Name _____

ECE Box # _____

Problem	Score	Points
1	_____	10
2	_____	30
3	_____	30
4	_____	30

ECE3204 D2009

Microelectronics II

Exam 1

- This is a **closed book, closed notes test**! Use of calculators is allowed. No pre-stored formulas or outside resource access!
- Show **all** your work. Partial credit may be given. If you think you need something that you can't remember, write down what you need and what you'd do if you remembered it.
- Look for the simple, straightforward way to solve the problem for the level of accuracy required. **Don't get entangled in unnecessary algebra**.
- As in real life, some problems may give you more information than you need. Don't assume that all information must be used! It's your job to decide what's relevant to the solution.
- Unless otherwise indicated or implied, you may assume all op-amps to be ideal.
- You will have 50 minutes to complete this exam. There are four problems on a total of 9 pages.

1) State the Microelectronics II Mantra:

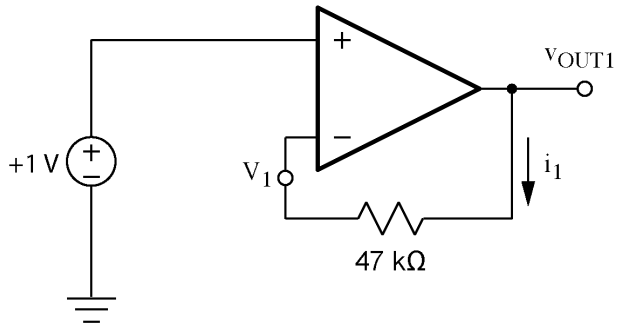
[10]

2) For each of the op-amp circuits in this problem, you may assume the op-amps to be ideal. For each circuit:

i) First, circle one choice to indicate whether the circuit is configured for positive or negative feedback. Then,

ii) **ONLY FOR THE CIRCUITS THAT HAVE NEGATIVE FEEDBACK**, determine the indicated voltages/currents.

[30]



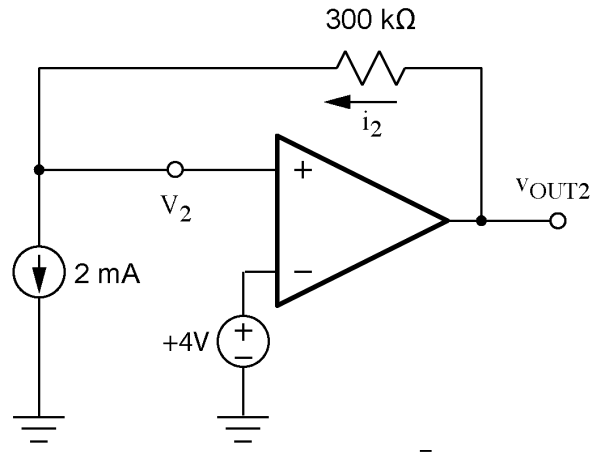
POSITIVE FEEDBACK

NEGATIVE FEEDBACK

v_{OUT1} = _____

v_1 = _____

i_1 = _____



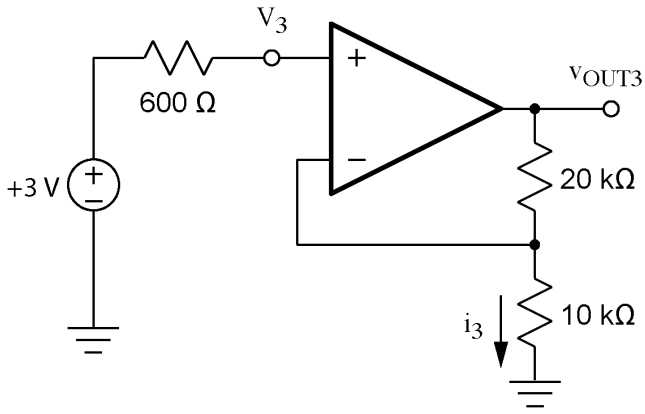
POSITIVE FEEDBACK

NEGATIVE FEEDBACK

v_{OUT2} = _____

v_2 = _____

i_2 = _____



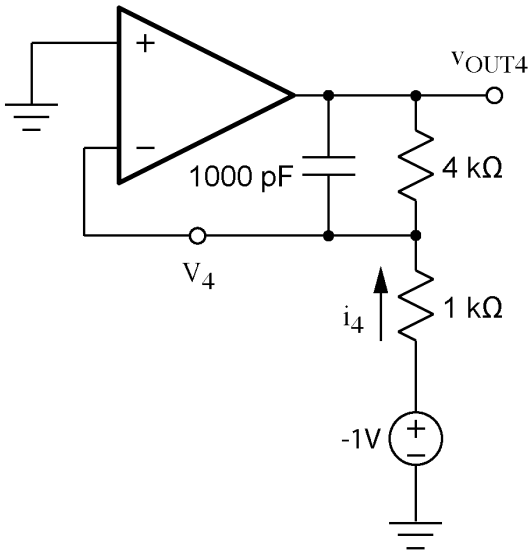
POSITIVE FEEDBACK

NEGATIVE FEEDBACK

v_{OUT3} = _____

v_3 = _____

i_3 = _____



POSITIVE FEEDBACK

NEGATIVE FEEDBACK

v_{OUT4} = _____

v_4 = _____

i_4 = _____

3) For the circuit shown on the opposite page, you may assume the op-amp to be ideal except for finite open-loop gain A. The open-loop DC gain is $A_0 = 50{,}000$ and the unity gain frequency is $f_T = 10$ MHz.

a) Using the space on the opposite page, carefully plot |A| as a magnitude Bode plot over a frequency range from 1 Hz to 100 MHz. Be sure to label any interesting asymptotic values, intersection points, and/or slopes in your plot.

[6]

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b) It is desired that the closed loop DC gain of the amplifier be +50. Find the required value of R_F. Nonstandard value is OK.

[6]

R_F = _____

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c) Given the choice of R_F in (b), what will the 3-dB bandwidth $f_{3\text{-dB}}$ of the closed loop transfer function v_{out}/v_{in} ?

[6]

$f_{3\text{-dB}}$ = _____

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d) Using the same space on the opposite page, carefully superimpose a magnitude plot of the closed loop transfer function $|v_{out}/v_{in}|$ over a frequency range from 1 Hz to 100 MHz. Be sure to label any interesting asymptotic values, intersection points, and/or slopes in your plot

[6]

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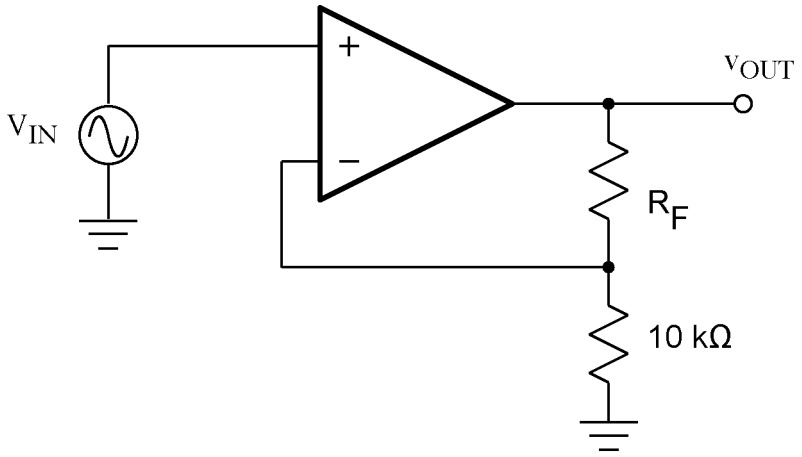
e) If a sine wave input of 1MHz is applied to the closed loop amplifier, what will be the magnitude of the closed loop gain $|v_{out}/v_{in}|$? (Accuracy ±10%; either a number or in dB is OK, just specify which)

[6]

$$\left|\frac{v_{out}}{v_{in}}\right|_{f=1MHz} = \_\_\_\_\_$$



Axes for (a,d):

4) In this problem, the circuit on the opposite page is used as a microphone amplifier in an audio application. The input is modeled as a pure sine wave (zero DC component) which can range in frequency from 20Hz to 20kHz.

Assume the op-amp to be ideal except for the following:

- Input offset voltage V_{OS}
- Output voltage limt V_{OMAX}
- Output slew rate limit SR

Performance specifications for a range of op-amps are given below:

Op-amp	**V_{OS}**	**V_{OMAX}**	**SR**	**Cost**
LM741	± 6.0 mV	± 12 V	0.5 V / µs	$ 0.47
LF356	± 1.0 mV	± 13 V	12.0 V / µs	$ 1.10
LM318	± 2.0 mV	± 13 V	70.0 V / µs	$ 2.55
UO9661	± 0.1 mV	± 14 V	75.0 V / µs	$ 5.40

For parts (a) and (b), you use the LM741 (from your lab kit) in the circuit.

a) Given a 20 mV peak sine wave input at a low frequency of 20 Hz: Use the area on the following page to plot the resulting output voltage. *Assume the worst-case combination of maximum error sources*. Be sure to indicate any interesting values of amplitude or other waveform characteristics.

[10]

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b) Given a 20 mV peak sine wave input at the a frequency of 20 kHz: Use the area on the following page to plot the resulting output voltage. *Assume the worst-case combination of maximum error sources*. Be sure to indicate any interesting values of amplitude or other waveform characteristics.

[10]

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c) Given the choices from the table above, what is the lowest cost op-amp that would provide undistorted output waveforms for both (a) and (b)? Circle one:

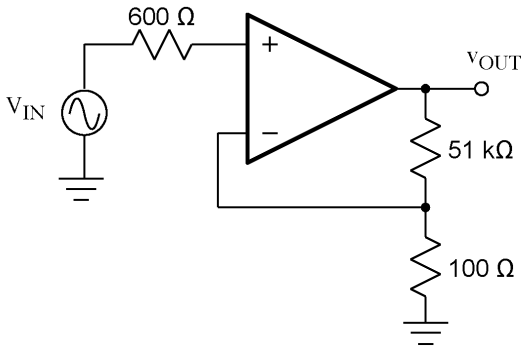
[2]

LM741 LF356 LM318 UO9661 NONE OF THE ABOVE

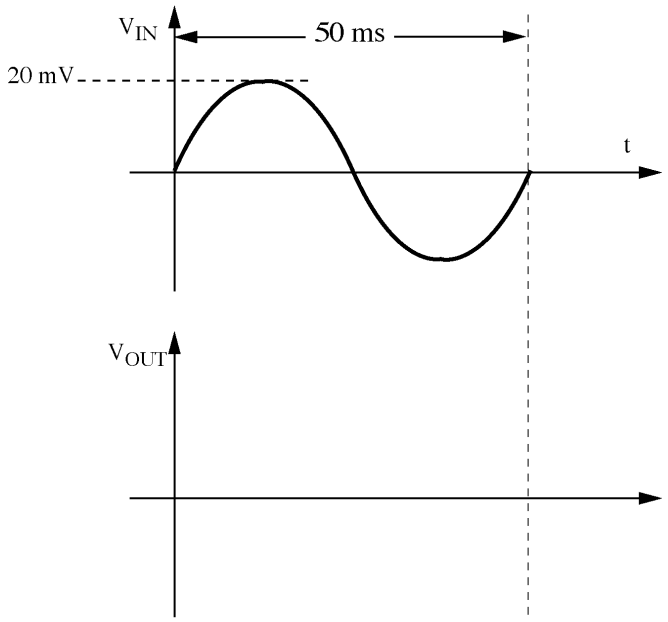
Explain!

[8]

$(20\text{mV})\sin(2\pi ft)$



Axes for (a):



Axes for (b):