1. Pharmacokinetic model formulation
   a. Sketch a process flow diagram for a pharmacokinetic model which includes a one-compartment pancreas and a two-compartment brain, connected by the bloodstream.
   b. Formulate model equations for the concentrations of a molecule in the brain. Assume the flux between the two compartments is membrane-limited and passive, i.e., \( n = -h(C_1 - C_\text{II})/R \). Also, assume the molecule is degraded in the inner compartment with first-order rate constant \( k_d \).
   c. Identify input, output and state variables and parameters for the most general model (i.e. the whole system). Is your system under-, over-, or exactly determined?

2. Consider the following input function:
   \[
   u(t) = \begin{cases} 
   0 & t < 0 \\
   3t & 0 \leq t < 3 \\
   9 & t \geq 3 
   \end{cases}
   \]
   a. Sketch the function.
   b. Find \( u(s) \), its Laplace function.

3. [SEM04 #3.8] Find the \( x(t) \) which solves the following integro-differential equation.
   \[
   \ddot{x} + 3\dot{x} + 2x - 2 \int_{0}^{t} e^{-\tau} \, d\tau = 0
   \]

4. [SEM #3.6] Using partial fraction expansion where required, find \( x(t) \) for:
   a. \( X(s) = \frac{s(s + 1)}{(s + 2)(s + 3)(s + 4)} \)
   b. \( X(s) = \frac{s + 1}{(s + 2)(s + 3)(s^2 + 4)} \)
   c. \( X(s) = \frac{s + 4}{(s + 1)^2} \)
   d. \( X(s) = \frac{1}{s^2 + s + 1} \)

5. Bequette: Chap. 3 #7.
   Also, add part (v): Solve for \( y(t) \) numerically using Matlab.
   Plot your analytic and numerical solutions on the same axis.