1. (10 pts) Partial fraction expansion (Nise 2.2)
Find the inverse Laplace transform of the following function using partial fraction expansion:

\[ \frac{s - 2}{s(s + 1)(s + 4)^2} \]

2. (15 pts) Laplace transform review (Nise 2.2)
For each transfer function below determine \( h(t) \).

i) \( H_1(s) = \frac{1}{s^2 + 4s + 53} \)
ii) \( H_2(s) = \frac{s}{s^2 + 4s + 53} \)
iii) \( H_3(s) = \frac{s + 3}{s^2 + 4s + 53} \)
iv) \( H_4(s) = \frac{s^2}{s^2 + 4s + 53} \)
v) \( H_5(s) = \frac{s^2 + 4}{s^2 + 4s + 53} \)

3. (10 pts) Initial value, final value (Nise 2.2)
For each of the following Laplace transforms \( Y_i(s) \) determine \( y_i(t = 0^+) \) and if the limit exists, \( \lim_{t \to \infty} y_i(t) \):

i) \( Y_1(s) = \frac{1}{s(s + 3)} \)
ii) \( Y_2(s) = \frac{s}{s^2 + 3} \)
iii) \( Y_3(s) = \frac{s + 1}{s(s + 3)} \)
iv) \( Y_4(s) = \frac{s - 3}{s(s + 3)} \)
v) \( Y_5(s) = \frac{1}{(s + 1)(s + 2)} \)

4. (15 pts) Electrical circuit example (Nise 2.4)
For the circuit in Fig. 1. below, using ideal op-amp assumptions, determine \( H(s) = \frac{V_o(s)}{V_i(s)} \).

5. (15 pts) Equivalent models (Nise 2.5)
For the translational mechanical system in Fig. 2, write the transfer function relating input force \( f(t) \) to output velocity \( \dot{x}_2(t) \).

6. (20 pts) Equivalent electrical circuit (Nise 2.9)
Draw the equivalent electrical circuit for the system in Fig. 2, (with voltage corresponding to force, and current corresponding to velocity \( \dot{x}_2(t) \), and re-derive the transfer function from voltage input to current output for the circuit to verify that it is equivalent to the transfer function found in problem 5 above.

7. (15 pts) Linearization (Nise 2.11)
A system is described by \( f(t) = m\ddot{x}(t) + b\dot{x}(t) + f_s(x, t) \), where \( f_s \) is the force from a non-linear spring. The spring is defined by \( x_s(t) = 1 - e^{-f_s(t)} \) where \( x_s(t) \) is the spring displacement. Find the transfer function \( X(s)/F(s) \) for small excursions around \( f(t) = 1 \).