1.) Let $S$ be the amount (pounds) of sugar in a tank at time $t$ (minutes). A solution containing 1/2 pound of sugar per gallon begins flowing into the tank at the rate of 5 gallons per minute and the well-stirred mixture flows out of the tank at the rate of 5 gallons per minute. Initially, the tank holds 200 gallons with 25 pounds of sugar. Set up a differential equation for the rate $\frac{dS}{dt}$ and solve the D.E. for $S$. How many pounds of sugar are in the tank after 30 minutes?

2.) Solve the differential equation for problem 1.) if

   a.) the flow rate IN is 5 gallons per minute and the flow rate OUT is 4 gallons per minute.
   b.) the flow rate IN is 5 gallons per minute and the flow rate OUT is 7 gallons per minute.

3.) Solve the following first-order linear differential equations.

   a.) $y' + y + 3$  b.) $y' - y = x + 1$  c.) $y' + \frac{1}{x} y = e^x - 2$
   
   d.) $y' + 2xy = \frac{1}{1 + e^{x^2}}$  e.) $y' - \frac{1}{x} y = xe^{x^3} + x^2 - 1$

   f.) $y' + \tan x \cdot y = \sec x - \tan x + 1$  g.) $y' + \sec x \cdot y = \sec x - \tan x + 1$

   h.) $xy' - y = x(\ln x)^3$  i.) $xy' + y = x^3 - x^2 + x - 1$  j.) $x^2 y' + 2xy = x \ln x$

4.) Use any method to solve the following differential equations. Some can be integrated directly. Some may be first-order linear or separable.

   a.) $\frac{dy}{dx} = \ln x$  b.) $\frac{dy}{dx} = \frac{x^2}{y(1 + x^3)}$  c.) $\frac{dy}{dx} = \frac{y^2}{x(1 + y^3)}$
   
   d.) $\frac{dy}{dx} - x^5 y^2 = 0$  e.) $\frac{dy}{dx} = \frac{x + x^3}{1 + x^4}$  f.) $\frac{dy}{dx} - y^2 = y$

   g.) $\frac{dy}{dx} + 3x^2 y = 7x^2$  h.) $\frac{dy}{dx} = \frac{x \cos(x^2)}{y^2 \sin y}$  i.) $y' + y^3 = y$ and $x = 0$, $y = 2$

   j.) $y' + 2y = e^{-2x} \tan^2(7x)$  k.) $y' \cdot \cos^2 x + y = 1$  l.) $xy' + 2y = x \cos x$

   m.) $\tan x \cdot y' = y^2(y + 1) \cot x$  n.) $\cos(5x^2) \cdot y' = x \cdot \sec^2(3y)$

   o.) $(e^{2x} - e^x) \cdot e^{2y} \cdot \sin(e^y) \cdot y' = (1 + e^x)e^x$  p.) $\cos^3 y \cdot \sin y \cdot dy = \tan^3(10x) \cdot dx$

5.) Consider the differential equation $\frac{dy}{dx} + 3x = 2xy$. 

6.) Determine the equilibria for each autonomous D.E. and determine their stability using the indicated method.

   a.) \( \frac{dN}{dt} = N^3 - 4N \) (Sign Chart Method)

   b.) \( \frac{dN}{dt} = N(3 - N)(N - 5) \) (Derivative, \( g'(N) \), Method)

   c.) \( \frac{dN}{dt} = \frac{N^2 - 9N}{N^2 + 9} \) (Any Method)

THE FOLLOWING PROBLEM IS FOR RECREATIONAL PURPOSES ONLY.

7.) A camp cook wants to measure four ounces of vinegar out of a jug, but he has only an unmarked five-ounce container and an unmarked three-ounce container. How can he do it?