ECE 113 - Spring 2015	
Final Exam	
Student Name:	
Problem 1 (25 pts)	
Problem 2 (26 pts)	
Problem 3 (25 pts)	
Problem 4 (24 pts)	
Total	

Problem 1: Circuit Analysis (25pts)

Part I (15pts)

The switch in Fig. 1.1 has been in position *A* for a long time and is moved to position *B* at t = 0. The circuit parameters are $R = 1\Omega$, $V_A = 5V$, $I_B = 1A$, $L = 1H$, $C = 1F$ (V_A and I_B are DC sources).

a) Find the initial voltage $v_c(0^-)$ across the capacitor and initial current $i_L(0^-)$ through the inductor. *(3pts)*

b) Solve for $V_C(s)$ for t≥ 0 using the component values supplied above. *(6pts)*

c) Use the inverse Laplace transformation to obtain $v_c(t)$. *(2pts)*

d) Obtain a plot of $v_c(t)$ from t=0 to 10 seconds in MATLAB, and comment on the nature of your plot. *(4pts)*

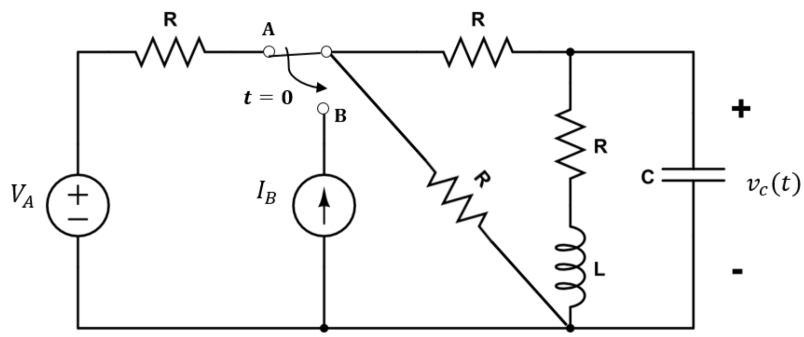

Fig. 1.1

Part II (10pts)

In bipolar transistor amplifier design, a by-pass capacitor is often connected across the emitter resistor R_E to effectively short out the emitter resistor at certain signal frequencies; thereby improving the transistor gain for the desired ac signals. The circuit in Fig. 1.2(a) is an example of a common-emitter amplifier.

a) Reduce the circuit to its Thévenin equivalent ($R_S = 12\Omega$, $R_\pi = 3\Omega$, $R_E = 3\Omega$, $R_L = 1\Omega$, and $\beta = 9$), as shown in Fig. 1.2(b). *(8pts)*
Hint*: Find the open circuit voltage and short circuit current to solve for* $Z_T(s)$.

b) Find the value of the by-pass capacitor C_E in Fig. 1.2(b), so that the voltage transfer function $\frac{V_C(s)}{V_T(s)}$ has a pole at $s = -1000\ rad/s$. *(2pts)*

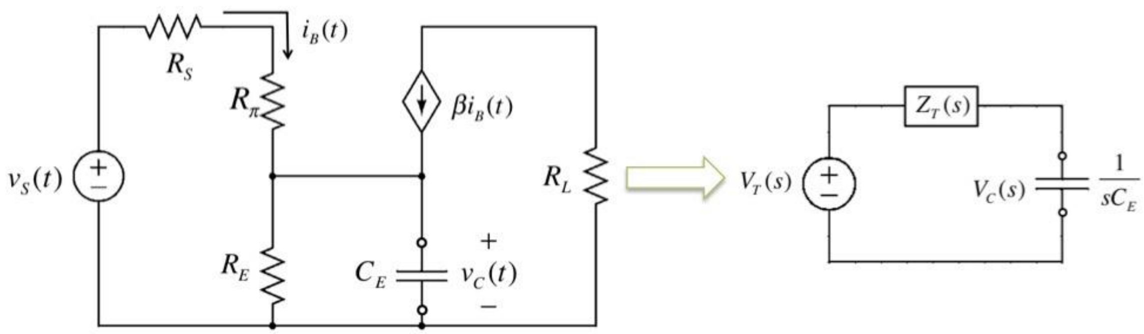

Fig. 1.2

Problem 2: Transfer Function & Circuit Design (26pts)

Part I (16pts)

Consider the cascade-connected circuits below with the following components: $C_1 = 0.1\mu F$, $R_1 = 20K\Omega$, $C_2 = 0.2\mu F$, $R_2 = 10K\Omega$, $R_3 = 10K\Omega$, $R_4 = 5K\Omega$, $C_3 = 0.02\mu F$ and $R_f = 100K\Omega$.

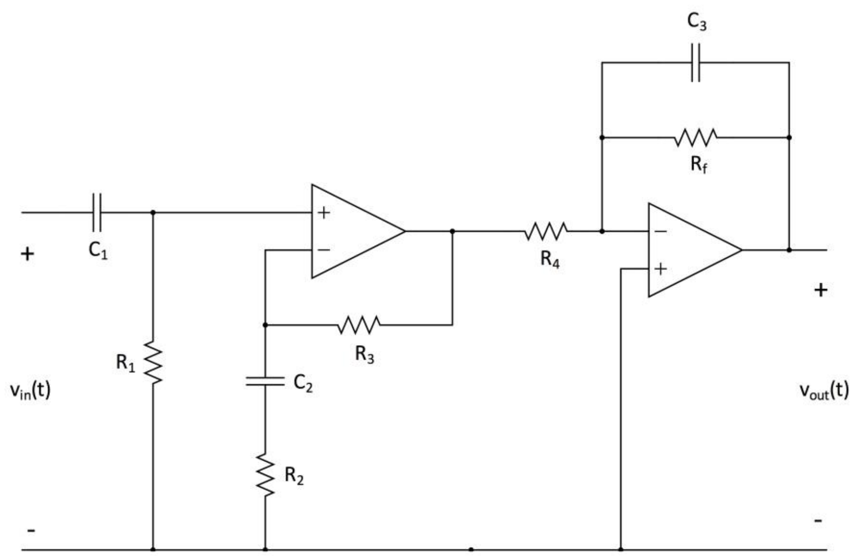

Fig. 2.1

a) Find the voltage transfer function $T_v(s) = \frac{V_{out}(s)}{V_{in}(s)}$. *(6pts)*
b) Find the step response $g(t)$ of the circuit. *(2pts)*
c) Find the sinusoidal steady state response of the circuit, for $V_{in} = 5\cos(25000t + 20^{\circ})$. *(5pts)*
d) Change the value of R_f such that the step response of the circuit is now $g_1(t) = [-2 \times 10^4 te^{-500t}]u(t)$. *(3pts)*

Part II (10pts)

a) Design a circuit that realizes the following transfer function:

$$T_v(s) \; = \frac{4(2s+1)}{(s+2)(s+1)}$$

Explain your design choices, considering issues of loading, device count, power, ease of implementation, etc. *(8pts)*

b) Scale the circuit so that the components use the following practical values:
1pF < C <10mF, 10nH < L < 10mH, 10Ω < R < 10 $M\Omega$ *(2pts)*

Problem 3: Frequency Response & Filters (25pts)

Part I (16pts)

Consider the circuit in Fig. 3.1 with the following components: $R_1 = 20K\Omega$, $R_2 = 10K\Omega$, $R_3 = 30K\Omega$ and $C_1 = 0.2\mu F$.

a) Find the driving point impedance Zin(s) of the circuit. *(3pts)*
b) Obtain the dc gain, infinite frequency gain, and cutoff frequency. Identify the type of gain response. *(6pts)*
c) Calculate the gain at ω=0.1ω_c, ω_c, and 10ω_c in dB, and sketch the frequency response. *(4pts)*
d) Select component values in order to increase the pass band gain to 20dB without changing the cutoff frequency. *(3pts)*

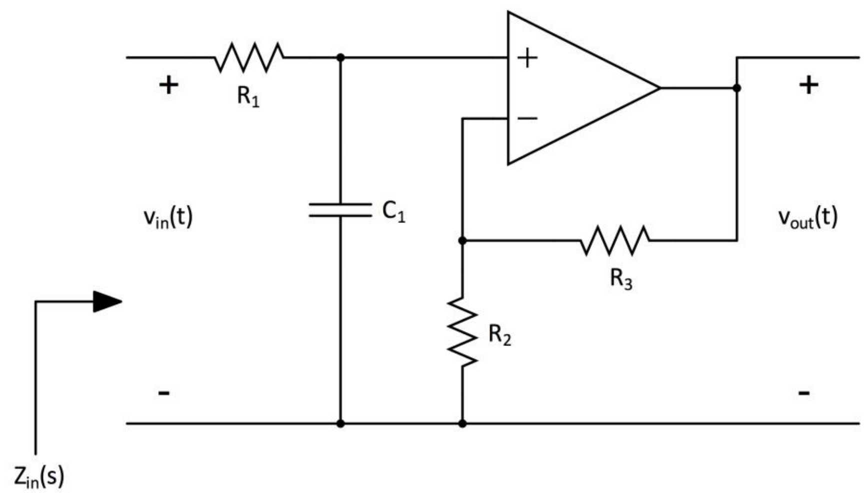

Fig. 3.1

Part II (9pts)

A young designer needed to design a filter whose cutoff frequency is 500 rad/s and gain is 4. The designer was perplexed when no matter how the stages shown in Fig. 3.2 are connected the results are not what were expected. Your goal is to explain the problem first, and then help him construct the circuit to achieve the desired results ($R_1 = 100\Omega$, $R_2 = 10K\Omega$, $R_3 = 10K\Omega$, $R_4 = 10K\Omega$, $R_5 = 70K\Omega$, $R_6 = 15K\Omega$, $C_1 = 0.1uF$). Verify that your new connection achieves the required gain (4), and cutoff frequency (500 rad/s).

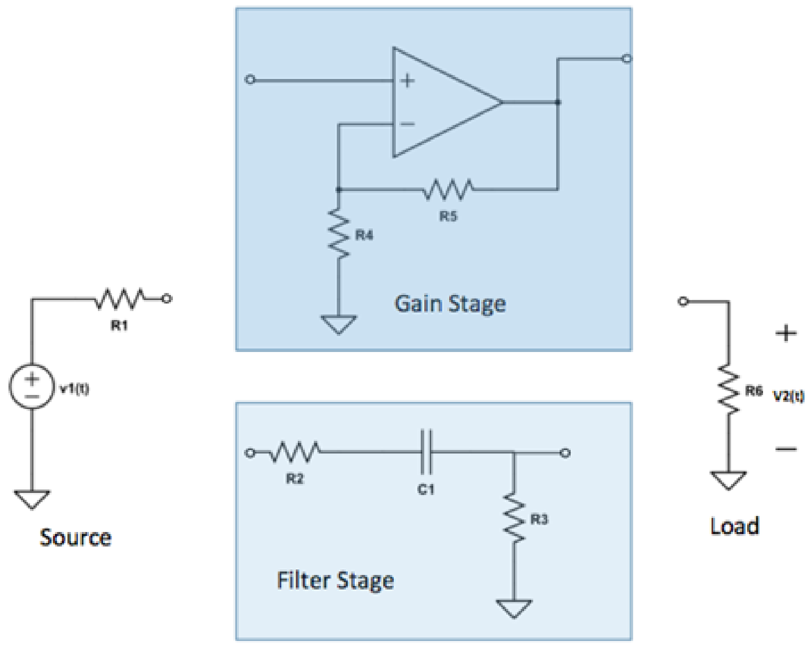

Fig. 3.2

Problem 4: Fourier Analysis & Convolution (24pts)

Part I (10pts)

a) Given that $f(t) = e^{-a(t-t_0)}u(t-t_0)$, where a > 0, determine the Fourier transform $F(\omega)$ of $f(t)$. *(2pts)*

b) Given that $g(t) = \frac{1}{a+jt}$, where a > 0, determine the Fourier transform $G(\omega)$ of $g(t)$ using the *duality property* and the result from part (a). *(2pts)*

c) Confirm the result of part (b) by calculating $g(t)$ from $G(\omega)$, using the inverse Fourier transform *integral*. *(3pts)*

d) The impulse responses of three linear time-invariant circuits are $h_1(t) = 3u(t)$, $h_2(t) = 2e^{-t}u(t)$ and $h_3(t) = 5e^{-3t}u(t)$. The circuits are connected as shown in Fig. 4.1. What is the step response g(t) of the overall connection? *(3pts)*

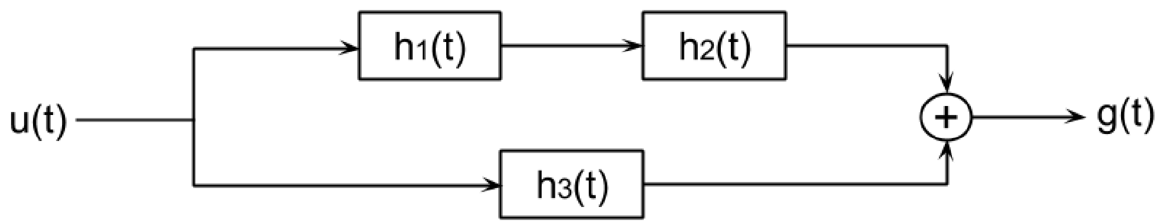

Fig. 4.1

Part II (14pts)

The periodic full-wave rectified sine wave (Fig. 4.2(a)) is applied to the RLC circuit (Fig. 4.2(b)).

a) Use the results in your textbook Figure 13-4 to find the Fourier series expression of the waveform in Fig. 4.2(a) for $V_A = 10V$ and $T_0 = 400\pi\ \mu s$. *(4pts)*

b) Given that v(t) drives the circuit of Fig. 4.2(b), find the amplitude of the first four nonzero terms in the Fourier series for $i(t)$ when $R = 1\Omega$, $L = 8mH$, and $C = 0.2\mu F$. What term in the Fourier series dominates the response? Explain. *(8pts)*

c) Sketch the amplitude spectrum of $i(t)$. *(2pts)*

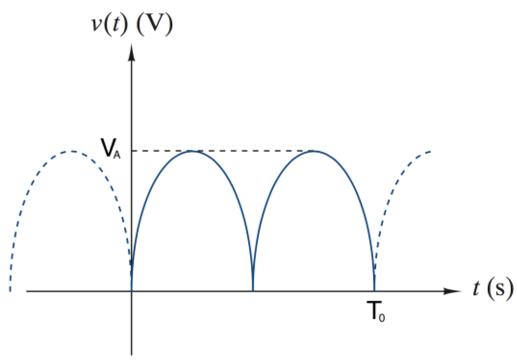

Fig. 4.2 (a)

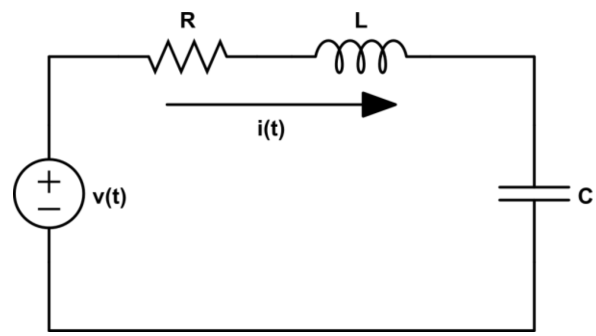

Fig. 4.2 (b)