = r = 2.3Ω **(1 mark)**

(6)

(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.



$$I_{rms} = \frac{I_o}{\sqrt{2}} \qquad V_{rms} = \frac{V_o}{\sqrt{2}}$$

$V_o = V_{RMS} \times (\sqrt{2})$

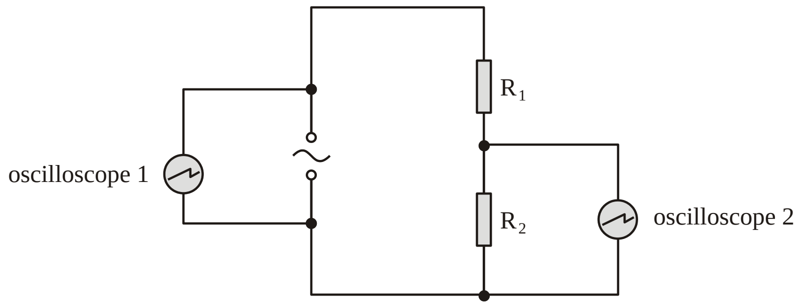
$= 3.5 \times (\sqrt{2}) =$ 4.9V **(1 mark)**

(ii) Draw on a grid like that on the right 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}.

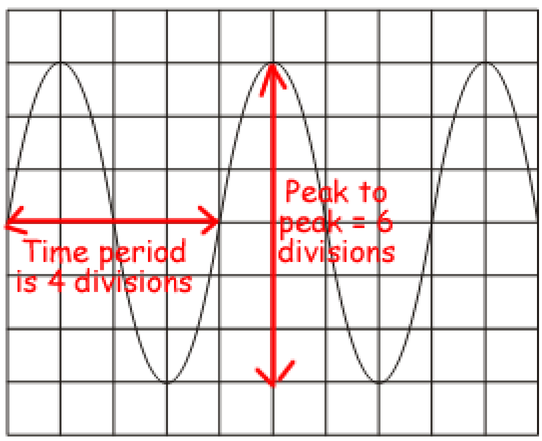
Trace will be a vertical line representing the peak to peak voltage = 2 x 4.9V = 9.8V
2.0 V is one division so 9.8/2 = 4.9 divisions **(1 mark)** are 9.8 volts. This trace will be positioned around the central line. **(1 mark)**

(3)
(Total 9 marks)

Q5. The circuit on the right 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.



(a) The grid on the right shows the trace obtained on the screen of oscilloscope 1. The time base of the oscilloscope is set at 10 ms per division and the voltage sensitivity at 15 V per division.



For the ac source, calculate

(i) the frequency,

T = 4 x 10ms = 40 ms = 40×10^{-3} s **(1 mark)**

F = 1/T = 25Hz **(1 mark)**

(ii) the RMS voltage.

$$I_{rms} = \frac{I_o}{\sqrt{2}} \qquad V_{rms} = \frac{V_o}{\sqrt{2}}$$

Peak voltage = ½ peak to peak voltage
= ½ x 6 x 15V = 45V **(1 mark)**
$V_{RMS} = 45/\sqrt{2} =$ 32V **(1 mark)**

=

(4)

(b) The resistors have the following values: R_1 = 450 Ω and R_2 = 90 Ω.
Calculate
(i) the RMS current in the circuit,
Total resistance = 450 + 90 = 540 Ω V_{RMS} = 32V
V = IR so I = V/R = 32/540 = 0.059A **(1 mark)**

(ii) the RMS voltage across R_2

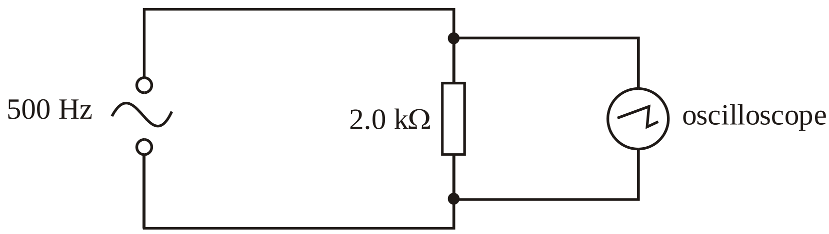
32V shared by 540 Ω means each ohm gets 32/540
and the 90 Ω resistor will get (32/540) x 90 = 5.3V **(1 mark)**

(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.
5.3V RMS would give a peak value of √2 x 5.3
and a peak to peak value of √2 x 5.3 x 2 = 15V **(1 mark)**
If the sensitivity was 1V/div the screen would need to be 15 divisions high, if the 5V/div sensitivity **(1 mark)** was chosen the trace would be 3 divisions high – that would be the best option as it would give the tallest trace that would fit on the screen **(1 mark)**

(3)
(Total 9 marks)

Q6. A sinusoidal alternating voltage source of frequency 500 Hz is connected to a resistor of resistance 2.0 kΩ and an oscilloscope, as shown in on the right.

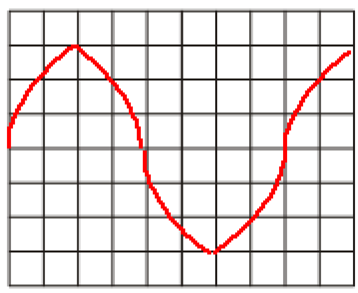


(a) The RMS current through the resistor is 5.3 mA. Calculate the peak voltage across the resistor.
$V_{RMS} = I_{RMS}R$ = 5.3 x 10-3 x 2000 = 10.6V (1 mark)
Vo = √2 x 10.6 = 15V (1 mark) (3 divisions)

(2)

b) The settings on the oscilloscope are:
timebase: 250 *μs* per division,
voltage sensitivity: 5.0 V per division.
Draw on a grid like the one on the right, which represents the screen of the oscilloscope, the trace that would be seen.

T = 1/f = 1/500 = 2.0×10^{-3}s **(1 mark)** = 8 divisions



oscilloscope trace:
correctly shaped ac. waveform (for more than 1 cycle) **(1 mark)**
correct peak value **(1 mark)** (allow C.E. for value from (a))
correct period **(1 mark)** (allow C.E. for value from (b)(i))

(4)
(Total 6 marks)