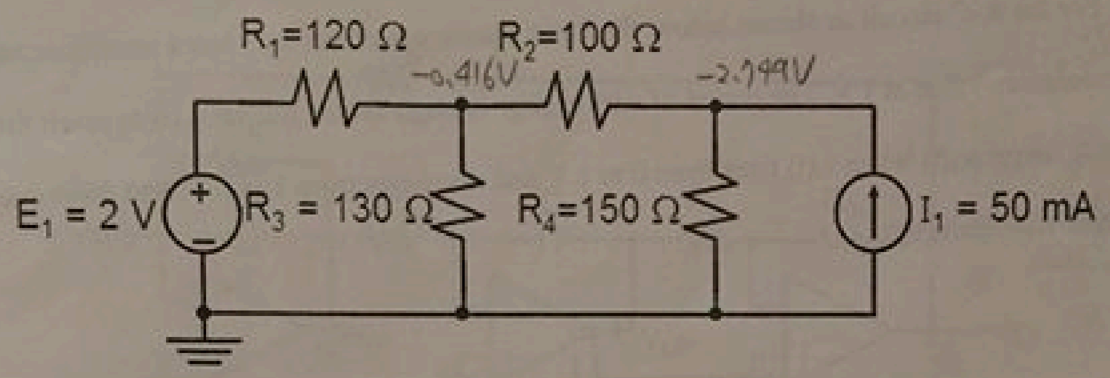
EE 2245 Microelectronics Laboratory

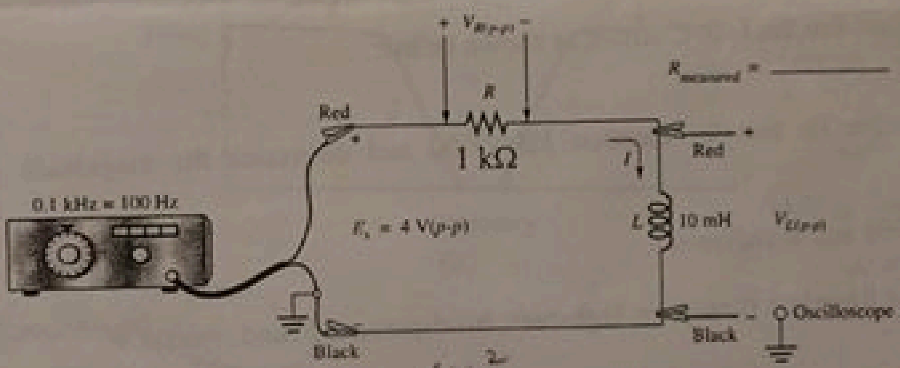
Final Examination, 1/15/2013

. (15%) DC and AC circuits

1) (10%) Please calculate the voltage V_i across each resistor R_i and the accompanying current I_i.



(2) (5%) For the R-L circuit shown below, are the magnitudes of the voltages $V_{R(p\text{-}p)}$ and $V_{L(p\text{-}p)}$ related to the input $E_{s(p\text{-}p)}$ by: $V_{L(p\text{-}p)} + V_{R(p\text{-}p)} = E_{s(p\text{-}p)}$? If yes, please provide your derivation; otherwise please provide your derivation of the correct answer.



$\frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$

2. (15%) Transient Response

(1) (6%) For the R-L-C circuit as shown below, the input $v_i(t)$ is a unit-step and all initial conditions are zero. The input-output relationship is given by $\frac{v_o(s)}{v_i(s)} = \frac{100}{s^2+s+100}$. Please calculate the overshoot and rise time of its step response.

$e^{-at} \leftrightarrow \frac{1}{s+a}$

$e^{-at}\cos\omega t \leftrightarrow \frac{s+a}{(s+a)^2+\omega^2}$

$t_r = 0.165$ s

$M_p = 0.951$

$1 \leftrightarrow \frac{1}{s}$

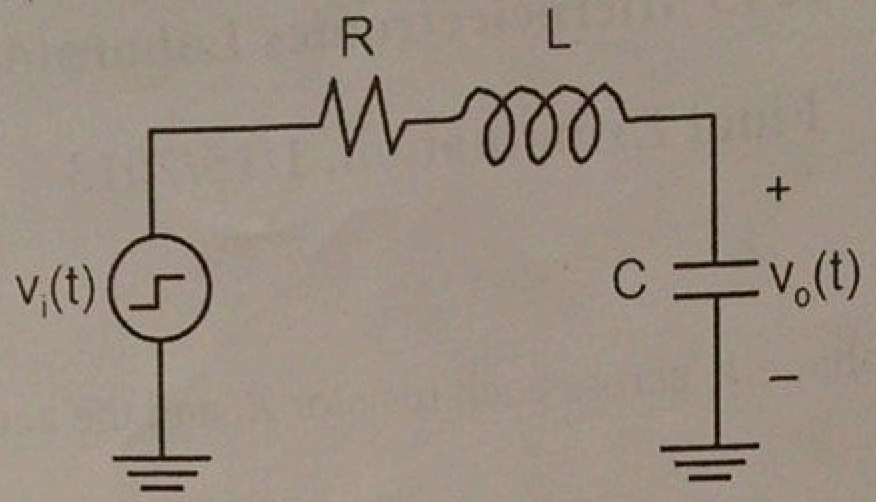
$\cos\omega t \leftrightarrow \frac{s}{s^2+\omega^2}$

$\sin\omega t \leftrightarrow \frac{\omega}{s^2+\omega^2}$

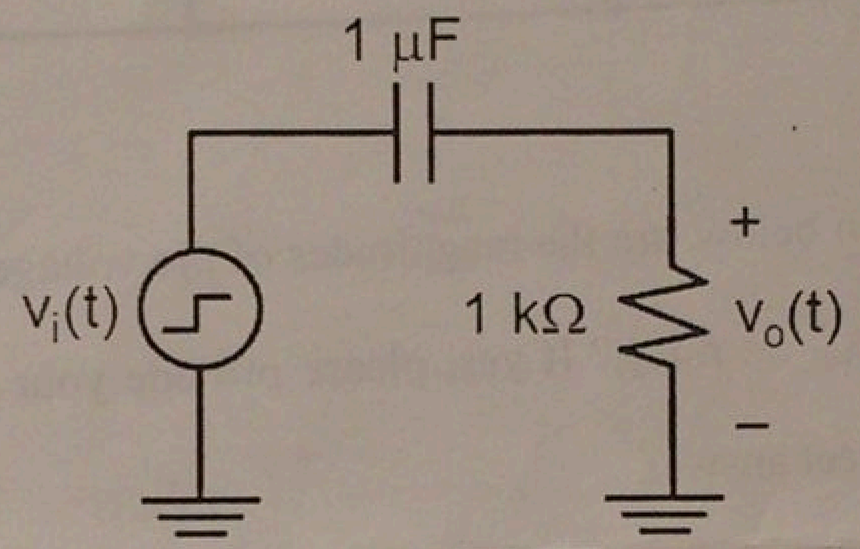
$e^{-at}\sin\omega t \leftrightarrow \frac{\omega}{(s+a)^2+\omega^2}$

$t_r = \frac{\tan^{-1}\left(\frac{-\sqrt{1-\xi^2}}{\xi}\right)}{\omega_n\sqrt{1-\xi^2} = \omega_d}$

$M_p = e^{-\left(\frac{\xi}{\sqrt{1-\xi^2}}\right)}$



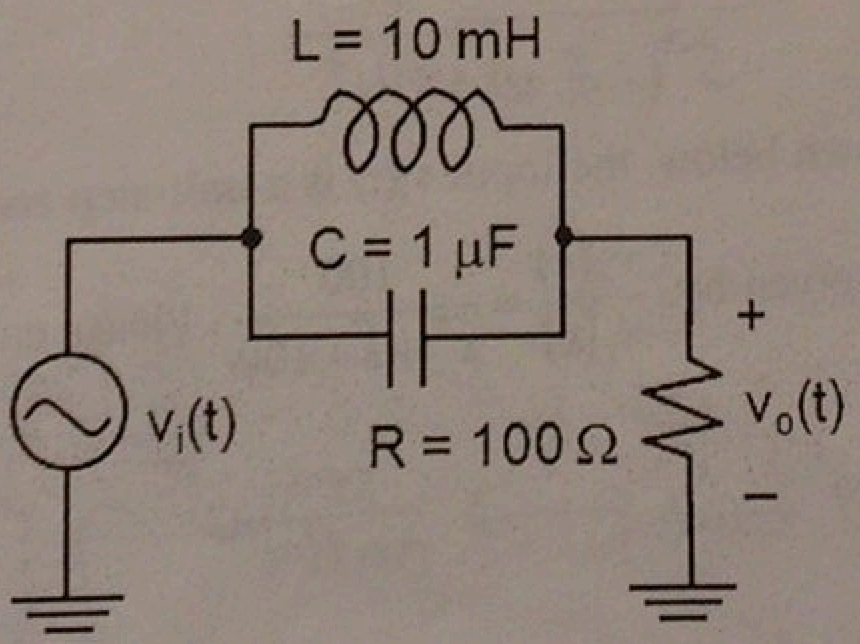
(2) (9%) For the R-C circuit as shown below, the input square waveform $v_i(t)$ has a minimum value at 0 V and a maximum value at 1 V. The period of $v_i(t)$ is large enough for the output $v_o(t)$ to reach the steady state. Please derive $v_o(t)$ when $v_i(t)$ rises from 0 to 1 V and decreases from 1 to 0 V, and draw one period of the output waveform $v_o(t)$.



3. (10%) Passive Filter: For the L-R-C circuit as shown below:

(1) (7%) Please derive its transfer function $V_o(s)/V_i(s)$ and determine the magnitude $\left|\frac{V_o(j\omega)}{V_i(j\omega)}\right|$ at frequency $\omega = 0$, 10000 and ∞ radian/sec.

(2) (3%) What type of filter is it (low-pass, high-pass, band-pass, and band reject)?



4. (16%) Active Filter

Consider the circuit shown in Fig.4a. Assume all Opamps are ideal Opamp and that the resistors (R_i)

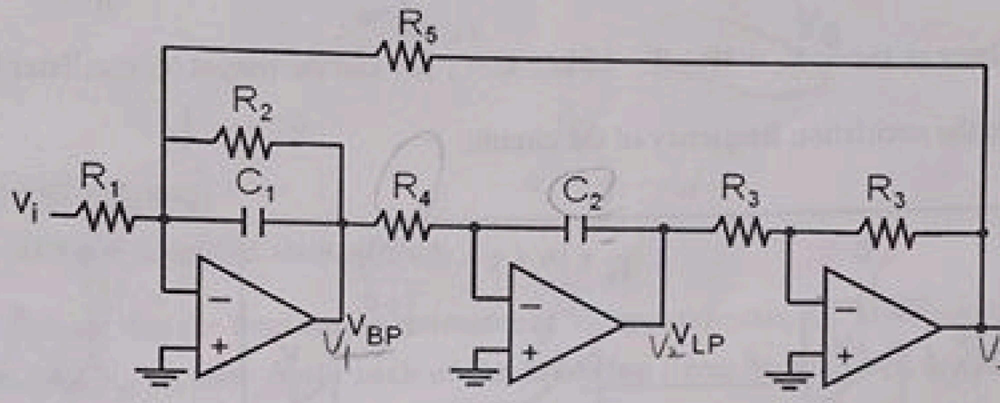
$C_1\uparrow$, $C_2\uparrow$

$Q\uparrow$ $Q\downarrow$

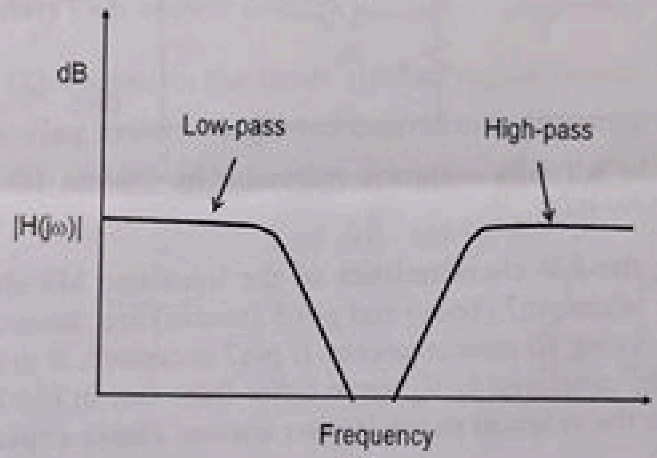
and capacitors (C_i) are selected to let the transfer function $H(s)=V_{BP}(s)/V_i(s)$ have band-pass characteristics.

(1) (10%) Please derive the transfer function $H(s) = V_{BP}(s)/V_i(s)$ and then determine whether the quality factor will increase or decrease by increasing C_1 and C_2, respectively.

(2) (6%) Would it be possible to modify the transfer function $H(s)=V_{BP}(s)/V_i(s)$ to have **band-stop characteristics**, as shown in Fig.4b? If no, please **explain** your answer. If yes, please describe clearly **how the resistors (R_i) and capacitors (C_i) should be changed.**



(a)



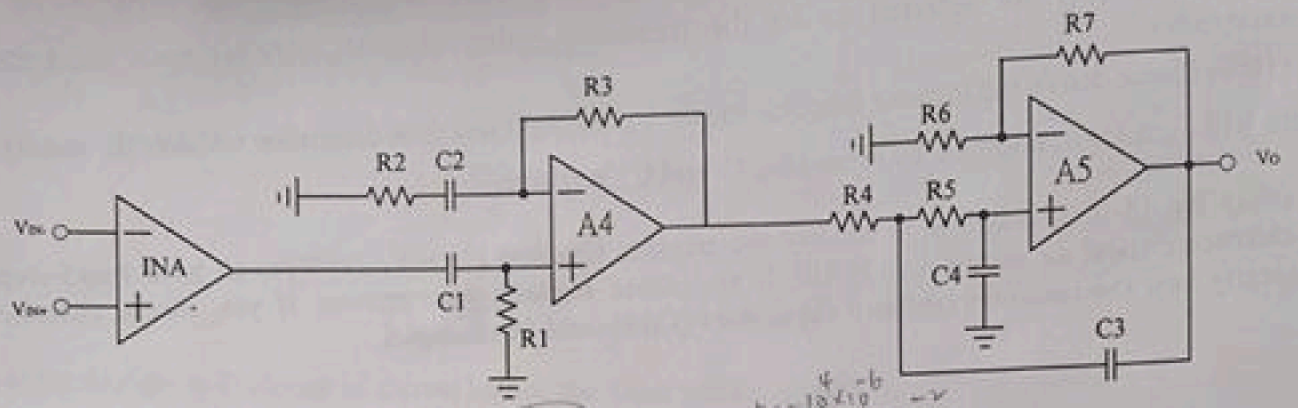
(b)

5. (10%) ECG Recording Circuit

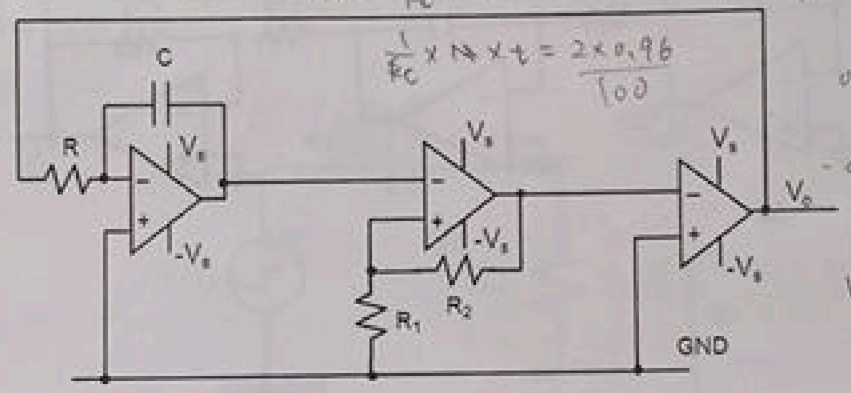
Consider the ECG recording circuit shown below.

1) (5%) If the ECG recordings contain too much 60-Hz interferences, how could we modify the circuit to reduce interferences? Describe clearly **how the resistors (R_i) and capacitors (C_i) should be changed** in your answer. Please **explain** your answers clearly.

2) (5%) If the ECG recordings contain too-much low-frequency (<1Hz) interferences, how could we modify the circuit to reduce interferences? Describe clearly **how the resistors (R_i) and capacitors (C_i) should be changed** in your answer. Please **explain** your answers clearly.

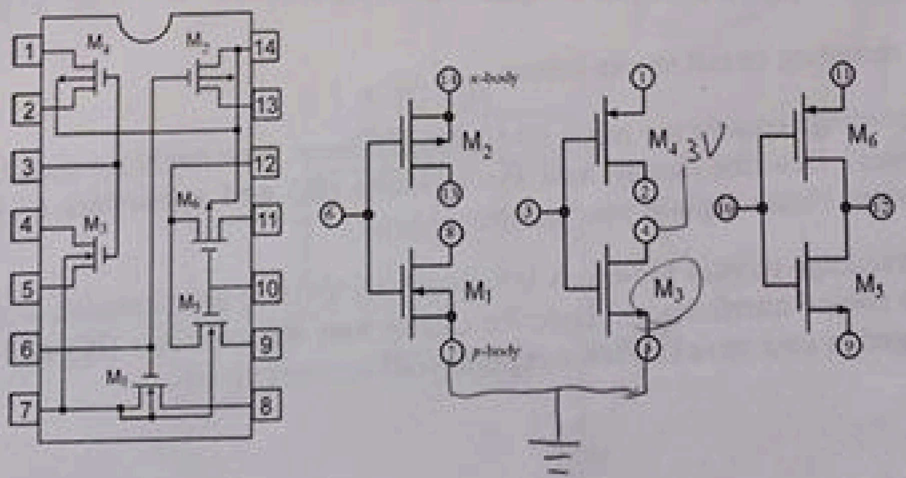


6. (10%) For the oscillator as show, $R_1 = 4R_2$, $R = 10\ k\Omega$, $C = 1\ \mu F$, and the output V_o oscillates between ± 12 V. Please calculate the oscillation frequency of the circuit.



7. (8%) DC characteristics of MOSFETs

Assume that we are measuring the I-V characteristics of the transistor M3 shown in Fig.7a. Fig.7b shows the measured I_d-V_g curve when pin7 (body) and pin 5 (source) are connected together to 0V. Let pin4 (drain) be connected to 3V during all measurements. If pin7 is connected to a higher voltage (0.3V) than pin 5 instead, how would the measured I_d-V_g curve differ from that in Fig.7b? Please **plot clearly how the new curve differs from the original curve** in your answer. Please **explain** your answer clearly (Hint : Consider the body effect)



(a)