

Answers to selected exercises for chapter 3

1.1 Apply $\cos(a + b) = \cos a \cos b - \sin a \sin b$, where

$$\begin{aligned} f_1(t) + f_2(t) &= A_1 \cos \omega_1 t + A_2 \sin \omega_1 t + A_3 \cos \omega_2 t + A_4 \sin \omega_2 t \\ &= (A_1 \cos \omega_1 t + A_2 \sin \omega_1 t) \cos \omega_1 t + (A_3 \cos \omega_2 t + A_4 \sin \omega_2 t) \sin \omega_1 t \\ &= C_1 \cos \omega_1 t + C_2 \sin \omega_1 t, \end{aligned}$$

where $C_1 = A_1 \cos \omega_1 t + A_2 \sin \omega_1 t$ and $C_2 = A_3 \cos \omega_2 t + A_4 \sin \omega_2 t$. Put $k = \omega_1/\omega_2 = C_2/C_1$ and look at signals that consist of $C_1 \cos k$ and $C_2 \sin k$ (this is possible since $(C_1 \cos k)^2 + (C_2 \sin k)^2 = 1$). Then $f_1(t) + f_2(t) = A_1 \cos \omega_1 t + \sin \omega_1 t \sin \omega_2 t = A \cos \omega_1 t + \sin \omega_1 t$.

1.2 Put $v_1 = A_1 e^{j\omega t}$ and $v_2 = A_2 e^{j\omega t}$, then $f_1(t) + f_2(t) = (v_1 + v_2) e^{j\omega t}$. Let $v = v_1 + v_2$, then $f_1(t) + f_2(t) = v e^{j\omega t}$. The signal $f_1(t) + f_2(t)$ is again a sinusoidal signal with amplitude $|v|$ and initial phase $\arg v$.

1.3 The power P is given by

$$\begin{aligned} P &= \frac{1}{T} \int_{-T/2}^{T/2} A^2 \cos^2(\omega t + \phi_0) dt = \frac{A^2}{T} \int_{-T/2}^{T/2} (1 + \cos(2\omega t + 2\phi_0)) dt \\ &= \frac{A^2}{2}. \end{aligned}$$

1.4 The energy content is $E = \int_{-\infty}^{\infty} e^{-\alpha t} dt = \frac{1}{\alpha}$.

1.5 The power P is given by

$$P = \frac{1}{T} \sum_{n=1}^N |\cos(n\pi/2)|^2 = \frac{1}{2}.$$

1.6 The energy content is $E = \sum_{n=1}^{\infty} e^{-n\alpha}$, which is a geometric series with ratio $1/2 < e^{-\alpha}$.

1.7 a. If $u(t)$ is real, then the integral, and so $p(t)$, is also real.

b. Since

$$\left| \int u(\tau) d\tau \right| \leq \int |u(\tau)| d\tau,$$

it follows from the boundedness of $u(t)$, so $|u(\tau)| \leq M$ for some constant M , that $p(t)$ is also bounded.

c. The linearity follows immediately from the linearity of integration. The time-invariance follows from the substitution $\xi = t - t_0$ in the integral $\int_{-\infty}^{\infty} u(t - t_0) dt$ representing the response to $u(t - t_0)$.

d. Calculating $\int_{-\infty}^{\infty} \cos(\omega\tau) d\tau$ gives the following response: $\sin(\omega t) = \sin(\omega t - \omega(0)/\omega) = 2 \sin(\omega/2) \cos(\omega t - \omega/2\omega)$.

e. Calculating $\int_{-\infty}^{\infty} \sin(\omega\tau) d\tau$ gives the following response: $(-\cos(\omega t) + \cos(\omega(0)/\omega) = 2 \sin(\omega/2) \sin(\omega t - \omega/2\omega)$.

f. From the response to $\cos(\omega t)$ it follows that the amplitude response is $(2 \sin(\omega/2\omega))^2$.

g. From the response to $\sin(\omega t)$ it follows that the phase response is $-\omega/2$ if $2 \sin(\omega/2\omega)/\omega > 0$ and $+\omega/2$ if $2 \sin(\omega/2\omega)/\omega < 0$. From

Fourier And Laplace Transforms Solution Manual

Annelies Wilder-Smith



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