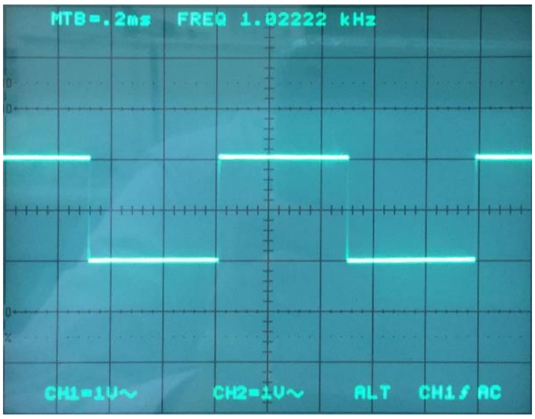
Name_____________________________________ ID_______________________

Model number of your DMM: _RD700_____

Model number of your Oscilloscope: _GOS-6103C

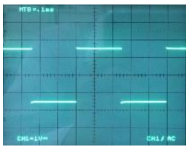
Problem 0

Display the calibration signal of the oscilloscope on both channel 1 and channel 2 of the oscilloscope. The ground levels of both channels should be in the middle of the screen.



< **GND**

No offset

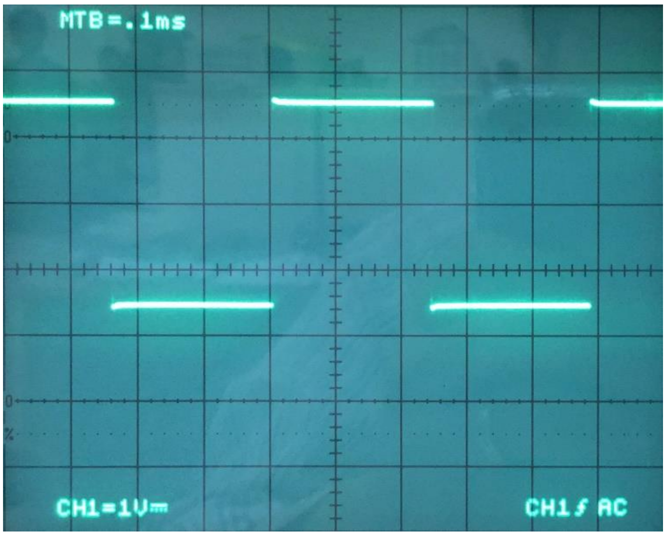


Problem 1

Use the function generator to generate a 3 V_{p-p} 2 kHz **square** waveform. Set the **DC offset** of the waveform to be 1 V. Display the waveform on channel 1 of the oscilloscope. Make sure that the scope is in **DC mode**.
Sketch the waveforms here. **Indicate the ground level on your sketch as well**.

Voltage/Division 1 V/DIV

Time/Division 0.1 ms/DIV



< **GND**

Measure V_{DC} and V_{AC} of this waveform.

Theoretically, if we have true-rms DMM (such as RD701), we should get 1.500V.

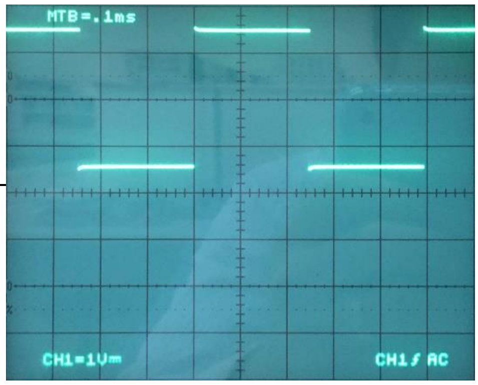
V_{DC} = 1.000 V V_{AC} = 1.441 V______________

Now, ***change*** the DC offset to 2 V.

Measure V_{DC} and V_{AC} of this waveform.

V_{DC} = 2.000 V______________ V_{AC} = 1.441 V

Again, if we have true-rms DMM (such as RD701), we should get 1.500V.



< GND

Name____ ID_________________________

Problem 2

Connect the circuit as shown in Figure 2.

Use R_1 = 1 kΩ and R_2 = 2 kΩ.

Measure the exact values of the resistance for R_1 and R_2.

Record these values in the table here along with the corresponding color codes.

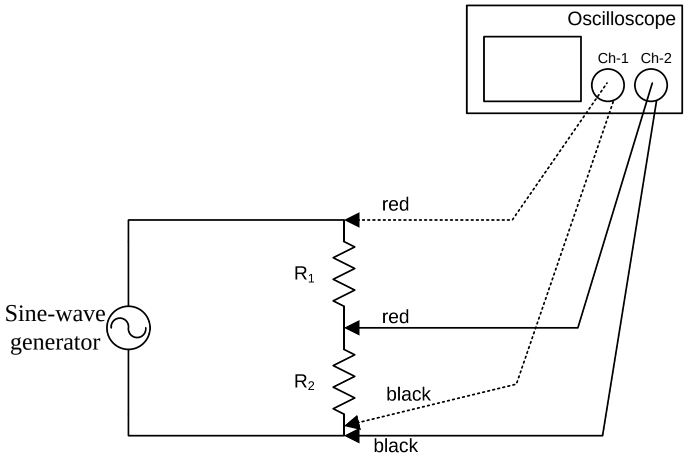


Figure 2

	Value	Color Code
R_1	1.008 kΩ	Brown Black Red
R_2	1.967 kΩ	Red Black Red

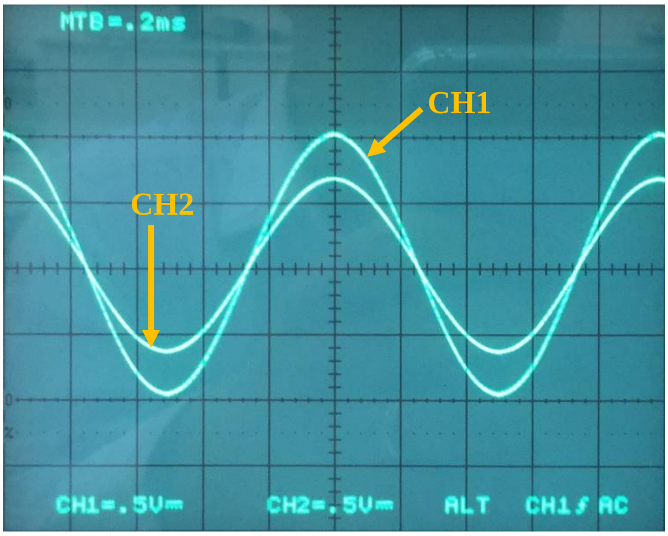
Set the function generator to generate a 2 $V_{p\text{-}p}$ 1 kHz **sinusoidal** waveform with **NO DC offset**.

a) Sketch the waveforms here. Make sure that you put appropriate labels ("Ch-1" or "Ch-2") on your sketch. Indicate the ground level on your sketch as well.

Note that there is only one space here for the voltage per division; so the setting should be the same for both channels.

Voltage/Division 0.5 V/DIV

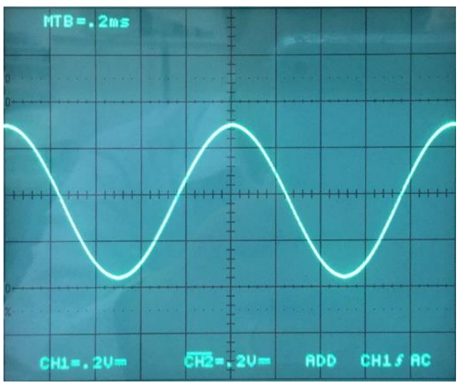
Time/Division 0.2 ms/DIV



< GND

b) From the oscilloscope display, read the peak-to-peak voltage V_1 across R_1, and the peak-to-peak voltage V_2 across R_2.

V_1 (p-p) = 0.674V V_2 (p-p) = 1.34 V



c) Measure the rms current I_1 through the resistor R_1.

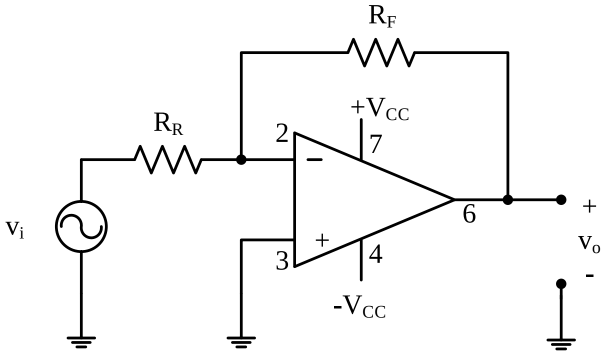
I_1 (rms) = 0.21 mA

Name______________________________________ ID________________________

Problem 3

Connect the circuit in the figure below. Channel 1 of the oscilloscope should display v_i and Channel 2 of the oscilloscope should display v_o.

$$\frac{0 - v_i}{R_R} + \frac{0 - v_o}{R_F} = 0$$



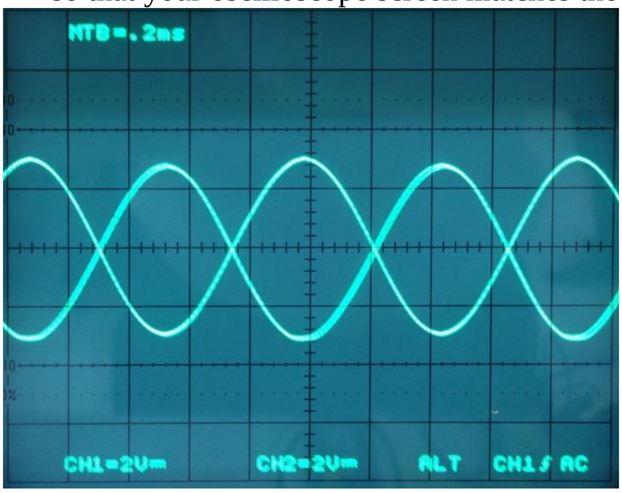
This is an inverting amplifier:

$$v_o = -\frac{R_F}{R_R} v_i$$

a. Select

- the resistance values R_F and R_R (which can be 5-kΩ, 10-kΩ, or 20-kΩ)
- the signal shape, amplitude, and frequency of the signal from the function generator
- the values of V_{CC} from the power supply ← If this is too low, the distortion (and clipping) will occur in the output.
- the settings on the oscilloscope panel

so that your oscilloscope screen matches the photo below.

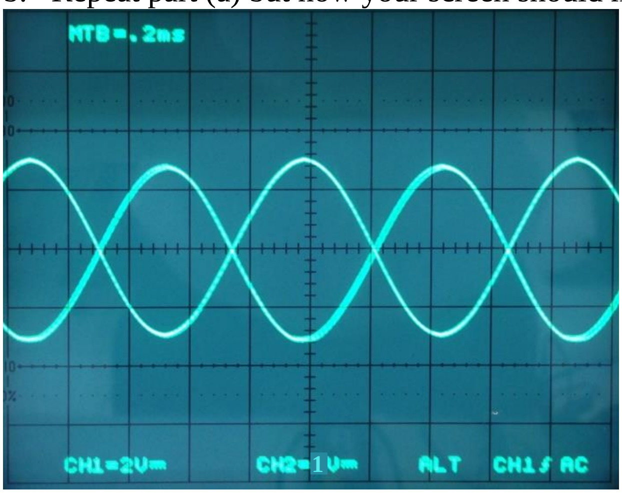


R_F = ________ } same
R_R = ________
f = ____________

Reading for the screen, we see that the input and the output have the same amplitude. Therefore, we must have $R_F = R_R$.

Reading from the screen, one cycle is approximately 4.5 divisions which corresponds to 4.5×0.2 = 0.9ms. So, the frequency is approximately 1/(0.9 ms) = 1.1 kHz. Use this as your starting value. Further adjust the frequency to match the graph.

b. Repeat part (a) but now your screen should match the new photo below.



R_F = ________
R_R = ________
f = ____________

Here, because the VOLT/DIV for CH2 is only 1 (instead of 2), but the traces look exactly the same, we know that

$$v_o = -\frac{1}{2} v_i$$

So, we need $\frac{R_F}{R_R} = \frac{1}{2}$.

Examples of $R_R = 2R_F$:

20kΩ and 10kΩ

10kΩ and 5kΩ

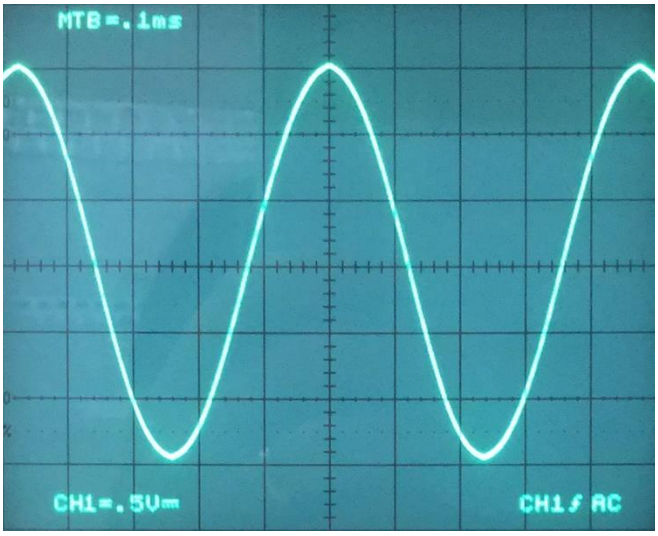
Name_______________________________________ ID________________________

Problem 4

a) Use the function generator to generate a 1 V_{AC} 2 kHz **sinusoidal** waveform with **NO DC offset**. Display it on channel 1 of the oscilloscope. Make sure that the scope is in DC mode.
Sketch the waveform here. Indicate the ground level on your sketch as well.

Voltage/Division 0.5 V/DIV

Time/Division 0.1 ms/DIV



< **GND**

Record the exact rms value here: 1.003 V
Record the exact frequency here: 2.0000 kHz
Find the peak-to-peak value of this signal: 3.030V_{rms}

Theoretically, if we have true-rms DMM, with the 1 V_{rms}, we should have 2.828 $V_{p\text{-}p}$.

For the rest of this problem, DO NOT adjust anything on the function generator. This means keep its OPEN-circuit voltage at 1 V_{rms}.

b) Connect the function generator output (with 1 V_{rms} OPEN-circuit voltage) across a 100Ω resistor. Measure the voltage (rms) across this resistor.

The exact resistance is 97.9 Ω.
The rms voltage across the resistor is 0.667 V_{rms}. (Hint: Not 1.)

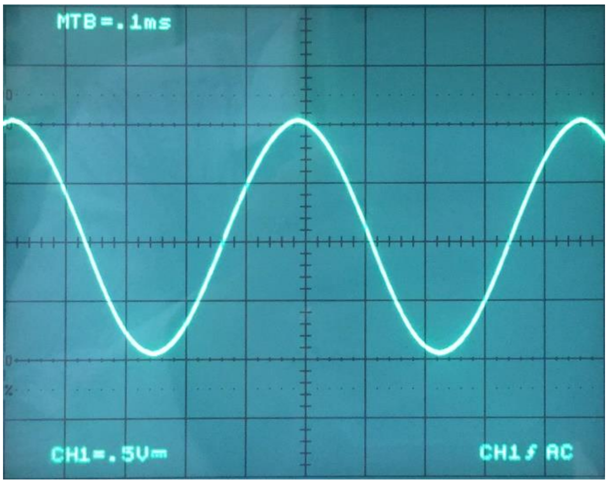
$$\frac{100}{50+100} \times 1\ V_{rms}$$

Display the voltage across the resistor on channel 1 of the oscilloscope. Make sure that the scope is in DC mode. Sketch the waveforms here. Indicate the ground level on your sketch as well.

Name_______________________________________ ID________________________

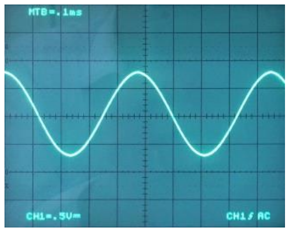
Voltage/Division 0.5 V/DIV

Time/Division 0.1 ms/DIV



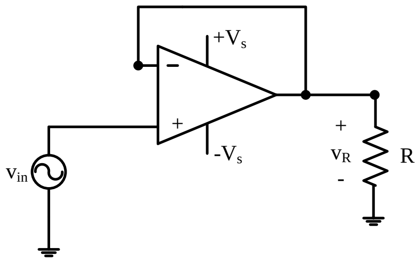
< **GND**

c) Change the resistor to 50Ω. (If you can't find a 50Ω resistor, you can construct one using two 100 Ω resistors.) Measure the voltage (rms) across this resistor.



The exact resistance is 49.0 Ω.
The rms voltage across the resistor is 0.500 V_{rms}. (Hint: Not 1.)

d) Connect the circuit as shown in the figure below:



Use V_S = 10 V. The input v_{in} is again the 2 kHz sinusoidal waveform with 1 V_{rms} OPEN-circuit voltage from the function generator. Measure the rms voltage across R when R is 100Ω.

The exact resistance is 97.9 Ω.
The rms voltage across the resistor is 1.000 V_{rms}.

e) Change the resistor to 50Ω. Measure the voltage (rms) across this resistor.

The exact resistance is 49.0 Ω.
The rms voltage across the resistor is 0.95 V_{rms}.

f) Why does the voltages across the resistor change when there is no op amp?
Without the op-amp, there is a voltage drop across the 50Ω inside the function generator because there is some current flowing through it (which is why we can use the voltage divider formula to calculate the output voltage).
However, when there is an op-amp, there is negligible current into the non-inverting terminal of the op-amp. Therefore, there is no current flowing through the 50Ω inside the function generator. Without any current, there is no voltage drop across the 50Ω. So, 100% of the open-circuit voltage is seen at the non-inverting terminal of the op-amp.

Name____ ID________________________

Problem 5

a) Connect the circuit as shown in Figure 3. Adjust the function generator to generate a 2 $V_{p\text{-}p}$ 2 kHz **sinusoidal** waveform with **NO DC offset**. Use R = 3.3 kΩ.

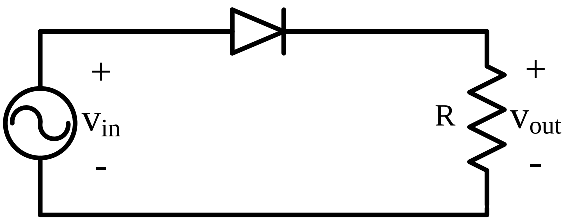


Figure 3

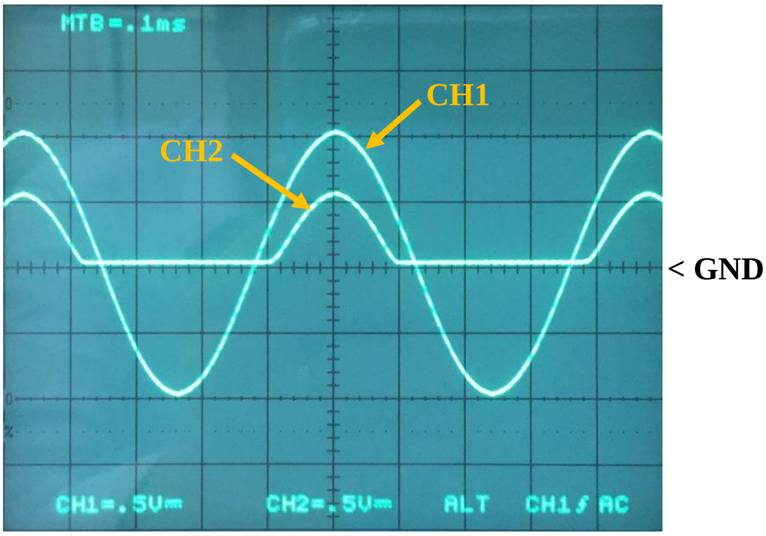
The exact value of R is 3.243 kΩ.

Display the voltage v_{in} across the function generator on channel 1 of the oscilloscope. Display the voltage v_{out} across the resistor R on channel 2 of the oscilloscope. Make sure that the scope is in DC mode. Sketch the waveforms here. Make sure that you put appropriate labels ("Ch-1" or "Ch-2") on your sketch. Indicate the ground level on your sketch as well.

Note that there is only one space here for the voltage per division; so the setting should be the same for both channels.

Voltage/Division 0.5 V/DIV

Time/Division 0.1 ms/DIV



b) Describe the relationship between v_{in} and v_{out}.

v_{out} is the "positive part" of "the v_{in} that is shifted down by 0.5V".

c) Measure the peak-to-peak, V_{AC}, and DC (average) values of v_{in} and v_{out}.

	$V_{peak\text{-}to\text{-}peak}$	V_{AC}	V_{DC}
v_{in}	2.00 V	0.671 V	small
v_{out}	0.53 V	0.160 V	122.9 mV