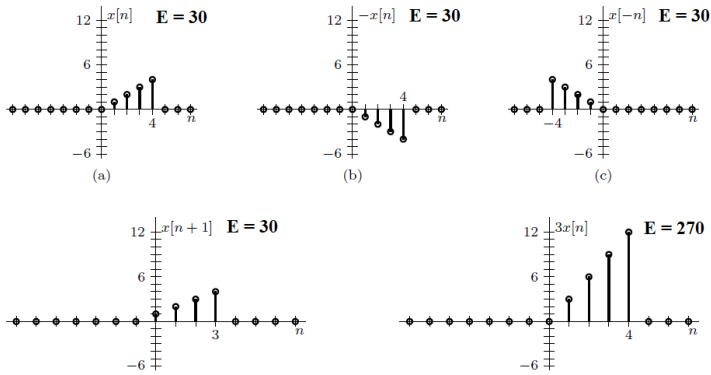


Answer Keys to HW 4

1)

- (a) $\cos(0.6\pi n + 0.3) + 3 \sin(0.5\pi n + 0.4)$ is periodic with period $N = 20$.
 (b) $\cos(1.6\pi n + 0.3) + 3 \sin(1.5\pi n + 0.4) + 8 \cos(1.8\pi n - \frac{\pi}{3})$ is periodic with period $N = 20$.
 (c) $\cos(0.7\pi n + 0.3) + 3 \sin(0.5\pi n + 0.4)$ is not periodic.

2)



3)

- (a) $P_{x_a} = \frac{1}{6} \sum_{n=0}^5 |x_a[n]|^2 = \frac{1}{6}(6^2 + 4^2 + 2^1 + 0^2 + 2^2 + 4^2) = \frac{76}{6} = \frac{38}{3}$.
 (b) $P_{x_b} = \frac{1}{12} \sum_{n=0}^{11} |x_b[n]|^2 = \frac{1}{12}((-3)^2 + (-2)^2 + (-1)^1 + 1^2 + 2^2 + 3^2) = \frac{28}{12} = \frac{7}{3}$.

4)

- (a) $\left. \frac{d^3}{dt^3} y(t) \right|_{t=nT} = \frac{1}{T^3} (y[n] - 3y[n-1] + 3y[n-2] - y[n-3])$
 (b) $y[n] - \frac{860}{462}y[n-1] + \frac{400}{462}y[n-2] = \frac{1}{462}x[n]$

5)

- (a) $y[n] = \frac{1}{5} (x[n] + x[n-1] + x[n-2] + x[n-3] + x[n-4])$.
 (b)
- (c) $y[n] - y[n-1] = \frac{1}{5} (x[n] - x[n-5])$.
 (d)

6)

- a) Time invariant, linear, causal, BIBO stable, dynamic, invertible
 b) Time invariant, linear, noncausal, BIBO stable, dynamic, invertible
 c) Time variant, linear, causal, BIBO unstable, dynamic, non-invertible

d) Time variant, linear, causal, BIBO unstable, dynamic, non-invertible

e) Time variant, nonlinear, causal, BIBO unstable, static, non-invertible

7)

In this problem, a signal $x[n]$ is sampled at a rate $F_s = 1$ kHz. It is desired to reduce the sampling rate by 60% to $0.4F_s = 400$ Hz.

- (a) The structures of Fig. 4.34a and Fig. 4.34b both change the input sampling rate of F_s to $\frac{L}{M}F_s$. Choosing L and M to be coprime, the desired rate $0.4F_s$ requires $L = 2$ and $M = 5$.
- (b) The structures of Fig. 4.34a and Fig. 4.34b both operate at $F_s = 1000$ Hz at the input and $0.4F_s = 400$ Hz at the output. However, the expander-before-compressor structure of Fig. 4.34a operates at a rate $LF_s = 2000$ Hz between the expander and compressor while the compressor-before-expander structure of Fig. 4.34b operates at a rate $F_s/M = 200$ Hz between the compressor and expander. Clearly, ordering the expander before the compressor requires faster component operation than ordering the compressor before the expander.