Sirindhorn International Institute of Technology
Thammasat University at Rangsit
School of Information, Computer and Communication Technology

Practice Problems for the Final Examination

COURSE : **ECS204** Basic Electrical Engineering Laboratory
INSTRUCTOR: Dr. Prapun Suksompong
TIME : ________________ (50 + 90 mins)
PLACE : BKD 3502

Name			ID	
Section		☐ 9 AM ☐ 1 PM	Bench#	

Instructions:

1. This document contains practice problems for the final examination.
2. There are two parts: A and B.
3. **Read these instructions and the questions carefully**.
4. Closed book. Closed notes.
5. In the first part (**part A**), you may use any equipment available on your workbench to solve your questions or verify your answers.
6. For **part B**, your scores depend strongly on your explanation. If the explanation is incomplete, zero score may be given even when the answers are correct.
7. **Basic calculators**, e.g. FX-991MS, **are permitted**, but borrowing is not allowed.
8. For the problems that ask for TA's signatures, lack of the signature(s) means ***no credit for the whole part***. Having the signatures mean that the values recorded are the same as the values measured. These signatures do not guarantee that you have the correct answers.
9. Allocate your time wisely. Some easy questions give many points.
10. The TAs will not help you debug your circuit.
11. When not explicitly stated/defined, all notations and definitions follow ones given in lecture.
12. **Units** are important.
13. When possible, record *at least two decimal places* from the DMM. Do not write 12 mA when you see 12.00 mA on the DMM's display.
14. Write your **first name and the last three digits of your ID** on each page of your examination paper, starting from page 2.
15. Do not cheat. The use of communication devices including mobile phones is prohibited in the examination room.
16. For the actual Part A of the final exam on Feb 15, 2013,
    a. group a: 9:30 – 10:30 AM
       group b: 10:40 – 11:40 AM
       group c: 1:30 – 2:30 PM
       group d: 2:40 – 3:40 PM
    b. arrive at least 10 minutes early
    c. do not leave the exam room until the end of the allotted time.
17. Clean your desk/bench before you leave the exam room.
18. Do not panic.

Printed on: February 5, 2013

Name______________________________________ ID_______________________

Part A

Basic Information

The following table might be useful for reading resistor code:

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White
0	1	2	3	4	5	6	7	8	9

The pin details of op amp 741 are shown in Figure 1 below.

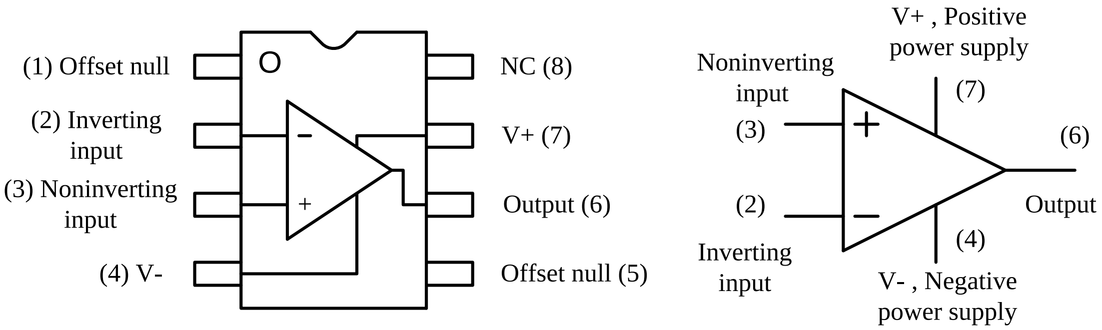


Figure 1

Reminders:

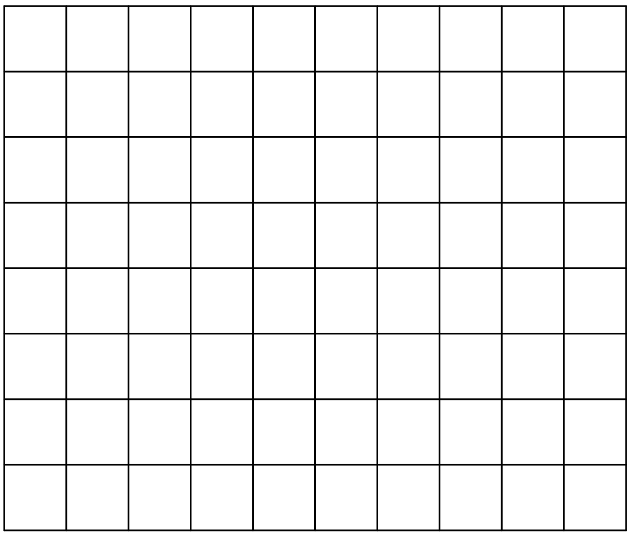
1. V_{DC} = measured voltage value using the DMM in DC mode.
2. V_{AC} = measured voltage value using the DMM in AC mode.
3. $V_{RMS} = \sqrt{\overline{v^2(t)}} = \sqrt{\frac{1}{T}\int_{t_0}^{t_0+T} v^2(t)dt}$ for periodic waveform $v(t)$ with period T

Problem 1

Use the function generator to generate a 3 $V_{p\text{-}p}$ 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 __________

Time/Division __________



Name____ ID_________________________

Measure the DC (average) voltage and V_{AC} of this waveform.

V_{DC} =______________________ V_{AC} = _______________________

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

Measure the DC (average) voltage and V_{AC} of this waveform.

V_{DC} =______________________ V_{AC} = _______________________

Remark: This easy problem also provides simple tests that the oscilloscope and the function generator are set correctly. With the help of DMM, you can produce a very precise peak-to-peak voltage values. If the values set by the DMM do not agree with the values observed on the scope, then some settings on the oscilloscope may be incorrect.

Problem 2

Connect the circuit as shown in Figure 2.

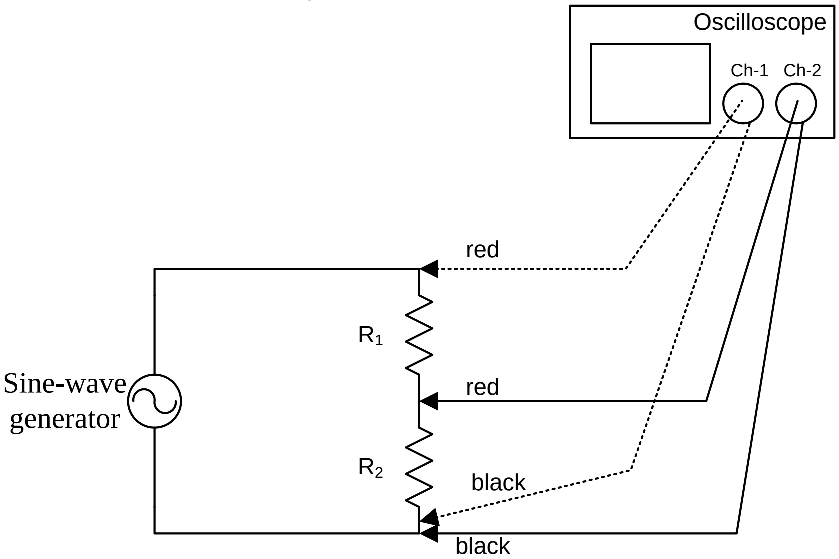


Figure 2

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 below along with the corresponding color codes.

	Value	Color Code
R_1		
R_2		

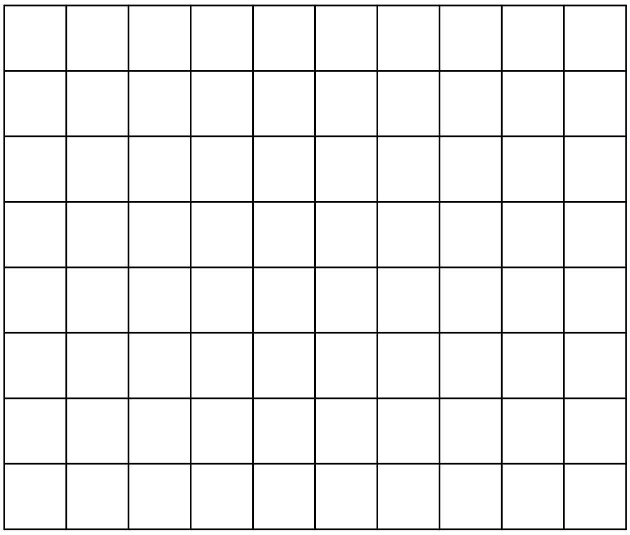
Set the function generator to generate a 2 $V_{p\text{-}p}$ 1 kHz **sinusoidal** waveform with **NO DC offset**.

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.

Name_______________________________________ ID________________________

Voltage/Division __________

Time/Division __________



b) Measure the rms voltage V_G across the generator, the rms voltage V_1 across R_1, and the rms voltage V_2 across R_2.

V_G (rms) = _____________ V_1 (rms) = _____________ V_2 (rms) = _____________

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

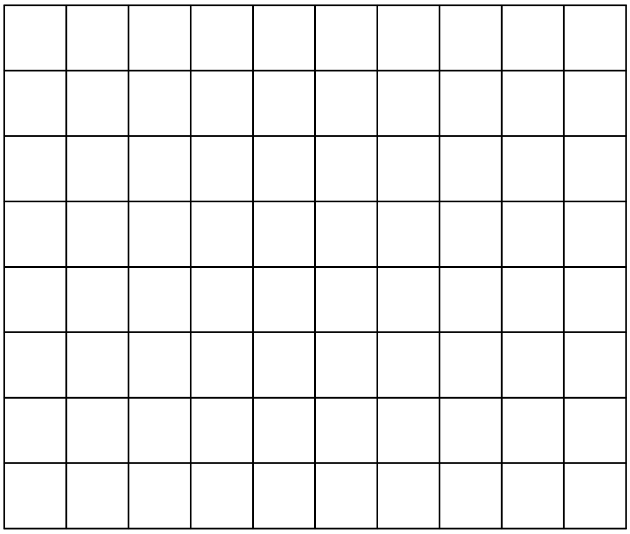
I_1 (rms) = _______________________

Problem 3

a) Use the function generator to generate a 1 V_{rms} 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 __________

Time/Division __________



Record the exact rms value here: ____________________
Record the exact frequency here: ____________________
Find the peak-to-peak value of this signal: __________________

Name_____________________________________ ID_______________________

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}.

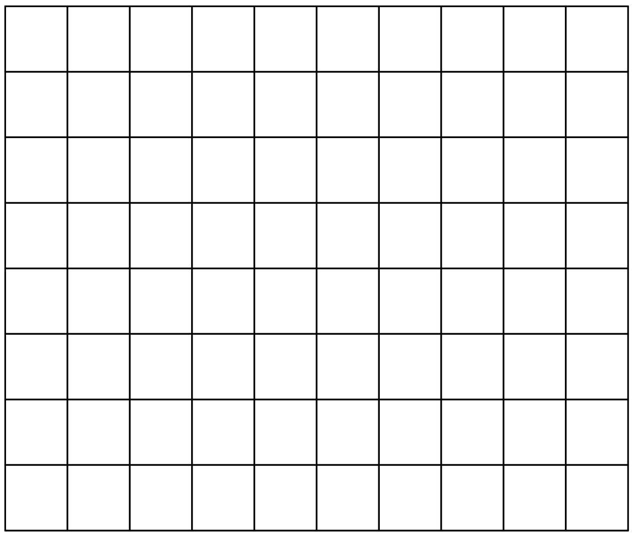
b) Connect the function generator output (with 1 V_{rms} OPEN-circuit voltage) across a 100Ω resistor. Measure the voltage (rms) across this resistor.

The exact resistance is ___________________.
The rms voltage across the resistor is _______________. (Hint: Not 1.)

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.

Voltage/Division _________

Time/Division _________



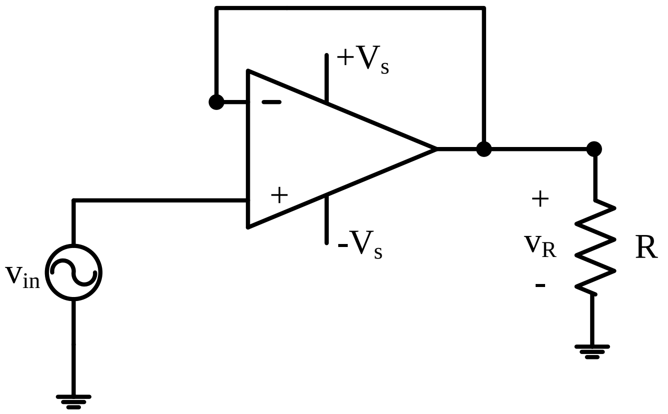
Ask one of the TAs to witness your result and obtain his/her signature.

____

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 ___________________.
The rms voltage across the resistor is _______________. (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 ____________________.
The rms voltage across the resistor is ________________.

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

The exact resistance is ____________________.
The rms voltage across the resistor is ________________.

f) Why does the voltages across the resistor change when there is no op amp?

Problem 4

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

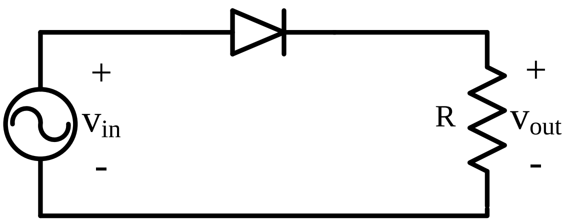
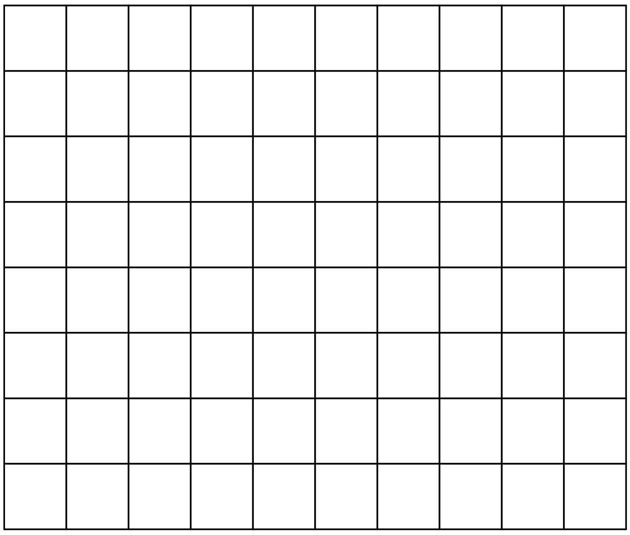


Figure 3

The exact value of R is ___________________.

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.

Name_____________________________________ ID_______________________



Voltage/Division __________

Time/Division __________

Ask one of the TAs to witness your result and obtain his/her signature.

____

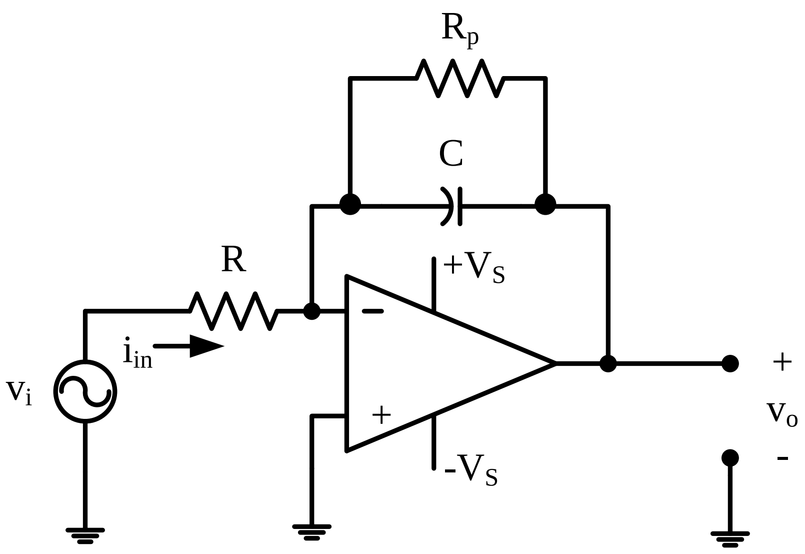
b) Describe the relationship between v_{in} and v_{out}.

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}			
v_{out}			

Problem 5

Connect the circuit as shown below.



Let R = 12 kΩ, R_p = 100 kΩ, V_S = 12V, and $v_i = 2\sin(2\pi ft)$.

Record the exact value of R and R_p and their corresponding color codes in the table below:

Name______________________________________ ID________________________

	Value	Color Code
R		
R_P		

Measure the rms voltage of the output v_o for the frequency *f* and capacitance value C given in the table below. Indicate your exact frequency and capacitance values in the table as well.

f		C		V_i (rms)	v_o (rms)
3 kHz		0.01 µF			
3 kHz		0.001 µF			
2 kHz		0.01 µF			
2 kHz		0.001 µF			

Sketch v_o when f = 2 kHz and C = 0.001 µF below.

Voltage/Division __________

Time/Division __________

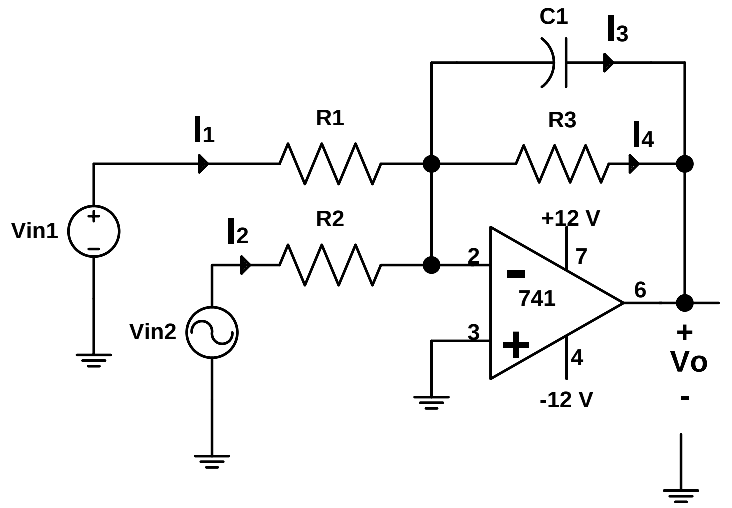
Ask one of the TAs to witness your result and obtain his/her signature.

____

Name____ ID_________________________

Problem 6

Connect the circuit as shown below.



where R1 = R2 = 1.2 kΩ

R3 = 3.3 kΩ

C1 = 0.047 µF

Vin1 = 1 Volt

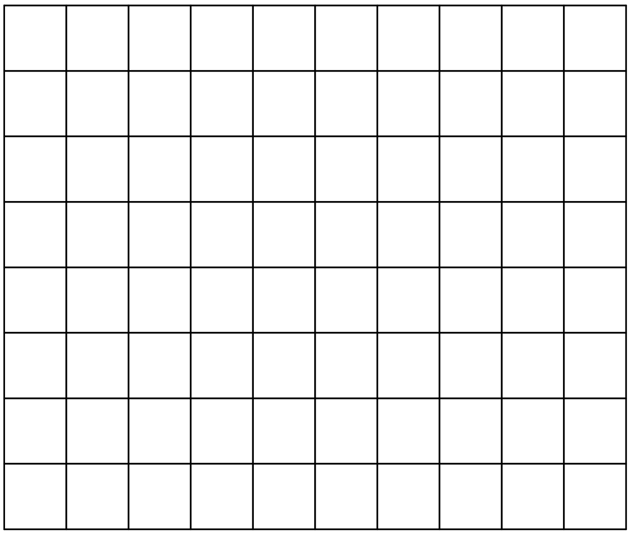
Vin2 = $2\sin\left(2000\pi t\right)$ Volt

Measure, calculate and fill in the blanks in the table shown.

Measurement	Condition	Type of Measurement	Value	Unit
Vin1	-	DC		
Vin1	-	RMS		
Vin2	-	DC		
Vin2	-	RMS		
Vo	Vin1 is active	DC		
Vo	Vin2 is active	RMS		
Vo	Vin1 andVin2 are active	DC		
Vo	Vin1 andVin2 are active	RMS		
I1	Vin1 andVin2 are active	DC		
I2	Vin1 andVin2 are active	RMS		
I3	Vin1 andVin2 are active	RMS		
I4	Vin1 andVin2 are active	DC		
Vo	Vin1 andVin2 are active	Vp-p		
I1	CALCULATE	Ap-p		
I2	CALCULATE	Ap-p		
I3	CALCULATE	Ap-p		
I4	CALCULATE	Ap-p		

Draw graph of V_o when V_{in1} and V_{in2} are active in DC mode. (5 point)

Name______________________________________ ID________________________



Voltage/Division _________

Time/Division _________

Part B

Resistor

Problem 7

Fill in the blanks for the reading of resistor color code. (8 pt.)

1st band	2nd band	3rd band	Value of Resistor
Red	Blue	Red	
			5.1 kΩ

The following table might be useful:

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White
0	1	2	3	4	5	6	7	8	9

Problem 8

Suppose you want to use a 1 kΩ resistor but you only have one 2 kΩ resistors and two 4 kΩ resistors. How would you connect the three resistors to get 1 kΩ?
Draw *and* explain your answer.

Problem 9

Is resistor active or passive element? Why?

Problem 10

What is the value of resistor if the color code is **orange black yellow**?

Write down the color code of a 27 kΩ resistor.

Name____ ID_________________________

DMM

Problem 11

Consider the circuit in Figure 2a. We want to find the value of the current that passes through R_3 when R_1 = 1.5 kΩ, R_2 = 3 kΩ, and R_3 = 3 kΩ.

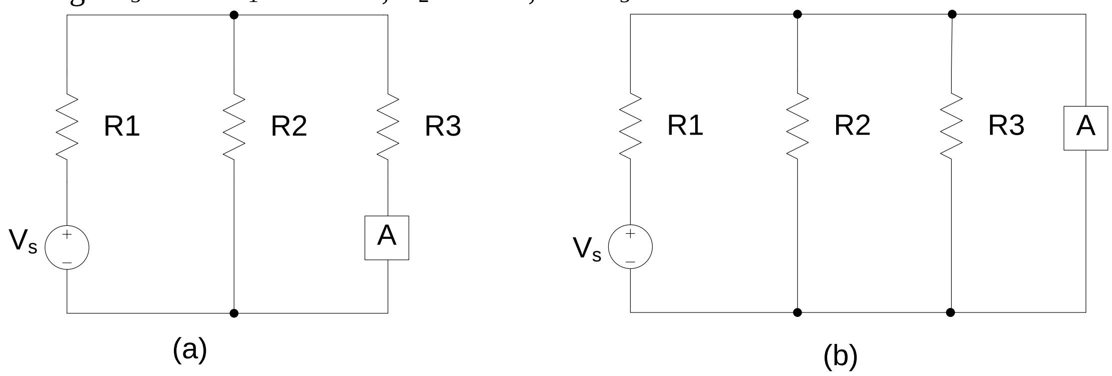


Figure 4

If V_s is 12 V, the ammeter (or DMM that is properly set as an ammeter) in Figure 2a should display
______________ A.

Now, suppose that you forget to "break the connection". Instead, you connect the ammeter across the resistor R_3 as in Figure 2b. In this case, the ammeter would display
______________ A.

Problem 12

What is a DMM? What is the purpose of using a DMM?

Problem 13

When you measure some electrical quantities by using a DMM, and the DMM shows O.L. What does it mean? How can you solve this problem?

Problem 14

How can you use a DMM to measure the values of capacitors? Explain clearly. Draw a figure for explanation.

Problem 15

On using a DMM as a voltmeter, what are the differences between DC mode and AC mode ?

Problem 16

When the DMM is used to measure a current, how can you tell whether it is in DC mode or AC mode?

Name____ ID_________________________

Oscilloscope

Problem 17

What is the difference between using an oscilloscope in DC mode and AC mode? Give some examples.

Problem 18

What are the values of AMPL/DIV and TIME/DIV of the oscilloscope for the sine wave signal with the amplitude $2\ V_{p\text{-}p}$ and frequency 1000 Hz in order to display its peak-peak value four divisions and its period five divisions ?

Problem 19

Explain why the probe grounds for both channel of the scope should be connected to the same place.

Problem 20

Is changing the DC offset on the signal generator the same as changing the vertical position of the trace in oscilloscope?

Circuit Analysis

Problem 21

State Ohm's law

Problem 22

What is the advantage of Thevenin and Norton equivalent circuit?

Problem 23

Consider the circuits in Figure 5 which is used to verify the superposition theorem. Figure 5a is the original circuit. Figure 5b is the modified circuit with V_{ps1} only. Figure 5c is the modified circuit with V_{ps2} only.

Name____ ID_________________________

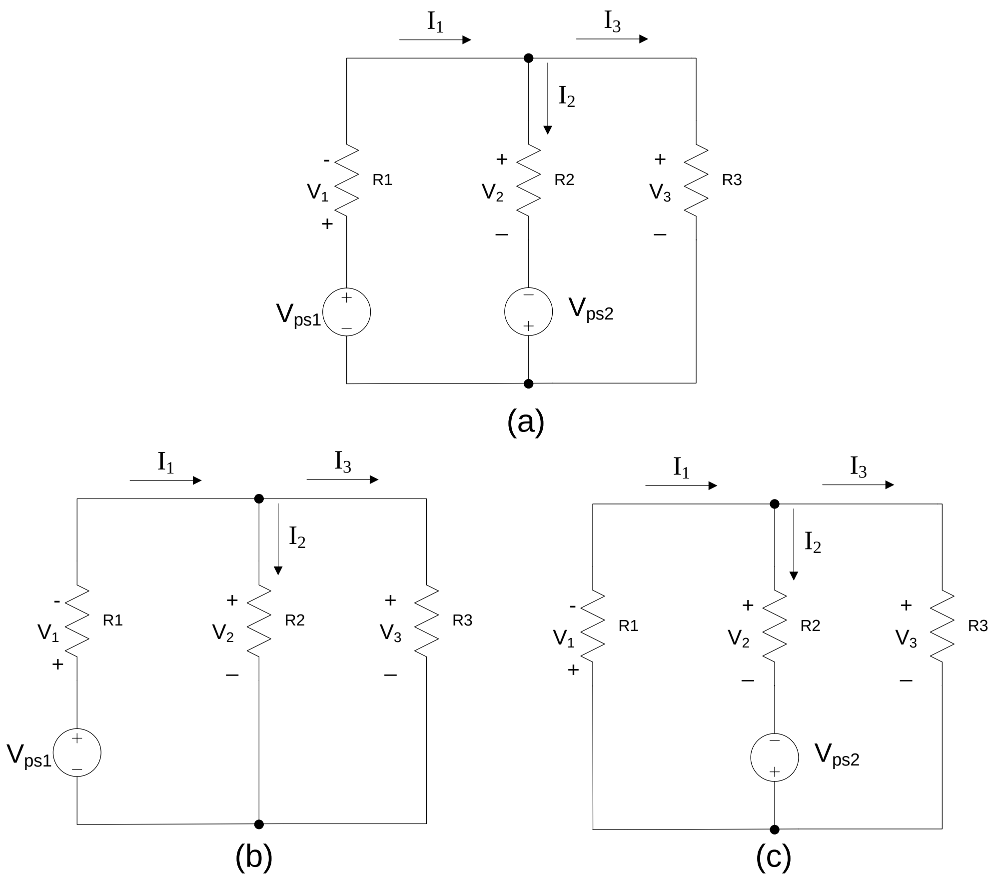


Figure 5 Circuits to verify superposition theorem

Complete the following table:

V_{ps1} Only (Fig. 1b)				V_{ps2} Only (Fig. 1c)				V_{ps1} and V_{ps2} together (Fig. 1a)			
I_1	8 A	V_1	80 V	I_1	2 A	V_1	20 V	I_1		V_1	
I_2	4 A	V_2	80 V	I_2		V_2	60 V	I_2		V_2	
I_3		V_3		I_3	-1 A	V_3		I_3		V_3	

Warning: Watch out for the sign of the current/voltage.
Hints:

- Look at each figure. How are the currents I_1, I_2, and I_3 related?
- In Figure 5b or Figure 5c, can you find the missing value of the voltage using the values of the voltage that are given?
- What does the superposition theorem tell you about the relationship between the values of the current in Figure 5b-c and the value of the current in Figure Figure 5a?

AC Analysis

Problem 24

Write the definition of the rms value of the signal.

Problem 25

A sinusoidal waveform has a period of 1 ms. What is its frequency?

Name______________________________________ ID________________________

Problem 26

How can you measure rms value in DC circuit?

Problem 27

Write the relationship among V_{p-p}, V_{0-p}, and V_{rms}.

Problem 28

Find V_{DC}, V_{p-p}, V_{0-p}, and V_{rms} of the following waveforms:

a) $2\sin(2000\pi t)$

b) $2\cos(2000\pi t)$

c) $2\cos(2000\pi t)+3$

Problem 29

What are the proper instruments you use to measure V_{p-p}, V_{rms}, I_{rms}, and R, respectively ?

Problem 30

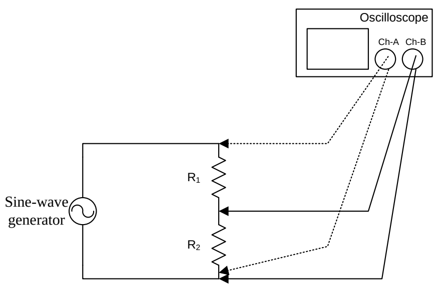
If only the waveforms of the voltage and the corresponding current are given, how can we know it is a resistive, an inductive, or a capacitive circuit ?

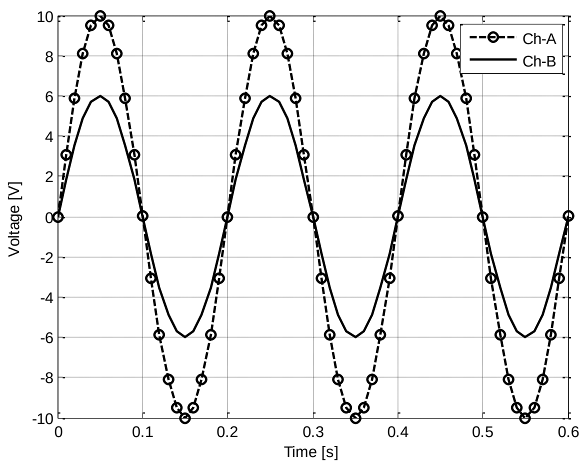
Problem 31

In a pure inductor circuit, the current__________the voltage by 90 degrees.

Problem 32

Consider the circuit and its corresponding measurements below.





Note that channel A of the oscilloscope displays the voltage across the generator. Channel B of the oscilloscope displays the voltage across R_2.

Name____ ID_________________________

Find the peak voltages and the peak-to-peak voltages across each component in the circuit. Put your answers in the table below.

	Peak voltage	Peak-to-peak voltage
Voltage across generator		
Voltage across R_2		
Voltage across R_1		

Problem 33

Consider the circuit and its corresponding measurements in Figure 6.

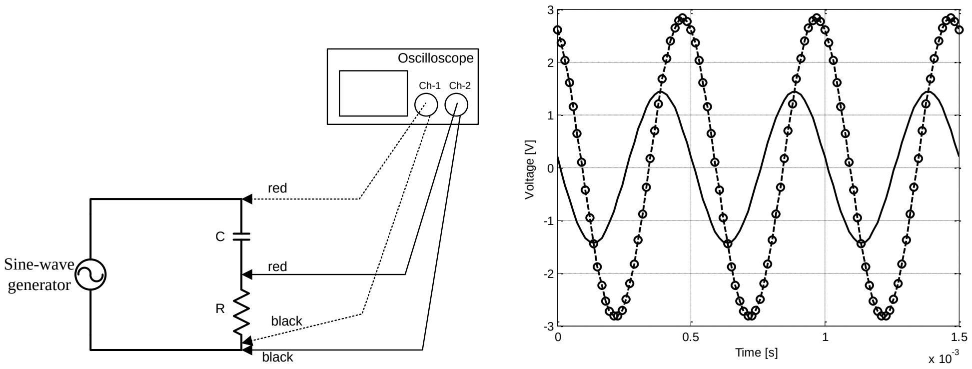


Figure 6

Note that channel 1 of the oscilloscope displays the voltage across the generator.
Channel 2 of the oscilloscope displays the voltage across R.
The plot which is marked by circles represents channel _______ (1 or 2).

Problem 34

Consider a series RLC circuit with a sinusoidal function generator shown in Figure 7.

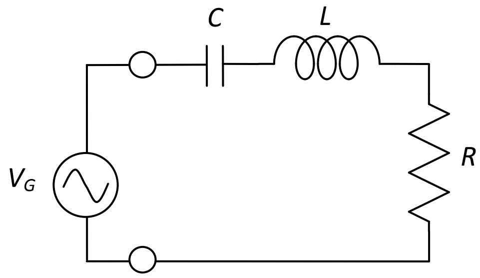


Figure 7

In Figure 8, the voltage across each element in the circuit is plotted as a function of the frequency *f*. Which plot in Figure 8 is the magnitude of the voltage across the resistor R? _______

Name________________________________ ID____________________

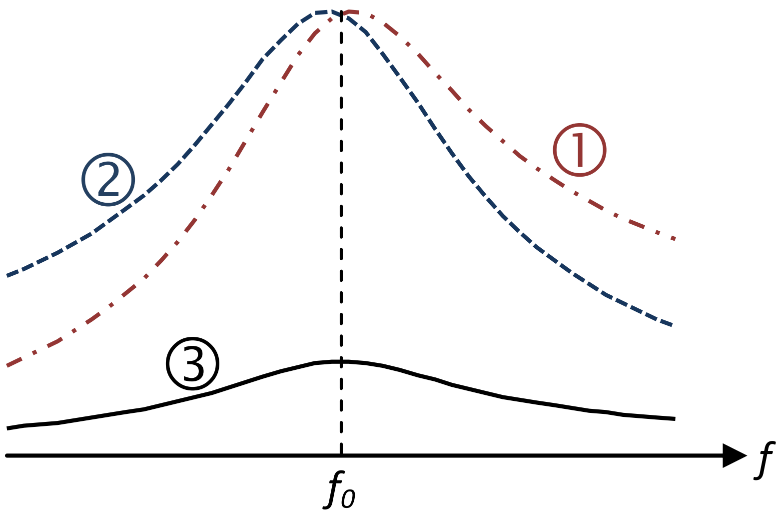


Figure 8

Which plot in Figure 8 is the magnitude of the voltage across the capacitor C? _______

There is a special name for f_0. It is usually called ____________________.

Problem 35

What happen at the resonant frequency in the series RLC circuits ? Write down two things.

Capacitor

Problem 36

The polarity of the electrolytic capacitor is almost always indicated by a printed band. Draw a capacitor and indicate (a) the polarity band, (b) the negative lead, and (c) the positive lead.

Problem 37

What is the value of the capacitor that is labeled with numerical code 103K ?

What is the value of the capacitor that is labeled with numerical code 242K ?

What is the numerical code of the capacitor that has the value $84nF$?

What is the numerical code of the capacitor that has the value $66nF$?

Problem 38

Which of the following equations describes the capacitor voltage when it is discharging?

a) $V(t) = V_{in}(1 - e^{\frac{-t}{\tau}})$ b) $V(t) = V_0 e^{\frac{-t}{\tau}}$

Name______________________________________ ID________________________

Diodes and Rectifiers

Problem 39

Write the definition of the DC value of a periodic signal.

Problem 40

How is a diode marked?

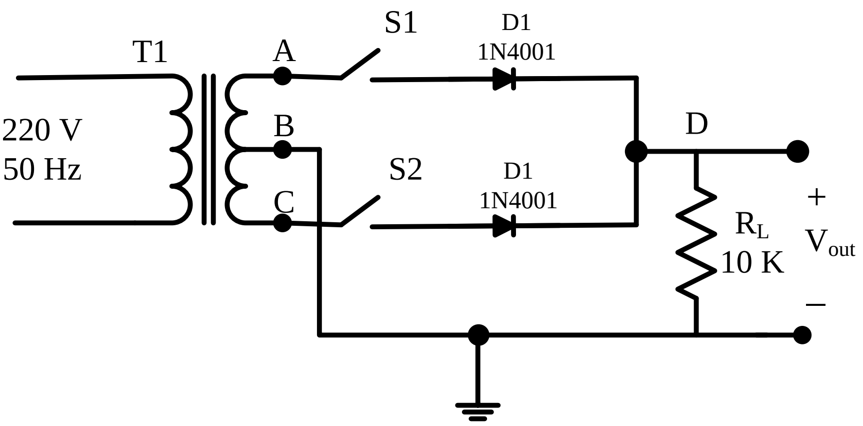
Problem 41

Complete the following sentences.

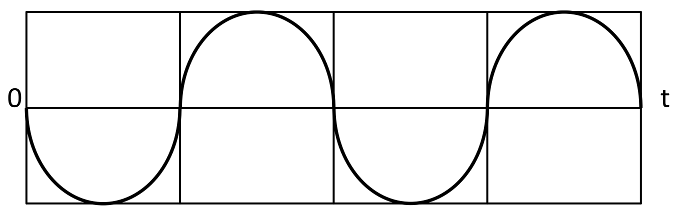
a. The _____________ with label 220/(12-0-12) means that the input voltage is 220V and 12V and ______ output. These values are all the RMS values, not peak-peak values.
b. Rectifier output contains considerable voltage variation called_____________.
c. A ____________ has unidirectional current characteristics; that is, it will permit current to flow through in one direction (when forward-biased), but not the other (reverse-biased).
d. A _____________ converts an ac voltage to a dc voltage.
e. To reduce voltage variation in the rectifier, a large ____________ is connected across the rectifier's output in ___________ with the load resistor.

Problem 42

Consider the circuit of rectifier shown below. Assume that diodes are ideal. The transformer's rating is 220/(12-0-12).



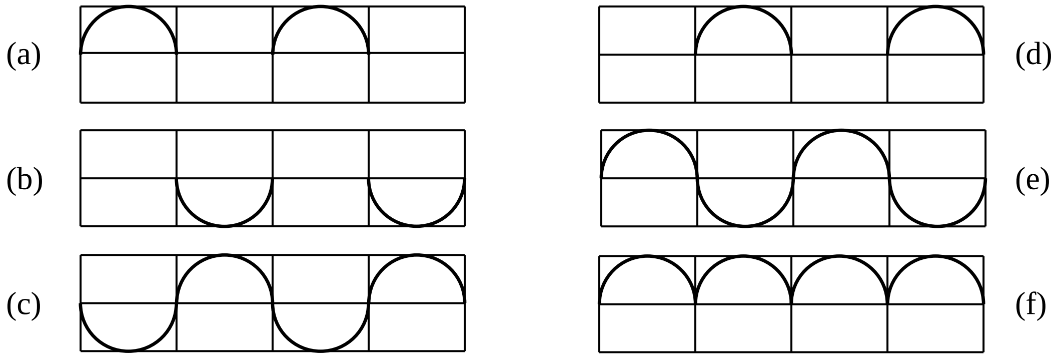
Suppose the voltage at point A (with respect to point B) is given by this waveform:



Name_______________________________________ ID________________________

Pick the waveforms below to match the voltage at the specified point (with respect to point B). Put your answers in the second column of the table.

i) The voltage at point C	
ii) The voltage at point D when S1 is open but S2 is closed.	
iii) The voltage at point D when S1 is closed but S2 is open.	
iv) The voltage at point D when S1 and S2 are closed.	

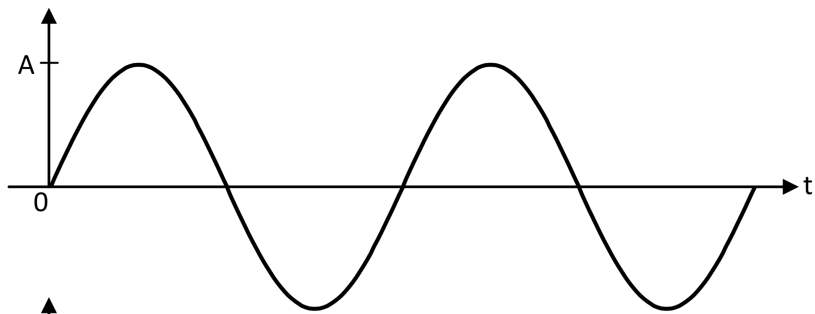


Problem 43

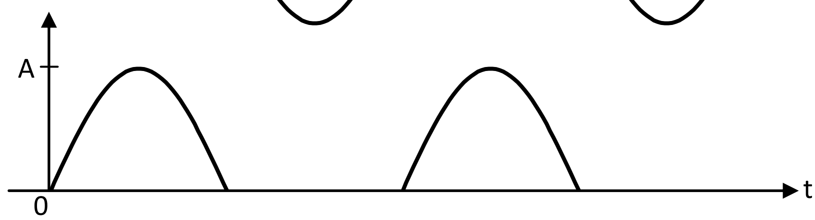
Find the DC voltage V_{DC} and the peak-to-peak voltage $V_{p\text{-}p}$ of the following signals.

Assume A = π.

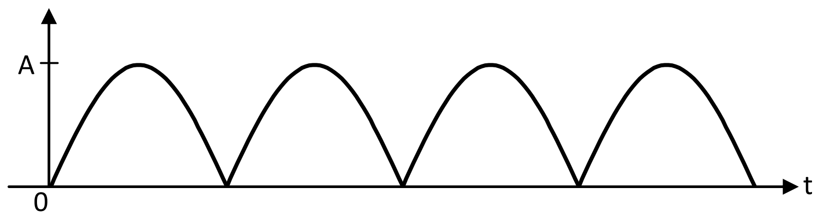
(a)



(b)



(c)



Name______________________________________ ID________________________

Put your answers in the following table.

	V_{DC}	V_{p-p}
Signal (a)		
Signal (b)		
Signal (c)		

Problem 44

Find the DC voltage V_{DC} and the peak-to-peak voltage V_{p-p} of the following signal:

$$\left|2\cos\left(2000\pi t\right)\right|.$$

Op Amp

Problem 45

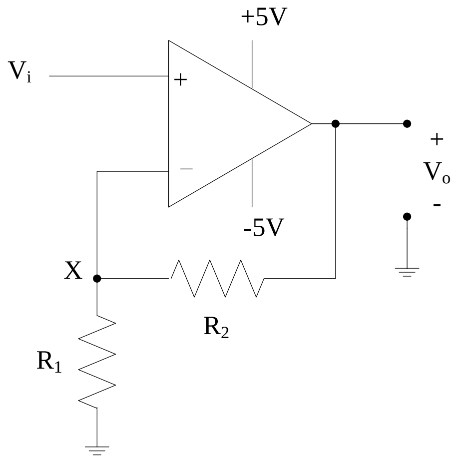
How can you obtain positive and negative power supply? (e.g. ±12 V which are Op-amp's power supply)? Draw diagram of power supply and your connection.

Problem 46

How can you test an op-amp whether it works properly ?

Problem 47

Consider a non-inverting amplifier circuit shown below. Assume that the op amp is ideal. Suppose $R_1 = R_2 = 1k\Omega$ and $V_i = 1V$.



a) Find the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)

b) Calculate the current through the resistor R_1.

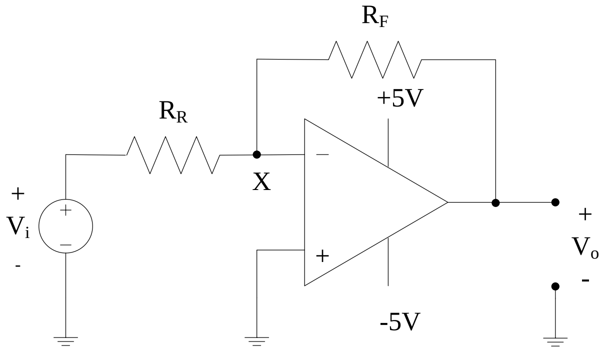
c) Calculate the current through the resistor R_2. (Hint: For an ideal op amp, the currents into both input terminals are zero.)

d) Calculate the voltage drop across the resistor R_2.

e) Calculate the output voltage V_o. (Hint: The answer should be the same as $(1 + (R_2/R_1))V_i$.)

Problem 48

Consider an inverting amplifier circuit shown below. Assume that the op amp is ideal. Suppose $R_R = 1k\Omega$, $R_F = 2k\Omega$, and $V_i = 2V$.



a) Calculate the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)

b) Calculate the current through the resistor R_R.

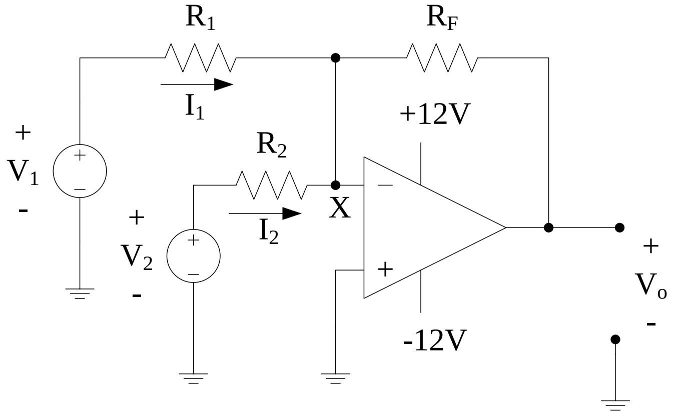
c) Calculate the current through the resistor R_F. (Hint: For an ideal op amp, the currents into both input terminals are zero.)

d) Calculate the voltage drop across the resistor R_F.

e) Calculate the output voltage V_o. (Hint: The answer should be the same as $-(R_F/R_R)V_i$.)

Problem 49

Consider a summing amplifier circuit shown below. Assume that the op amp is ideal. Suppose $R_1 = R_F = 2k\Omega$, $R_2 = 1k\Omega$, and $V_1 = V_2 = 1V$.



a) Find the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)

b) Calculate the current I_1 through the resistor R_1 and the current I_2 through the resistor R_2.

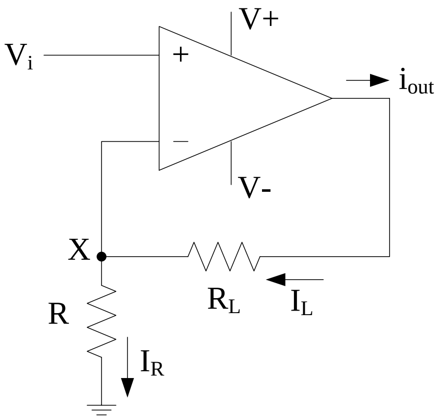
c) Calculate the current through the resistor R_F. (Hint: For an ideal op amp, the currents into both input terminals are zero.)

d) Calculate the voltage drop across the resistor R_F.

e) Calculate the output voltage V_o. (Hint: The answer should be the same as $-\left(\frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2\right)$.)

Problem 50

Consider a voltage-to-current converter circuit shown below.



Assume that the op amp is ideal. Suppose $R = R_L = 1\ \text{k}\Omega$, and $V_i = 5\ \text{V}$.

a) Calculate the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)

b) Calculate the current through the resistor *R*.

c) Find the current through the load resistor R_L.. (Hint: For an ideal op amp, the currents into both input terminals are zero.)

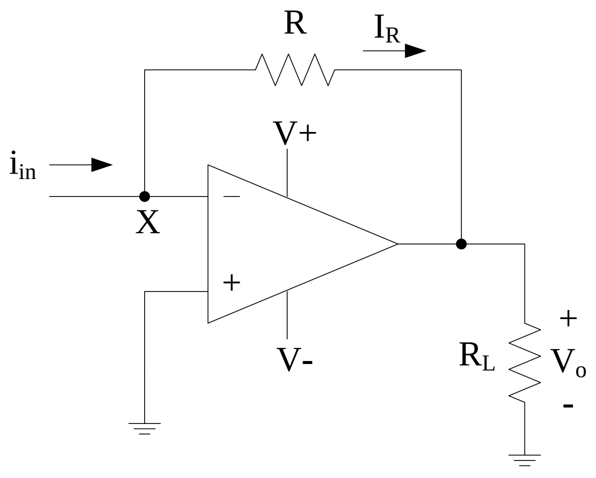
d) Find the output current i_{out}.

e) Change the load resistor to R_L = 2 kΩ, repeat part a)-d).

Name______________________________________ ID________________________

Problem 51

Consider a current-to-voltage converter circuit shown below.



Assume that the op amp is ideal. Suppose $R = R_L = 1\ \text{k}\Omega$, and $i_{\text{in}} = 6\ \text{mA}$.

a) Calculate the current through the resistor *R*. (Hint: For an ideal op amp, the currents into both input terminals are zero.)

b) Calculate the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)

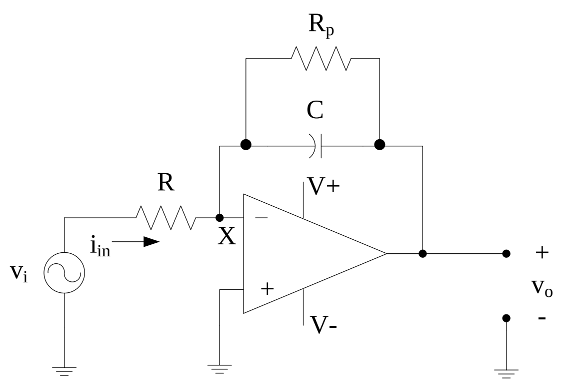
c) Calculate the voltage drop across the resistor *R*.

d) Calculate the output voltage V_o.

e) Change the load resistor to R_L = 2 kΩ, repeat part a)-d).

Problem 52

What is the purpose of adding R_p in the integrating amplifier below?



Name____ ID___________________________

General Questions

Problem 53

If there is an accident in the laboratory room, what should you do?

Problem 54

If there is a burning element due to a short circuit on your circuit board, what should you do first?