1. (20 pts) Analysis of a circuit (not pictured) yields the characteristic equation below.

\[ 0 = s^2 + 800s + 160000 \]

Further analysis yields the following initial and final conditions:

\[ i_L(0) = 40\, \text{mA} \quad v_L(0) = -12\, \text{V} \quad v_C(0) = 5\, \text{V} \quad i_C(0) = 60\, \text{mA} \]
\[ i_L(\infty) = 120\, \text{mA} \quad v_L(\infty) = 0\, \text{V} \quad v_C(\infty) = 15\, \text{V} \quad i_C(\infty) = 0\, \text{mA} \]

Write the full expression for \( i_L(t) \), including all the constants that you find. Include units in your answer.

2. (24 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

\[ H(s) = \frac{X_{out}(s)}{X_{in}(s)} = ? \]

Simplify your expression for \( H(s) \) so that the denominator is a simple polynomial, or, better still, a multiple of simple polynomials.

b) Find the value of \( K \) to make the transfer function critically damped.

c) If \( K \) is greater than this value the system will be: underdamped or overdamped

Circle one

d) Does the transfer function have a zero? Answer no or find the \( s \) value(s) of the zero(s).
3. (36 pts) The switch has been up in position 1 for a long time and is switched down to position 2 (as shown) at time \( t = 0 \).

SHOW YOUR WORK, no credit for guesses!

a) What are the final conditions of \( i_L \) and the \( v_C \)?

\[
\begin{align*}
  i_L(\infty) &= ? \\
  v_C(\infty) &= ?
\end{align*}
\]

b) Find the initial condition and initial slope of \( i_L \) that you would need to have in order to find all the constants in \( i_L(t) \). Don't find \( i_L(t) \) or it's constants, just the initial conditions.

c) Find the initial condition and initial slope of \( v_C \) that you would need to have in order to find all the constants in \( v_C(t) \). Don't find \( v_C(t) \) or it's constants, just the initial conditions.

4. (20 pts) The transformer shown in the circuit below is ideal. It is rated at 300/100 V, 1.0 kVA, 60 Hz.

Find the following:

a) The primary current (magnitude).

\[
|I_1| = ?
\]

b) The secondary current (magnitude).

\[
|I_2| = ?
\]

c) The secondary voltage (magnitude).

\[
|V_2| = ?
\]

d) The complex power (\( P \) and \( Q \)) used by the load.

\[
S_L = ?
\]

e) Is this transformer operating within its ratings? Show your evidence.

**Answers**

1. 120-mA - 80-mA-e\( \frac{400}{t^2} \) - 92 A-e\( \frac{400}{t^2} \) - 2160 A-e\( \frac{400}{t^2} \)

2. a) \( \frac{2 \cdot s + 3}{s^2 + 80 \cdot s + 1200 + \frac{40}{K}} \) - b) 0.1 - c) overdamped - d) -20 - \( \left\{ \frac{3}{2} \right\} \)

3. a) 50-mA - 30-V \-

3. c) 36-V \-

4. a) 3.72-A \-

4. b) 11.15-A \-

4. c) 70.5-V \-

4. d) 746 + 249-j VA \-

4. e) NO 11.15-A > 10-A