Name:

Student ID:

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Problem 1 (30 points)

Find the Laplace transform of each of the following functions:

(a) \( f(t) = (t - 1) \cdot u(t) \)

(b) \( f(t) = (t - 1) \cdot u(t - 1) \)

(c) \( f(t) = \frac{d}{dt}(t^2 \cdot e^{-at}) \)

(d) \( f(t) = \int_0^t e^{-a\tau} \cos(\omega\tau) \, d\tau \)

Problem 2 (35 points)

Consider the circuit below with \( i_L(0^-) = -2 \, A, \, I_{DC} = 4 \, A, \, R = 2 \, \Omega, \, L = 1 \, H. \)

(a) Sketch the equivalent circuit in the Laplace domain.

(b) Calculate \( V_o(s) \).

(c) Apply the initial and final value theorem to obtain \( v_o(0^+) \) and \( \lim_{t \to \infty} v_o(t) \), respectively. Explain these results by the circuit behavior in the time domain.

(d) Calculate \( i_L(t) \) and \( v_o(t) \).
Problem 3 (35 points)

The circuit given below has the following transfer function:

\[ H(s) = \frac{V_o(s)}{V_i(s)} = \frac{s^2}{s^2 + \frac{2}{R_2C}s + \frac{1}{R_1R_2C^2}} \]

(a) Evaluate the transfer function for \( R_1 = R_2 = 1 \, \Omega \) and \( C = 1 \, F \).

(b) Calculate \( v_o(t) \) for \( v_i(t) = 5 \, V \cdot u(t) \) and the transfer function from part (a).

(c) Calculate the impulse response \( h(t) \) of the circuit using the circuit elements from part (a).

(d) Derive the transfer function given above for general values of \( R_1, R_2, \) and \( C \).