Signature: Solution

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED TO DO SO.

EXAM 3
ELEE 2335
December 5, 1987

INSTRUCTIONS:

1. Sign your name on the upper left of this page.

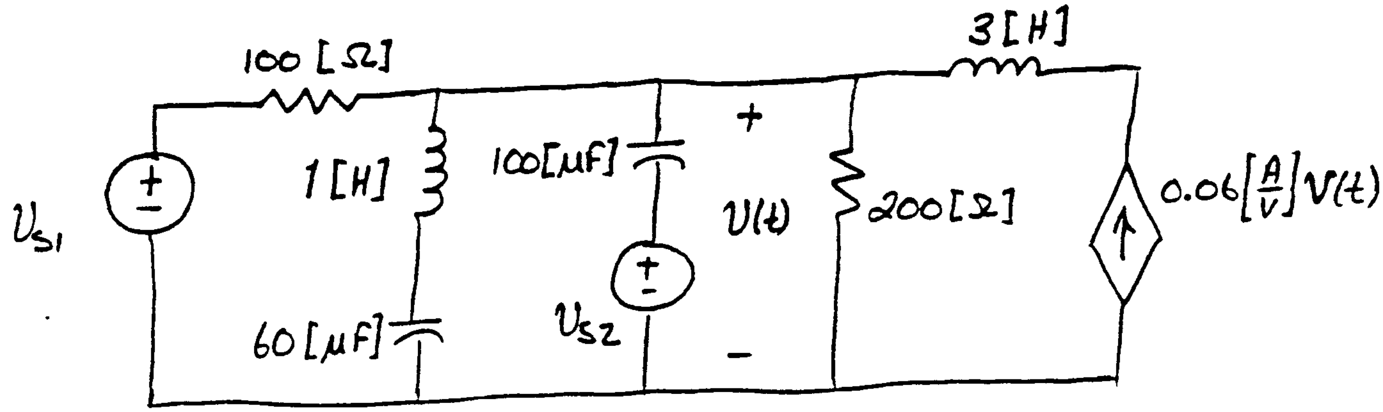
2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary. Indicate clearly where your work and answers may be found. Enclose your final answers in a box. No credit will be given unless the necessary work is shown. You are allowed a crib sheet which consists of three sides of 8-1/2" x 11" paper.

3. **Make sure that some kind of clear distinction is obvious between complex quantities (phasors and impedances) and time domain functions.** Underlined symbols, lines over symbols, or any other clear method will be acceptable. Show all of your units explicitly, both in your final answer and in your intermediate steps. Units in exam questions are placed within square brackets.

4. If your answers and work are not in ink, there will be no provision for changing your grade once the exam is returned to you. Do not use red ink.

1. 40
2. 30
3. 30

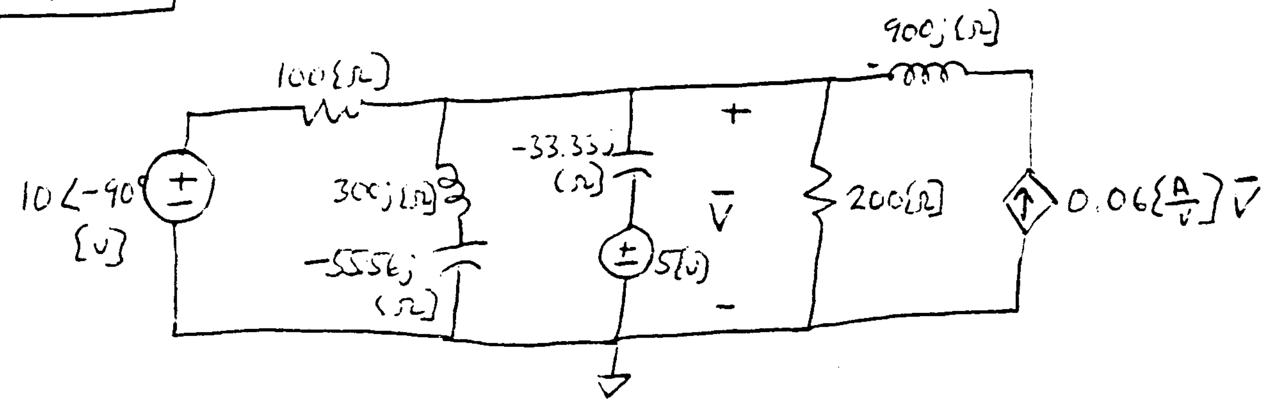
1. (40 Points) Find the steady state value of v(t) in the circuit below.



v_{s1} = 10 sin (300 t) [V] = 10 cos (300t − 90°) [V]

v_{s2} = 5 cos (300t) [V]

Solution | Convert to Phasor Domain



+10

Use complex Node Voltage Method. For $\bar{V}$ in {Volts]; →

$$\frac{\bar{V} - 10\angle 90^\circ}{100} + \frac{\bar{V}}{300j - 55.56j} + \frac{\bar{V} - 5}{-33.33j} + \frac{\bar{V}}{200} - 0.06\bar{V} = 0$$

+10

$$-0.06\bar{V} + \frac{\bar{V}}{100} + \frac{\bar{V}}{244.4j} + \frac{\bar{V}}{-33.33j} + \frac{\bar{V}}{200} = \frac{10\angle 90^\circ}{100} - \frac{5}{33.33j}$$

$$\bar{V}\left(-.06 + .01 + .005 - j\left((4.09 - 30)\times 10^{-3}\right)\right) = -0.1j + j.150$$

$$\bar{V}\left(-45 + j25.9\right)\times 10^{-3} = 0.05j$$

see next page ⇒

Room for Extra Work

$$\bar{V} = \frac{0.05\angle 90^\circ}{-45+j25.9} \times 10^3 = \frac{50\angle 90^\circ}{51\angle 150.1^\circ} \,[V]$$

$$\bar{V} = 963\angle -60.1^\circ \,[mV]$$ (+10)

So

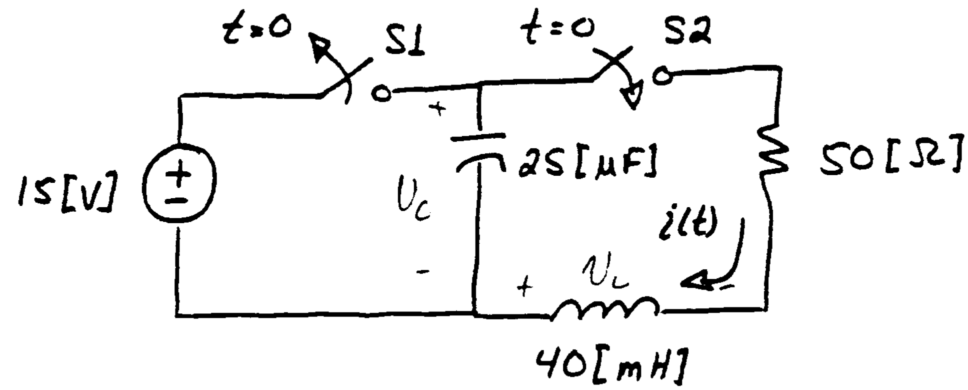
$$v(t) = 963\cos(300t - 60.1^\circ)\,[mV]$$ (+10)

-5 no units in answer

(-5) ~~-10~~ mixed domains

-2 math error

2. (30 Points) In the circuit below, the switch S1 had been closed for a long time, and S2 had been open for a long time. At t = 0, S1 opened and S2 closed. Find i(t) for t > 0.



General Solution:

$$i(t) = B_1 e^{-\alpha t} \cos \omega_d t + B_2 e^{-\alpha t} \sin \omega_d t$$

$$\alpha = \frac{R}{2L} = \frac{50}{2(40\times10^{-3})} = 625$$ +3

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(40\times10^{-3})(25\times10^{-6})}} = 1000$$ +3

$\omega_0^2 > \alpha^2 \Rightarrow$ UNDERDAMPED (above solution) +4

$$\omega_d = \sqrt{\omega_0^2 - \alpha^2} = 781$$ +3

INITIAL CONDITIONS +7

$i(t=0) = 0 = B_1$

$i(0) = 0 \Rightarrow V_R(0) = 0 \quad \therefore V_L(0) = -15[V] = -V_C(0)$

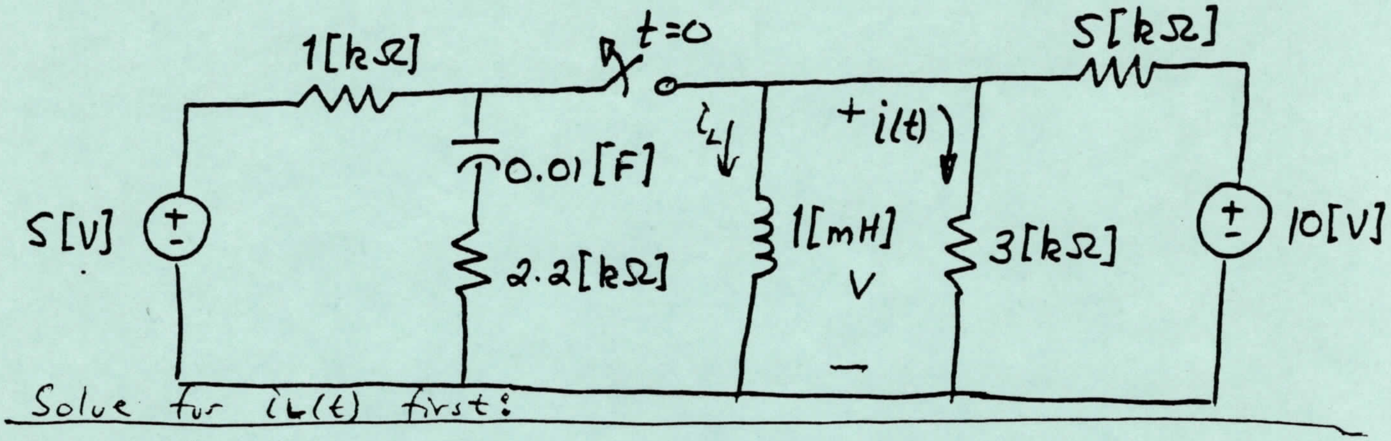
Thus $\frac{di}{dt}(0) = \frac{-V_L(0)}{L} = \frac{+15}{40\times10^{-3}} = 375\ [A/s]$

+7

$\frac{di}{dt}(0) = B_2 \omega_d \Rightarrow B_2 = 0.48\ [A]$

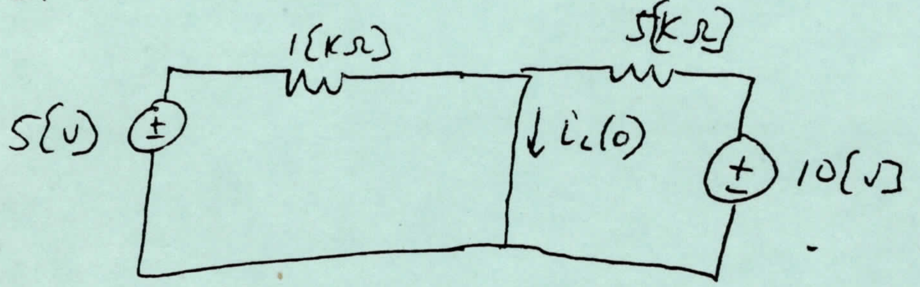
$$i(t) = 0.48 e^{-625t} \sin 781t \quad [A]$$ +3

3. (30 Points) The switch in the circuit below had been closed for a long time, and is opened at t = 0. Find i(t) for t > 0.



Solve for $i_L(t)$ first:

Circuit for t<0

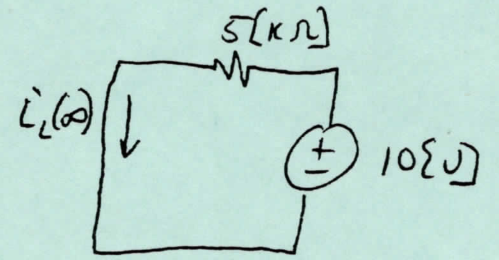


$$i_L(0) = \frac{5\{V\}}{1K\Omega} + \frac{10\{V\}}{5\{K\Omega\}}$$

$$i_L(0) = 7[mA]$$

(+10)

Circuit for t=∞



$$i_L(\infty) = 2\{mA\}$$

(+5)

$$\tau = \frac{L}{R_{eq}} = \frac{1[mH]}{3[K\Omega] \| 5[K\Omega]} = \frac{1[mH]}{1.875[K\Omega]} = 0.533\{\mu sec\}$$

(+5)

$$i_L(t) = 2\{mA\} + 5\{mA\} e^{-t/0.533\{\mu sec\}}$$

(+4)

$$V(t) = L\frac{di_L}{dt} = \frac{(10^{-3})(5\times10^{-3})}{-0.533\times10^{-6}} e^{-t/0.533\{\mu sec\}}$$

(+4)

$$i(t) = \frac{V(t)}{3000\{\Omega\}} = \left(-3.125 e^{-t/0.533\{\mu sec\}}\right)\{mA\}$$

(+2)