Test 1 - Fall 2011 (100pts max)
Name: Solution

ELECTRONICS I
October 11, 2011

I. (25 pts) A current amplifier has an input resistance $R_i = 1\ \text{k}\Omega$, an output resistance $R_0 = 10\ \text{k}\Omega$, and a short-circuit current gain $A_{is} = 100\text{A/A}$. It is connected between a voltage source $v_s$ of 100 mV with a source resistance of 100 kΩ and a load resistance of 1kΩ.

Calculate the value of $v_0$, $v_0/v_s$, $v_0/v_i$, where $v_i$ is the input voltage to the amplifier.


$v_i = \frac{1}{101}\, 100\ \text{mV}$ $\qquad v_o = A_{is}\, i_i \, \frac{10k \cdot 1k\Omega}{11\ k\Omega}$

$i_i = \frac{v_i}{1k\Omega} \rightarrow v_o = 100 \frac{v_i}{1k} \frac{10k \cdot 1k\Omega}{11\ k\Omega} = 90.9\, v_i$

$\frac{v_o}{v_i} = 90.9\ \text{V/V}$

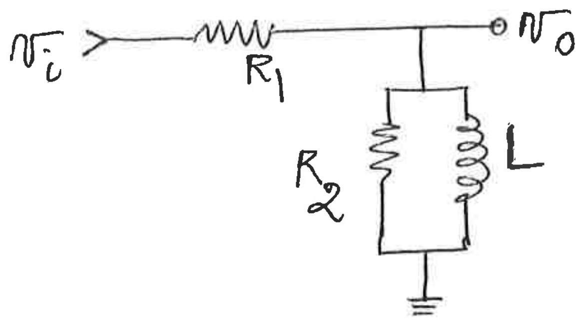
$v_o = 90.9\, v_i = 90\ \text{mV}$

$v_i = \frac{1}{101}\, 100\ \text{mV} = 0.99\ \text{mV} = 99\ 10^{-5}\ \text{V}$

$\frac{v_i}{v_s} = \frac{1}{101} \rightarrow \frac{v_o}{v_s} = \frac{v_o}{v_i}\frac{v_i}{v_s} = \frac{90.9}{101} = 0.9$

II. (25 pts) Calculate the transfer function $T(s) = v_O/v_i$ for the filter shown below.

(a) Is it a low-pass or high-pass filter? Discuss qualitatively.




The T(s) of the filter should be of one of the two forms

$$T(s) = \frac{K}{1+\frac{s}{\omega_0}} \qquad (1)$$

for a low-pass filter, or

$$T(s) = \frac{K}{1+\frac{\omega_0}{s}}, \qquad (2)$$

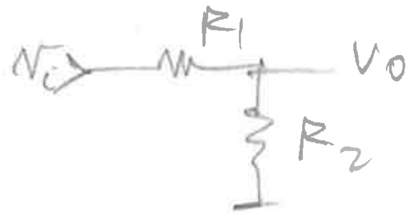
for a high-pass filter.

(b) Find the analytical expressions for K and the 3B break angular frequency $\omega_0$.

High-Pass $\quad Z_L \to 0$ at $\omega = 0 \Rightarrow v_o = 0$

$Z_L \to \infty$ at $\omega = \infty$ $\quad v_o$ finite

$\omega \to \infty$




$\to T(s=\infty) = K = \frac{R_2}{R_1+R_2}$

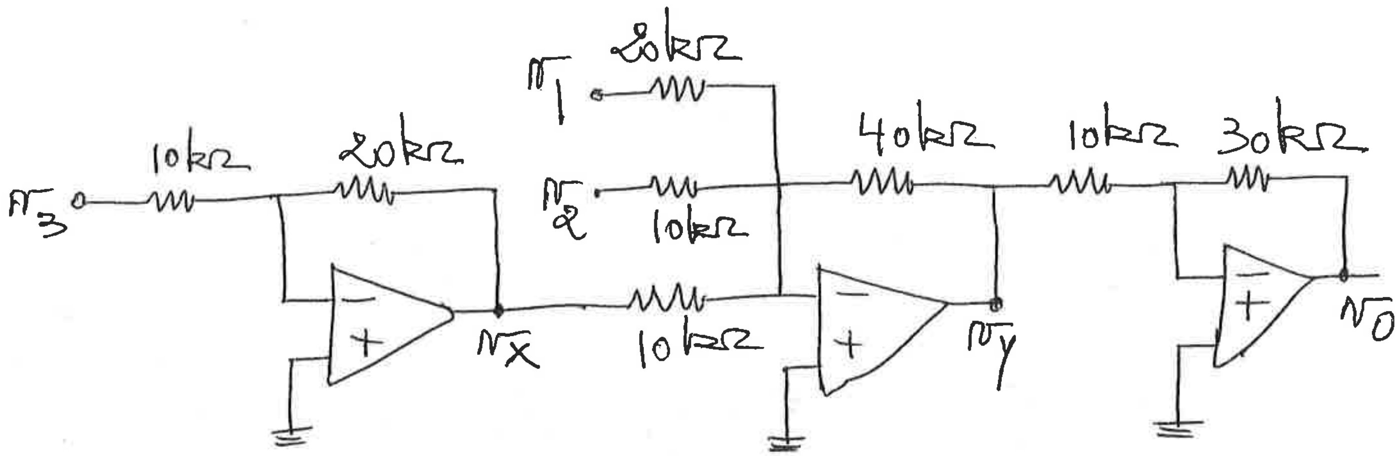
hold L, ground $v_i$, see $(R_1//R_2) \Rightarrow \omega_0 = \frac{1}{\tau}$

$$\tau = \frac{L}{(R_1//R_2)}$$

$$T(s) = \frac{\frac{R_2}{R_1+R_2}}{1 + \frac{(R_1//R_2)}{Ls}}$$

III. (25 pts) In the circuit shown below,

Calculate the voltage $v_0$ in terms $v_1$, $v_2$ and $v_3$. Assume all op-amps are ideal. Work your way from left to right and calculate the intermediate voltages $v_x$ and $v_y$.




$$v_x = -2v_3$$

$$v_y = -2v_1 - 4v_2 - 4v_x$$

$$= -2v_1 - 4v_2 + 8v_3$$

$$v_0 = -3v_y = 6v_1 + 12v_2 - 24v_3$$

IV. (25 pts) Calculate the transfer function $T(s) = v_0/v_i$ for the filter shown below. Assume the op-amp is ideal.

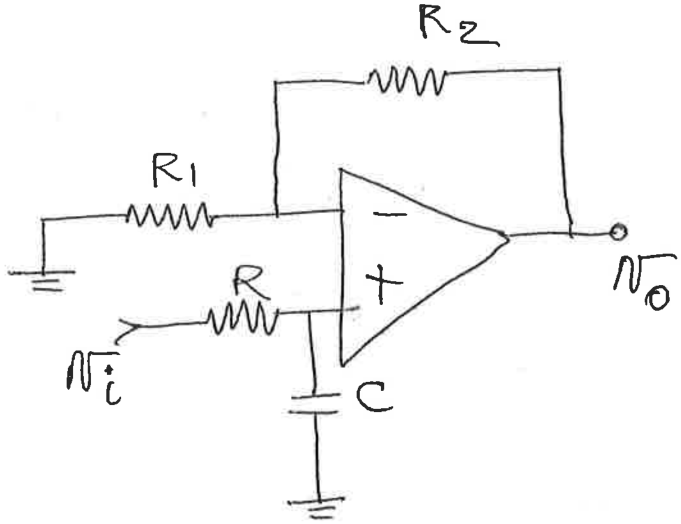
(a) Is it a low-pass or high-pass filter? Discuss qualitatively. → $\omega \to 0 \Rightarrow V_0$ finite

(b) Find the analytical expression for K and the 3dB angular frequency $\omega_0$

$\omega \to \infty$ $V_i \to 0$

$V_0 \to 0$

low-pass




$$\frac{v_+}{v_i} = \frac{1}{1 + \frac{s}{\omega_0}} \qquad \omega_0 = \frac{1}{RC}$$

$$v_- = v_+ \Rightarrow v_0 = \left(1 + \frac{R_2}{R_1}\right) v_+$$

$$T(s) = \frac{v_0}{v_i} = \frac{\left(1 + \frac{R_2}{R_1}\right)}{1 + \frac{s}{\omega_0}} \qquad \omega_0 = \frac{1}{RC}$$