EECE 2510 – Circuits and Signals, Biomedical Applications
Final Exam – Section 2

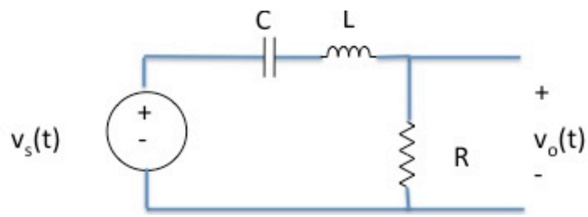
Name:

Instructions:

- Closed book, closed notes; Computers and cell phones are not allowed
- Scientific calculators are allowed
- **Complete all 4 problems**
- Show all work and **place a box around all your final answers**
- Write your name on all pages
- You may write on both sides of the pages

Question 1 (32 Points) **Name:**

1A) Consider the circuit below and given **C = 100 μF**, **L = 10 mH**, **R = 10 Ω** give **Z_c, Z_L**, and ***$V_o(t)$*** for



i) $V_s(t)$ = 1V **(3 points)**

Z_C =	***Z_L =***	***$V_o(t)$ =***

ii) $V_s(t) = 1\cos(10^{10}t)$ V **(3 points)**

Z_C =	***Z_L =***	***$V_o(t)$ =***

iii) $V_s(t) = 1\cos(10^{3}t)$ V **(5 points)**

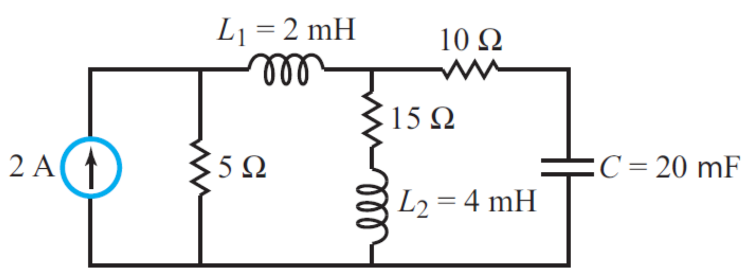
Z_C =	***Z_L =***	***$V_o(t)$ =***

1B) Write the following in **complex exponential notation** and write the associated **phasor voltage (5 points):**

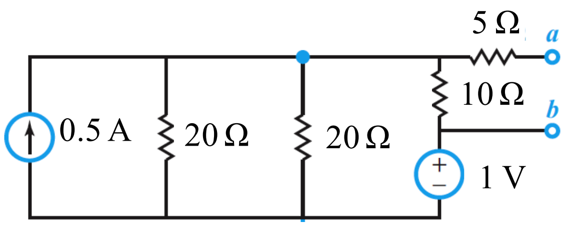
i) $v(t) = 3\cos(1000t + 45^{\circ})$

ii) $v(t) = -6\cos(100t - 30^{\circ}) + 4\sin(100t + 45^{\circ})$

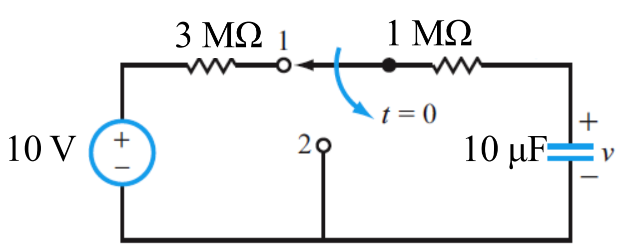
1C) Find $\boldsymbol{V_C}$ (the voltage across the capacitor) in DC conditions for the circuit below: **(5 Points)**



1D) Find the **Thevenin Equivalent** circuit of the following circuit across terminals (a,b): **(6 points)**



1E) The switch in the figure below is at position 1 for a long time before it is thrown to position 2 at t = 0 Write an expression for i) V_c (voltage across the capacitor) at time $t=0^-$, and ii)$V_C(t)$ for t>0 **(5 points)**



Question 2 (22 Points) **Name:**

2A) For the circuit below, find the equivalent phasor-domain quantities: **(5 points)**

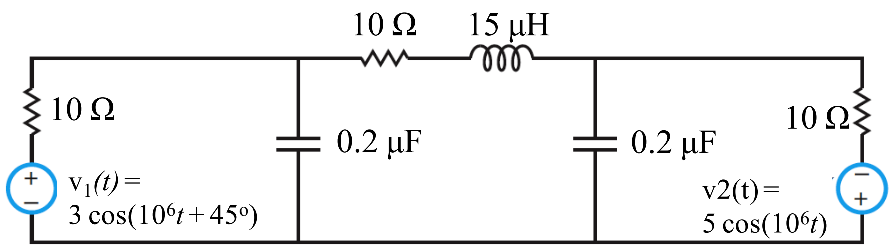
V_1 =

V_2 =

Z_L =

Z_C =

Z_R =

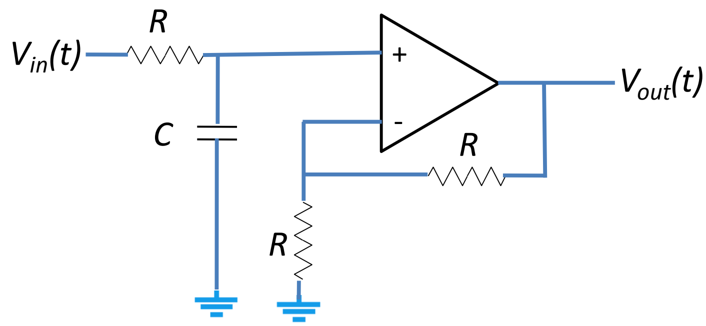


2B) For this circuit, apply the **Node-voltage method** in phasor domain to give two systems of equations and two unknowns node voltages **VN1 and VN2 (indicate these on the figure above).** Write these, simplify and put in **matrix form** below. Place a box around your final answer to make it easy for a grader to find. YOU DO NOT HAVE TO SOLVE VN1 and VN2. **(8 Points)**

2C) Now apply the **Mesh-current method** in phasor domain to give three systems of equations and three unknowns node voltages **I1, I2, and I3 (indicate these on the figure above).** Write these, simplify and put in **matrix form** below. Place a box around your final answer to make it easy for a grader to find. YOU DO NOT HAVE TO SOLVE I1, I2 and I3. **(9 Points)**

Question 3 (22 Points) **Name:**

3A) Use the ideal op-amp approximation (phasor domain) to solve the phasor quantity $\mathbf{V_{out}}$ as a function of $\mathbf{V_{in}}$ as a function of R and C. **(10 points)**



3B) What is the "in-band" gain of this circuit? What kind of filter is this? Justify your answer based directly on output expression in 3A, i.e. you should not require any explicit calculations **(4 points)**

3C) Using the expression you obtained in part 3A), if **R = 10kΩ** and **C = 1μF**,
What is $\mathbf{V_{out}(t)}$ **if** $\mathbf{V_{in}(t) = 2 + 2\cos(1000t + \pi/3)}$ **?**
If you could not obtain any expression for part (a) explain in as much detail as you can how you would solve this problem in order to get partial credit. **(8 points)**

Question 4 (24 Points) **Name:**

(4A) Sketch the signal given by the following expression: $x(t) = 3u(t+1) - u(t) + u(t-2) - 3u(t-4)$. Be sure to label your sketch clearly for full credit. **(5 points)**

(4B) An analog-to-digital converter (also called ADC or A/D) uses a sampling rate of F_s = 6000 samples/second. An audio signal is recorded by a microphone to produce the electrical signal
$\mathbf{x(t) = 3\sin(4000\pi t + \pi/3) + 6\cos(9000\pi t - \pi/6)}$ volts and is then sampled by this ADC and stored on a computer.

(B-i) What is the resulting discrete time (DT) sinusoid? The frequencies of the DT sinusoid should be converted to the lowest equivalent frequency. **(6 points)**

(B-ii) If this DT sinusoid is played through speakers connected to a computer using the same sampling rate F_s to reconstruct the signal, what frequencies (pitches) will be heard in the sound? **(3 points)**

(B-iii) Do these frequencies match those in the original signal? Why or why not? **(3 points)**

(4C) The ADC has a dynamic range of -5 to 5 volts and quantizes numbers to 12 bit accuracy.

(C-i) What is the amplitude resolution of this ADC in volts (that is, what is the equivalent in volts to a difference of one quantization level in the quantized signal)? **(3 points)**

(C-ii) Based on your answer to (C-i), for the first component of x(t) (i.e. $3\sin(4000\pi t + \pi/3)$ volts), what is the maximum quantization error in volts for any given sample? **(2 points)**

(C-iii) For the second component of x(t), (i.e. $6\cos(9000\pi t - \pi/6)$ volts, what is the maximum quantization error in volts for any given sample? **(2 points)**