

**Midterm 2**  
**EE40**  
**Fall 2012**

**NAME:** \_\_\_\_\_

*Instructions*

Read all of the instructions and all of the questions before beginning the exam.

There are 4 problems in this exam. The total score is 100 points. Points are given next to each problem to help you allocate time. Do not spend all your time on one problem.

Unless otherwise noted on a particular problem, you must show your work in the space provided, on the back of the exam pages or in the extra pages provided at the back of the exam.

Draw a BOX or a CIRCLE around your answers to each problem.

Be sure to provide units where necessary.

GOOD LUCK!

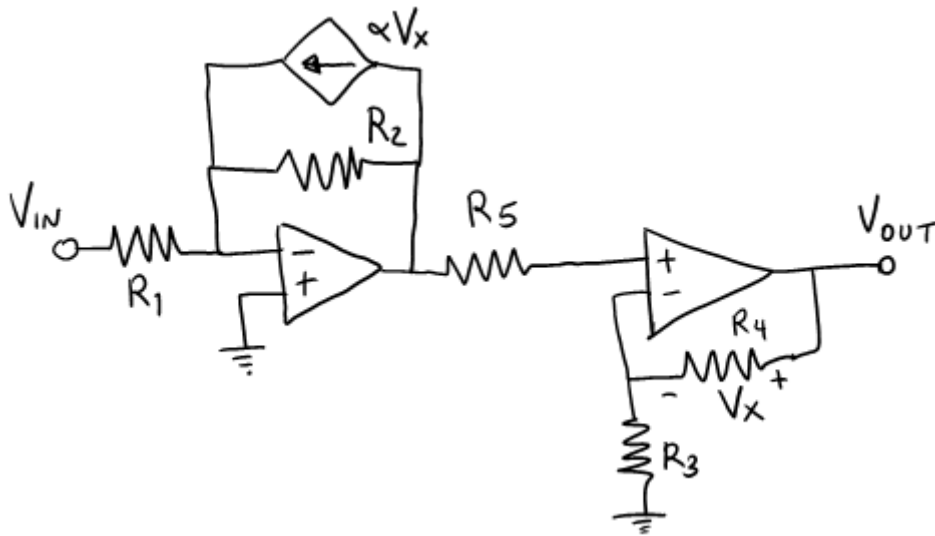
| <b>PROBLEM</b> | <b>POINTS</b> | <b>MAX</b> |
|----------------|---------------|------------|
| <b>1</b>       |               |            |
| <b>2</b>       |               |            |
| <b>3</b>       |               |            |
| <b>4</b>       |               |            |
| <b>5</b>       |               |            |

*“A human being should be able to change a diaper, plan an invasion, butcher a hog, conn a ship, design a building, write a sonnet, balance accounts, build a wall, set a bone, comfort the dying, take orders, give orders, cooperate, act alone, solve equations, analyze a new problem, pitch manure, program a computer, cook a tasty meal, fight efficiently, die gallantly. Specialization is for insects.”*

— Robert A. Heinlein

**Problem 1** *Op amps* (n points)

Consider the following circuit:



In the BOX BELOW, provide the voltage gain of this circuit from  $V_{IN}$  to  $V_{OUT}$ .

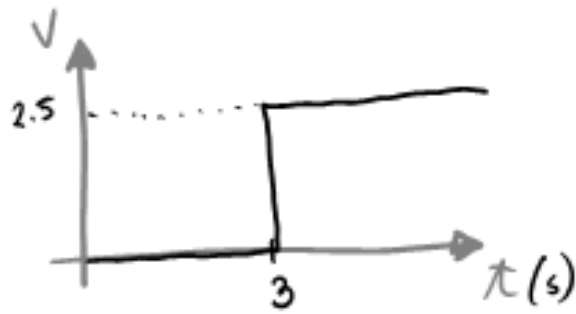
*"Lions and tigers and bears! Oh my!"  
Dorothy, The Wizard of Oz.*

**Problem 2** *R's and C's and L's, oh my!* (n points)

Consider the following circuit:



$v_s(t)$  is provided in the plot below.

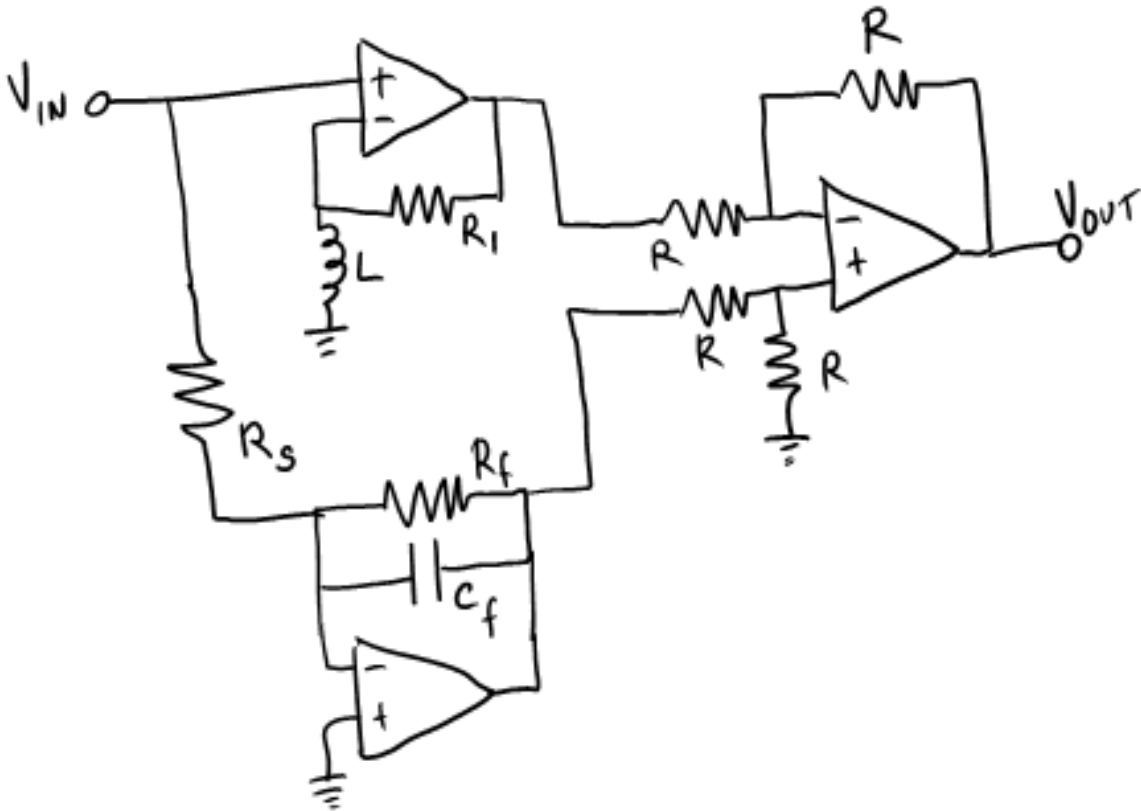


In the BOX BELOW, provide  $v_L(t)$  for all time.

*"The gods do not protect fools. Fools are protected by more capable fools."  
— Larry Niven (Ringworld)*

**Problem 3** Set phasors to stun! [Get it? Ah! I kill me.] (n points)

Consider the circuit below. Assuming  $v_{IN}(t)$  is a sinusoid with a frequency  $\omega$  which has been applied long enough for any transients to disappear, what is  $v_{OUT}(t)/v_{IN}(t)$  as a function of  $\omega$ ?



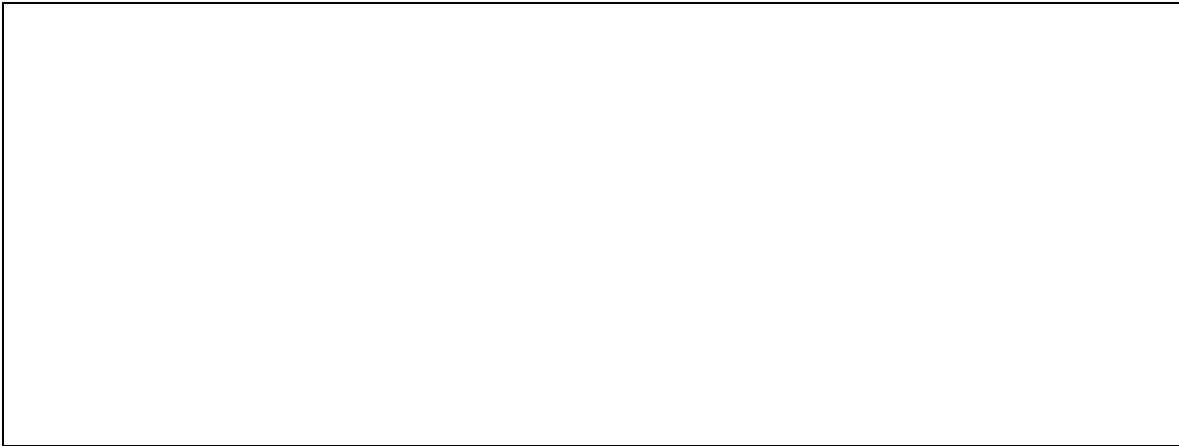
*"Vendrán las iguanas vivas a morder a los hombres que no sueñan"*  
— Federico García Lorca, *Ciudad Sin Sueño*

**Problem 4** *Do you grok in fullness?* (25 points)

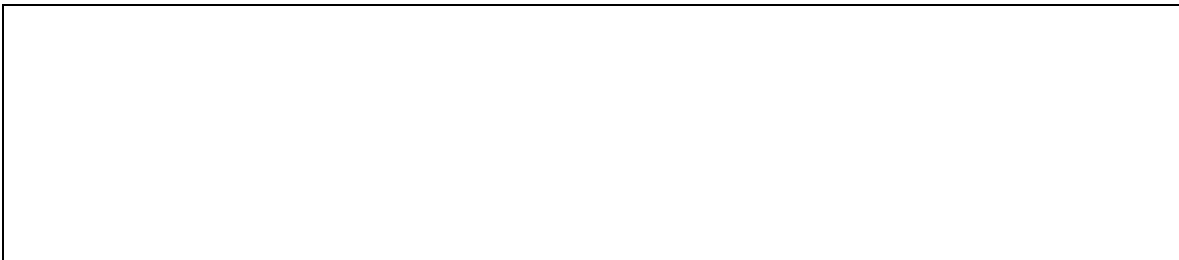
A certain circuit has this voltage transfer function:

$$H(\omega) = \left( \frac{1}{1 + j \frac{\omega}{\omega_c}} \right)^N$$

a) For  $N = 4$ , draw the circuit that produces this transfer function.



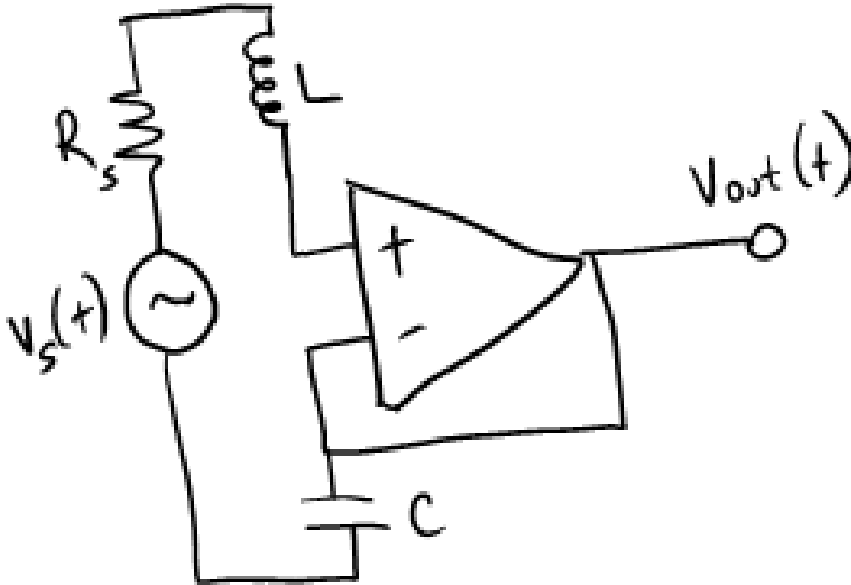
b) **In dB**, what is the magnitude of the transfer function at the cutoff frequency?



*"Don't Panic."*  
— Douglas Adams, *The Hitchhiker's Guide to the Galaxy*

**Problem 5** *A bit more...* (25 points)

Consider the circuit below. Assume a non-ideal op-amp with external component values fixed at  $R_S$ ,  $L$  and  $C$  and internal values of  $R_{IN}$ ,  $R_{OUT}$  and  $A$ .



For what  $v_S(t)$  is  $v_{OUT}(t)$  not phase-shifted relative to  $v_S(t)$ ?