Your name: ______________________________

# EECS 215.
# Final Exam
# December 19, 2016

**This text consists of 6 problems with points as indicated to total 60 points.**

Read through the entire exam before beginning.
**Show all work** (on the pages provided in this booklet) to earn partial credit.

**No credit will be given if no work is shown.**

Briefly explain major steps, include units, and write your final answers in the areas provided.
Do not unstaple the pages.

**Exam policies**

- The College of Engineering Honor Code is followed. Please write and sign the honor code pledge ("I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code.") in the box below.
- No food allowed during exam.
- Three sides of 8.5x11 inch notes pages are allowed. No books allowed (closed book exam).
- Calculators allowed (But **you may not use the following functions: graphs, integrals, derivatives**).
- No communication of any kind is allowed. No use of cell phones, computers, or any devices besides calculators. Violation of this will be treated as an honor code violation.

In which section are you enrolled? ☐**EECS 215-001 (Finelli)** ☐**EECS 215-002 (Zhang)**

Write and sign the honor pledge:

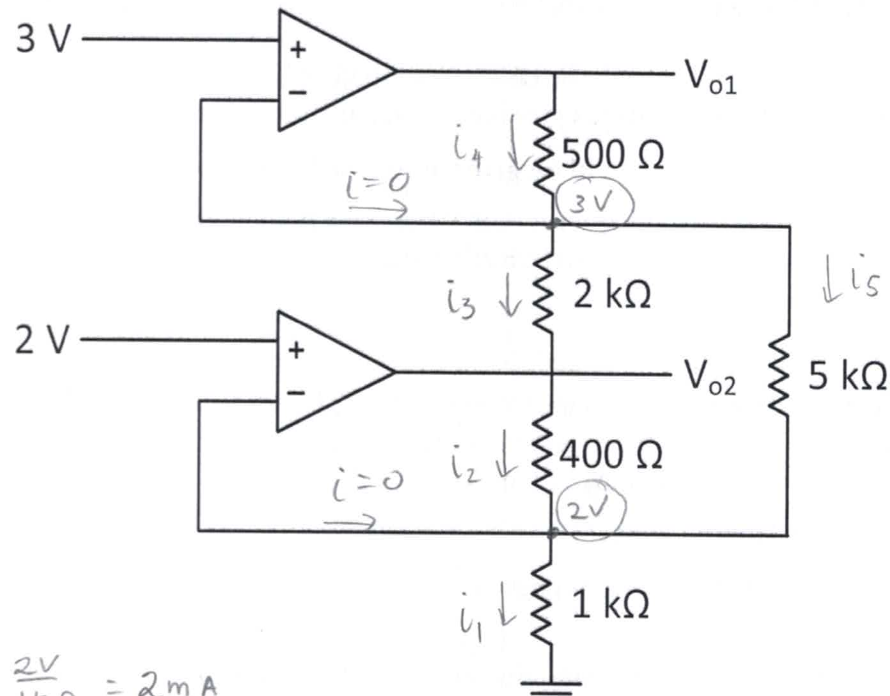
Signed: Answer Key

Do not write in this space

| | |
|---|---|
| Problem 1: [ ]/10 | Problem 4: [ ]/10 |
| Problem 2: [ ]/10 | Problem 5: [ ]/10 |
| Problem 3: [ ]/10 | Problem 6: [ ]/10 |

**Total score [ ]/10**

1. Assume that the two op amps below are ideal.
   a. (5 points) Calculate $v_{o1}(t)$
   b. (5 points) Calculate $v_{o2}(t)$




$i_1 = \frac{2V}{1k\Omega} = 2mA$

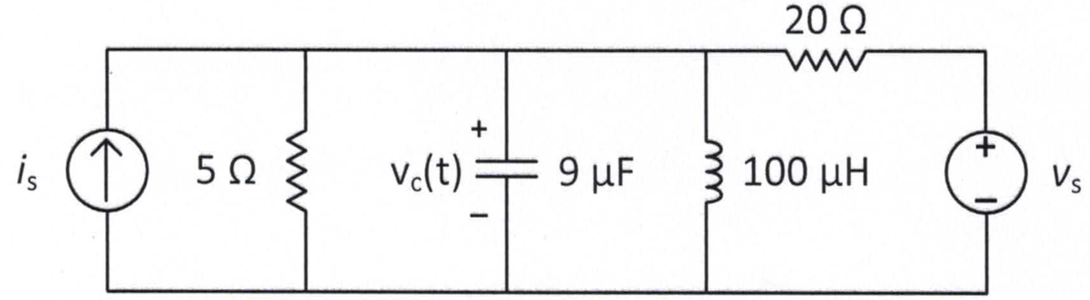
$i_5 = \frac{3V - 2V}{5k\Omega} = 0.2mA$

$i_2 = i_1 - i_5 = 1.8mA \Rightarrow v_{o2} = 400 i_2 + 2V = \boxed{2.72V}$ $v_{o2}$

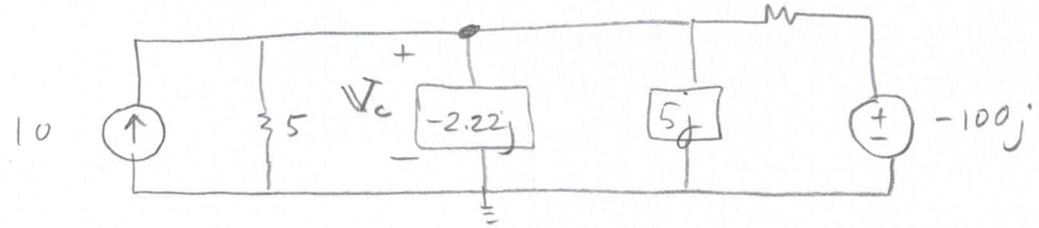
$i_3 = \frac{3 - v_{o2}}{2k} = 0.14mA$

$i_4 = i_3 + i_5 = 0.34 mA \Rightarrow v_{o1} = 500 i_4 + 3V = \boxed{3.17V}$ $v_{o1}$

2. For the circuit below, $i_s(t) = 10\cos 50{,}000\,t$ A and $v_s(t) = 100\sin 50{,}000\,t$ V.
   a. (2 points) Draw the phasor domain representation of the circuit.
   b. (8 points) Use nodal analysis in the phasor domain to find the steady-state expression $v_{ss}(t)$




phasor domain circuit




KCL at top node:

$$-10 + \frac{V_c}{5} + \frac{V_c}{-2.22j} + \frac{V_c}{5j} + \frac{V_c + 100j}{20} = 0$$

$$10 - 5j = V_c\underbrace{\left(\frac{1}{5} + \frac{1}{-2.22j} + \frac{1}{5j} + \frac{1}{20}\right)}_{.25 + .25j}$$

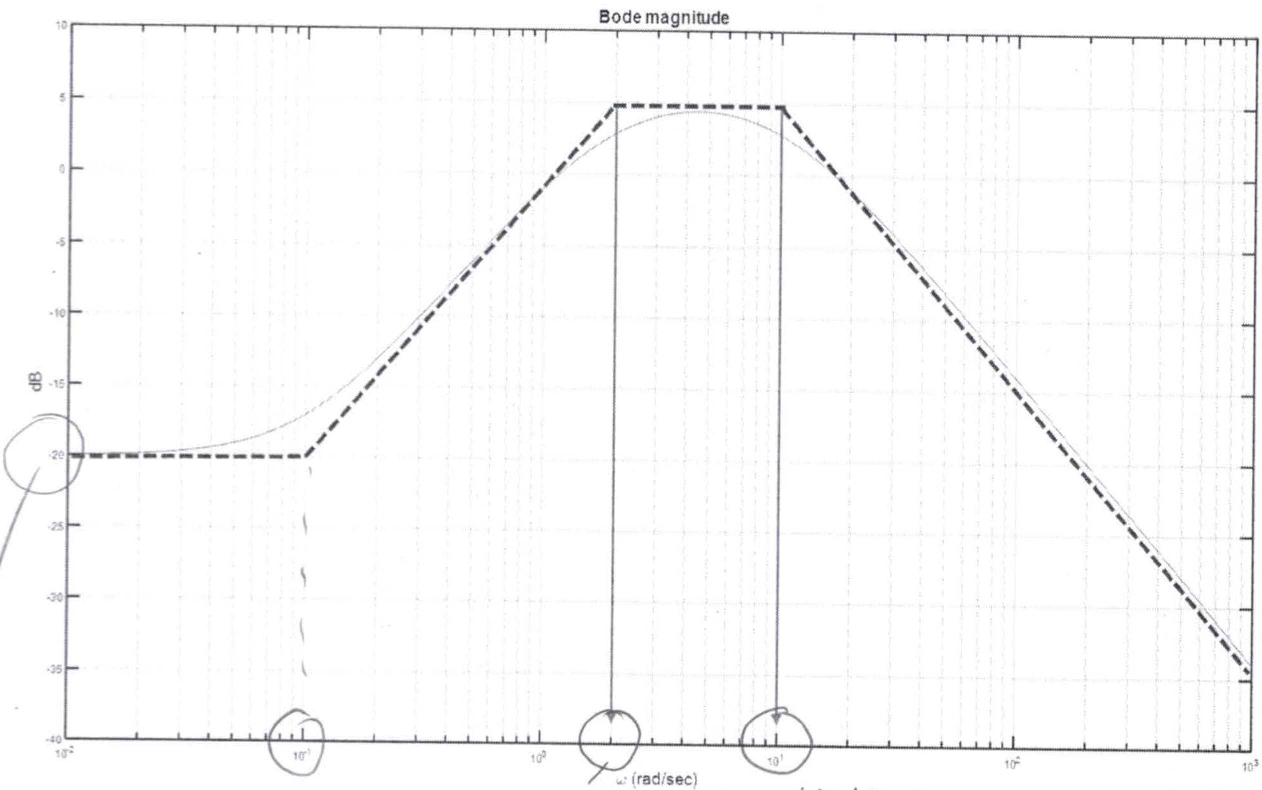
$$V_c = \frac{10-5j}{.25(1+j)} = \frac{4(2-j)}{(1+j)} = 10 - 30j = 31.63\angle -71.6^\circ$$

$$\boxed{v_{c\text{-}ss}(t) = 31.63\cos(50{,}000t - 71.6^\circ)\ \text{V}}$$

3. A given circuit has a Bode magnitude plot shown below (and the straight line approximation as shown by the dotted line).

   a. (5 points) Find the transfer function $\boldsymbol{H}(\omega)$. Leave each separate term in standard form (for example: $\boldsymbol{H}(\omega) = \dfrac{K\left(1+\frac{j\omega}{\omega_{c1}}\right)\left(1+\frac{j\omega}{\omega_{c2}}\right)}{j\omega\left(1+\frac{2\zeta j\omega}{\omega_k}+\left(\frac{\omega}{\omega_k}\right)^2\right)}$

   b. (5 points) At $\omega = 0, \theta(\omega) = 0$ . Plot the Bode phase plot on the attached semilog paper.




$W = .1$

$W = 2$ → pole at $w_c = 2$

$W = 10$ → pole at $w_c = 10$

$20 \log K = -20 \Rightarrow K = 0.1$

zero at $w_c = .1$

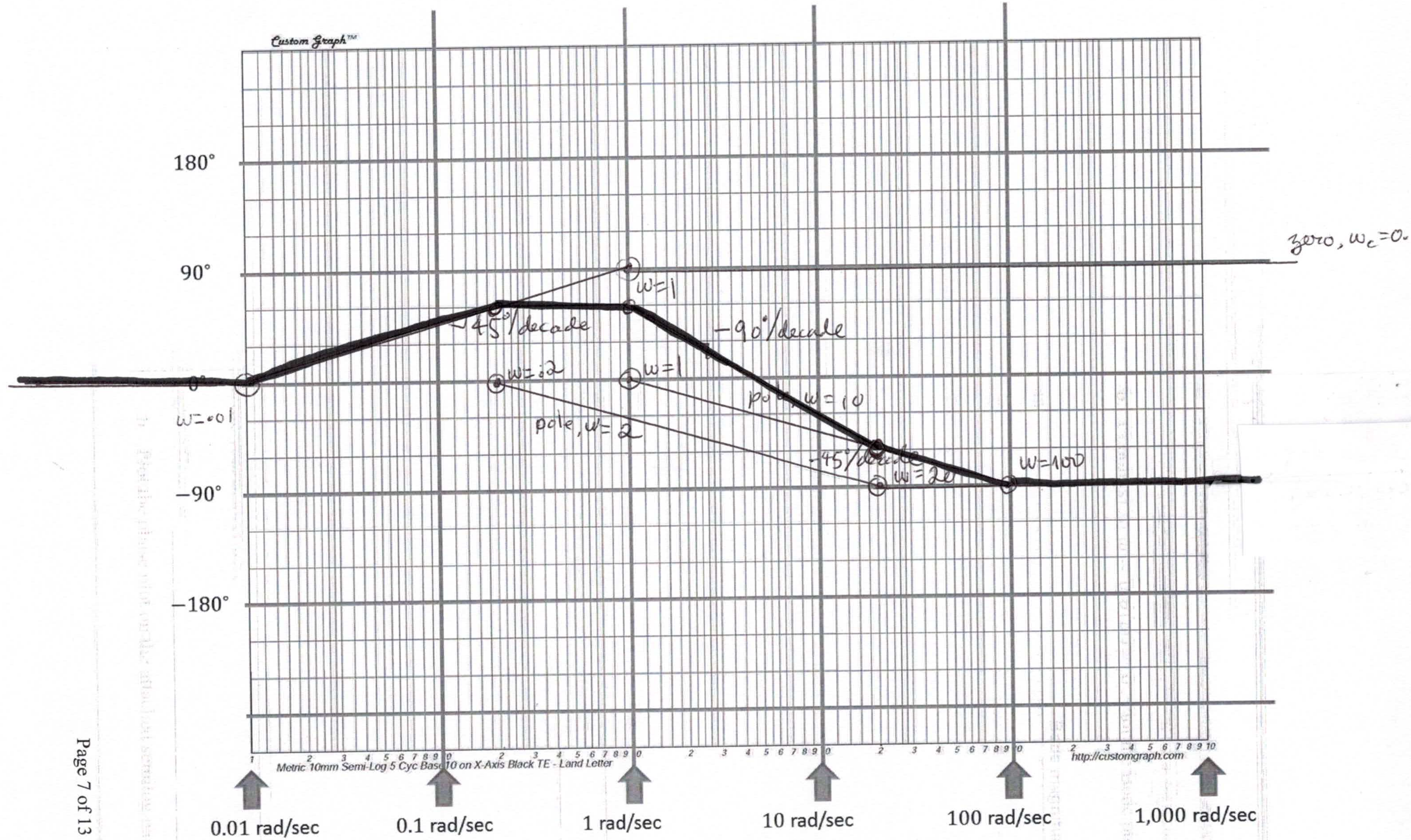
$$\boxed{H(w) = \frac{.1\left(1+\frac{jw}{.1}\right)}{\left(1+\frac{jw}{2}\right)\left(1+\frac{jw}{10}\right)}}$$

Write your answer here:

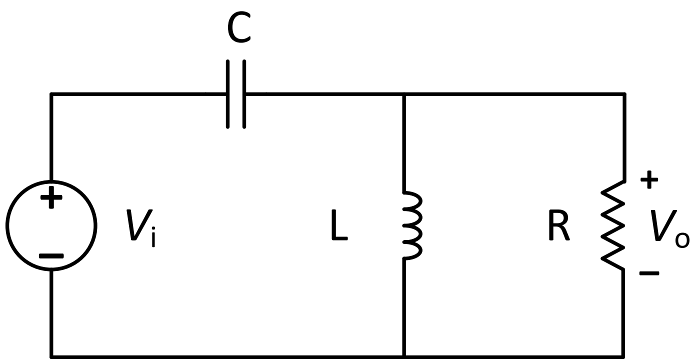
a. $\boldsymbol{H}(\omega) =$ ______________________________

b. Plot the phase plot on the attached semilog paper

Problem 3 score: [ ]/10


Custom Graph™
180°
90°
0°
−90°
−180°
zero, $w_c$=0.
w=1
+45°/decade
−90°/decade
w=.2
w=1
w=.01
pole, w=10
pole, w=2
−45°/decade
w=20
w=100
Metric 10mm Semi-Log 5 Cyc Base 10 on X-Axis Black TE - Land Letter
http://customgraph.com
0.01 rad/sec
0.1 rad/sec
1 rad/sec
10 rad/sec
100 rad/sec
1,000 rad/sec

4. Given the circuit below
   a. (5 points) Find the transfer function $\boldsymbol{H}(\omega) = \boldsymbol{V}_o/\boldsymbol{V}_i$
   b. (5 points). Find $|\boldsymbol{H}(\omega)|$ at $\omega = 0$ and $\omega \to \infty$ and $\angle \boldsymbol{H}(\omega)$ at $\omega = 0$ and $\omega \to \infty$




$$H(\omega) = \frac{R /\!/ j\omega L}{R /\!/ j\omega L + \frac{1}{j\omega C}} = \frac{\frac{j\omega RL}{j\omega L + R}}{\frac{j\omega RL}{j\omega L + R} + \frac{1}{j\omega C}} = \frac{j^2\omega^2 RLC}{j^2\omega^2 RLC + j\omega L + R}$$

$$= \frac{RLC(j\omega)^2}{R\left(1 + j\omega\frac{L}{R} + j^2\omega^2 LC\right)} = \frac{LC(j\omega)^2}{1 + j\omega\frac{L}{R} + \left(j\frac{\omega}{\frac{1}{\sqrt{LC}}}\right)^2}$$

$\omega = 0$ $\quad |H(\omega)| = 0 \quad \angle H(\omega) = 0°$

$\omega \to \infty$ $\quad |H(\omega)| = 1 \quad \angle H(\omega) = 0°$

Write your answer here:

a. $\boldsymbol{H}(\omega)$ ____________________

b. $|\boldsymbol{H}(\omega)|$ at $\omega = 0$ ____________________

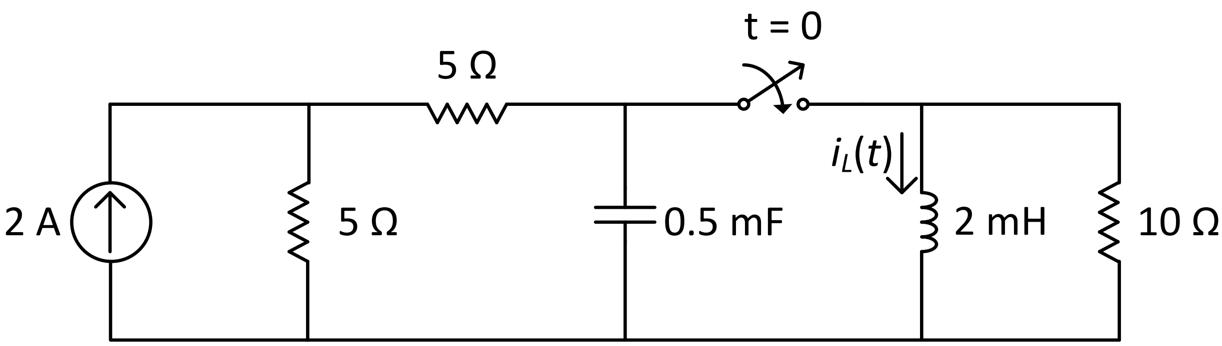
$\angle \boldsymbol{H}(\omega)$ at $\omega = 0$ ____________________

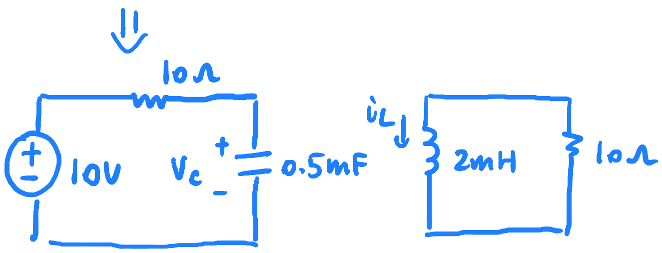
$|\boldsymbol{H}(\omega)|$ at $\omega \to \infty$ ____________________

$\angle \boldsymbol{H}(\omega)$ at $\omega \to \infty$ ____________________

Problem 4 score: [ ]/10

5. For the circuit below:
   c. (1 point) Determine the initial value for $i_L$ at $t = 0$
   d. (1 point). Determine the final value for $i_L$ at $t \to \infty$
   e. (8 points) Solve for $i_L(t), t \geq 0$



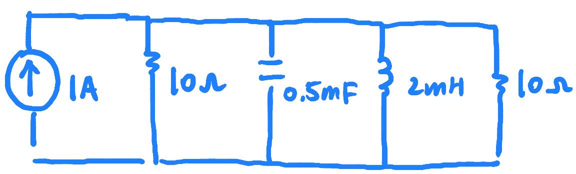



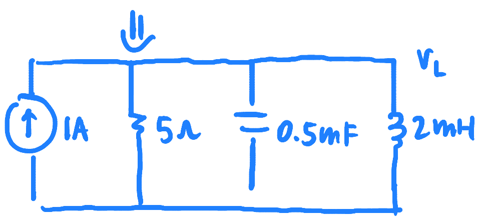

$V_c(0^-) = 10\,V$

$i_L(0^-) = 0\,A$

$V_c(0) = 10V$

$\boxed{i_L(0) = 0\,A}$




$V_L(0) = V_c(0) = 10V$

$\boxed{i_L(\infty) = 1A}$

$$\alpha = \frac{1}{2RC} = \frac{1}{2\times 5\times 0.5\times 10^{-3}} = 200 \quad rad/s$$

$$w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2\times 10^{-3}\times 0.5\times 10^{-3}}} = 1000 \ rad/s$$

$\alpha < w_0$ , underdamped

$$w_d = \sqrt{w_0^2 - \alpha^2} = \sqrt{1000^2 - 200^2} = 980 \ rad/s$$

$$D_1 = i_L(0) - i_L(\infty) = 0 - 1 = -1$$

$$D_2 = \frac{\frac{1}{L}V_L(0) + \alpha\,(i_L(0) - i_L(\infty))}{w_d} = \frac{\frac{1}{2\times 10^{-3}}\times 10 + 200\,(0-1)}{980} = 4.9$$

$$i_L(t) = e^{-200t}\left(-\cos 980t + 4.9 \sin 980t\right) + 1 \quad A$$

Write your answer here:

a. $i_L$ at $t = 0$: ______

b. $i_L$ at $t \to 0$: ______

c. $i_L(t), t \geq 0 =$ ______

Problem 5 score: [ ]/10

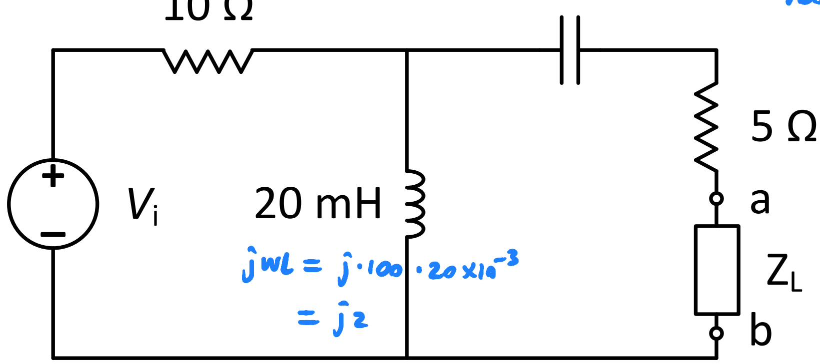
6. For the circuit below, $V_i = 20\cos 100t$ $\quad \omega = 100$ rad/s

   a. (6 points) Remove $Z_L$, find $V_{oc}$ (in polar form) between terminals a and b and $Z_{TH}$ (in rectangular form) between terminals a and b.

   b. (2 points) Determine the value for $Z_L$ so that the power dissipated by the load is maximized.

   c. (2 points) For the $Z_L$ you selected in part (b), how much average power is dissipated by the load?

$-\frac{j}{\omega C} = -\frac{j}{100 \cdot 10^{-3}} = -j10$




$V_{oc} = V_i \cdot \frac{j2}{j2+10} = 20 \cdot \frac{j2}{j2+10} = 20 \cdot 0.196\angle 78.7^\circ = 3.922\angle 78.7^\circ$ V

$Z_{TH} = j2 /\!/ 10 + 5 - j10 = 5.385 - j8.077$ Ω

$Z_L = Z_{TH}^* = 5.385 + j8.077$ Ω $\qquad R = 5.385$ Ω

$P_{av} = \frac{|V_{oc}|^2}{8R} = \frac{3.922^2}{8 \times 5.385} = 0.357$ W