

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

Practice Problems for the Final Examination

COURSE : ECS210 Basic Electrical Engineering Laboratory
INSTRUCTOR: Dr. Prapun Suksompong
TIME : _____ (170 mins)
PLACE : BKD 3502

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|---------|---|--------|--|
| Name | | ID | |
| Section | <input type="checkbox"/> 9 AM <input type="checkbox"/> 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. Allocate your time wisely.
9. 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.
10. Allocate your time wisely. Some easy questions give many points.
11. The TAs will not help you debug your circuit.
12. When not explicitly stated/defined, all notations and definitions follow ones given in lecture.
13. **Units** are important.
14. 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.
15. Write your **first name and the last three digits of your ID** on each page of your examination paper, starting from page 2.
16. Do not cheat. The use of communication devices including mobile phones is prohibited in the examination room.
17. For the actual Part A of the final exam on Feb 21, 2011,
 - a. group a: 1:15 – 2:00 PM
 - group b: 2:15 – 3:00 PM
 - b. arrive at least 5 minutes early
 - c. do not leave the exam room until the end of the allotted time.
18. Clean your desk/bench before you leave the exam room.
19. Do not panic.

| ID | Group |
|------------|-------|
| 5222770950 | b |
| 5222771164 | a |
| 5222780082 | b |
| 5222780256 | a |
| 5222780272 | a |
| 5222780363 | b |
| 5222780892 | a |
| 5222781387 | a |
| 5222781486 | b |
| 5222781510 | a |
| 5222781577 | a |
| 5222781619 | a |
| 5222781718 | a |
| 5222781825 | b |
| 5222781999 | b |
| 5222782161 | b |
| 5222782401 | a |
| 5222782427 | b |
| 5222790362 | b |
| 5222790479 | b |
| 5222790867 | a |
| 5222791030 | a |
| 5222791097 | b |
| 5222791253 | b |
| 5222791493 | a |
| 5222792129 | a |
| 5222792764 | b |
| 5222800138 | b |
| 5222800302 | b |
| 5222800658 | a |

Part A

In this part, *provide at least three significant digits for all your measurements.*

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

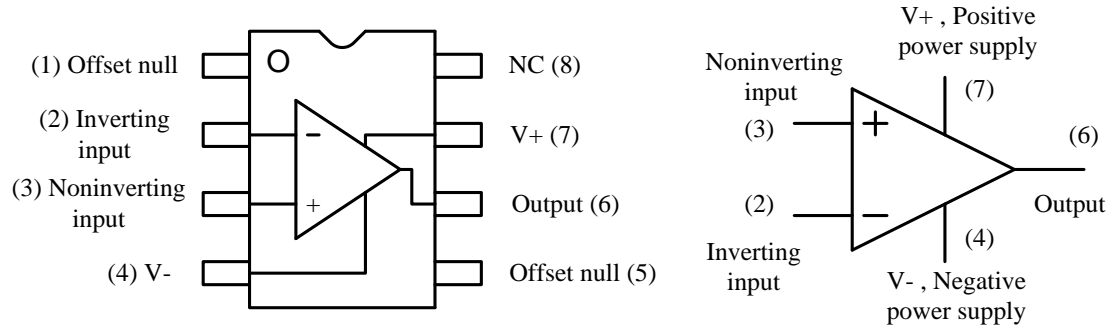
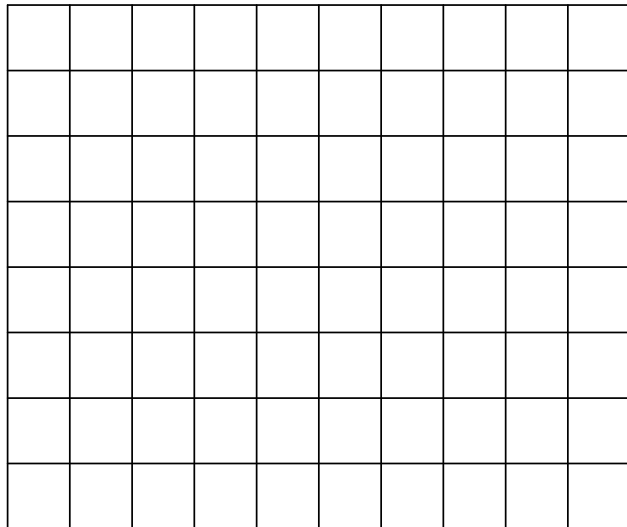


Figure 1

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 _____
 Time/Division _____



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

V_{DC} = _____ V_{~~rms~~ ^{AC}} = _____

Change the DC offset to 2 V.

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

V_{DC} = _____ V_{~~rms~~ ^{AC}} = _____

Problem 2

Connect the circuit as shown in Figure 2.

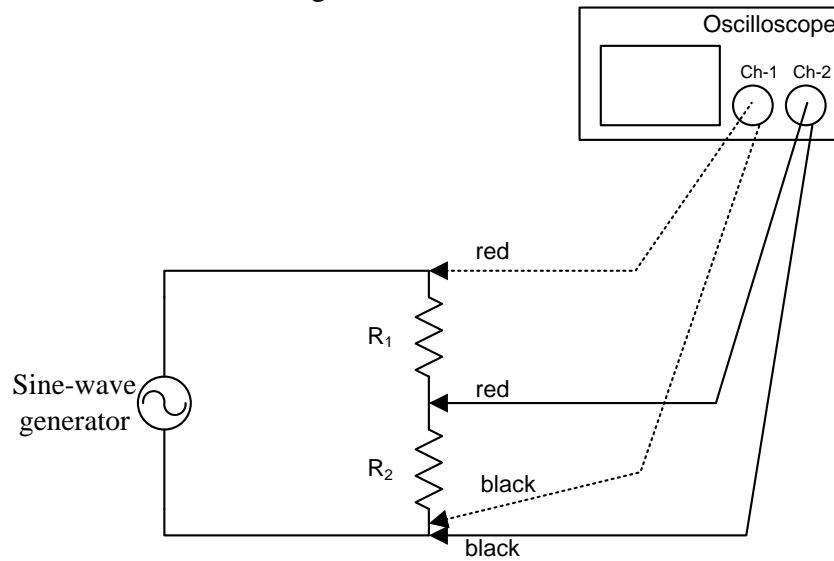


Figure 2

Use $R_1 = 1\text{ k}\Omega$ and $R_2 = 2\text{ k}\Omega$.

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.

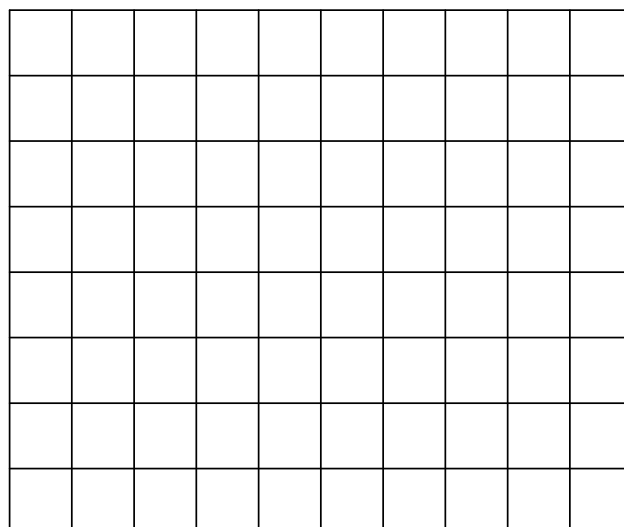
| | Value | Color Code |
|-------|-------|------------|
| R_1 | | |
| R_2 | | |

Set the function generator to generate a 2 V_{p-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.

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) = _____

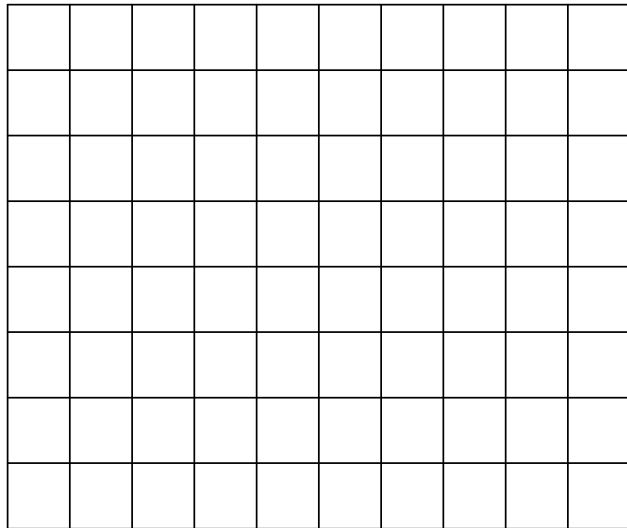
Problem 3

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: _____

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.

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Voltage/Division _____

Time/Division _____

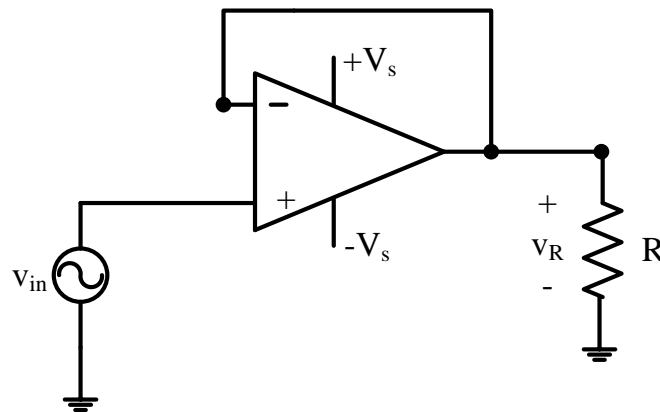
Ask one of the TAs to witness your result and obtain his/her signature.

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 $V_S = 10\text{ V}$. 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 $2\text{ V}_{\text{p-p}}$ 2 kHz **sinusoidal** waveform with **NO DC offset**. Use $R = 3.3\text{ k}\Omega$.

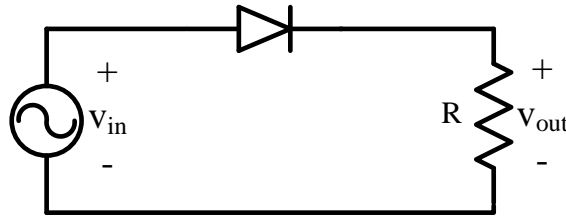


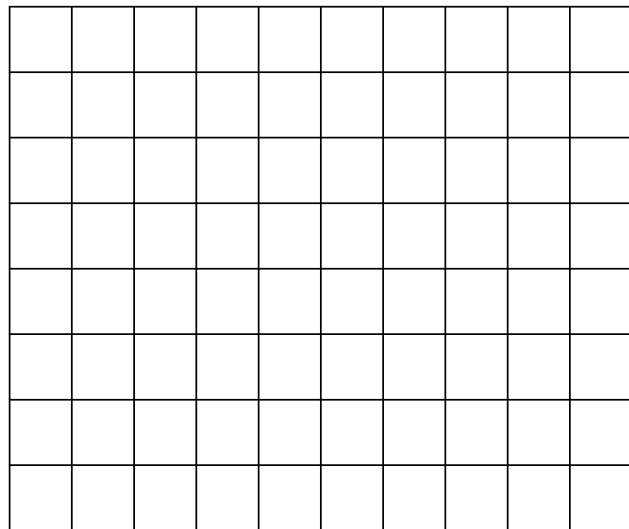
Figure 3

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.

Voltage/Division _____

Time/Division _____



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

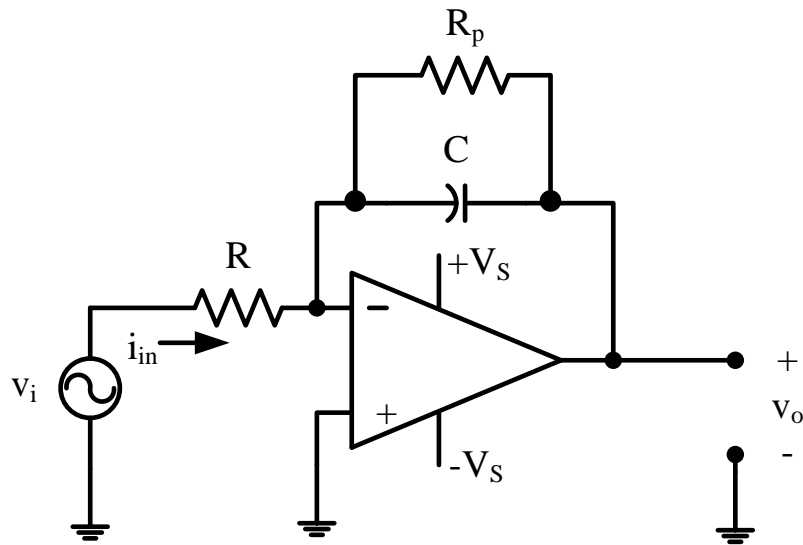
b) Describe the relationship between v_{in} and v_{out} .

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

| | $V_{\text{peak-to-peak}}$ | V_{rms} ^{V_{AC}} | V_{DC} |
|-----------|---------------------------|--|-----------------|
| V_{in} | | | |
| V_{out} | | | |

Problem 5

Connect the circuit as shown below.



Let $R = 12\text{ k}\Omega$, $R_p = 100\text{ k}\Omega$, $V_S = 12\text{V}$, 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:

| | 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 $f = 2\text{ kHz}$ and $C = 0.001\text{ }\mu\text{F}$ below.

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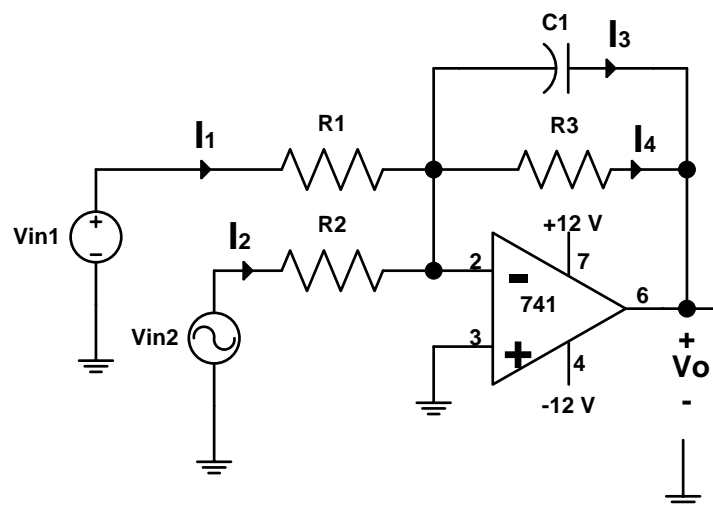
Voltage/Division _____

Time/Division _____

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

Problem 6

Connect the circuit as shown below.



where $R1 = R2 = 1.2 \text{ k}\Omega$

$R3 = 3.3 \text{ k}\Omega$

$C1 = 0.047 \text{ }\mu\text{F}$

$V_{in1} = 1 \text{ Volt}$

$V_{in2} = 2\sin(2000\pi t) \text{ Volt}$

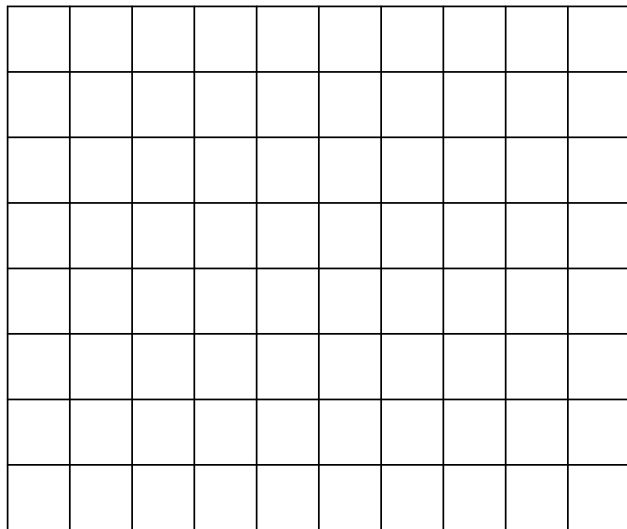
Measure, calculate and fill in the blanks in the table shown.

| Measurement | Condition | Type of Measurement | Value | Unit |
|------------------|--|---------------------|-------|------|
| V _{in1} | - | DC | | |
| V _{in1} | - | RMS | | |
| V _{in2} | - | DC | | |
| V _{in2} | - | RMS | | |
| V _o | V _{in1} is active | DC | | |
| V _o | V _{in2} is active | RMS | | |
| V _o | V _{in1} and V _{in2} are active | DC | | |
| V _o | V _{in1} and V _{in2} are active | RMS | | |
| I ₁ | V _{in1} and V _{in2} are active | DC | | |
| I ₂ | V _{in1} and V _{in2} are active | RMS | | |
| I ₃ | V _{in1} and V _{in2} are active | RMS | | |
| I ₄ | V _{in1} and V _{in2} are active | DC | | |
| V _o | V _{in1} and V _{in2} are active | V _{p-p} | | |
| I ₁ | CALCULATE | A _{p-p} | | |
| I ₂ | CALCULATE | A _{p-p} | | |
| I ₃ | CALCULATE | A _{p-p} | | |
| I ₄ | CALCULATE | A _{p-p} | | |

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

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.

DMM

Problem 11

Consider the circuit in Figure 2a. We want to find the value of the current that passes through R₃ when R₁ = 1.5 kΩ, R₂ = 3 kΩ, and R₃ = 3 kΩ.

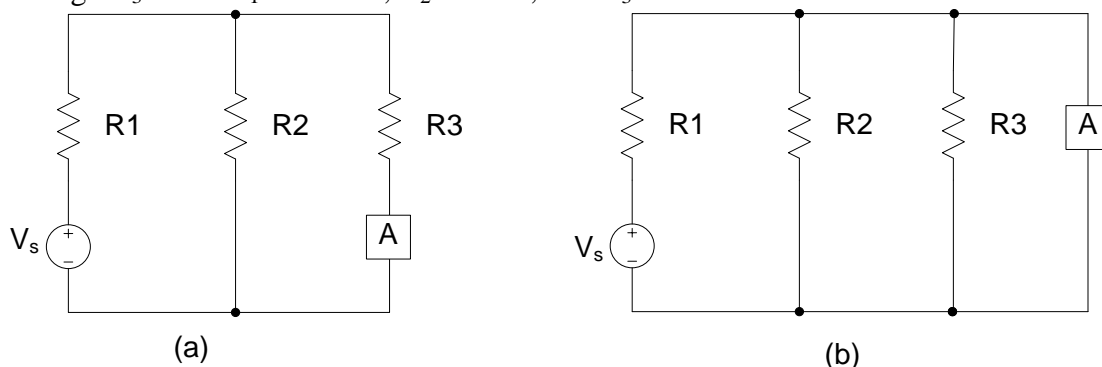


Figure 4

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?

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 $2 V_{p-p}$ 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.

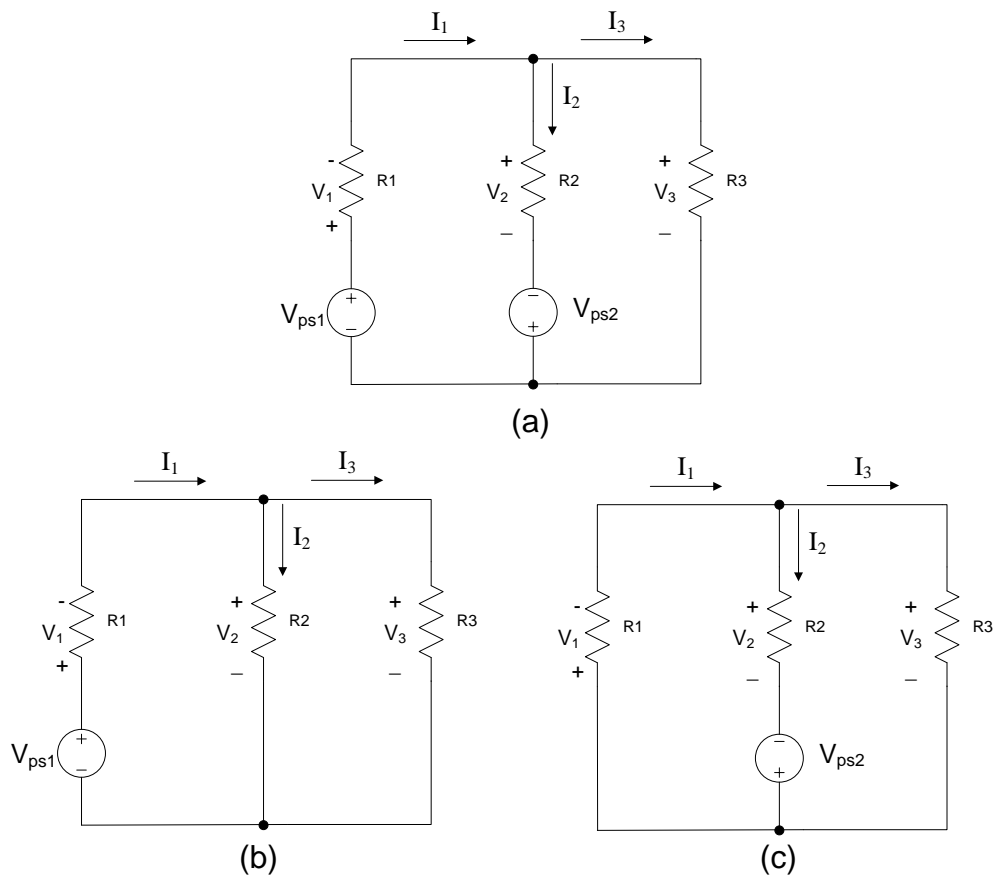


Figure 5 Circuits to verify superposition theorem

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 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?

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:

- $2\sin(2000\pi t)$
- $2\cos(2000\pi t)$
- $2\cos(2000\pi t) + 3$

Problem 29

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

Problem 30

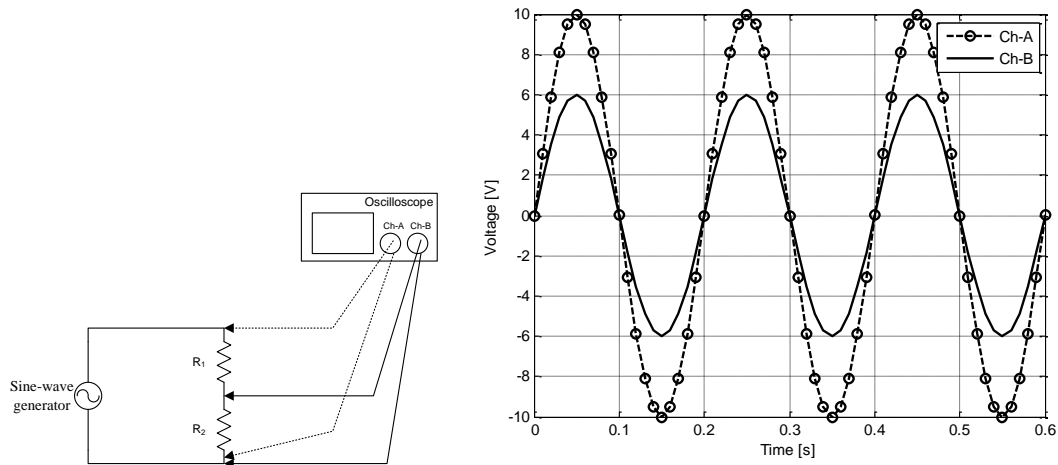
If only the waveforms of the voltage and the corresponding current are given, how can we know it is a resistive, an inductive, or a capacitive circuit ?

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 .

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.

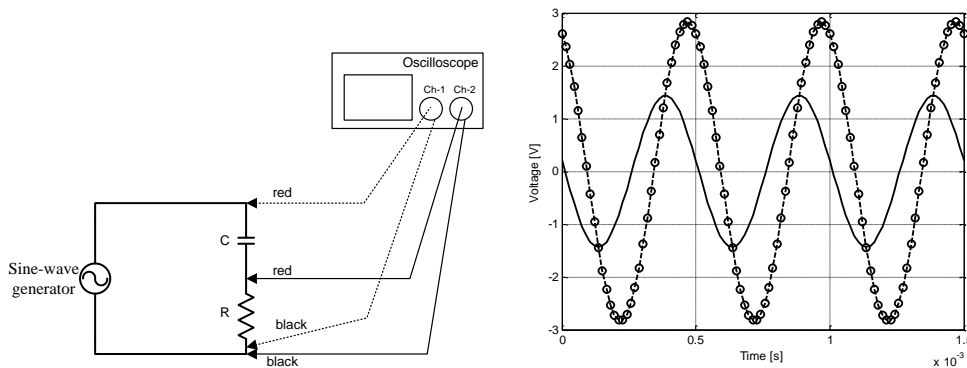


Figure 6

Note that channel 1 of the oscilloscope displays the voltage across the generator. Channel 2 of the oscilloscope displays the voltage across R_2 .

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.

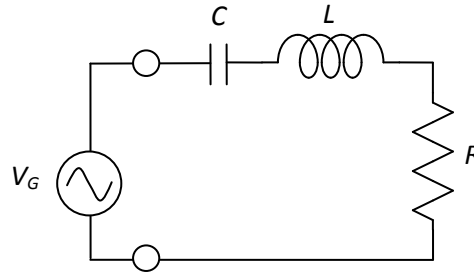


Figure 7

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 ? _____

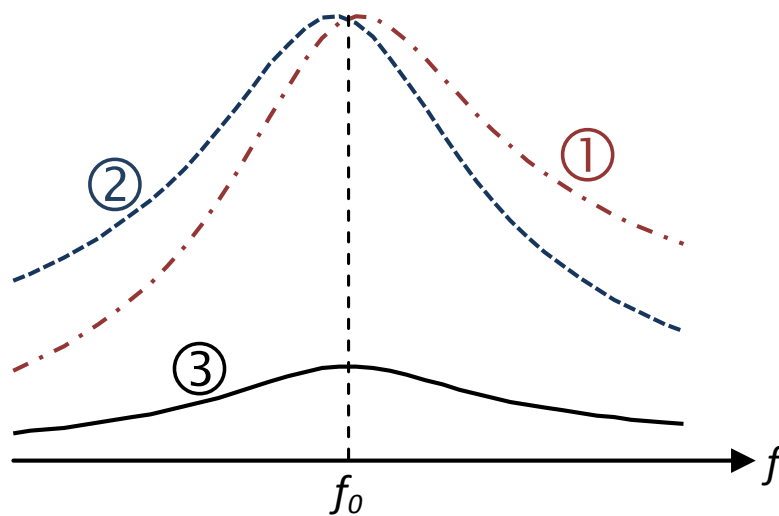


Figure 8

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 happens 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) $V(t) = V_0 e^{-\frac{t}{\tau}}$

Diodes and Rectifiers

Problem 39

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

Problem 40

How is a diode marked?

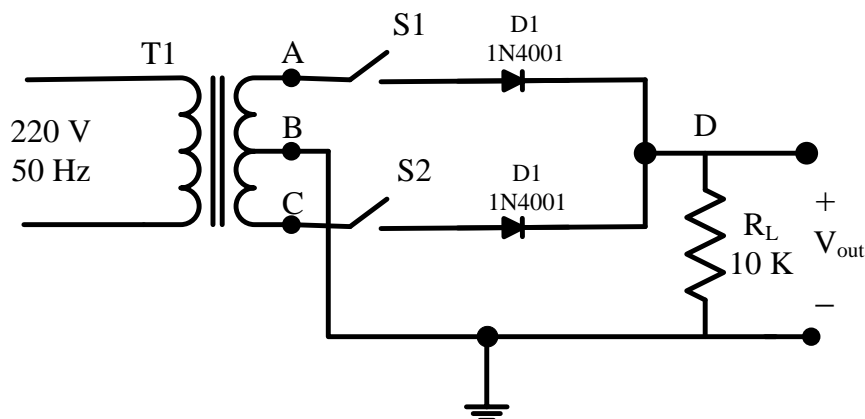
Problem 41

Complete the following sentences.

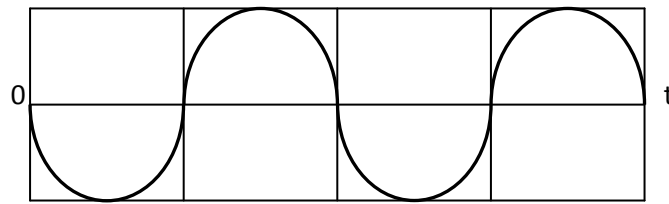
- The _____ with label 220/(12-0-12) means that the input voltage is 220V and 12V and _____ output. These values are all the RMS values, not peak-peak values.
- Rectifier output contains considerable voltage variation called _____.
- A _____ has unidirectional current characteristics; that is, it will permit current to flow through in one direction (when forward-biased), but not the other (reverse-biased).
- A _____ converts an ac voltage to a dc voltage.
- 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).

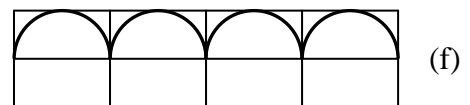
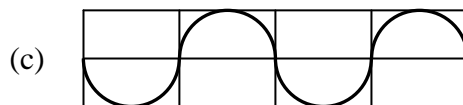
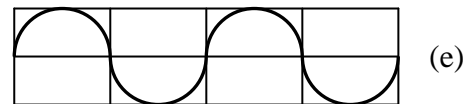
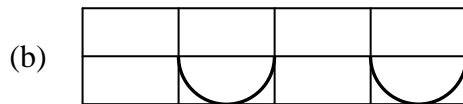


Suppose the voltage at point A (with respect to point B) is given by this waveform:



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.

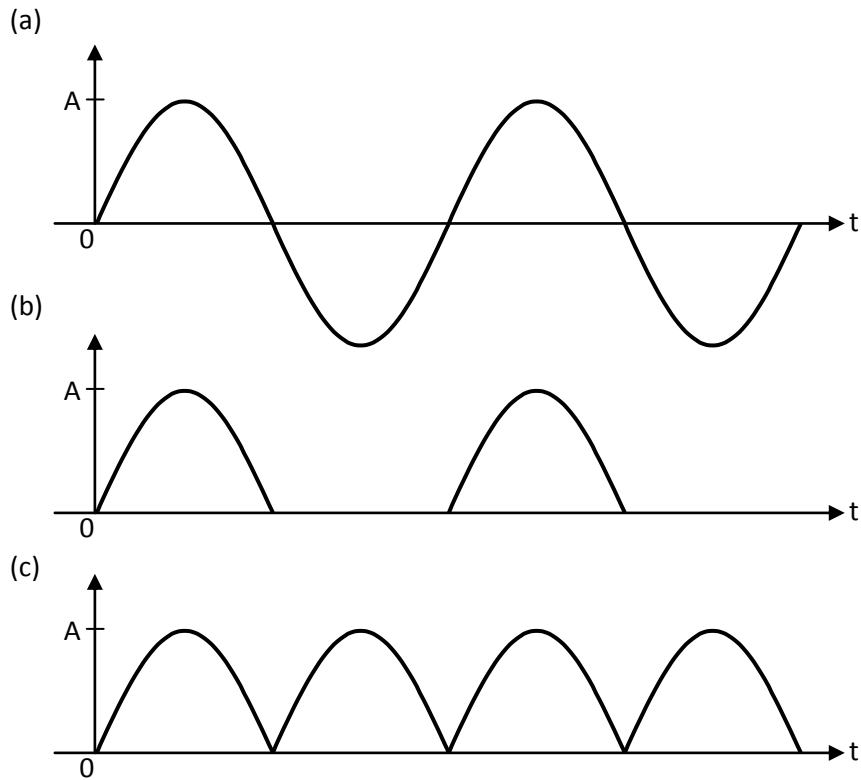
| | |
|---|--|
| i) The voltage at point C | |
| ii) The voltage at point D when S1 is open but S2 is closed. | |
| iii) The voltage at point D when S1 is closed but S2 is open. | |
| iv) The voltage at point D when S1 and S2 are closed. | |



Problem 43

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

Assume $A = \pi$.



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:

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

Op Amp

Problem 45

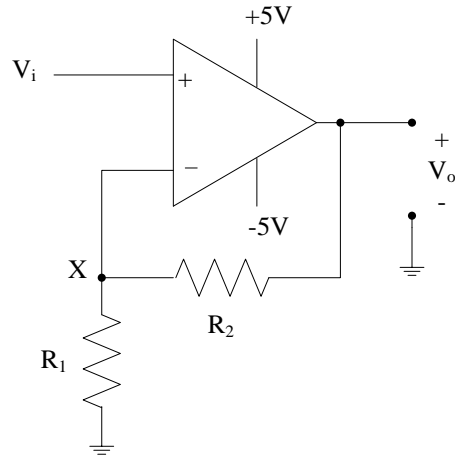
How can you obtain positive and negative power supply? (e.g. ± 12 V which are Op-amp's power supply)? Draw diagram of power supply and your connection.

Problem 46

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

Problem 47

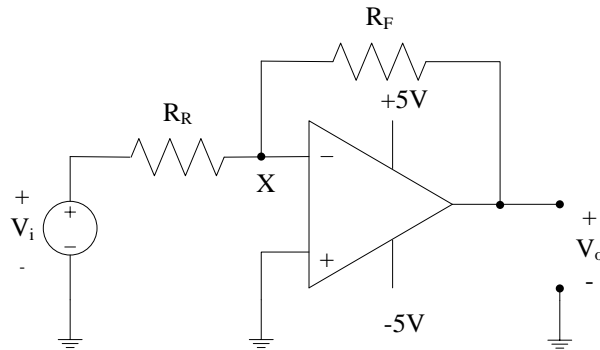
Consider a non-inverting amplifier circuit shown below. Assume that the op amp is ideal. Suppose $R_1 = R_2 = 1k\Omega$ and $V_i = 1V$.



- Find the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)
- Calculate the current through the resistor R_1 .
- Calculate the current through the resistor R_2 . (Hint: For an ideal op amp, the currents into both input terminals are zero.)
- Calculate the voltage drop across the resistor R_2 .
- 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 $V_i = 2V$.

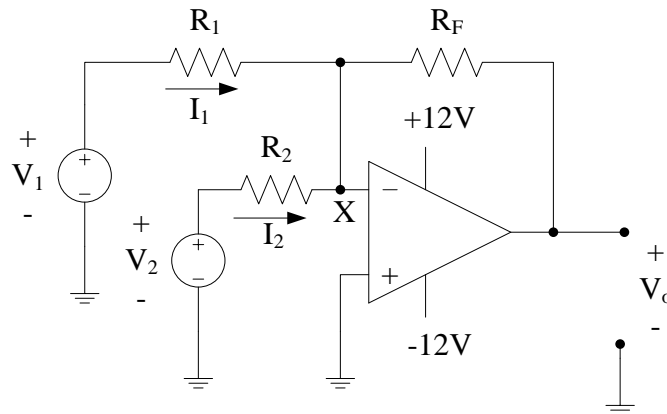


- Calculate the voltage at point X. (Hint: For an ideal op amp, the voltage across the input terminals is equal to zero.)
- Calculate the current through the resistor R_R .
- Calculate the current through the resistor R_F . (Hint: For an ideal op amp, the currents into both input terminals are zero.)
- 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 .

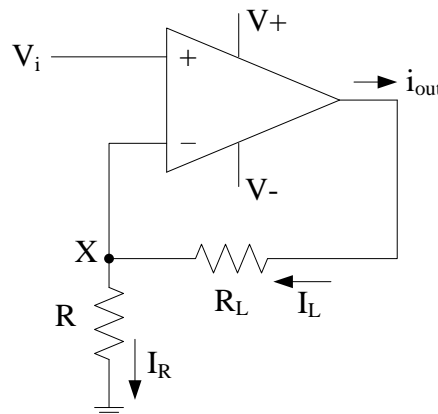
c) Calculate the current through the resistor R_F . (Hint: For an ideal op amp, the currents into both input terminals are zero.)

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.

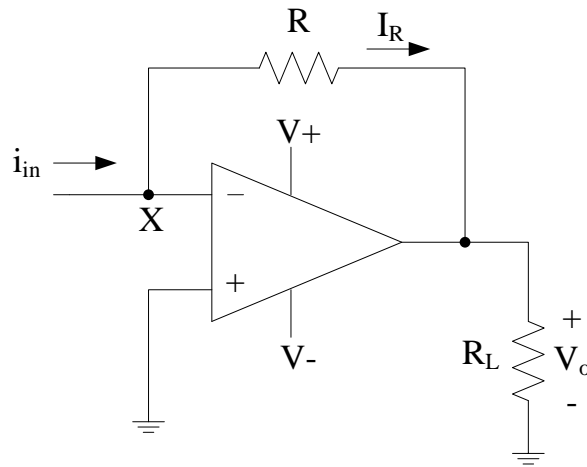


Assume that the op amp is ideal. Suppose $R = R_L = 1k\Omega$, and $V_i = 5V$.

- 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 $R_L = 2 \text{ k}\Omega$, repeat part a)-d).

Problem 51

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

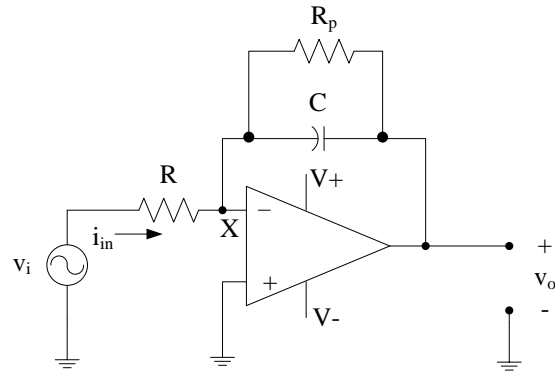


Assume that the op amp is ideal. Suppose $R = R_L = 1 \text{ k}\Omega$, and $i_{in} = 6 \text{ mA}$.

- 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 $R_L = 2 \text{ k}\Omega$, repeat part a)-d).

Problem 52

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



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?