Exam III
Tuesday, April 11, 2000

Solutions

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Name: ____________________________________________

Student ID: ________________________________________

Check Your Division:
☐ 201-1 (DeCarlo)    ☐ 201-2 (Capano)    ☐ 201-3 (Tan)

INSTRUCTIONS:
♦ There are ten (10) multiple choice worth 6 points each; there is one (1) workout problem worth 40 points.

♦ Our goal is to assess what you know, not what you do not know. To maximize our assessment of your knowledge and understanding, do NOT dwell on a single problem. If you get stuck, move on to the next problem and return later, time permitting. It is important to work patiently, efficiently, and in an organized manner.

♦ This is a closed book, closed notes exam. No scrap paper is permitted. You are permitted only a calculator.

♦ All students are expected to abide by the usual ethical standards of the university, i.e., your answers must reflect only your own knowledge and reasoning ability.

Equations for second order circuits:

\[ Ae^{s_1 t} + Be^{s_2 t} \]
\[ (A + Bt)e^{s_1 t} \]
\[ e^{-\sigma t} [A\cos(\omega_d t) + B\sin(\omega_d t)] \]
1. The phasor current $I$ for the node sketched below is:

(1) $5.8e^{j76^\circ}$ A  
(2) $5.8e^{-j166^\circ}$ A  
(3) $2e^{-j45^\circ}$ A  
(4) $2e^{-j135^\circ}$ A  
(5) $10.1e^{-j53^\circ}$ A  
(6) $7.7e^{j17^\circ}$ A  
(7) none of these

2. The characteristic equation for the circuit below is:

(1) $s^2 + 2s + 1 = 0$  
(2) $s^2 + s + 2 = 0$  
(3) $s^2 + 0.5s + .05 = 0$  
(4) $s^2 + 2s + 2 = 0$  
(5) $s^2 + s + 1 = 0$  
(6) $s^2 + 0.5s + 1 = 0$  
(7) none of these
3. Find the voltage $v_C(t)$ across the capacitor when the circuit below is in steady state:

(1) $50 \cos (100t - 30^\circ) \text{ V}$  
(2) $5 \cos (100t - 30^\circ) \text{ V}$  
(3) $7.07 \cos(100t - 45^\circ)$  
(4) $50 \cos (100t - 75^\circ) \text{ V}$  
(5) $5 \cos (100t - 45^\circ) \text{ V}$  
(6) $7.07 \cos(100t - 75^\circ) \text{ V}$  
(7) none of these

4. The RLC circuit below has an underdamped response of the form

$$v_C(t) = e^{-\sigma t} \left[ A \cos(\omega_d t) + B \sin(\omega_d t) \right] + V_f \text{ (V)}$$

for $t > 0$. The range of $R$ leading to this response is:

(1) $R < 0.25 \ \Omega$  
(2) $R > 0.25 \ \Omega$  
(3) $R = 0.25 \ \Omega$  
(4) $R < 0.5 \ \Omega$  
(5) $R > 0.5 \ \Omega$  
(6) $R = 0.5 \ \Omega$  
(7) none of these
5. In the circuit shown below, the input voltage is $v_{\text{in}}(t) = 10\cos(20t)$ V and the input current is $i_{\text{in}}(t) = 2\cos(20t)$ A. The value of the inductance $L$ is:

- (1) 0.1 H
- (2) 0.2 H
- (3) 0.25 H
- (4) 0.4 H
- (5) 0.5 H
- (6) $j0.25$ H
- (7) none of these

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\begin{circuitikz}
\draw (0,0) to [short, i=$i_{\text{in}}(t)$] (2,0);
\draw (2,0) to [cC, v=$v_{\text{in}}(t)$] (2,-2);
\draw (2,-2) to [short, v=$Y_{\text{in}}$] (0,-2);
\draw (2,-2) to [i=$L$] (5,-2);
\draw (5,-2) to [cR, v=-$5\Omega$] (7,-2);
\end{circuitikz}
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6. In the circuit below, it is known that $i_L(0^+) = 20$ A and $\left. \frac{di_L(t)}{dt} \right|_{t=0^+} = -560$ $\text{A/\text{sec}}$. The initial condition $v_C(0^-)$ is:

- (1) $-24$ V
- (2) $-12$ V
- (3) 136 V
- (4) 12 V
- (5) 24 V
- (6) 36 V
- (7) none of these

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\begin{circuitikz}
\draw (0,0) to [short, i=$i_L(t)$] (2,0);
\draw (2,0) to [cL, v=$v_L(t)$] (4,0);
\draw (4,0) to [cC, v=$25\text{ mF}$] (6,0);
\draw (6,0) to [short, v=$v_C(t)$] (4,0);
\draw (6,0) to [r=$0.1\text{ H}$] (6.5,0);
\end{circuitikz}
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7. Find the value of L in Henries that makes the zero-input response underdamped with roots \( s_{1,2} = -2 \pm j2 \).

(1) 1 H  (2) 2 H  (3) 3 H  
(4) 4 H  (5) 5 H  (6) 6 H  
(7) none of these

8. Calculate the admittance, \( Y_{\text{in}}(j\omega) \), for the circuit below assuming \( \omega = 5 \text{ rad/sec} \).

(1) 0.1 \(-\) j1 mho  (2) 0.1 \(-\) j0.4 mho  (3) 0.1 + j0.6 mho  
(4) 10 + j3.5 mho  (5) 10 + j0.7 mho  (6) 0.1 + j1.4 mho  
(7) none of these
9. The circuit shown below has the characteristic equation,

\[ s^2 + 2s + 1 = 0 \]

and the initial conditions

\[ v_C(0^+) = 0 \]
\[ \left. \frac{dv_C(t)}{dt} \right|_{t=0^+} = 0 \]

Determine the voltage drop across the capacitor, \( v_C(t) \) (in volts):

(1) \(-10(1 + t)e^{-t} + 10 \) (V)  \( \quad \) (2) \(-10(1 + t)e^{-t} + 10 \) (V)  \( \quad \) (3) \(-10(1 + t)e^{-t} \) (V)
(4) \(-10(1 + t)e^{-t} + 1 \) (V)  \( \quad \) (5) \(-(1 + t)e^{-10t} \) (V)  \( \quad \) (6) \(-(1 + t)e^{-10t} + 10 \) (V)
(7) none of these
10. In the op amp circuit below, \( v_s(t) = u(t) \) V and \( v_c(0) = 1 \) V. The response \( v_{out}(t) \) is:

(1) \(-u(t) \) (V)  
(2) \(-2u(t) \) (V)  
(3) \(-tu(t) \) (V)  
(4) \(-2t u(t) \) (V)  
(5) \(-2t u(t) + 1 \) (V)  
(6) \(-2t u(t) - 1 \) (V)  
(7) \(1 + 2t u(t) \) (V)
Workout Problem. (40 points)
In the following circuit, the switch has been closed for a long time. It is open at t = 0 sec.
Analyze the problem as indicated. Your partial/full credit depends not only on your answer, but on the clarity of your work and the methodology used. (No work; no credit.)
Be organized, properly labeling each part.

(a) (5 pts) Find \( i_L(0^-) = i_L(0^+) \) and \( v_C(0^-) = v_C(0^+) \).

(b) (13 pts) Draw the equivalent circuit valid at \( t = 0^+ \) and find \( i_C(0^+) \) and \( v_L(0^+) \).

(c) (6 pts) Find the characteristic equation and the natural frequencies (i.e., roots of the characteristic equation) of the circuit for \( t > 0 \).

(d) (2 pts) Write down the form of the response \( i_L(t) \) based on your answer to (c).

(e) (14 pts) Find all constants associated with the response form. (Answers that are incorrect but consistent with (d) may not warrant full credit.)