Name:	Lab Day:
Course:	Group:

OSCILLOSCOPE WORKSHEET

- Information on the function generator and the oscilloscope used in this prac is included in PRACTICALS - PART II of the Course I Lab documentation.
- **The results of all measurements are to be correctly quoted which includes stating the uncertainty in the measurement as well as the units.**
- Learning to use an oscilloscope is an important component of this course, so get involved, do not leave all the work to your partner!

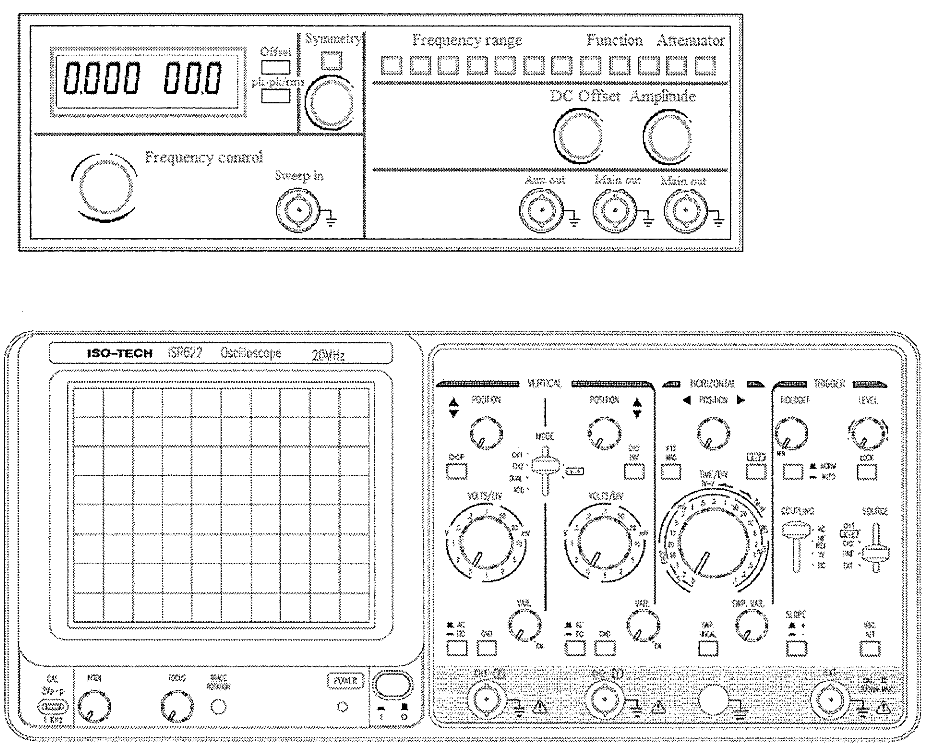


Figure 1: Front panels of the function generator and the oscilloscope

1 A note on wave forms and RMS, peak, and peak-to-peak voltages

For this worksheet you need to know what is meant by the root mean square voltage (RMS), the peak voltage, and the peak-to-peak voltage of an AC signal.

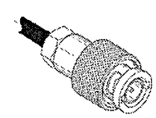
- The root mean square (RMS) voltage may be thought of as the "effective" voltage of an AC signal. It is the voltage used in power calculations because it is the AC equivalent of a DC voltage of that value if it were used in the same circuit.
  Note: The RMS value is depends on the shape of the AC signal.
- The peak voltage is what we would normally refer to as the "amplitude" of an AC signal.
- The peak-to-peak voltage is the voltage difference between the two extremes of the AC signal.

For symmetric AC signals:

Sine wave	$V_{peak} = \frac{V_{peak-peak}}{2}$	$V_{RMS} = \frac{V_{peak}}{\sqrt{2}}$
Square wave	$V_{peak} = \frac{V_{peak-peak}}{2}$	$V_{RMS} = V_{peak}$
Triangular wave	$V_{peak} = \frac{V_{peak-peak}}{2}$	$V_{RMS} = \frac{V_{peak}}{\sqrt{3}}$

2 Settings to start with

After turning the function generator and the oscilloscope on, use the BNC to banana-plug co-axial cable to connect the 'Main out' (50Ω) of the function generator to the CH1 input of the oscilloscope as shown in Figure 2.



BNC connector

Incidentally, BNC stands for 'Bayonet Neill-Concelman' and is a connector often used with co-axial cable on high frequency equipment.

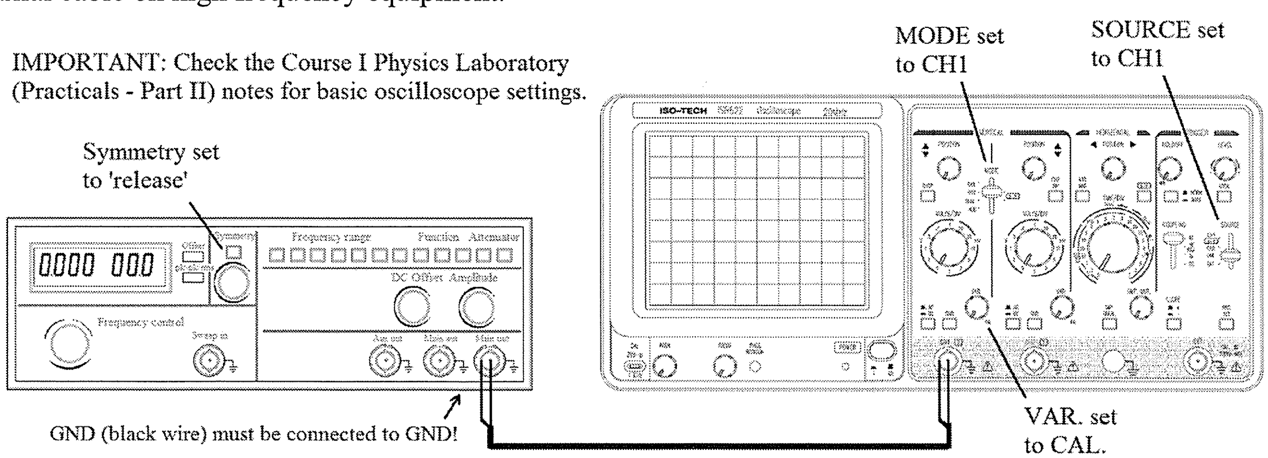


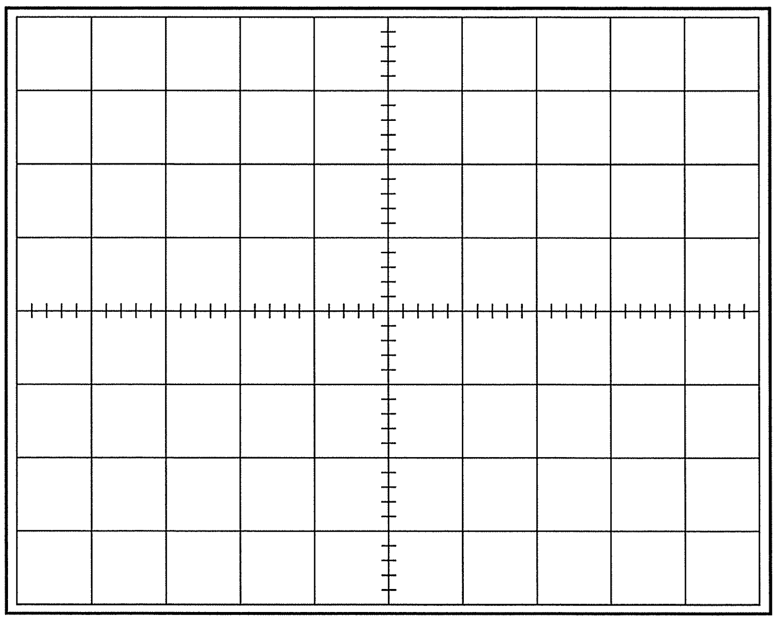
Figure 2: Connection for Basic Functions exercise

2.1 Sine wave:

Select the **sine wave** function on the function generator.

Select a voltage and a frequency on the function generator of your choice, but the voltage must be **between 4.0 V and 5.0 V** and the frequency must be between **2 kHz and 3 kHz**.

Adjust the oscilloscope until you see a clear representation of at least one cycle of the signal on the display of the oscilloscope. Sketch the signal you see on the oscilloscope:



Record the **oscilloscope** settings here: VOLTS/DIV .... TIME/DIV	Record the **function generator** readings here: $V_{pk\text{-}pk}$ = ... V_{RMS} = ... Frequency = ...

For the **sine wave**, using the diagram you have sketched above and the oscilloscope settings recorded on the previous page (See also Course I Laboratory Guide to Measurement, Analysis and Reporting):

Calculate the best approximation of the **voltage** ....

....

Calculate the uncertainty in reading of the **voltage** ....

....

Calculate the uncertainty in the **voltage** as a result of the instrument rating ....

....

Calculate the combined uncertainty ....

....

Quote the result of the **voltage** measurement ....

Calculate the best approximation of the **period** ....

....

Calculate the uncertainty in the reading of the **period** ....

....

Calculate the uncertainty in the **period** as a result of the instrument rating ....

....

Calculate the combined uncertainty ....

....

Quote the result of the **period** measurement ....

Calculate the **frequency** (with its uncertainty) of the measured signal ....

....

Are the results of your measurements of the voltage and frequency from the oscilloscope in agreement with the voltage and frequency displayed on the function generator display? Explain.

....

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....

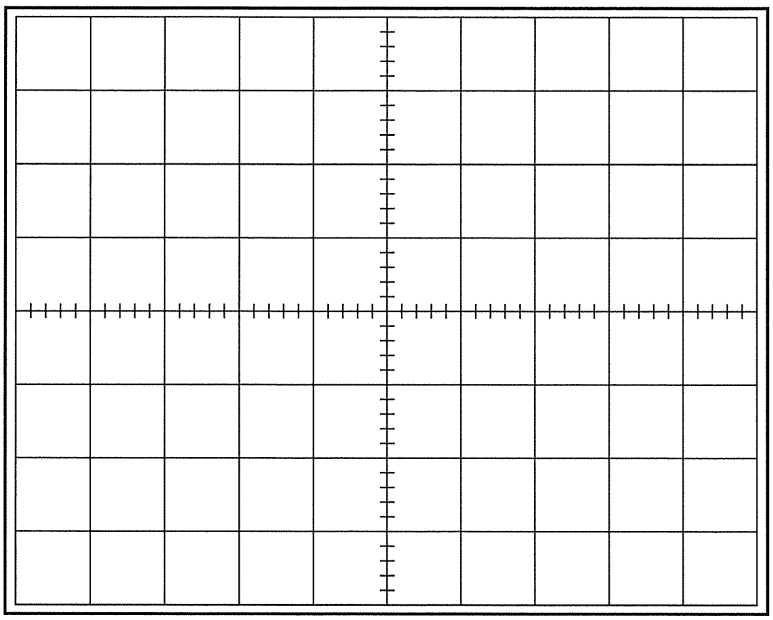
....

2.2 Square wave

Select the **square wave** function on the function generator.

Select a voltage and a frequency on the function generator of your choice, but the voltage must be **between 3.0 V and 4.0 V** and the frequency must be **between 4 kHz and 5 kHz**.

Adjust the oscilloscope until you see a clear representation of at least one cycle of the signal on the display of the oscilloscope. Sketch the signal you see on the oscilloscope:



Record the **oscilloscope** settings here:	Record the **function generator** readings here:
VOLTS/DIV	$V_{pk\text{-}pk}$ = ...
TIME/DIV	V_{RMS} = ...
	Frequency = ...

For the **square wave**, using the diagram you have sketched above and the oscilloscope settings recorded on the previous page (See also Course I Laboratory Guide to Measurement, Analysis and Reporting):

Calculate the best approximation of the **voltage** ....

....

Calculate the uncertainty in reading of the **voltage** ....

....

Calculate the uncertainty in the **voltage** as a result of the instrument rating ....

....

Calculate the combined uncertainty ....

....

Quote the result of the **voltage** measurement ....

Calculate the best approximation of the **period** ....

....

Calculate the uncertainty in the reading of the **period** ....

....

Calculate the uncertainty in the **period** as a result of the instrument rating ....

....

Calculate the combined uncertainty ....

....

Quote the result of the **period** measurement ....

Calculate the **frequency** (with its uncertainty) of the measured signal ....

....

Are the results of your measurements of the voltage and frequency from the oscilloscope in agreement with the voltage and frequency displayed on the function generator display? Explain.

....

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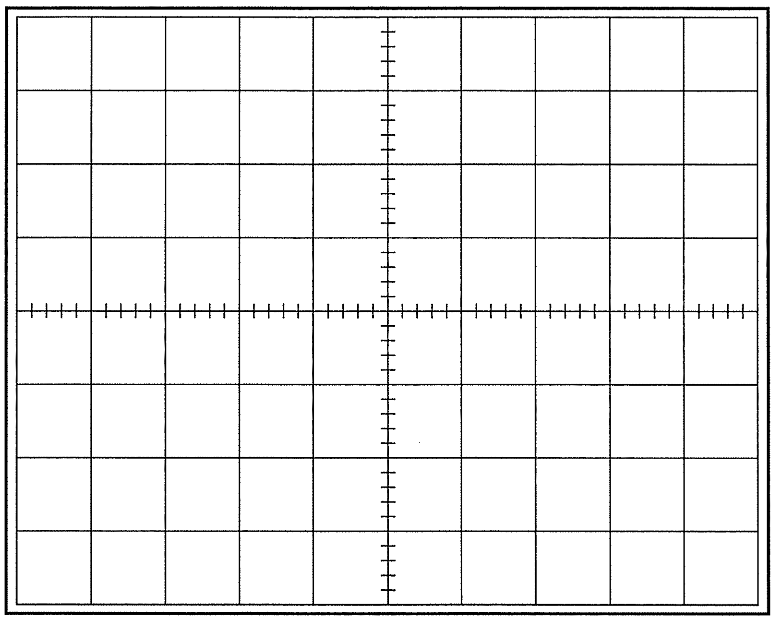
....

2.3 Triangular wave

Select the **triangular wave** function on the function generator.

Select a voltage and a frequency on the function generator of your choice, but the voltage must be **between 5.0 V and 6.0 V** and the frequency must be **between 1 kHz and 2 kHz**.

Adjust the oscilloscope until you see a clear representation of at least one cycle of the signal on the display of the oscilloscope. Sketch the signal you see on the oscilloscope:



Record the **oscilloscope** settings here:	Record the **function generator** readings here:
VOLTS/DIV	V_{pk-pk} = ...
TIME/DIV	V_{RMS} = ...
	Frequency = ...

For the **triangular wave**, the diagram you have sketched above and the oscilloscope settings recorded on the previous page (See also Course I Laboratory Guide to Measurement, Analysis and Reporting):

Calculate the best approximation of the **voltage** ....

....

Calculate the uncertainty in .reading of the **voltage** ....

....

Calculate the uncertainty in the **voltage** as a result of the instrument rating ....

....

Calculate the combined uncertainty ....

....

Quote the result of the **voltage** measurement ....

Calculate the best approximation of the **period** ....

....

Calculate the uncertainty in the reading of the **period** ....

....

Calculate the uncertainty in the **period** as a result of the instrument rating ....

....

Calculate the combined uncertainty ....

....

Quote the result of the **period** measurement ....

Calculate the **frequency** (with its uncertainty) of the measured signal ....

....

Are the results of your measurements of the voltage and frequency from the oscilloscope in agreement with the voltage and frequency displayed on the function generator display? Explain.

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3 Using the dual input on the oscilloscope

Use the two resistors of unknown value, connect up the following circuit:

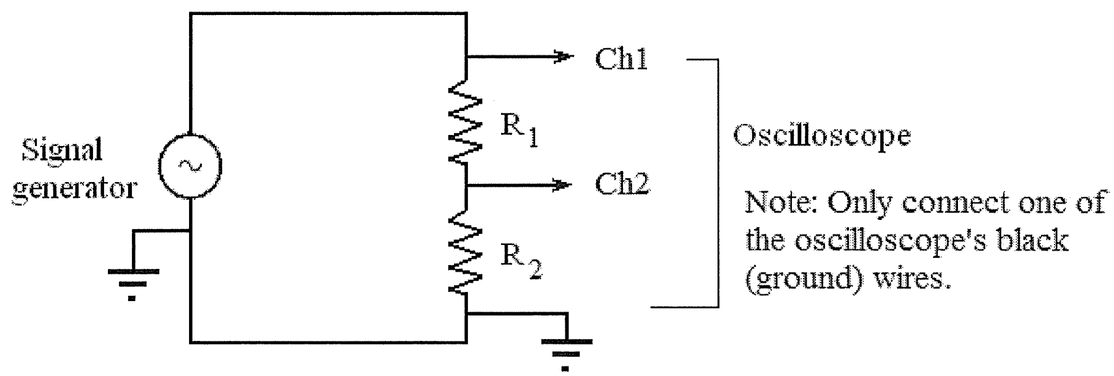

Figure 3: Circuit with two resistors in series

3.1 Measure $V_{(R1+R2)}$ and V_{R2}

Select the **sine wave function** on the function generator. Set the frequency to (2.0 ± 0.1) kHz and the amplitude to (4.0 ± 0.1) V peak-to-peak. The CH2 INV button must be 'released'. Set the VOLTS/DIV setting on both channels of the oscilloscope to 1.0 V per division.

Watch the screen as you switch the MODE selector on the oscilloscope from CH1, to CH2, and then to DUAL. You should see two signals on the oscilloscope. Make sure you are able to identify which signal is CH1 and which is CH2.

Measure and record (including uncertainties) the peak-to-peak voltages of the two signals: $V_{(R1+R2)}$, should be on CH1 and V_{R2} should be on CH2.

$V_{(R1+R2)}$ = ...

V_{R2} = ...

Record the supply voltage on the function generator display here (remember you are using the peak-to-peak value):

V_{supply} = ...

Is V_{supply} the same as $V_{(R1+R2)}$? (Yes/No) Explain ....

....

Could the internal resistance of the function generator be playing a role here?

3.2 Measure V_{R1}

With the settings on the function generator unchanged, use the ▲ and ▼ POSITION buttons to centre the two signals on the screen.

Then press the CH2 INV button 'in'; observe what has happens to the signal on the display of the oscilloscope. (The CH2 signal goes 180° "out of phase" with respect to the signal on CH1.)

With the CH2 INV button 'in' (i.e. with that signal inverted), switch the MODE selector to ADD. The signal you should see on the oscilloscope's display is **the difference between the two input voltages**, i.e. the signal on the screen is the voltage across R_1.

Record the result of the measurement of V_{R1} below:

V_{R1} = ... Is $V_{(R1+R2)} = V_{R1} + V_{R2}$? Explain.

....

....

....

....

....

....

....

....

4 Introduction to the problem of "ground loops"

For the circuit in Figure 3, complete the following diagram:

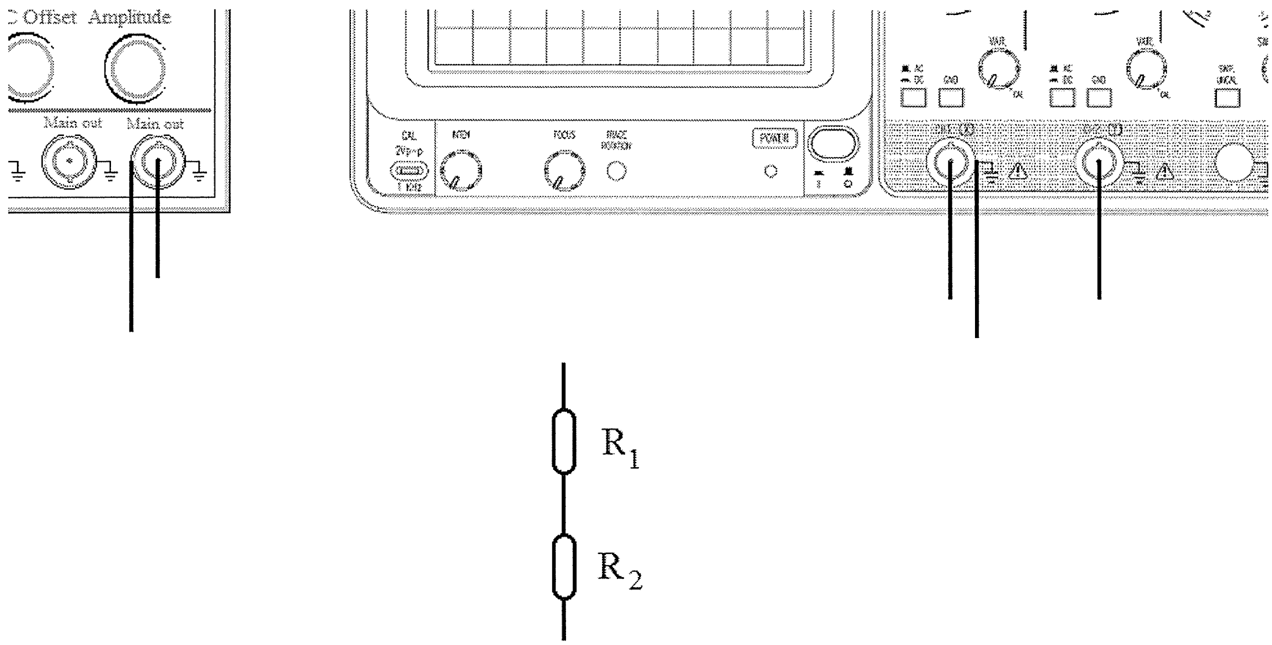

Figure 4: Complete the drawing above, which is the same circuit as in Figure 3

Use the diagram in Figure 4 to explain why only one of the oscilloscope's ground (earth) wires was connected? i.e. Why could we not measure V_{R1} directly by connecting the red wire and the GND connection of CH2 across R_1? ....

....

....

....

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....

....

5 Triggering exercise

Use the circuit as shown in Figure 3. Set the MODE switch to DUAL and the CH2 INV button to 'release'. Make sure the TRIGGER LEVEL LOCK button is 'in'.

5.1 AC/DC and GND buttons on channel inputs

Identify the AC/DC and GND buttons on the oscilloscope and consider what the functions of these two buttons are by looking at the schematic diagram in Figure 5:

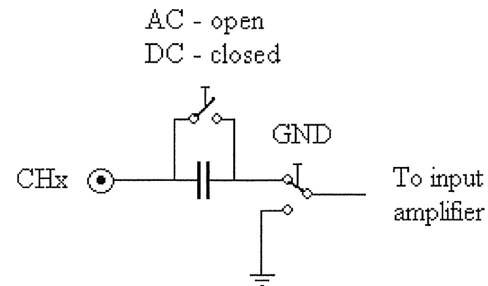


Figure 5: AC/DC and GND functions on an oscilloscope

Note that if the GND button is pressed 'in', then that input to that channel goes to zero. Test this by pressing the **CH2** GND button 'in' and then releasing the CH2 GND button.

Now press the CH1 GND button 'in'. What happens on the screen? ....

....

5.2 Selecting the trigger input signal

Now switch the SOURCE selector to CH2. What happens? ....

....

The SOURCE selector is used to select the signal to which the screen is to be synchronized.

5.3 Adjusting the trigger level

Release the TRIGGER LEVEL LOCK button. Use the ◀ and ▶ POSITION buttons to move the signals so that you can see the start of the wave on the screen. Slowly turn the LEVEL adjustment to the left and the right. What happens? ....

....

.... Restore the LEVEL LOCK button to 'in'.

6 Verifying Kirchhoff's law; $\sum V = 0$

Use a standard resistor R_s, of known value, as well as the two resistors of unknown value and connect up the following series circuit:

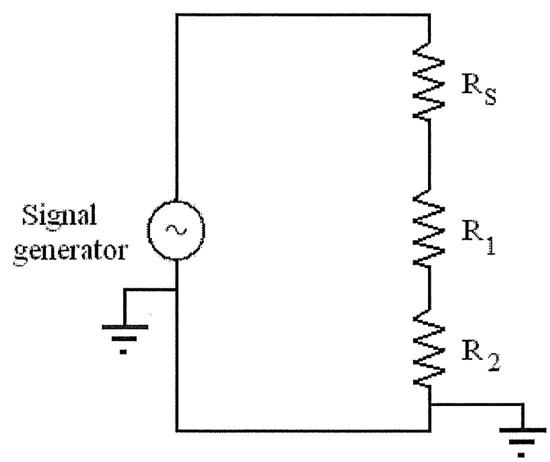


Figure 6: Circuit with three resistors in series

Frequency should be set to (2.0 ± 0.1) kHz and the amplitude set to (4.0 ± 0.1) V peak-to-peak.

6.1 Measure V_{RS}, V_{R1} and V_{R2}

Using the techniques learnt in the previous section of this worksheet, measure and record the voltages across the resistors. If you wish to change the VOLTS/DIV setting, make sure that the setting on both channels is the same. Results are to be properly quoted (includes uncertainty).

V_{RS} = ...

V_{R1} = ...

V_{R2} = ...

6.2 Calculate the sum of the voltage 'drops'

Add up the three voltage 'drops', making sure to use the correct propagation formula:

$V_{(RS+R1+R2)}$ = ...

Does this result verify Kirchhoff's law that $\sum V = 0$? Explain ....

....

....

7 Determine the resistance of the unknown resistors R_1 and R_2

Using the resistor of known value, R_S, and the results from the previous section of this worksheet:

7.1 Calculate *I*

Using ohm's law and the appropriate propagation formula, remembering that the standard resistor has a tolerance of 5%:

....

....

....

....

I = ...

7.2 Use ohm's law to calculate the value of R_1 and R_2

Calculated values of R_1 and R_2 are:

....

....

....

....

R_1 = ...

R_2 = ...

7.3 Demonstrator check

Take this worksheet and the box with the two unknown resistors in it to a demonstrator for verification of your results.

Demonstrator to check the resistor values and to sign here..........................

8 Measuring a phase angle (also called a phase shift)

Use the given capacitor, C, and the standard resistor, R_s, to connect up the following RC circuit:

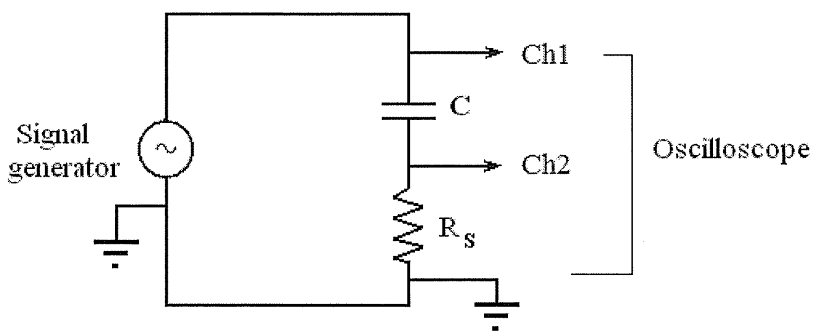


Figure 7: RC circuit to measure a phase shift

Select the sine wave function on the function generator and set the frequency to (T.B.A.) kHz and the amplitude to (6.0 ± 0.1) V peak-to-peak.

8.1 CH1 shows supply voltage, CH2 shows 'current'

Because the voltage shown on CH2 is the voltage across the resistor - and the voltage across the resistor is "in phase with" the current in a resistor – then the CH2 signal represents the current at all points in the series circuit. Use the POSITION buttons as well as the TIME/DIV setting to get the screen to look something like Figure 8 below. Note that the amplitudes may be different from those shown in Figure 8.

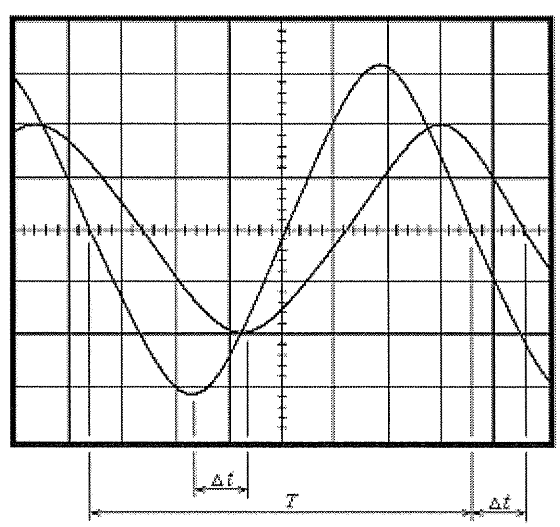
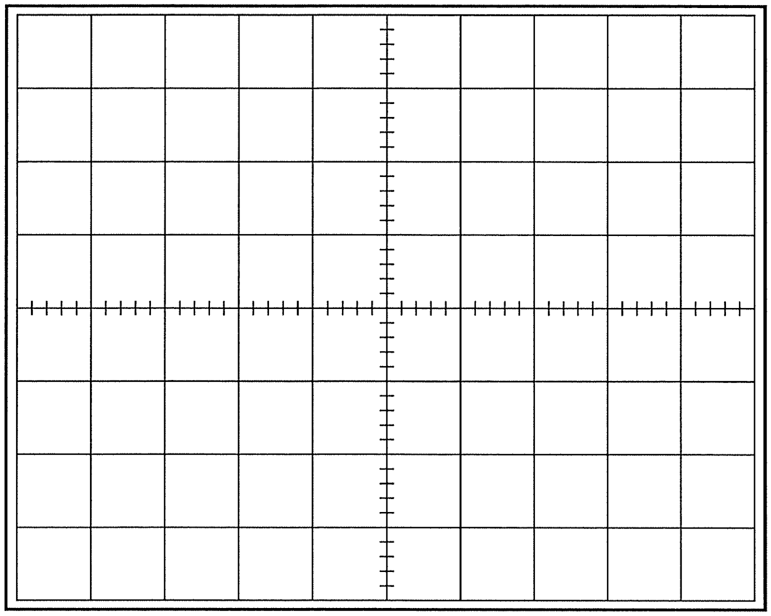


Figure 8: Typical oscilloscope display with phase shifted signals

8.2 Measure the period and the time difference between the signals

Make a sketch of the signals that are on the oscilloscope screen:



Record the oscilloscope setting here:	Using the **instructions in the Lab Guide**, determine the period of the signals as well as the time delay between them (include uncertainty):
TIME/DIV	T = ...
	Δt = ...

8.3 Calculate the phase angle between the signals

Note that if the period T represents a complete cycle, 2π; then Δt represents the phase angle φ.

Calculate the phase angle ϕ (with the uncertainty) in radians and degrees and record the result here:

....

....

Is the voltage 'leading' the current, or is the current 'leading' the voltage? ....

....