

2 Signals and Systems: Part I

Solutions to Recommended Problems

S2.1

(a) We need to use the relations $\omega = 2\pi f$, where f is frequency in hertz, and $T = 2\pi/\omega$, where T is the fundamental period. Thus, $T = 1/f$.

$$(i) \quad f = \frac{\omega}{2\pi} = \frac{\pi/3}{2\pi} = \frac{1}{6} \text{ Hz}, \quad T = \frac{1}{f} = 6 \text{ s}$$

$$(ii) \quad f = \frac{3\pi/4}{2\pi} = \frac{3}{8} \text{ Hz}, \quad T = \frac{8}{3} \text{ s}$$

$$(iii) \quad f = \frac{3/4}{2\pi} = \frac{3}{8\pi} \text{ Hz}, \quad T = \frac{8\pi}{3} \text{ s}$$

Note that the frequency and period are independent of the delay τ , and the phase θ .

(b) We first simplify:

$$\cos(\omega(t + \tau) + \theta) = \cos(\omega t + \omega\tau + \theta)$$

Note that $\omega\tau + \theta$ could also be considered a phase term for a delay of zero. Thus, if $\omega_s = \omega_r$ and $\omega_s\tau_s + \theta_s = \omega_r\tau_r + \theta_r + 2\pi k$ for any integer k , $y(t) = x(t)$ for all t .

$$(i) \quad \omega_s = \omega_r, \quad \omega_s\tau_s + \theta_s = 2\pi, \quad \omega_r\tau_r + \theta_r = \frac{\pi}{3}(1) - \frac{\pi}{3} = 0 + 2\pi k$$

Thus, $x(t) = y(t)$ for all t .

(ii) Since $\omega_s \neq \omega_r$, we conclude that $x(t) \neq y(t)$.

$$(iii) \quad \omega_s = \omega_r, \quad \omega_s\tau_s + \theta_s = \frac{1}{2}(1) + \frac{1}{2} \neq \frac{1}{2}(1) + \frac{1}{2} + 2\pi k$$

Thus, $x(t) \neq y(t)$.

S2.2

(a) To find the period of a discrete-time signal is more complicated. We need the smallest N such that $\Omega N = 2\pi k$ for some integer $k > 0$.

$$(i) \quad \frac{\pi}{3} N = 2\pi k \rightarrow N = 6, \quad k = 1$$

$$(ii) \quad \frac{3\pi}{4} N = 2\pi k \rightarrow N = 8, \quad k = 2$$

(iii) $\frac{1}{2} N = 2\pi k \rightarrow$ There is no N such that $\frac{1}{2} N = 2\pi k$, so $x[n]$ is not periodic.

(b) For discrete-time signals, if $\Omega_s = \Omega_r + 2\pi k$ and $\Omega_s\tau_s + \theta_s = \Omega_r\tau_r + \theta_r + 2\pi k$, then $x[n] = y[n]$.

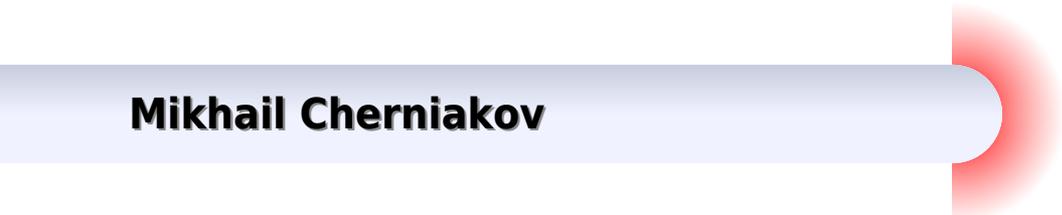
$$(i) \quad \frac{\pi}{3} \neq \frac{8\pi}{3} + 2\pi k \text{ (the closest is } k = -1), \text{ so } x[n] \neq y[n]$$

$$(ii) \quad \Omega_s = \Omega_r, \quad \frac{3\pi}{4}(2) + \frac{\pi}{4} = \frac{3\pi}{4} - \pi + 2\pi k, \quad k = 1, \text{ so } x[n] = y[n]$$

$$(iii) \quad \Omega_s = \Omega_r, \quad \frac{1}{2}(1) + \frac{1}{2} = \frac{1}{2}(0) + \frac{1}{2} + 2\pi k, \quad k = 0, \quad x[n] = y[n]$$

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