ECE 20100 – Spring 2018
Exam #3

April 12, 2018

Section (include on scantron)

Michelusi (9:30) – 0001 Tan (1:30) – 0004 Li (10:30) – 0005

Hosseini (12:30) – 0006 Cui (11:30) – 0007

Kildishev (12:30) – 0008 Liu (8:30) – 0009 Zhu (3:30) – 0010

Instructions

1. DO NOT START UNTIL TOLD TO DO SO.
2. Write your name, section, professor, and student ID# on your **Scantron** sheet. We may check PUIDs.
3. This is a CLOSED BOOKS and CLOSED NOTES exam.
4. The use of a TI-30X IIS calculator is allowed.
5. If extra paper is needed, use the back of test pages.
6. Cheating will not be tolerated. Cheating in this exam will result in, at the minimum, an F grade for the course. In particular, **continuing to write after the exam time is up is regarded as cheating**.
7. If you cannot solve a question, be sure to look at the other ones, and come back to it if time permits.
8. ***All of the problems*** on Exam #3 provide evidence for satisfaction of this ECE 20100 Learning Objective:

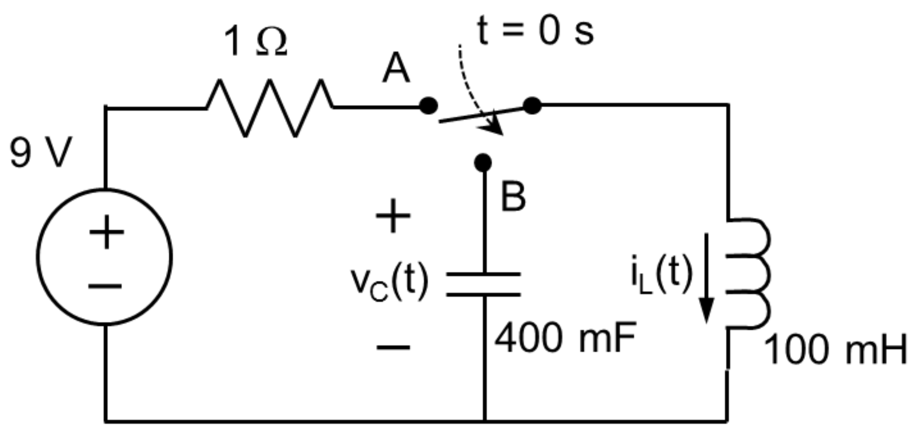
    iii) An ability to analyze 2nd order linear circuits with sources and/or passive elements.

    The minimum score needed to satisfy this objective will be posted on Blackboard after the exam has been graded. Remediation options will be posted in Blackboard if you fail to satisfy any of the course outcomes.

By signing the scantron sheet, you affirm you have not received or provided assistance on this exam.

Question 1

In the circuit below, the switch changes to position "B" at t = 0 s after being in position "A" for a long time. Find $v_C(t)$ for $t \geq 0$ s. Assume $v_C(0^+) = 0$ V.



(1) $v_c(t) = 4\ cos(5\ t) - 4\ sin(5\ t)$ V

(2) $v_c(t) = 4\ cos(25\ t) - 4\ sin(25\ t)$ V

(3) $v_c(t) = -1.8\ sin(5\ t)$ V

(4) $v_c(t) = -9\ sin(5\ t)$ V

(5) $v_c(t) = -6 \times 10^3\ sin(25t)$ V

(6) $v_c(t) = 9\ cos(5\ t) - 1.8\ sin(5\ t)$ V

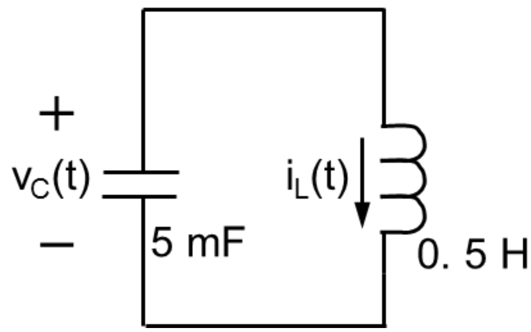
(7) $v_c(t) = -4.5\ sin(5\ t)$ V

(8) $v_c(t) = 0$ V

(9) None of the above

Question 2

The inductor current for $t \geq 0$ is $i_L(t) = 2\cos(20t) - 6\sin(20t)$ A. Find the capacitor voltage, $v_C(0)$ at time $t = 0$ s (in V).



(1) –12

(2) –24

(3) –36

(4) –48

(5) –60

(6) –72

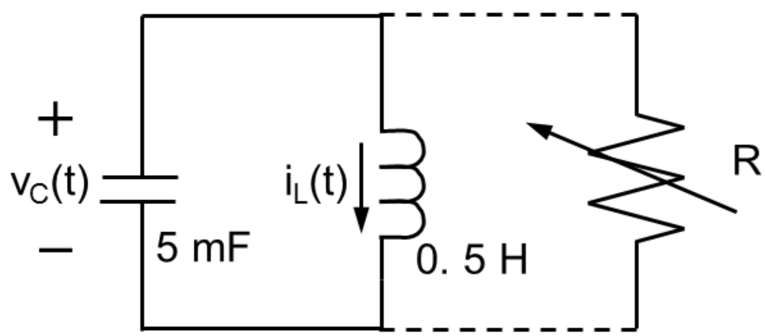
(7) –120

(8) –240

(9) None of the above

Question 3

Suppose a variable resistor is added to the circuit in Q2 as shown below. Find the correct statement.



(1) *R* has no effect on the LC curcuit.

(2) All finite *R* values force inductor current to zero immediately.

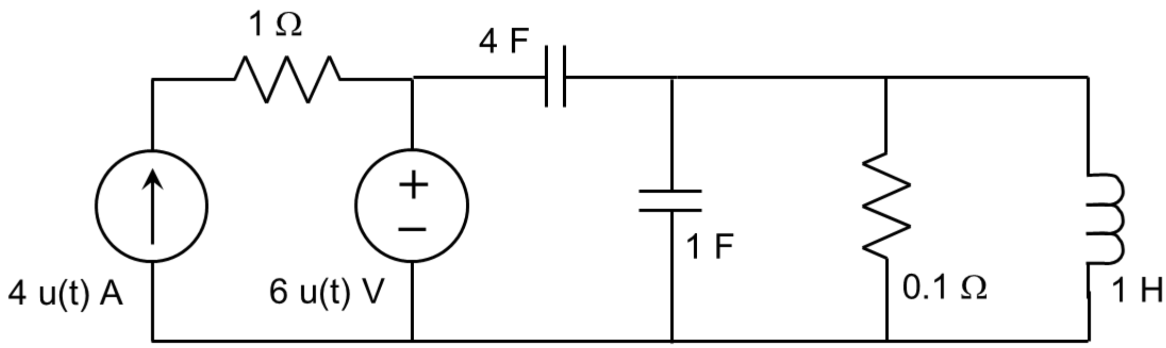
(3) As *R increases,* damping *increases*.

(4) As *R increases,* damping *decreases*.

(5) None of the above

Question 4

Find the characteristic equation for the circuit shown below.



(1) $s^2 + 2s + 0.2 = 0$

(2) $s^2 + 4s + 0.2 = 0$

(3) $s^2 + 8.33s + 0.833 = 0$

(4) $s^2 + 0.1s + 0.2 = 0$

(5) $s^2 + 16.67s + 0.833 = 0$

(6) $s^2 + 0.2s + 0.833 = 0$

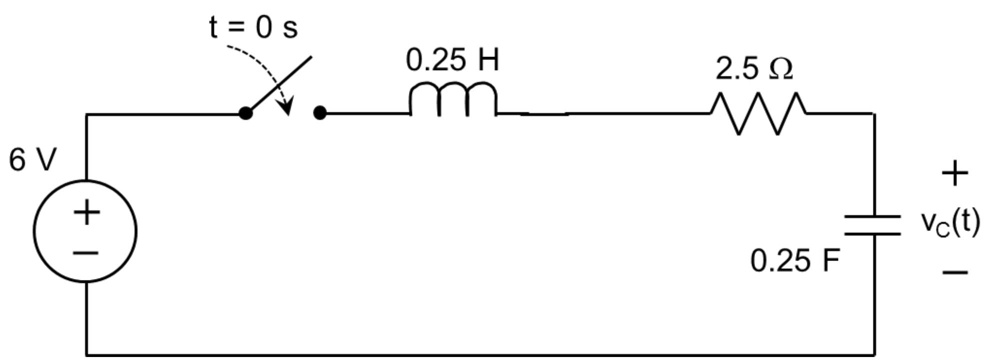
(7) $s^2 + 5s + 0.2 = 0$

(8) $s^2 + 5s + 1 = 0$

(9) None of the above

Question 5

The switch in the circuit shown below closes at t = 0 s after having been open for a long time. Find $v_c(t)$ for $t \geq 0$ (in V), assuming $v_c(o^+) = 0$ V.



(1) $6 - 6(1 + t)\, e^{-2t}$

(2) $6 + 2e^{-8t} - 8e^{-2t}$

(3) $6 - 6(1 + t)\, e^{-8t}$

(4) $6 + (-8 \cos 8t + 6 \sin 8t)\, e^{-2t}$

(5) $6 + (-6 \cos 8t + 8 \sin 8t)\, e^{-2t}$

(6) $6 + 8e^{-8t} - 2e^{-2t}$

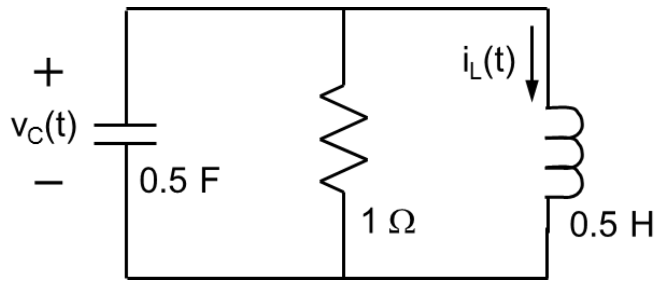
(7) $8 - 6(1 + t)\, e^{-8t}$

(8) $8 - 6(1 + t)\, e^{-2t}$

(9) None of the above

Question 6

The initial conditions for the circuit shown are $i_L(0^-)$ = 4 A and $v_C(0^-)$ = 24 V. Find the value of $\frac{dv_C(0^+)}{dt}$ (in V/s).



(1) 0

(2) –4

(3) –16

(4) –28

(5) –56

(6) 4

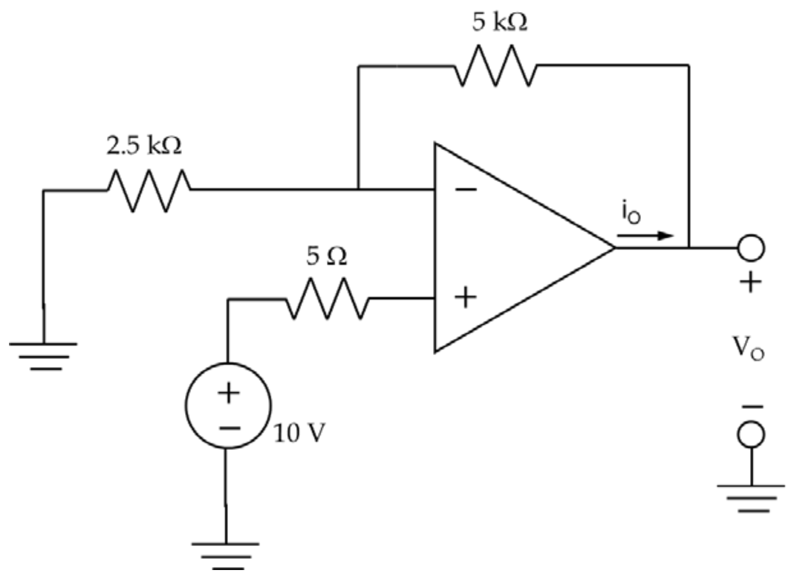
(7) 16

(8) 28

(9) None of the above

Question 7

In the ideal op amp circuit shown below, what is the <u>current</u> i_o at the output terminal of the op amp (in mA):



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

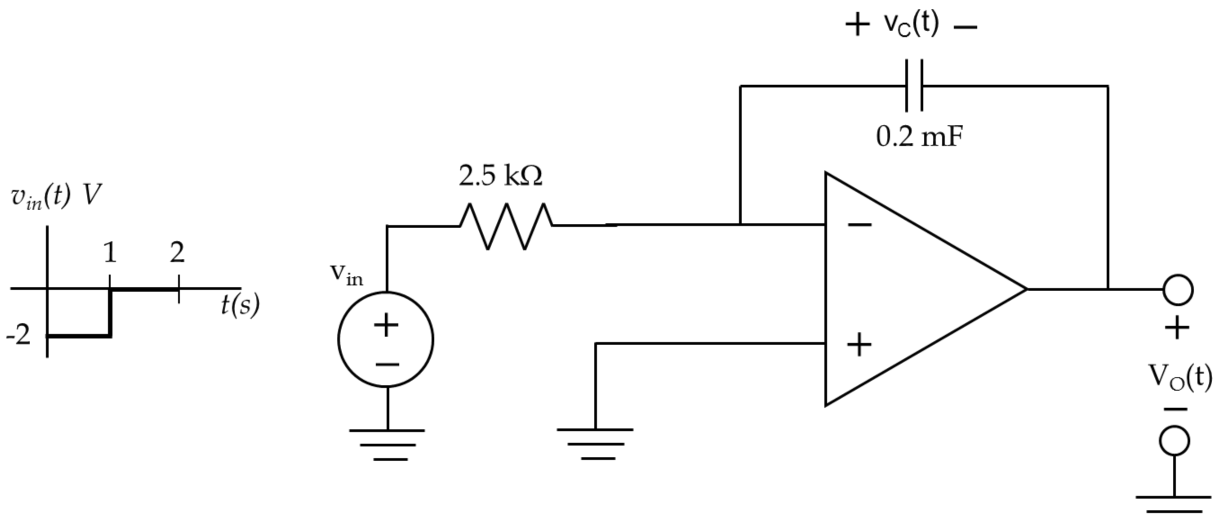
(7) 7

(8) 8

(9) None of the above

Question 8

Find $v_o(t)$ at t = 2s, assuming $v_c(0^-)$ = 0V, for the ideal op amp below.



(1) 2

(2) 4

(3) 6

(4) 8

(5) –2

(6) –4

(7) –6

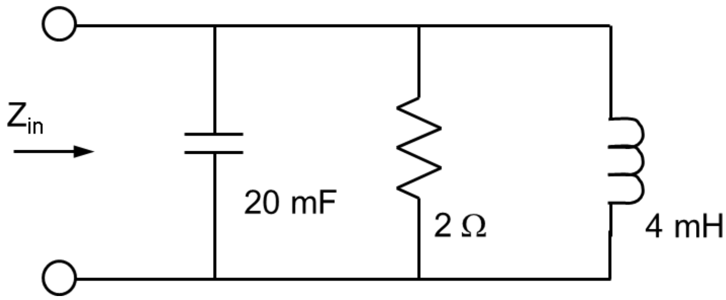
(8) –8

(9) 0

(10) None of the above

Question 9

Assuming ω = 100 rad/s, find the impedance for the circuit shown (in Ω),



(1) 0.707 + j0.707

(2) 0.707 – j0.707

(3) 1 + j

(4) 1 – j

(5) 1.414 + j1.414

(6) 1.414 – j1.414

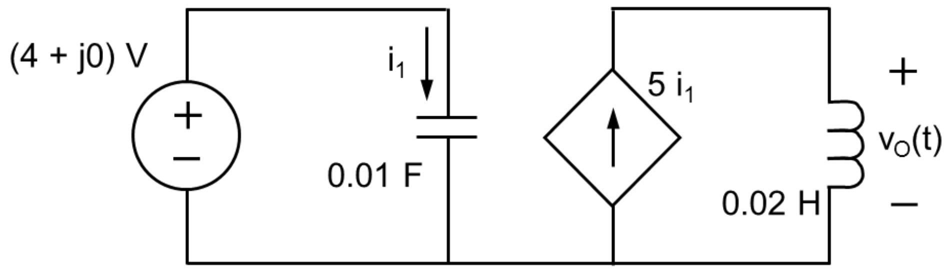
(7) 2 + j2

(8) 2 – j2

(9) None of the above

Question 10

Assuming ω = 100 rad/s in the circuit below, find the phasor form of $v_O(t)$.



(1) (40 + j20) V

(2) (–40 + j20) V

(3) (20 + j40) V

(4) (–20 + j40) V

(5) (10 + j10) V

(6) (10 – j10) V

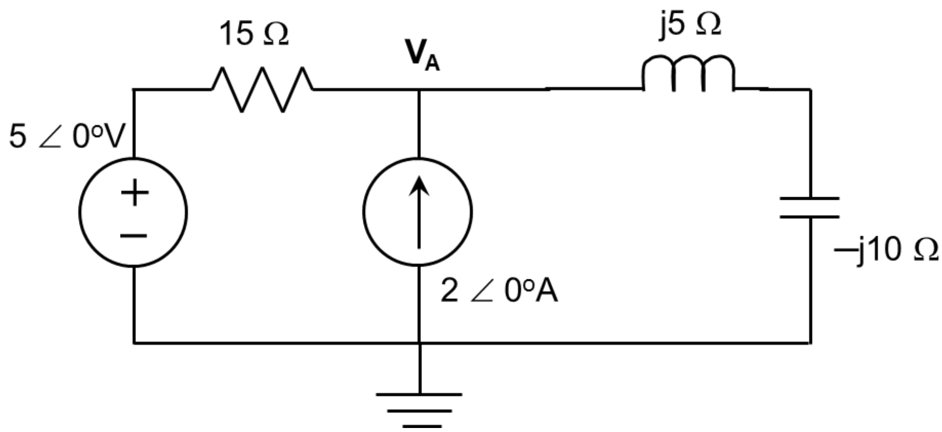
(7) 40 V

(8) –40 V

(9) None of the above

Question 11

Find the phasor voltage $\mathbf{V_A}$ (in V).



(1) 5

(2) (5 – j5)

(3) (5 + j5)

(4) (1 – j10)

(5) (–13.7 + j10)

(6) (3.5 – j10.5)

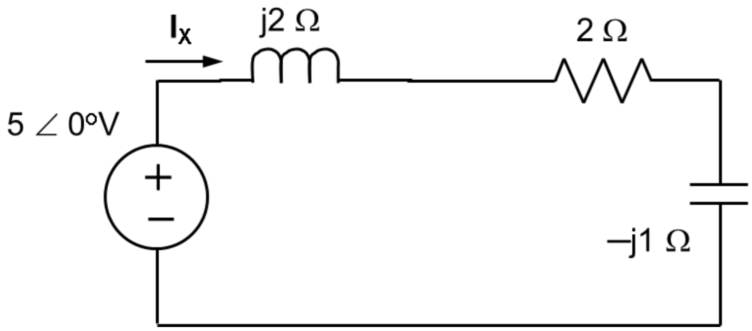
(7) (2.5 + j20)

(8) (–5 + j5)

(9) None of the above

Question 12

Find the phasor current $\mathbf{I}_X$ (in A):



(1) $3.1 \angle 153.4^o$

(2) $0.2 \angle -26.6^o$

(3) $2.2 \angle 63.4^o$

(4) $2.2 \angle 153.4^o$

(5) $0.2 \angle 63.4^o$

(6) $2.2 \angle -26.6^o$

(7) $3.1 \angle -63.4^o$

(8) $0.2 \angle -63.4^o$

(9) None of the above

Potentially Useful Formulas

First order circuit: $x(t) = x(\infty) + \left[x(t_o^+) - x(\infty)\right]e^{-\left(t-t_o^+\right)/\tau}$, τ = L/R or τ = RC

Series RLC: $s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$

Parallel RLC: $s^2 + \frac{1}{RC}s + \frac{1}{LC} = 0$

$$x(t) = x(\infty) + \left(A\cos\omega_d t + B\sin\omega_d t\right)e^{-\sigma t}$$

$$x(t) = x(\infty) + \left(A + Bt\right)e^{-\sigma t}$$

$$x(t) = x(\infty) + \left(Ae^{s_1 t} + Be^{s_2 t}\right)$$

$s_1, s_2 = \frac{-b \pm \sqrt{b^2 - 4c}}{2}$ for $s^2 + bs + c = 0$, where $c = \left(LC\right)^{-1}$

$$\sigma = \frac{b}{2} = \begin{cases} R/2L & \text{(series)} \\ \dfrac{1}{2RC} & \text{(parallel)} \end{cases}$$

$$\omega_o = 1/\sqrt{LC}$$

$$s_{1,2} = -\sigma \pm \sqrt{\sigma^2 - \omega_o^2}$$

$$\omega_d = \frac{\sqrt{4c - b^2}}{2} = \sqrt{\omega_o^2 - \sigma^2}$$

$x(t) = x(\infty) + \left[x(t_0^+) - x(\infty)\right]e^{-(t-t_0)/\tau}$, where $\tau = R_{TH}C$ or $\tau = \frac{L}{R_{TH}}$

$$-\ln x = \ln\frac{1}{x}$$

TABLE 9.2 General Solutions for Constant-Source Second-Order Networks

General solution of the driven differential equation

$$\frac{d^2x}{dt^2} + b\frac{dx}{dt} + cx = F$$

having characteristic equation $s^2 + bs + c = (s - s_1)(s - s_2) = 0$, with roots

$$s_1, s_2 = \frac{-b \pm \sqrt{b^2 - 4c}}{2}$$

Case 1. Real and distinct roots; $b^2 - 4c > 0$:

$$x(t) = K_1 e^{s_1 t} + K_2 e^{s_2 t} + X_F$$

where $X_F = F/c$, and

$$x(0^+) = K_1 + K_2 + X_F$$
$$x'(0^+) = s_1 K_1 + s_2 K_2$$

Case 2. The roots $s_1 = -\sigma + j\omega_d$ and $s_2 = -\sigma - j\omega_d$ of the characteristic equation are distinct but complex; $b^2 - 4c < 0$:

$$x(t) = e^{-\sigma t}[A\cos(\omega_d t) + B\sin(\omega_d t)] + X_F$$

where again $X_F = F/c$, and

$$x(0^+) = A + X_F$$
$$x'(0^+) = -\sigma A + \omega_d B$$

Case 3. The roots are real and equal; $s_1 = s_2$ and $b^2 - 4c = 0$:

$$x(t) = (K_1 + K_2 t)e^{s_1 t} + X_F$$

where again $X_F = F/c$, and

$$x(0^+) = K_1 + X_F$$
$$x'(0^+) = s_1 K_1 + K_2$$

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Solution Key:

1. (7)
2. (5)
3. (4)
4. (1)
5. (2)
6. (5)
7. (4)
8. (2)
9. (3)
10. (8)
11. (6)
12. (6)