# American University of Beirut
## Department of Electrical and Computer Engineering
## EECE 290 – Analog Signal Processing

**Quiz II**

**Open Book and Notes**
**No Programmable Calculators**
**No Wireless Devices**

**90 minutes**
**April 10, 2018**

**Name: ___________________________**

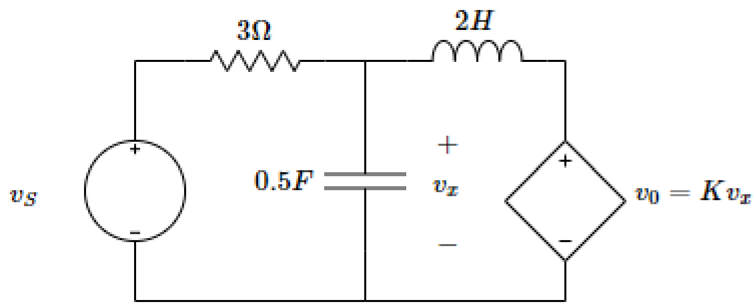
**Instructor Name:______________________________**

# This question sheet must only be returned.

**This exam has 12 problems, 50 pts, and 8 pages.**

## Problem 1(4 pts)

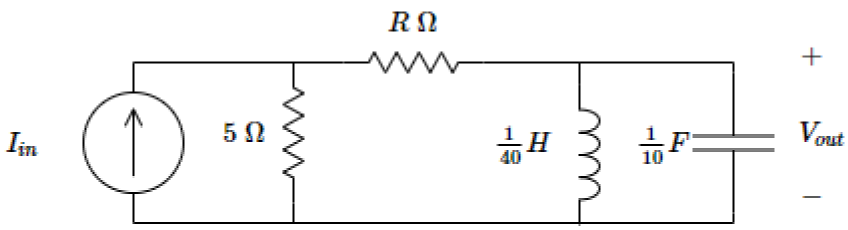
Assume zero initial conditions for the inductance and for the capacitor. Find the transfer function $H(s) = \frac{V_0(s)}{V_s(s)}$ of the circuit below for K=0.5, 1, 3




| Version a | Version b | Version c |
|---|---|---|
| a. $H(s) = \frac{s}{3s^2+2s+4.5}$ | a. $H(s) = \frac{s}{3s^2+2s+1.5}$ | a. $H(s) = \frac{s}{3s^2+2s+1.5}$ |
| b. $H(s) = \frac{1}{3s+1}$ | b. $H(s) = \frac{1}{3s+1}$ | b. $H(s) = \frac{1}{3s+1}$ |
| c. $H(s) = \frac{2s}{3s^2+2s+6}$ | c. $H(s) = \frac{2s}{3s^2+2s+6}$ | c. $H(s) = \frac{2s}{3s^2+2s+6}$ |
| d. $H(s) = \frac{6s}{3s^2+2s+12}$ | d. $H(s) = \frac{6s}{3s^2+2s+12}$ | d. $H(s) = \frac{6s}{3s^2+2s+12}$ |
| e. None of the above | e. None of the above | e. None of the above |

## Problem 2 (4 pts)

For the circuit shown below, let $I_{in}(s)$ be the input and $V_{out}(s)$ be the output. Determine the system transfer function $H(s) = \frac{V_{out}(s)}{I_{in}(s)}$ for R=5, 10, 15 Ω, assuming zero initial conditions for both the inductor and capacitor.



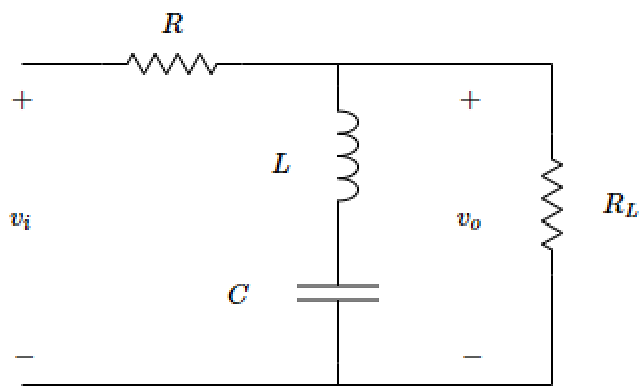

(Hint: Convert the current source to a voltage source and back to a current source)

| Version a | Version b | Version c |
|---|---|---|
| a. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{15s^2+10s+6000}$ | a. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{10s^2+10s+4000}$ | a. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{20s^2+10s+8000}$ |
| b. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{10s^2+10s+4000}$ | b. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{20s^2+10s+8000}$ | b. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{10s^2+10s+4000}$ |

| | | |
|---|---|---|
| c. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{20s^2+10s+8000}$<br>d. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{25s^2+100s+1000}$<br>e. None of the above | c. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{25s^2+100s+1000}$<br>d. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{15s^2+10s+6000}$<br>e. None of the above | c. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{15s^2+10s+6000}$<br>d. $\frac{V_{out}(s)}{I_{in}(s)} = \frac{50s}{25s^2+100s+1000}$<br>e. None of the above |

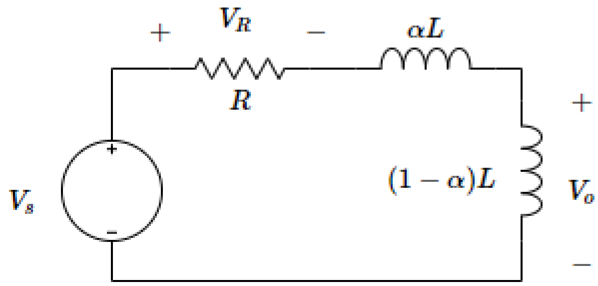
## Problem 4 (4 pts)

If R={10,20,30} Ω, L=1$\mu F$, C=4 pF. Find the quality factor of the filter




| Version a | Version b | Version c |
|---|---|---|
| a. $Q = 25\left(1+\frac{20}{R_L}\right)$<br>b. $Q = \frac{50}{3}\left(1+\frac{30}{R_L}\right)$<br>c. $Q = \frac{50}{4}\left(1+\frac{40}{R_L}\right)$<br>d. $Q = 50\left(1+\frac{10}{R_L}\right)$<br>e. None of the above | a. $Q = 50\left(1+\frac{10}{R_L}\right)$<br>b. $Q = 25\left(1+\frac{20}{R_L}\right)$<br>c. $Q = \frac{50}{3}\left(1+\frac{30}{R_L}\right)$<br>d. $Q = \frac{50}{4}\left(1+\frac{40}{R_L}\right)$<br>e. None of the above | a. $Q = 50\left(1+\frac{10}{R_L}\right)$<br>b. $Q = 25\left(1+\frac{20}{R_L}\right)$<br>c. $Q = \frac{50}{3}\left(1+\frac{30}{R_L}\right)$<br>d. $Q = \frac{50}{4}\left(1+\frac{40}{R_L}\right)$<br>e. None of the above |

The following figure represents the circuit to be used to solve Problem 5, 6 and 7. Note that α=0.4, 0.6, 0.8




**Problem 5 (4 pts)**
What is the transfer function of $V_R/V_s$? What is the cutoff frequency?

| Version a | Version b | Version c |
|---|---|---|
| a. $H(j\omega) = \frac{\alpha}{R+j\omega L}, \omega_c = \frac{L}{R}$<br>b. $H(j\omega) = \frac{\alpha R}{R+j\omega L}, \omega_c = \frac{\alpha L}{R}$<br>c. $H(j\omega) = \frac{R}{R+j\omega L}, \omega_c = \frac{L}{R}$<br>d. $H(j\omega) = \frac{R}{R+j\alpha\omega L}, \omega_c = \frac{\alpha L}{R}$<br>e. None of the above | a. $H(j\omega) = \frac{\alpha}{R+j\omega L}, \omega_c = \frac{L}{R}$<br>b. $H(j\omega) = \frac{\alpha R}{R+j\omega L}, \omega_c = \frac{\alpha L}{R}$<br>c. $H(j\omega) = \frac{R}{R+j\alpha\omega L}, \omega_c = \frac{\alpha L}{R}$<br>d. $H(j\omega) = \frac{R}{R+j\omega L}, \omega_c = \frac{L}{R}$<br>e. None of the above | a. $H(j\omega) = \frac{R}{R+j\omega L}, \omega_c = \frac{L}{R}$<br>b. $H(j\omega) = \frac{\alpha}{R+j\omega L}, \omega_c = \frac{\alpha L}{R}$<br>c. $H(j\omega) = \frac{\alpha R}{R+j\omega L}, \omega_c = \frac{\alpha L}{R}$<br>d. $H(j\omega) = \frac{R}{R+j\alpha\omega L}, \omega_c = \frac{L}{R}$<br>e. None of the above |

**Problem 6 (4 pts)**
What is the transfer function of $V_o/V_s$?

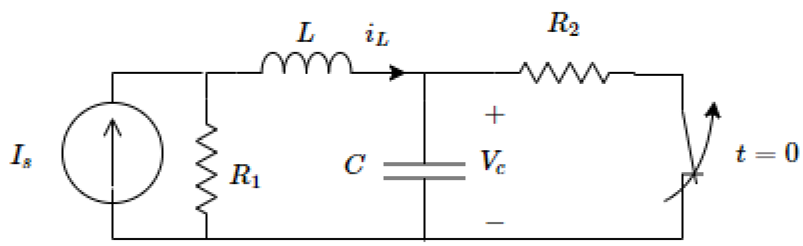
| Version a | Version b | Version c |
|---|---|---|
| a. $H(j\omega) = \frac{\alpha j\omega L}{R+j\alpha\omega L}$<br>b. $H(j\omega) = \frac{(1-\alpha)j\omega L}{R+j(1-\alpha)\omega L}$<br>c. $H(j\omega) = \frac{\alpha j\omega L}{R+j\omega L}$<br>d. $H(j\omega) = \frac{(1-\alpha)j\omega L}{R+j\omega L}$<br>e. None of the above | a. $H(j\omega) = \frac{(1-\alpha)j\omega L}{R+j\omega L}$<br>b. $H(j\omega) = \frac{\alpha j\omega L}{R+j\alpha\omega L}$<br>c. $H(j\omega) = \frac{(1-\alpha)j\omega L}{R+j(1-\alpha)\omega L}$<br>d. $H(j\omega) = \frac{\alpha j\omega L}{R+j\omega L}$<br>e. None of the above | a. $H(j\omega) = \frac{\alpha j\omega L}{R+j\alpha\omega L}$<br>b. $H(j\omega) = \frac{(1-\alpha)j\omega L}{R+j\omega L}$<br>c. $H(j\omega) = \frac{(1-\alpha)j\omega L}{R+j(1-\alpha)\omega L}$<br>d. $H(j\omega) = \frac{\alpha j\omega L}{R+j\omega L}$<br>e. None of the above |

**Problem 7 (2 pts)**
What is the gain of $V_0/V_s$ at the cutoff frequency?

| Version a | Version b | Version c |
|---|---|---|
| a. $0.6/\sqrt{2}$<br>b. $0.4/\sqrt{2}$<br>c. $1/\sqrt{2}$<br>d. 0.6<br>e. None of the above | a. $0.6/\sqrt{2}$<br>b. $0.4/\sqrt{2}$<br>c. $1/\sqrt{2}$<br>d. 0.4<br>e. None of the above | a. 0.2<br>b. $0.8/\sqrt{2}$<br>c. $0.2/\sqrt{2}$<br>d. $1/\sqrt{2}$<br>e. None of the above |

The following figure represents the circuit to be used to solve Problem 8, 9 and 10.

If $I_s$ = {3, 6, 9} A, $R_1$=6 Ω, $R_2$=12 Ω, L= 3 H, C= 1 F. The switch opens at t=0, after having been closed for a long time.




## Problem 8 (2 pts)

What is the value of $i_L(0^+)$?

| Version a | Version b | Version c |
|---|---|---|
| a. 2 A | a. 1 A | a. 1 A |
| b. 1 A | b. 3 A | b. 2 A |
| c. 3 A | c. 2 A | c. 4 A |
| d. 4 A | d. 4 A | d. 3 A |
| e. None of the above | e. None of the above | e. None of the above |

## Problem 9 (2 pts)

What is the value of $v_C(0^+)$?

| Version a | Version b | Version c |
|---|---|---|
| a. 9 V | a. 9 V | a. 36 V |
| b. 36 V | b. 24 V | b. 9 V |
| c. 12 V | c. 36 V | c. 12 V |
| d. 24 V | d. 12 V | d. 24 V |
| e. None of the above | e. None of the above | e. None of the above |

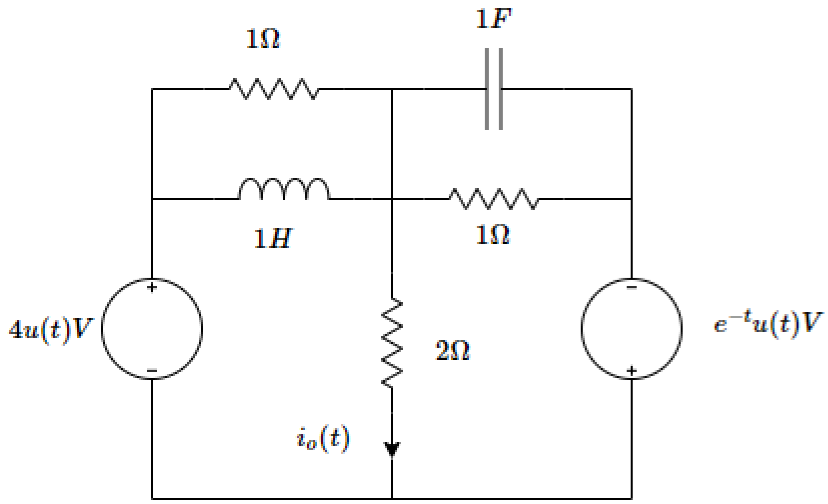
## Problem 10 (4 pts)

What is the expression for $I_L(s)$?

| Version a | Version b | Version c |
|---|---|---|
| a. $\frac{6s+12}{3s^2+6s+1}$ | a. $\frac{6s+12}{3s^2+6s+1}$ | a. $\frac{3s+6}{3s^2+6s+1}$ |
| b. $\frac{3s+6}{3s^2+6s+1}$ | b. $\frac{3s+6}{3s^2+6s+1}$ | b. $\frac{6s+12}{3s^2+6s+1}$ |
| c. $\frac{9s+18}{3s^2+6s+1}$ | c. $\frac{9s+18}{3s^2+6s+1}$ | c. $\frac{9s+18}{3s^2+6s+1}$ |
| d. $\frac{s+2}{3s^2+6s+1}$ | d. $\frac{s+2}{3s^2+6s+1}$ | d. $\frac{s+2}{3s^2+6s+1}$ |
| e. None of the above | e. None of the above | e. None of the above |

## Problem 11 (10 pts)

Consider the circuit shown below (initial conditions for the inductor and capacitor are zero).

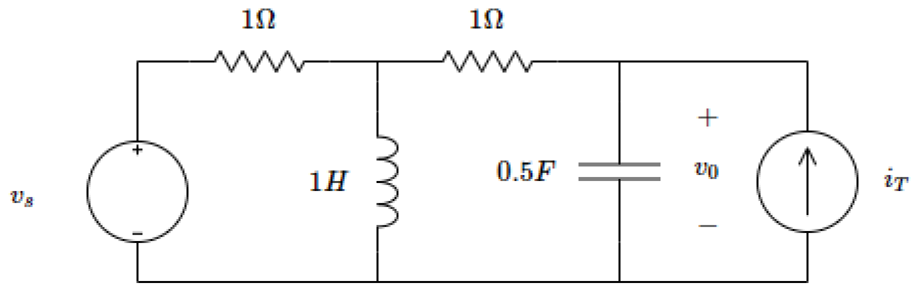



1. Determine the *s*-domain representation of this circuit and re-draw the circuit (3pts)

2. Find $I_o(s)$, clearly and neatly show your work (4pts)

3. Deduce $i_o(t)$ flowing in the 2 Ω resistor (3 points)

## Problem 12 (10 pts)




It is required to find $v_0(t)$ when the voltage and current source are respectively given by: $v_s(t) = K_1 u(t)$ and $i_T(t) = K_2\delta(t)$. Assume no initial conditions on the capacitor and inductor