1. Conceptual Understanding:
   (a) What does it mean to say that a differential equation is first-order (or second-order or third-order...)
   (b) What does it mean to say that a differential equation is linear or nonlinear?

2. Use Separation of Variables to find the general solutions to the following differential equations.
   (a) \( y' + 4xy^2 = 0 \)
   (b) \( \sqrt{1-x^2}y' = xy \)
   (c) \( (1+x^2)y' = x^3y \)
   (d) \( \sqrt{1+y^2}y' + \sec x = 0 \)

3. Solve \( y' = 4y + 24 \) subject to the condition that \( y(0) = 5 \).

4. Solve \( y' + 6y = 12 \) subject to the condition that \( y(2) = 10 \).

5. Recall that Newton’s law of Cooling stipulates that the temperature \( y(t) \) of a cooling object with respect to time satisfies the differential equation

\[
y' = -k(y - T_0),
\]

where \( k \) is a constant depending on the object and \( T_0 \) is the temperature of the ambient environment.

Frank’s car engine runs at 210°F. On a 70°F day, he turns off the ignition and notes that five minutes later, the engine has cooled to 160°F.

   (a) Find the cooling constant \( k \).
   (b) When will the engine cool to 100°F?

6. A cup of coffee with cooling constant \( k = 0.09 \text{min}^{-1} \) is placed in a room of temperature 20°C.

   (a) How quickly is the coffee cooling when the temperature is 80°C?
   (b) Use the linear approximation to estimate the change in temperature over the next 6 s when the temperature is 80°C.
   (c) If the coffee is initially served at 90°C, how long will it take to reach an optimal drinking temperature of 65°C?

7. (Extra) A tank has the shape of the parabola \( y = x^2 \) revolved about the \( y \)-axis. Water leaks from a hole of area \( B = 0.0005 \text{ m}^2 \) at the bottom of the tank. Let \( y(t) \) be the water level at time \( t \). How long does it take for the tank to empty if the initial water level is \( y(0) = 1 \text{ m} \)?