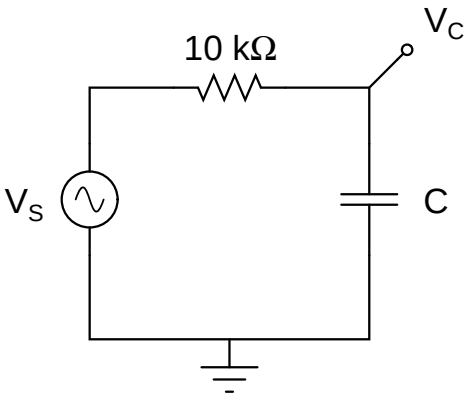
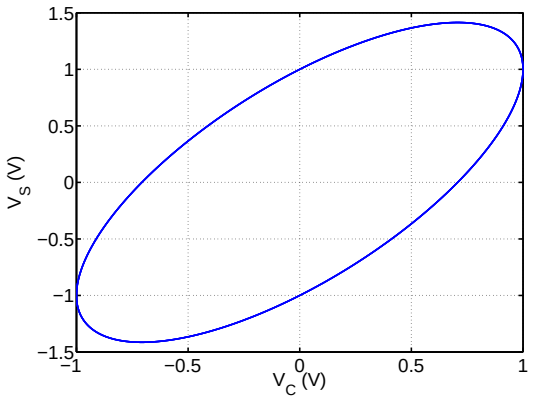
Name: _____

Problem 2: 1st Order RC Circuit

The RC circuit shown in Figure 2(a) is driven with a sinusoidal signal with a peak voltage of 1.414 V. At a frequency of 2.5 kHz, V_S and V_C are measured on a scope using XY mode and the Lissajous figure shown in Figure 2(b) is obtained. Assume the scope does not load the circuit.



(a) RC Circuit under test.



(b) Oscilloscope trace showing V_C on the y–axis and V_S on the x–axis.

Figure 2: RC Circuit.

What is C? _____

Name: _____

Problem 5: Circuit Loading

A two–year–old constructs the circuit shown in Figure 5 and asks:

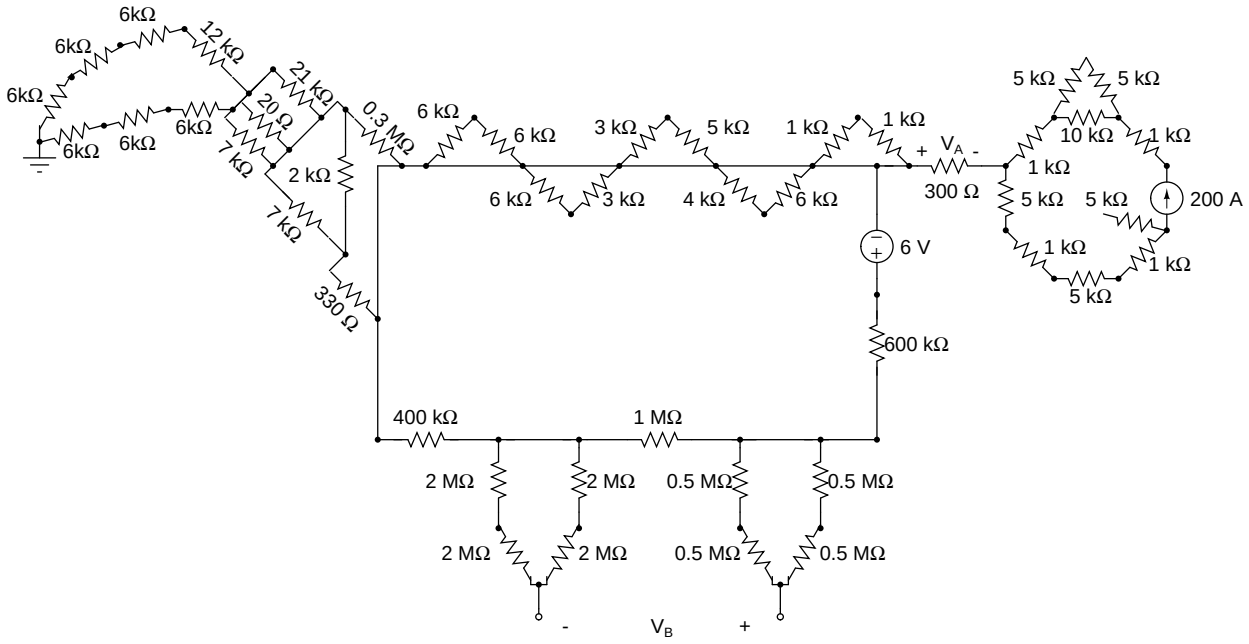


Figure 5: Circuit assembled by 2–year old.

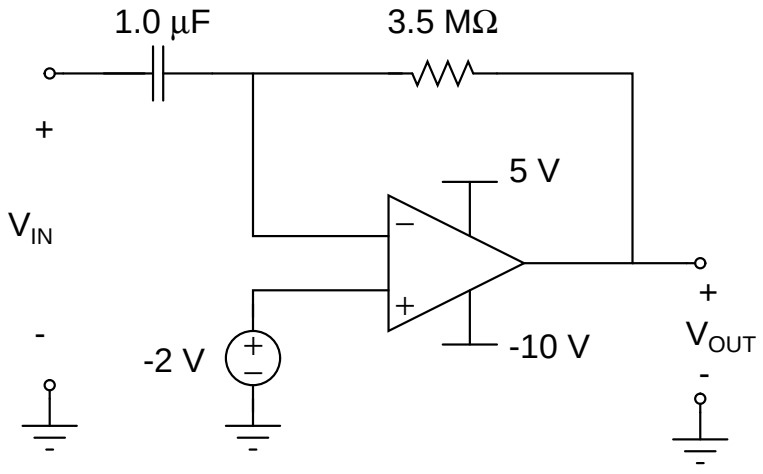
What is V_A? _____ What is V_B? _____

If the voltages are measured using the DVM with an input impedance of 1 MΩ,

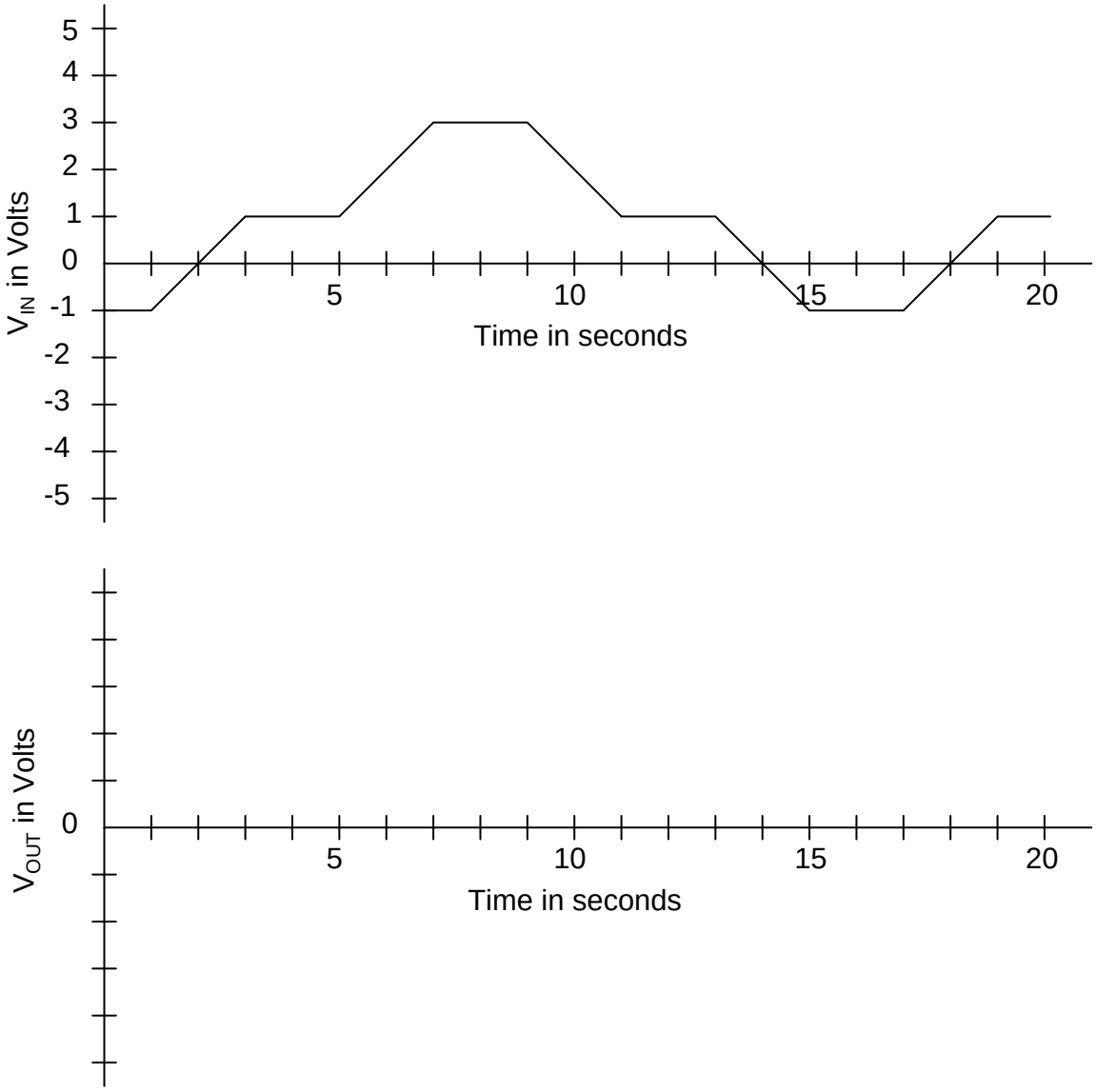
what are the measured values of V_A? _____and V_B? _____

Problem 1: OpAmp Circuit

Consider the OpAmp circuit shown below. Assume the OpAmp is ideal.



For the input voltage V_{IN} shown on page 3, plot the output voltage V_{OUT} as a function of time. Make sure to label the voltage levels on the y–axis.


5
4
3
2
1
0
-1
-2
-3
-4
-5
V_{IN} in Volts
5
10
15
20
Time in seconds
V_{OUT} in Volts
0
5
10
15
20
Time in seconds

Problem 2: Low Pass Filter

Use the results obtained from the low pass filter you designed in Lab 7 and your knowledge of filters, signals and decibels to answer the following questions:

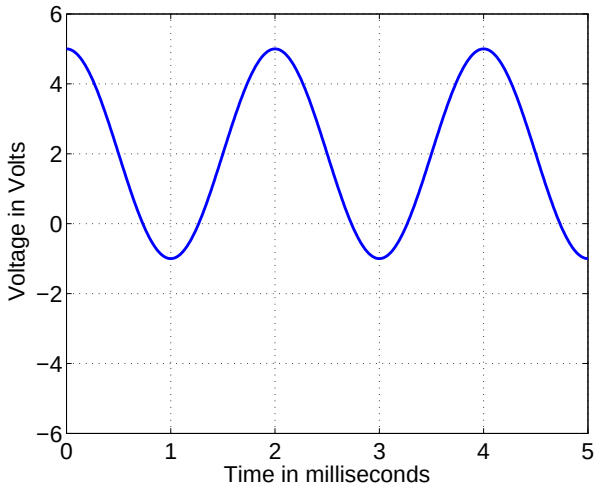
1 When a 2 V peak–to–peak triangular wave with a frequency of 5 kHz was applied to your filter, how far below the fundamental frequency was the 3rd harmonic signal in dB? _____

2 When a 5 V peak–to–peak triangular wave with a frequency of 5 kHz is applied to your filter, how far below the fundamental frequency will the 3rd harmonic signal be in dB? _____

3 When a 2 V peak–to–peak **square wave** with a frequency of 5 kHz is applied to your filter, how far below the fundamental frequency will the 3rd harmonic signal be in dB? _____

Problem 3: Use of a function generator and oscilloscope

You generate the following signal using the HP33120A function generator and display it on the oscilloscope using dc input coupling:



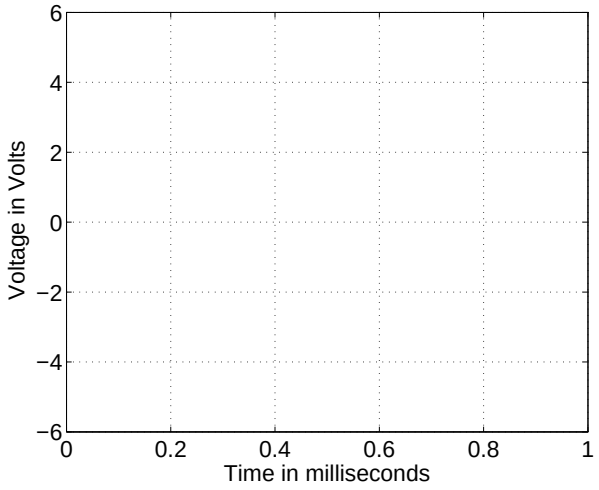
Signal from HP33120A function generator as it appears on the oscilloscope.

1. What is the frequency of the signal in Hz? _____
2. What is the frequency of the signal in radians/sec? _____
3. What is the amplitude of the signal in V? _____
4. What is the DC offset of the signal in V? _____

In order to generate this signal using the HP33120A function generator:

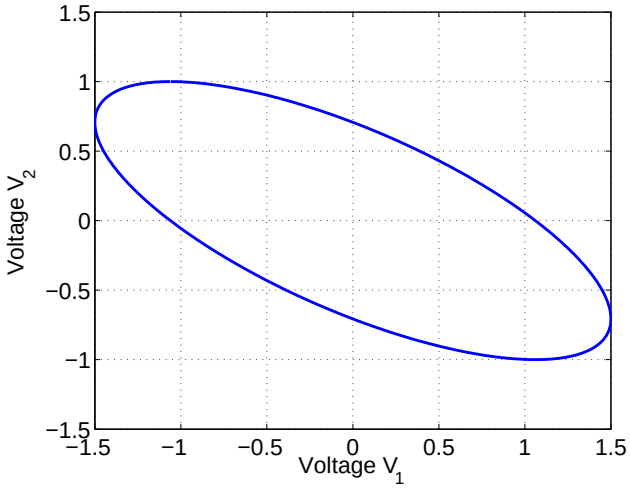
1. What value do you enter for the magnitude? _____
2. What value do you enter for the offset? _____

Sketch on the graph below how this signal would appear on the oscilloscope when using ac input coupling



How signal would appear on the scope with AC coupling.

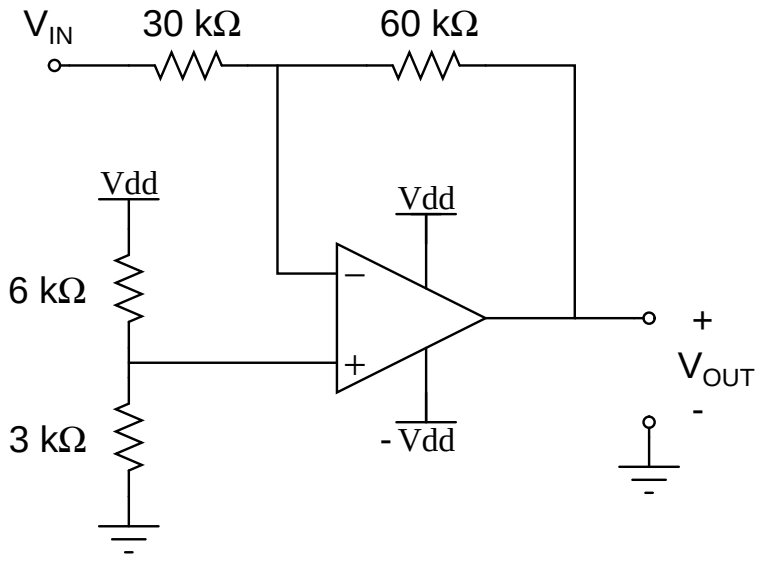
The phase difference between two signals is determined using the scope in the XY mode and the Lissajous figure shown below is obtained.



1. What is the ratio of V_1 / V_2 in dB? _____
2. What is the phase angle between V_1 and V_2? _____

Problem 1: OpAmp Circuit #1

Consider the OpAmp circuit shown below. Assume the OpAmp is ideal and $V_{dd} = 9$ V.



1. What is the function of this circuit?
   (a) inverting amplifier
   (b) non–inverting amplifier
   (c) comparator
   (d) Schmitt trigger
   (e) inverting integrator
   (f) none of the above

2. V_{IN} is a triangular waveform with 1 V peak–to–peak voltage and 0 V DC offset. What type of waveform is V_{OUT}?
   (a) sinusoidal waveform
   (b) triangular waveform
   (c) square waveform
   (d) DC output equal to 0 V
   (e) DC output equal to V_{dd}
   (f) DC output equal to $-V_{dd}$

3. $V_{IN} = 0$ V. What is V_{OUT}?

(a) -15 V (b) -9 V (c) -6 V (d) -3 V (e) 0 V (f) 3 V (g) 6 V (h) 9 V (i) 15 V

4. $V_{IN} = -3$ V. What is V_{OUT}?

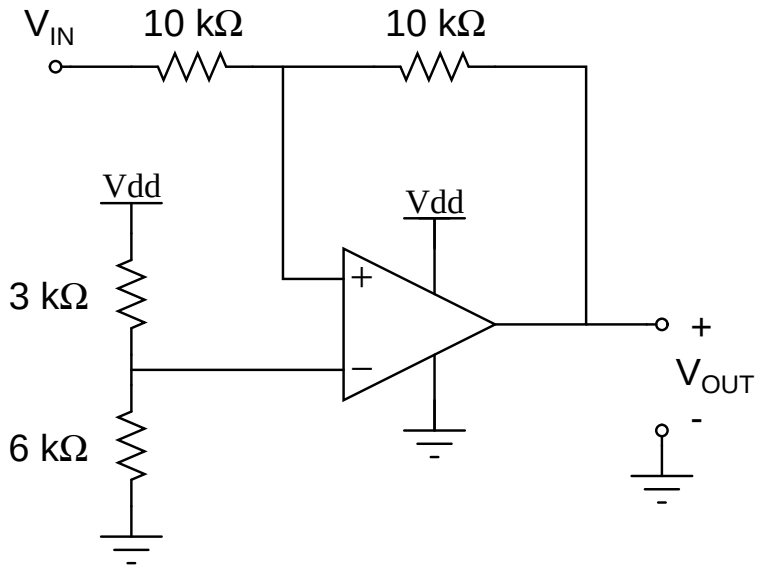
(a) -15 V (b) -9 V (c) -6 V (d) -3 V (e) 0 V (f) 3 V (g) 6 V (h) 9 V (i) 15 V

5. $V_{IN} = 3$ V. What is V_{OUT}?

(a) -15 V (b) -9 V (c) -6 V (d) -3 V (e) 0 V (f) 3 V (g) 6 V (h) 9 V (i) 15 V

Problem 2: OpAmp Circuit #2

Consider the OpAmp circuit shown below. Assume the OpAmp is ideal and $V_{dd} = 9$ V.



6. What is the function of this circuit?

   (a) inverting amplifier
   (b) non–inverting amplifier
   (c) comparator
   (d) Schmitt trigger
   (e) inverting integrator
   (f) none of the above

7. V_{IN} is a triangular waveform with 1 V peak–to–peak voltage and 0 V DC offset. What type of waveform is V_{OUT}?

   (a) sinusoidal waveform
   (b) triangular waveform
   (c) square waveform
   (d) DC output equal to 0 V
   (e) DC output equal to V_{dd}
   (f) DC output equal to -V_{dd}

8. $V_{IN} = 2$ V. What is V_{OUT}?

(a) -9 V (b) 0 V (c) 1 V (d) 3 V (e) 5 V (f) 7 V (g) 9 V (h) 12 V
(i) can not be determined (j) none of the others

9. $V_{IN} = 12$ V. What is V_{OUT}?

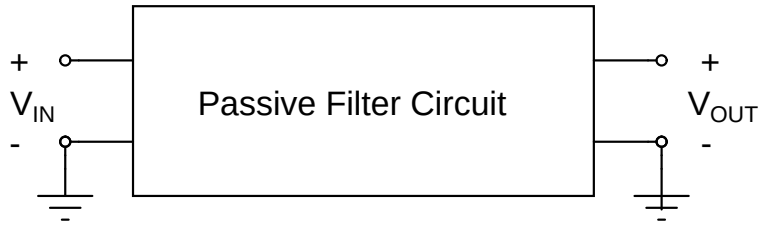
(a) -9 V (b) 0 V (c) 1 V (d) 3 V (e) 5 V (f) 7 V (g) 9 V (h) 12 V
(i) can not be determined (j) none of the others

10. $V_{IN} = 9$ V. What is V_{OUT}?

(a) -9 V (b) 0 V (c) 1 V (d) 3 V (e) 5 V (f) 7 V (g) 9 V (h) 12 V
(i) can not be determined (j) none of the others

Problem 3: Filter Circuit

Consider the passive filter circuit shown below:



11. V_{IN} is a square wave with a 50% duty cycle, a frequency of 10 kHz and a peak–to–peak voltage of 6 V. What type of filter could be used to generate V_{OUT} that is a sinusoidal waveform with a frequency of 30 kHz?

    (a) low pass filter
    (b) band pass filter
    (c) band reject filter
    (d) high pass filter
    (e) no filter can produce the desired output waveform

12. For the conditions in question 11, what would be the maximum peak–to–peak voltage of the 30 kHz signal?

    (a) 0 V (b) 1 V (c) 1.5 V (d) 2 V (e) 2.5 V (f) 3 V (g) 4 V (h) 5 V

13. V_{IN} is a sinusoidal wave with a frequency of 10 kHz and a peak–to–peak voltage of 5 V. What type of filter could be used to generate V_{OUT} that is a sinusoidal waveform with a frequency of 30 kHz?

    (a) low pass filter
    (b) band pass filter
    (c) band reject filter
    (d) high pass filter
    (e) no filter can produce the desired output waveform

14. V_{IN} is a square wave with a 50% duty cycle, a frequency of 50 kHz and a peak–to–peak voltage of 10 V. What type of filter could be used to generate V_{OUT} that is a sinusoidal waveform with a frequency of 100 kHz?

    (a) low pass filter

    (b) band pass filter

    (c) band reject filter

    (d) high pass filter

    (e) no filter can produce the desired output waveform

15. V_{IN} is a square wave with a 50% duty cycle, a frequency of 1 kHz and a peak–to–peak voltage of 10 V. The filter is a low pass filter. What is the minimum required order of the filter such that the 11th harmonic is at least 40 dB below the fundamental frequency?

    (a) 0th order

    (b) 1st order

    (c) 2nd order

    (d) 3rd order

    (e) 4th order

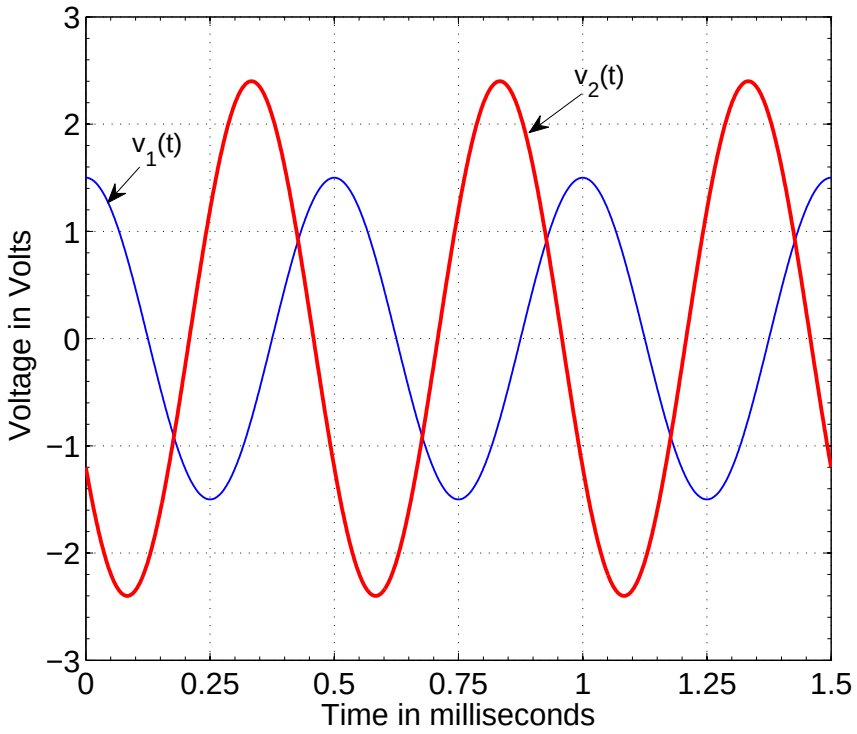
    (f) can not be done

Problem 1 Shown below are the oscilloscope traces for the two voltage waveforms:

$$v_1(t) = \hat{V}_1 \sin(\omega t + \phi_1)$$

and

$$v_2(t) = \hat{V}_2 \sin(\omega t + \phi_2)$$



For the questions on the next page, circle the "best" answer:

1. What is $\hat{V}_1$ in Volts?

   (a) 1.5
   (b) 2.4
   (c) 3.0
   (d) 4.8
   (e) None of the above or can not be determined from the information given

2. What is $\hat{V}_2$ in Volts?

   (a) 1.5
   (b) 2.4
   (c) 3.0
   (d) 4.8
   (e) None of the above or can not be determined from the information given

3. What is ω in radians/sec?

   (a) 1,000
   (b) 1,256
   (c) 2,000
   (d) 12,560
   (e) None of the above or can not be determined from the information given

4. What is $|\phi_1 - \phi_2|$ in degrees?

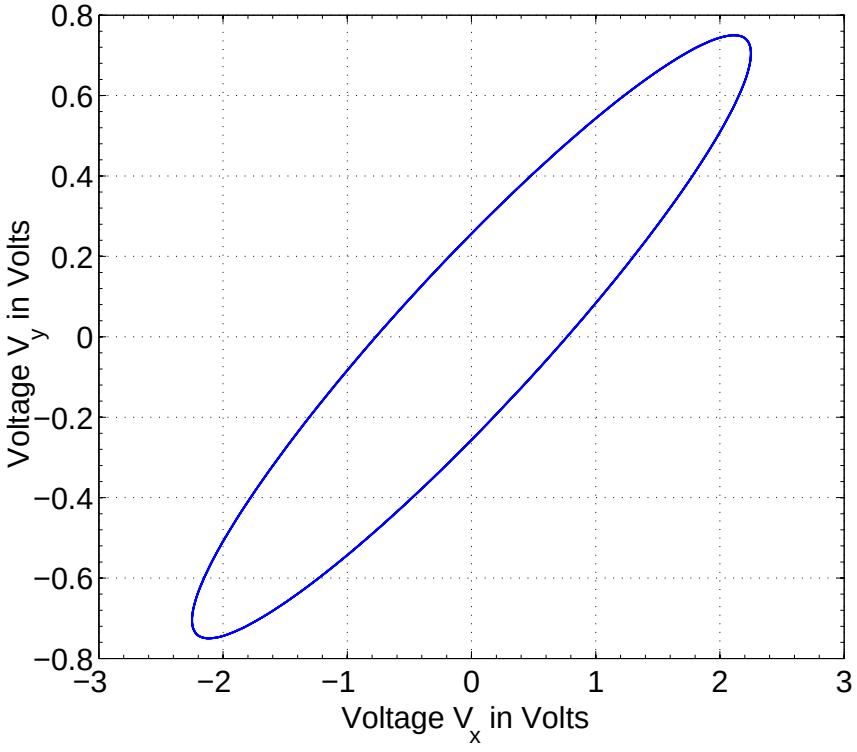
   (a) 60
   (b) 90
   (c) 120
   (d) 150
   (e) None of the above or can not be determined from the information given

Problem 2 Shown below is the oscilloscope trace in XY–mode for the two voltage waveforms:

$$v_x(t) = \hat{V}_x \sin(\omega t + \phi_1)$$

and

$$v_y(t) = \hat{V}_y \sin(\omega t + \phi_2)$$



For the questions on the next page, circle the "best" answer:

1. What is $\hat{V}_x$ in Volts?

   (a) 0.75
   (b) 1.5
   (c) 2.25
   (d) 4.5
   (e) None of the above or can not be determined from the information given

2. What is $\hat{V}_y$ in Volts?

   (a) 0.75
   (b) 1.5
   (c) 2.25
   (d) 4.8
   (e) None of the above or can not be determined from the information given

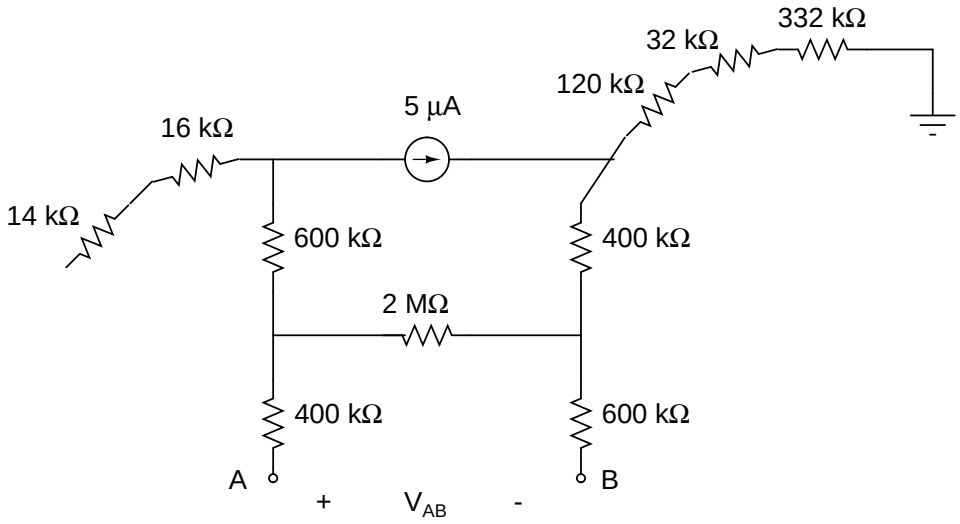
3. What is ω in radians/sec?

   (a) 1,500
   (b) 1,256
   (c) 6,280
   (d) 12,560
   (e) None of the above or can not be determined from the information given

4. What is $|\phi_1 - \phi_2|$ in degrees?

   (a) 20
   (b) 45
   (c) 110
   (d) 160
   (e) None of the above or can not be determined from the information given

Problem 3 Consider the circuit shown below:



What is the Voltage V_{AB} in this circuit? _____

If a Digital Volt Meter (DVM) having an input Resistance of 1 MΩ is placed across terminals "A" and "B," what voltage V_{AB} is measured? _____

Problem 1 The op–amp below is ideal. The input signal is V_{in}.

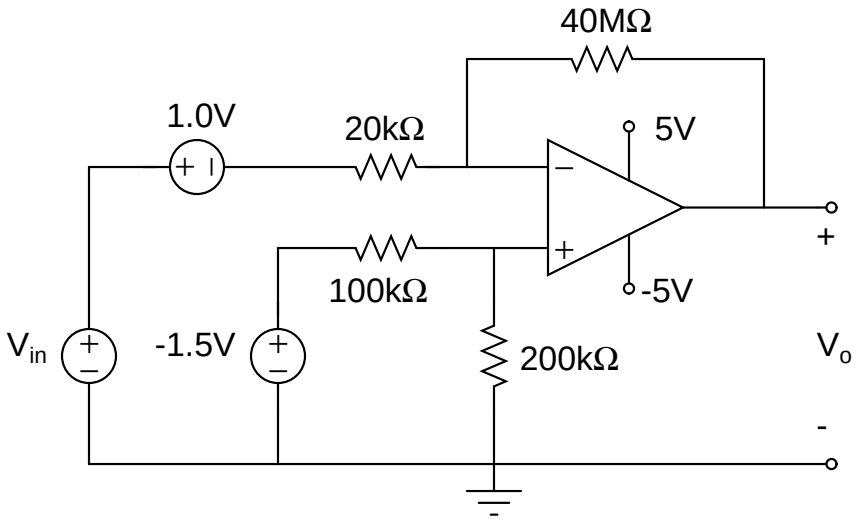


Figure 1: Circuit #1

Which of the following best describes Circuit #1?

1. Inverting OpAmp with DC offset
2. Non–Inverting OpAmp with DC offset
3. Inverting Integrator
4. Non–Inverting Integrator
5. Schmitt Trigger

Write the equation for the output voltage V_o as a function of the input voltage V_{in}? Sketch the output voltage V_o for the given input voltage V_{in} shown on the next page. Make sure to label the "Y–axis" of the graph.

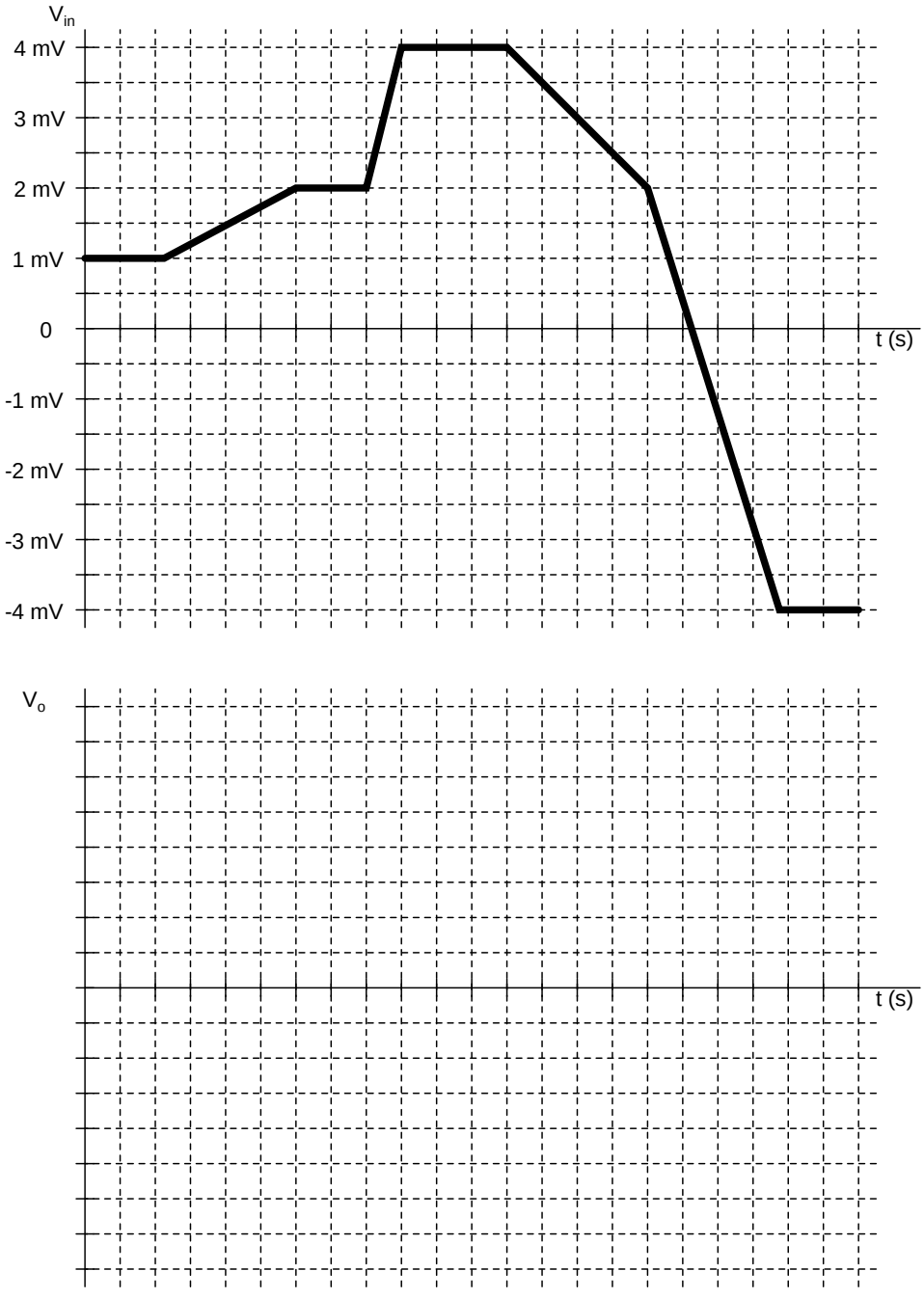


Figure 2: Input and output voltages for Circuit #1

Problem 2 The op–amp below is ideal. The input signal is V_{in}.

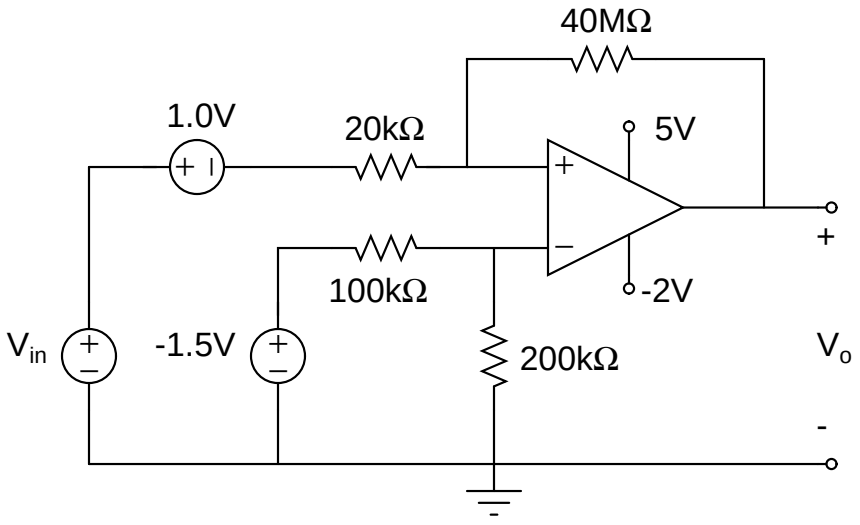


Figure 3: Circuit #2

Which of the following best describes Circuit #2?

1. Inverting OpAmp with DC offset
2. Non–Inverting OpAmp with DC offset
3. Inverting Integrator
4. Non–Inverting Integrator
5. Schmitt Trigger

Write the equation for the output voltage V_o as a function of the input voltage V_{in}? Sketch the output voltage V_o for the given input voltage V_{in} shown on the next page. Make sure to label the "Y–axis" of the graph.

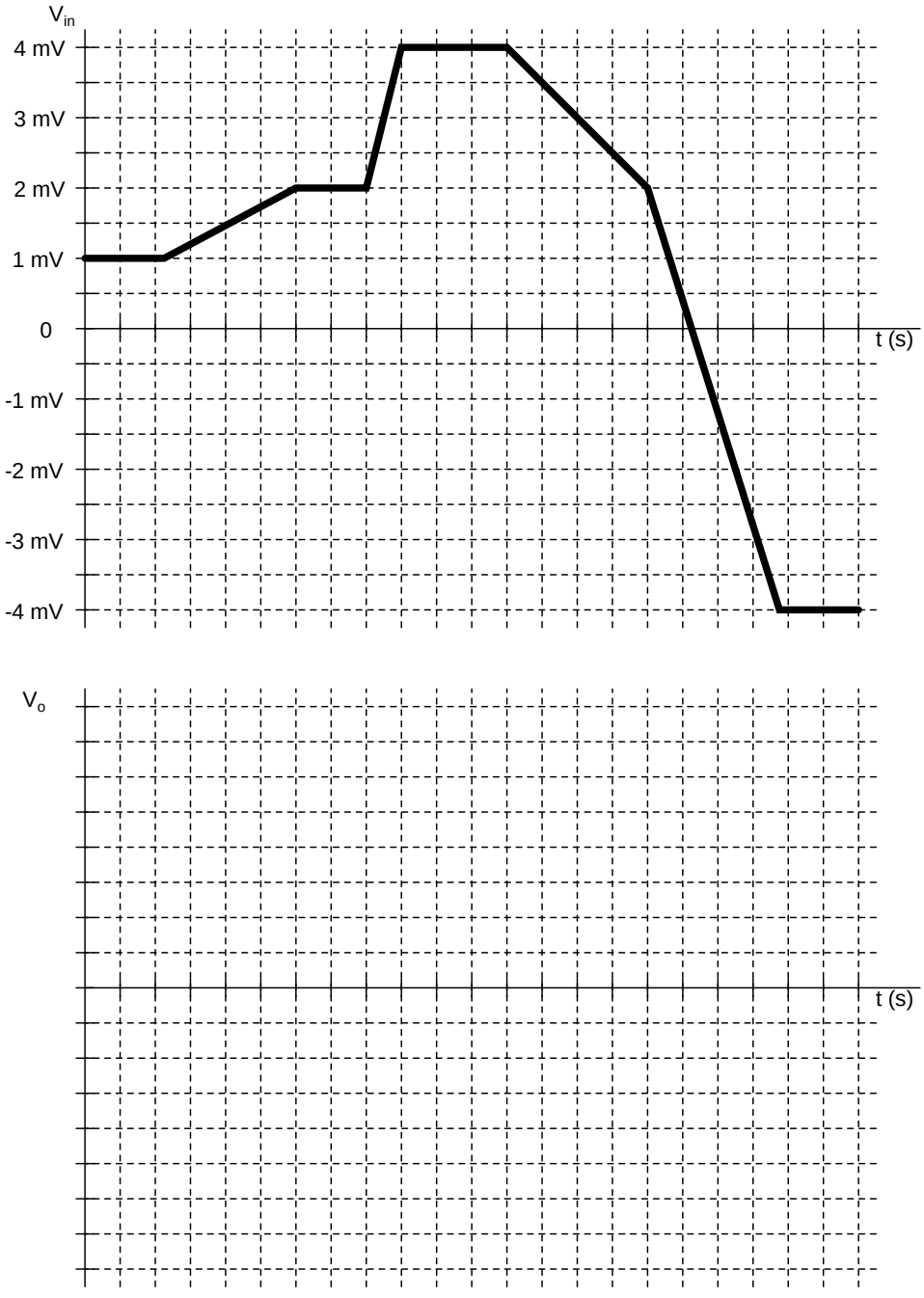
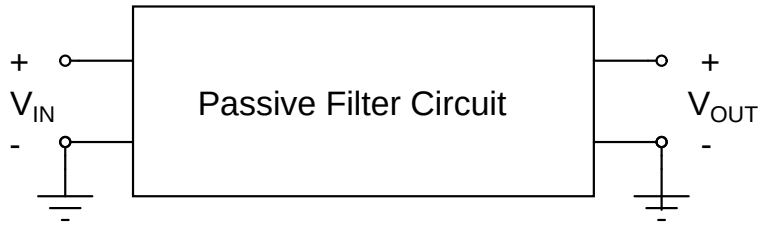


Figure 4: Input and output voltages for Circuit #2

Problem 3: Filter Circuit

Consider the ideal passive filter circuit shown below:



For the questions below circle the most correct answer:

1. V_{IN} is a square wave with a 50% duty cycle, a frequency of 25 kHz and a peak–to–peak voltage of 5 V. V_{OUT} is a sinusoidal waveform with a single frequency of 50 kHz. What type of filter could be used to generate V_{OUT}?

   (a) low pass filter
   (b) band pass filter
   (c) band reject filter
   (d) high pass filter
   (e) none of the above

2. V_{IN} is a square wave with a 50% duty cycle, a frequency of 25 kHz and a peak–to–peak voltage of 5 V. V_{OUT} that is a sinusoidal waveform with a single frequency of 75 kHz? What type of filter could be used to generate V_{OUT}?

   (a) low pass filter
   (b) band pass filter
   (c) band reject filter
   (d) high pass filter
   (e) none of the above

3. V_{IN} is a triangular wave with a frequency of 20 kHz and the filter is a low pass filter with a cutoff frequency of 60 kHz. What is the relative amplitude of the 3rd harmonic to the fundamental at the output of the filter?

   (a) -22.08 dB
   (b) -19.08 dB
   (c) -16.08 dB
   (d) -12.54 dB
   (e) -3 dB
   (f) +3 dB
   (g) none of the above

4. V_{IN} is a triangular wave with a frequency of 20 kHz and the filter is a high pass filter with a cutoff frequency of 20 kHz. What is the relative amplitude of the 3rd harmonic to the fundamental at the output of the filter?

   (a) -22.08 dB
   (b) -19.08 dB
   (c) -16.08 dB
   (d) -12.54 dB
   (e) -3 dB
   (f) +3 dB
   (g) none of the above

5. V_{IN} is a triangular wave with a frequency of 20 kHz and the filter is a high pass filter with a cutoff frequency of 60 kHz. What is the relative amplitude of the 3rd harmonic to the fundamental at the output of the filter?

   (a) -22.08 dB
   (b) -19.08 dB
   (c) -16.08 dB
   (d) -12.54 dB
   (e) -3 dB
   (f) +3 dB
   (g) none of the above

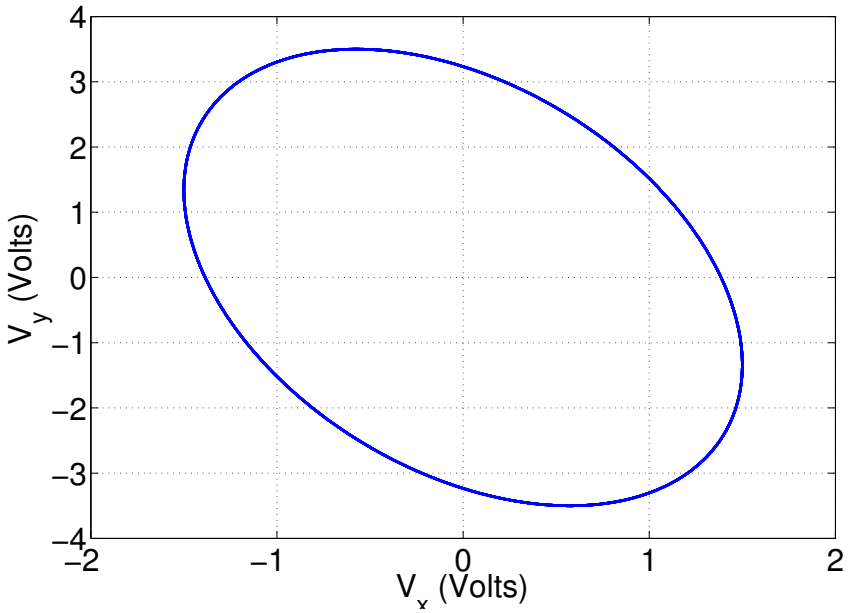
Problem 2 The Lissajous figure, using the XY–mode on the scope, produced by two voltage waveforms

$$V_x(t) = X_0 \sin(\omega t + \phi_1)$$

and

$$V_y(t) = Y_0 \sin(\omega t + \phi_2)$$

is shown below.



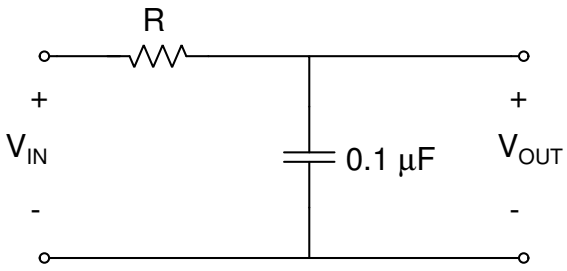
(a) What is X_0? _____

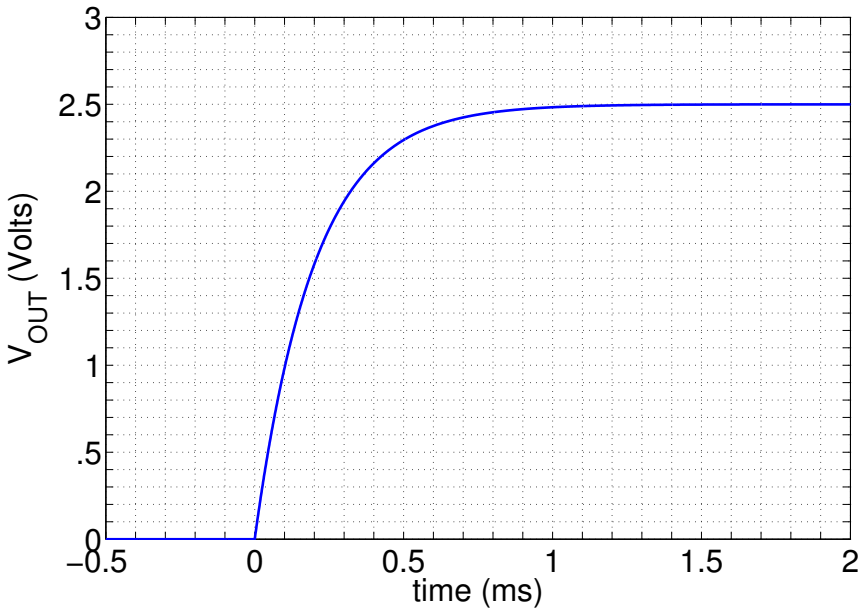
(b) What is Y_0? _____

(c) What is $|\phi_1 - \phi_2|$ in degrees? _____

(d) What is $|\phi_1 - \phi_2|$ in radians? _____

Problem 3 Consider the RC circuit and step response at $t = 0$ shown below:





The step response is given by $\mathrm{V_{OUT}}(t) = \mathrm{V_0}\left(1 - e^{-t/\tau}\right)$ for $t \geq 0$

(a) What is $\mathrm{V_0}$? _____

(b) What is R? _____

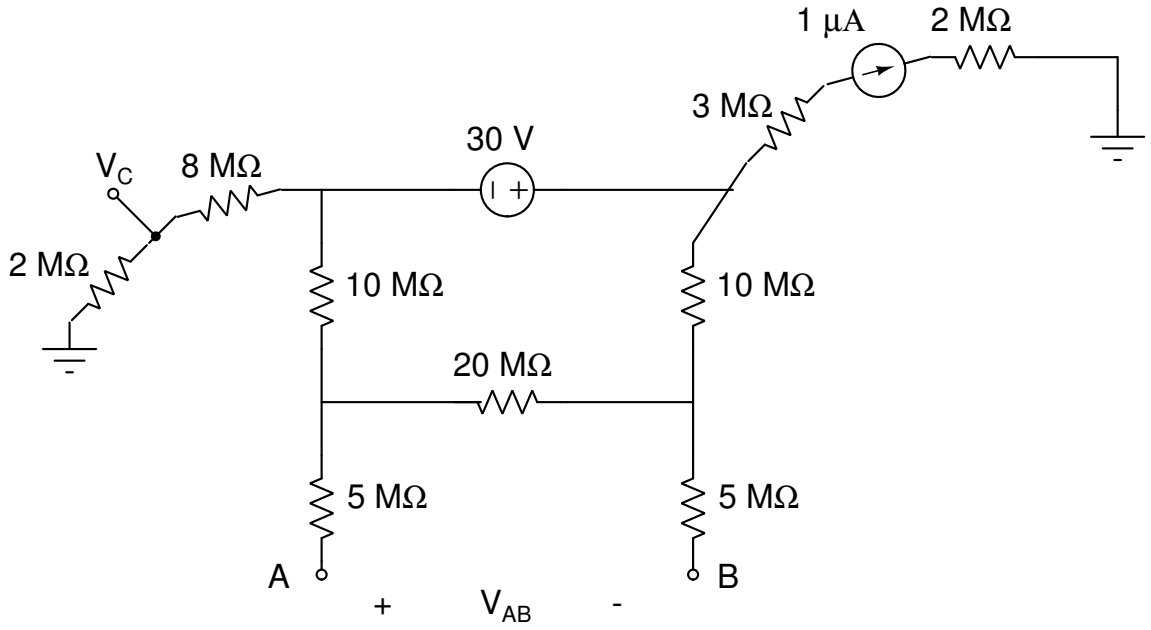
(c) What is the rise-time? _____

(d) Is this circuit a low pass, high pass, band pass or band reject filter? _____

(e) At what frequency is $\mathrm{V_{OUT}}/\mathrm{V_{IN}} = -20\mathrm{dB}$? _____

(f) At what frequency is $\mathrm{V_{OUT}}/\mathrm{V_{IN}} = -28\mathrm{dB}$? _____

Problem 4 A digital volt meter (DVM), having an input resistance of 10 MΩ, is used to make measurements on the circuit below.



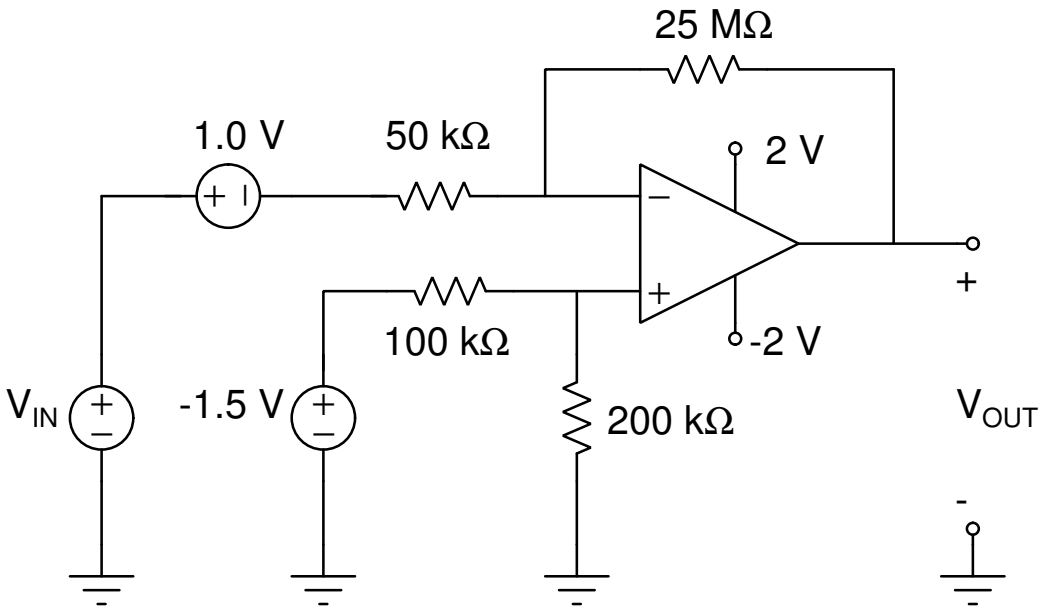
(a) What is the actual voltage V_{AB}? _____

(b) What is the measured voltage V_{AB}? _____

(c) What is the actual voltage V_C with respect to ground? _____

(d) What is the measured voltage V_C with respect to ground? _____

Problem 5 In the schematic below, assume the OpAmp is ideal.



(a) Is this circuit an inverting amplifier, a non-inverting amplifier, an inverting differentiator, an inverting integrator, or a Schmitt trigger? _____

(b) When $V_{IN} = 1.0\text{mV}$, what is V_{OUT}? _____

(c) When $V_{IN} = -1.0\text{mV}$, what is V_{OUT}? _____

(d) When $V_{IN} = 10\text{mV}$, what is V_{OUT}? _____

(e) When $V_{IN} = -10\text{mV}$, what is V_{OUT}? _____