Problem 3.1

(a) $y[n] = x[n] - x[0]$ is linear.

(b) $y[n] = x[n] - 1$ is nonlinear (a system like this, nonlinear only because of the constant offset, is called “affine”). For example,

$$x_1[n] = \cos \pi n \Rightarrow y_1[n] = \begin{cases} 0 & n \text{ even} \\ -2 & n \text{ odd} \end{cases}$$

$$x_2[n] = 1 \Rightarrow y_2[n] = 0$$

$$x_3[n] = x_1[n] + x_2[n] \Rightarrow y_3[n] = \cos \pi n \neq y_1[n] + y_2[n]$$

Problem 3.2

(a) $y[n] = x[n] - x[0]$ is time-varying. For example,

$$x_1[n] = \cos \pi n \Rightarrow y_1[n] = \begin{cases} 0 & n \text{ even} \\ -2 & n \text{ odd} \end{cases}$$

$$x_2[n] = x_1[n] - 1 \Rightarrow y_2[n] = \begin{cases} 0 & n \text{ even} \\ 2 & n \text{ odd} \end{cases} \neq y_1[n - 1]$$

(b) $y[n] = x[n] - 1$ is time-invariant.

Problem 3.3

$$y[n] = \begin{cases} 0 & n \leq -2, n \geq 4 \\ 0.5 & n = -1, 3 \\ 1.5 & n = 0, 2 \\ 2 & n = 1 \end{cases}$$

Matlab Exercises
Problem 3.4