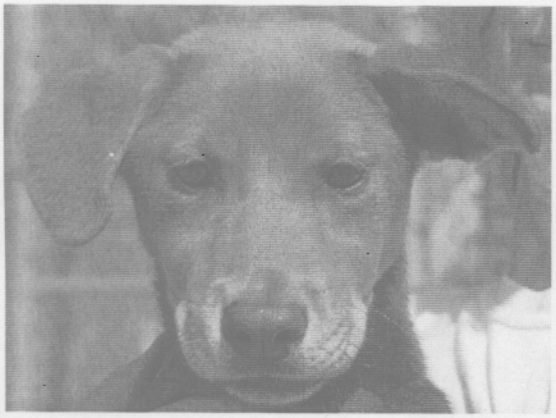
BME154L (Palmeri)

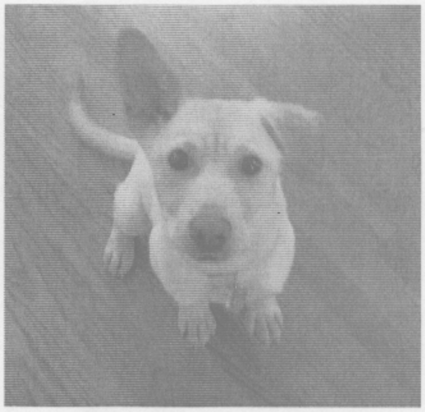
Spring 2012

Exam #1

Instructions:

- Write your name at the top of each page.
- Show all work (this is *critical* for partial credit!).
- Remember to include units with all answers and label all plot axes.
- Clearly box all answers.
- Assume that all components are ideal unless otherwise stated.
- Assume that op amps rail at $\pm$ 12 V unless otherwise stated.





Avery & Ziva wish you good luck!!

In keeping with the Duke Community Standard, I have neither given nor received aid in completion of this examination.

Signature:______________________________

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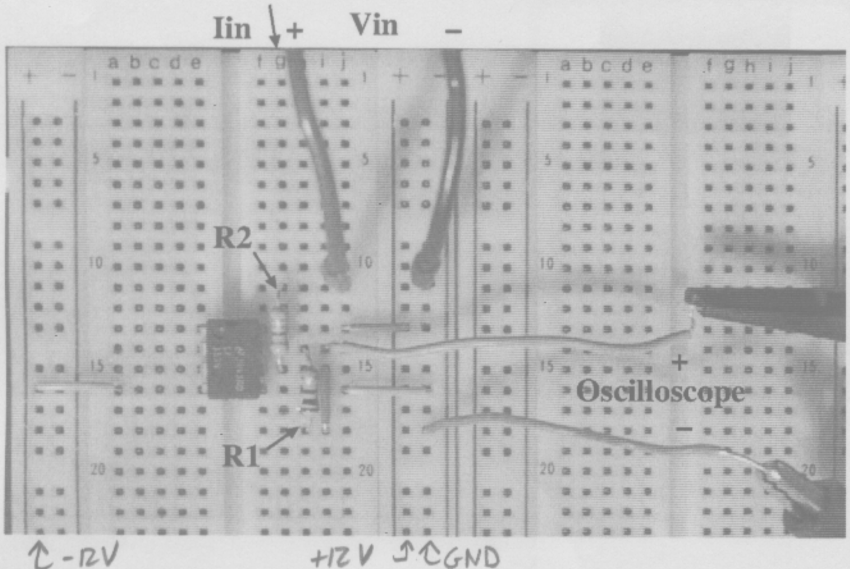
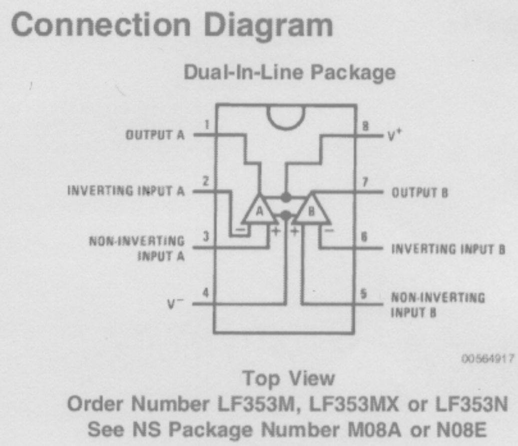
Problem #1 [25 points]





You have built the circuit above in lab using the chip with the included relevant pin diagram, where $R_1 = 20\ \text{k}\Omega$ and $R_2 = 10\ \text{k}\Omega$.

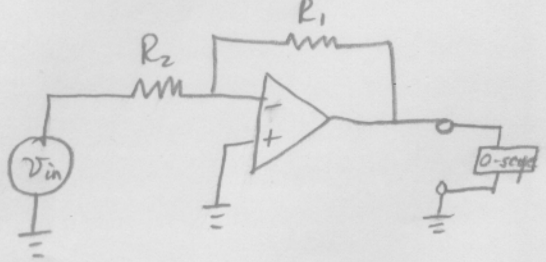
(a) Draw the circuit schematic associated with this photograph, labeling R_1 and R_2, GND, and the connections for V_{in} and the oscilloscope.

(b) Briefly describe how you would go about measuring the input current into this circuit (i_{in}) using the procedures you commonly use in lab.

(c) The power supply has not been attached to this breadboard. Clearly indicate where you would make those connections on the breadboard diagram (-12 V, GND, +12 V).

(d) Your lab partner mistakenly pulls R_1 completely out of your breadboard, but everything else is intact. Sketch the transfer functions of this circuit for V_{in} = [-1.5:1.5] V with and without R_1 in the breadboard on the same plot.

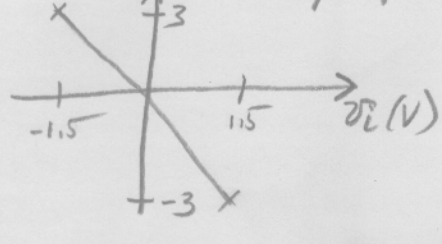
(a)



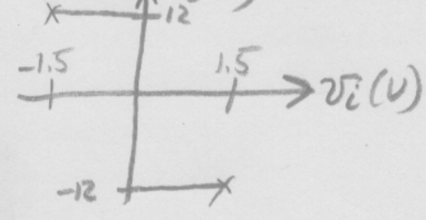
(b) Ammeter in series w/ R_2.

(c) See diagram

(d)



w/o R_1 (no feedback)



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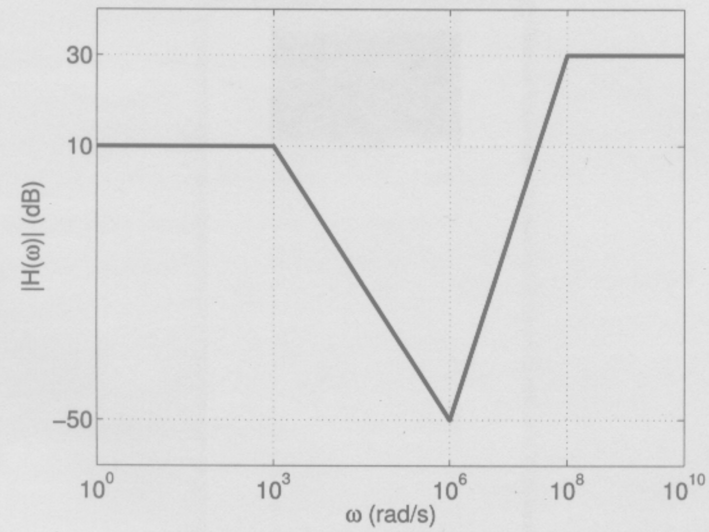
Problem #2 [50 points]



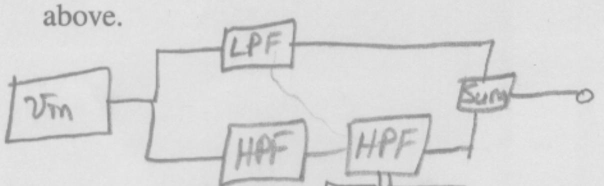
(a) Design a circuit that has a transfer function approximated by the Bode magnitude plot above. Specify all component values, including the power being supplied to any op amps that you choose to use.

(b) What is the maximum peak-to-peak input voltage that your circuit can input and still remain operating in its linear range for an input signal frequency of 10^2 rad/s and 10^{10} rad/s?

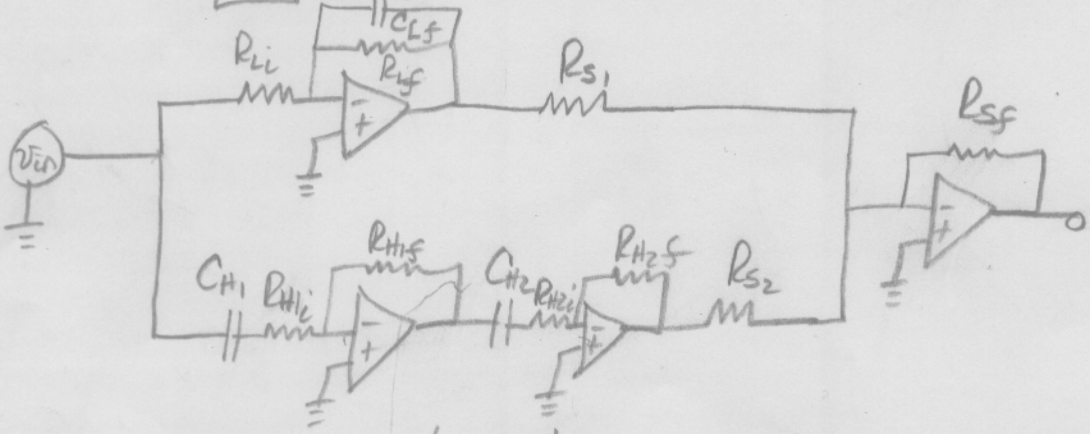
(c) Evaluate Z_{in} and Z_{out} for your circuit as a whole (i.e., from its input and output terminals, respectively).

(d) Sketch the phase of the transfer function of your circuit over the same frequency range as the Bode plot above.

(a)



All op amps powered w/ ±12V.



$\omega_{c_L} = 10^3 \text{ rad/s} = \frac{1}{C_{Lf}R_{Lf}}$

$\uparrow$ kR

$\omega_{cH_1} = \omega_{cH_2} = 10^8 \text{ rad/s} = \frac{1}{C_{H_1}R_{H_1i}} = \frac{1}{C_{H_2}R_{H_2i}}$

kR

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$$G_L = 10^{10/20} = \frac{R_{Lf}}{R_{Li}} = 3.16$$

$$G_H = \sqrt{10^{30/20}} = \frac{R_{H_1f}}{R_{H_1i}} = \frac{R_{H_2f}}{R_{H_2i}} = 31.6$$

$$R_{S_1} = R_{S_2} = R_{Sf}$$

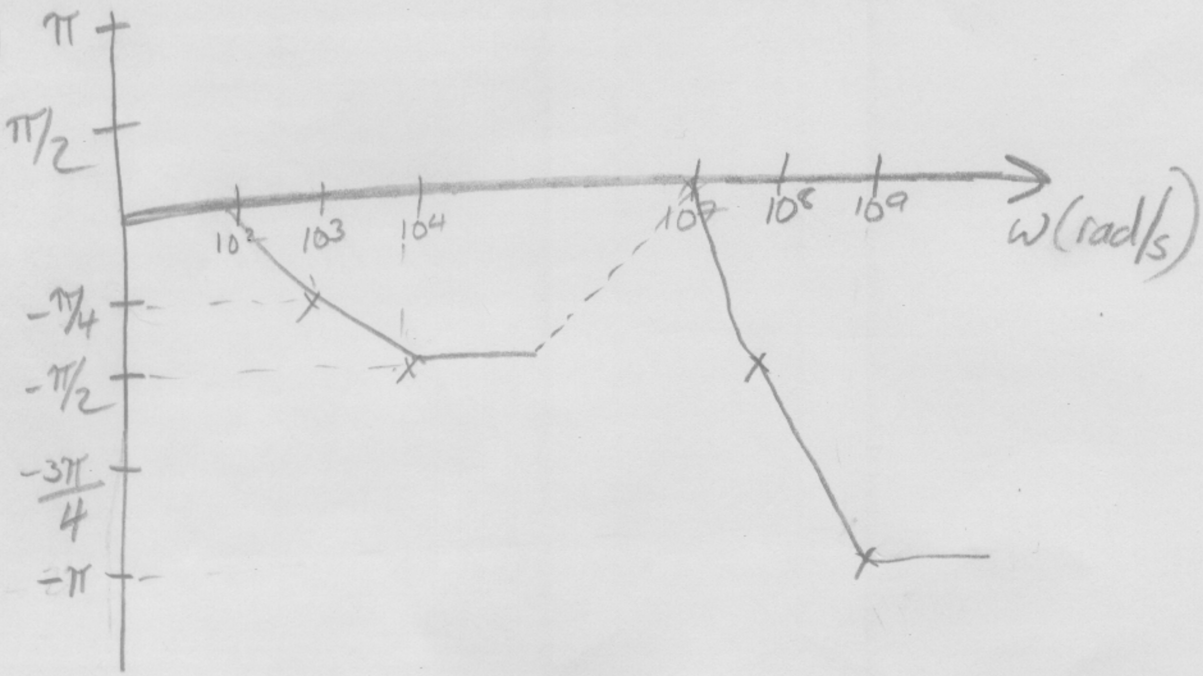
(b) @ 10^2 rad/s : $\frac{12V}{3.16} \cong 3.8\,V \longrightarrow \pm 3.8V$

@ 10^{10} rad/s : $\frac{12V}{31.6} \cong 0.38V \longrightarrow \pm 0.38V$

(c) $Z_{in} = R_{Li} \,//\, (C_{H_1} + R_{H_1i})$

$Z_{out} = 0$

(d)



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Problem #3 [25 points]

An orthopedic surgery lab is growing cells for an experiment in two incubators that must be held within 1 °C of one another for 24 hours. Each incubator has a thermistor in it to measure temperature. The thermistors have a resistance of 1 kΩ at 27 °C (the starting temperature of each incubator), and that resistance varies by 10 Ω / °C (consider the error on these thermistors to be negligible).

Design a circuit that creates a 5 V output signal when there is a ≥ 1 °C temperature difference between the two incubators (NOTE - that is a relative difference in temperature, not an absolute deviation from 27 °C). Be sure to include a block diagram!

Design constraints:

- Use a single Wheatstone bridge as a detection circuit for both thermistors,
- You only have a single power supply that provides ± 12 V for your circuit,
- You can use all analog circuit components, relays and transistors, but no digital logic gates.