ECE 20100 – Spring 2017
Exam #3

April 13, 2017

Section (circle below)

Qi (12:30) – 0001   Tan (10:30) – 0004   Hosseini (7:30) – 0005

Cui (1:30) – 0006   Jung (11:30) – 0007

Lin (9:30) – 0008   Peleato-Inarrea (2:30) – 0009

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:

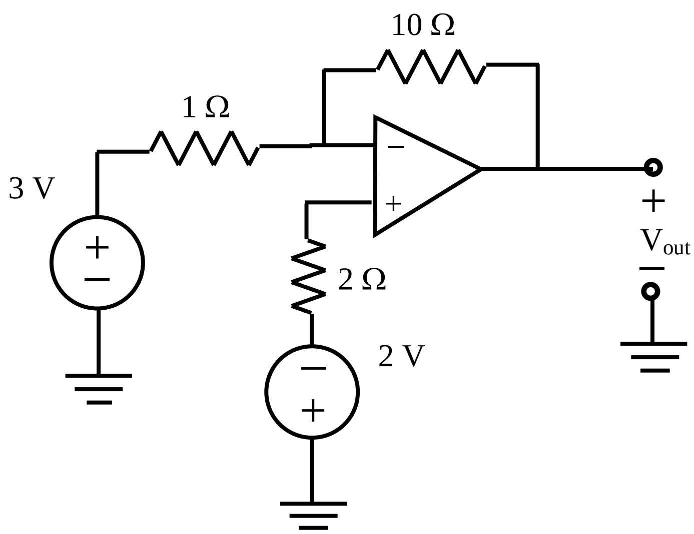
   iii) An ability to analyze 2nd order linear circuits with sources and/or passive elements.

   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

For the ideal op amp circuit below, the output voltage V_{out} is (in Volts):



(1) –28

(2) –30

(3) –32

(4) –36

(5) –40

(6) –48

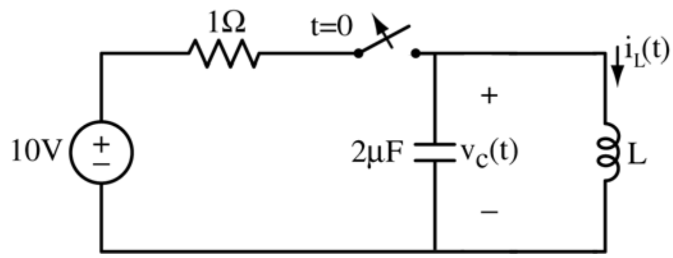
(7) –50

(8) –52

(9) None of the above

Question 2

The switch in the circuit below opens at $t = 0$ after having been closed for a long time. The sum of energy stored in the inductor and energy stored in the capacitor is 1J at $t = 0$. Find the value of the inductance L (in H).



(1) 0.01

(2) 0.02

(3) 0.05

(4) 0.10

(5) 0.20

(6) 0.25

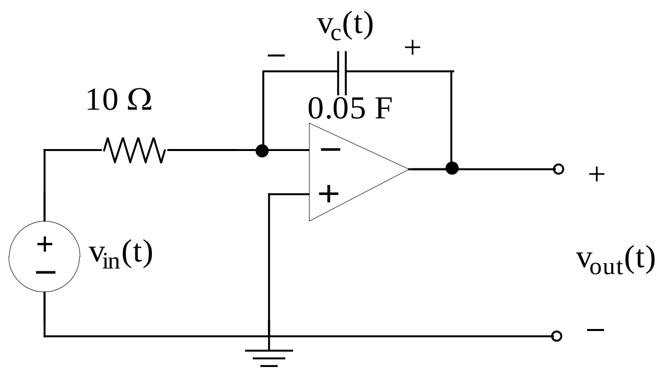
(7) 1

(8) 0

(9) None of the above

Question 3

In the ideal op. amp. circuit shown below, the capacitor voltage, $v_c(t)$, is 0 V for $t < 0$. The input voltage is $v_{in}(t) = 7\,e^{-2t}\,u(t)$ V. Find the output voltage, $v_{out}(t)$ (in V), for $t > 0$ sec.



(1) $7(1 + e^{-2t})$

(2) $14e^{-2t}$

(3) $-14e^{-2t}$

(4) $7e^{-2t}$

(5) $-7e^{-2t}$

(6) $-7(1 - e^{-2t})$

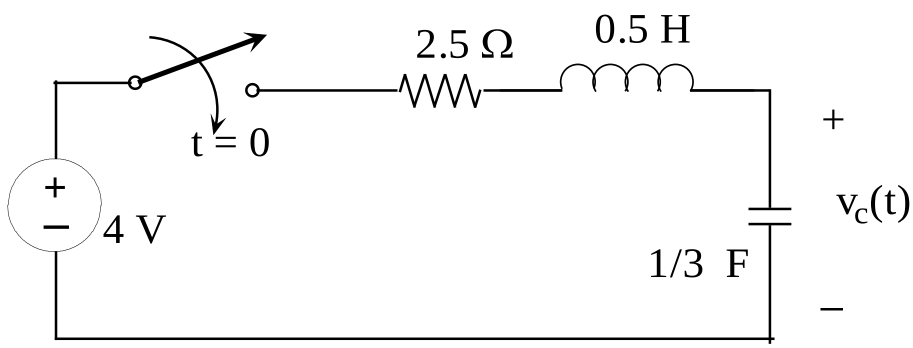
(7) $7(1 - e^{-2t})$

(8) 8

(9) None of the above

Question 4

The switch in the circuit below has been open for a long time. It closes at t = 0 s. The initial capacitor voltage prior to the switch closing is 0 V. The roots to the characteristics equation are $s_1 = -2\ s^{-1}$ and $s_2 = -3\ s^{-1}$. The complete response of the circuit is



(1) $v_c(t) = 8\,e^{-2t} - 8\,e^{-3t}$ V

(2) $v_c(t) = -12\,e^{-2t} + 8\,e^{-3t}$ V

(3) $v_c(t) = 12\,e^{-2t} - 8\,e^{-3t}$ V

(4) $v_c(t) = 4 - 12\,e^{-2t} + 8\,e^{-3t}$ V

(5) $v_c(t) = 4 + 8\,e^{-2t} - 12\,e^{-3t}$ V

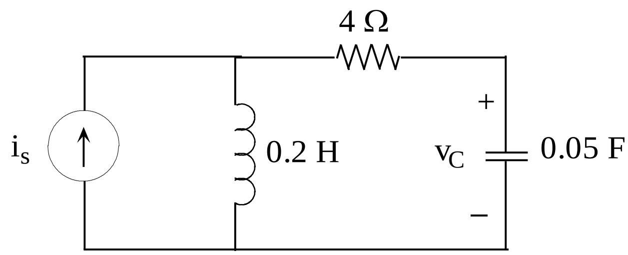
(6) $v_c(t) = 4 - 12\,e^{-2t} + 12\,e^{-3t}$ V

(7) $v_c(t) = 12\,e^{-2t} + 12\,e^{-3t}$ V

(8) None of the above

Question 5

In the circuit below, the current source is $i_s(t) = 10 \cos(10t)$ A. In the sinusoidal steady state, the phasor voltage V_C , in V, is



(1) 1 + j 1

(2) 2 + j 2

(3) 4 – j 3

(4) – 4

(5) 10

(6) 6+ j 3

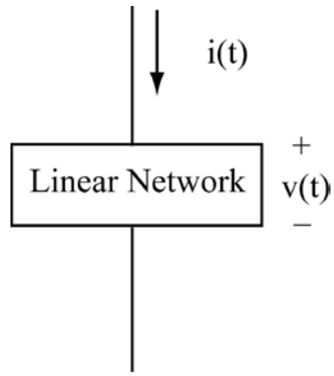
(7) j 7

(8) 5

(9) None of the above

Question 6

In the circuit shown below, the current phase is behind the voltage phase by 30°. The circuit contains:



(1) R only

(2) L only

(3) C only

(4) R and L

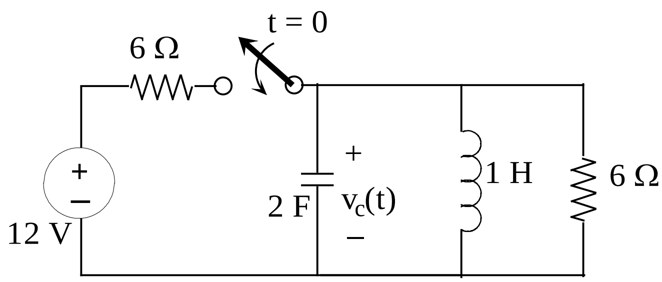
(5) R and C

(6) L and C

(7) None of the above

Question 7

The switch in the circuit below has been open for a long time. It closes at t = 0 s. Find $\frac{dv_c}{dt}$ at $t = 0^+$ (in V/s).



(1) 1

(2) 2

(3) 3

(4) 4

(5) 5

(6) 6

(7) 7

(8) 8

(9) None of the above

Question 8

For the voltage $v(t) = 5\cos(10t) + 5\cos(10t + 120^o)$ V, find the phasor representation in polar form (in V).

(1) $5\sqrt{2}\angle 60^o$

(2) $10\angle 120^o$

(3) $5\angle -120^o$

(4) $5\sqrt{2}\angle -60^o$

(5) 10

(6) $10\angle 60^o$

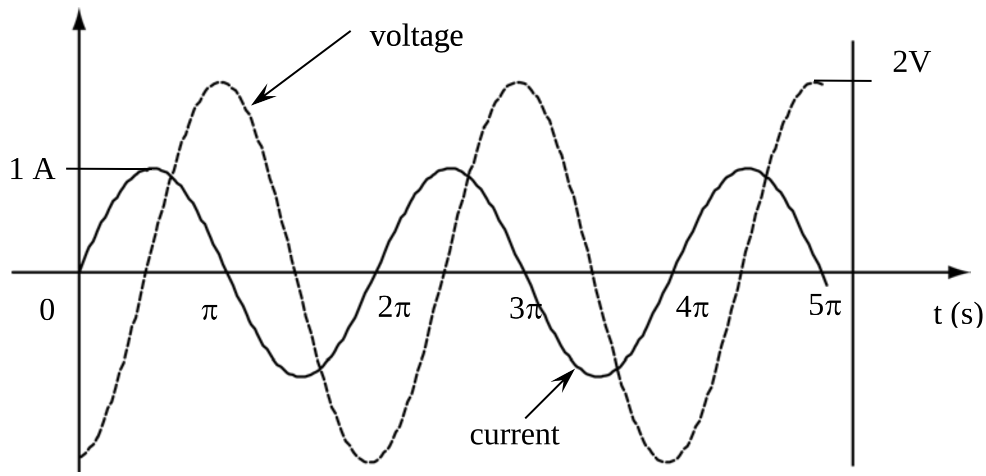
(7) $5\angle 60^o$

(8) $5\sqrt{2}\angle -120^o$

(9) None of the above

Question 9

In the following figure, the dashed line is the waveform of a voltage *v(t),* and the solid line is the waveform of a current *i*(t). The *x*-axis is time in seconds. If we view *v*(t) and *i*(t) as the voltage and current of a two-terminal linear device, find the correct device.



(1) 0.5 Ω resistor

(2) 0.5 H inductor

(3) 0.5 F capacitor

(4) 1 H inductor

(5) 1 F capacitor

(6) 2 Ω resistor

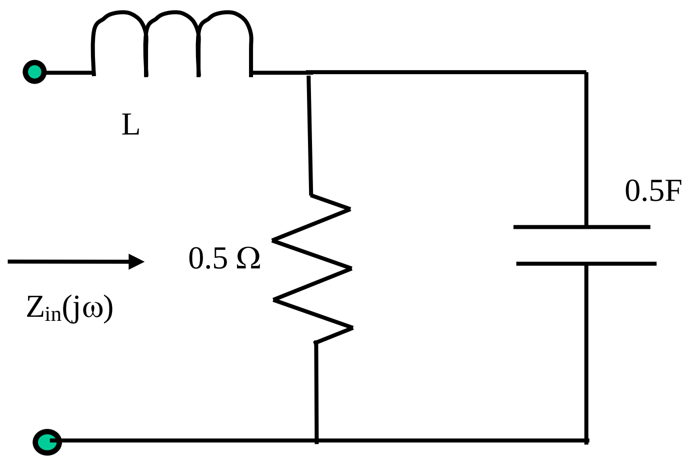
(7) 2 H inductor

(8) 2 F capacitor

(9) None of the above

Question 10

Find the value of the inductance L (in H) to yield an equivalent impedance of $Z_{in}(j\omega) = (0.40 + j0.20)\ \Omega$ assuming $\omega = 2$ rad/sec.



(1) 0.1

(2) 0.2

(3) 0.3

(4) 0.4

(5) 0.5

(6) 0.6

(7) 0.7

(8) 0.8

(9) None of the above

Potentially Useful Formulas

Energy stored in capacitor and inductor: $Cv^2/2$, $Li^2/2$

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

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 $c = (LC)^{-1}$

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

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

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

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

$$v_L(t) = L\frac{di_L(t)}{dt} \qquad i_C(t) = C\frac{dv_C(t)}{dt}$$

$$i_L(t) = i_L(t_0) + \frac{1}{L}\int_{t_0}^{t} v_L(t')dt' \qquad v_C(t) = v_C(t_0) + \frac{1}{C}\int_{t_0}^{t} i_C(t')dt'$$

$$W_L(t_0, t_1) = \frac{L}{2}\left[\left(i_L(t_1)\right)^2 - \left(i_L(t_0)\right)^2\right] \qquad W_C(t_0, t_1) = \frac{C}{2}\left[\left(v_C(t_1)\right)^2 - \left(v_C(t_0)\right)^2\right]$$

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