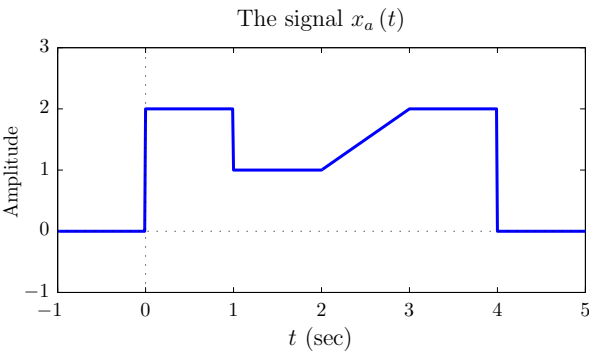


Chapter 1

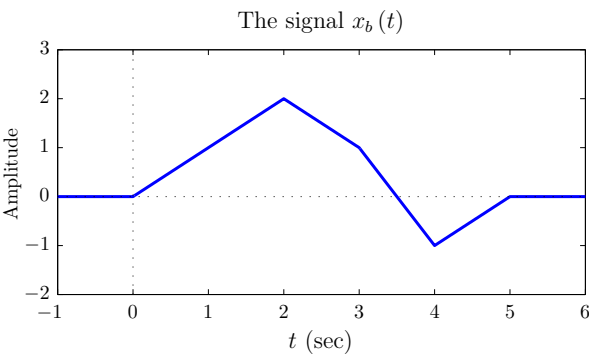
Signal Representation and Modeling

1.1.

a.



b.



1.2.

a.

$$x_a(t) = \begin{cases} 0, & t < -1 \text{ or } t > 3 \\ 2t+2, & -1 < t < 0 \\ -t+2, & 0 < t < 1 \\ 1, & 1 < t < 2 \\ -t+3, & 2 < t < 3 \end{cases}$$

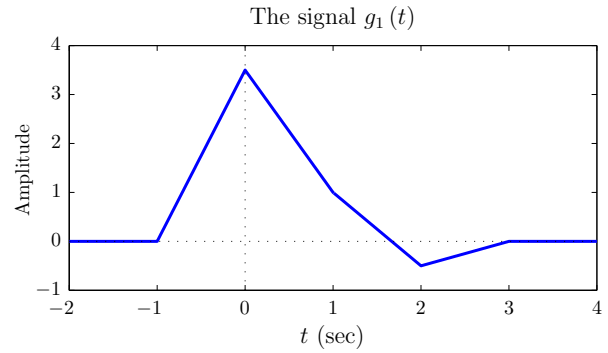
b.

$$x_a(t) = \begin{cases} 0, & t < -1 \text{ or } t > 3 \\ 1.5t+1.5, & -1 < t < 0 \\ -1.5t+1.5, & 0 < t < 2 \\ 1.5t-4.5, & 2 < t < 3 \end{cases}$$

1.3.

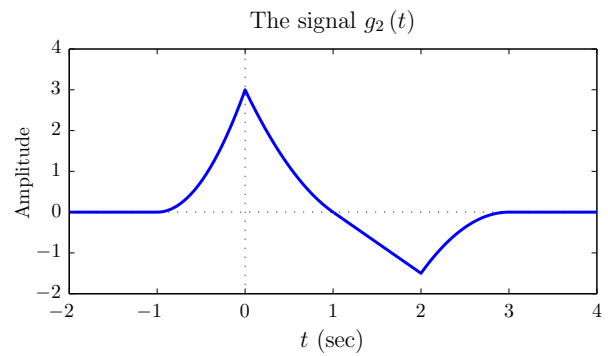
a.

$$g_1(t) = \begin{cases} 0, & t < -1 \text{ or } t > 3 \\ 3.5t + 3.5, & -1 < t < 0 \\ -2.5t + 3.5, & 0 < t < 1 \\ -1.5t + 2.5, & 1 < t < 2 \\ 0.5t - 1.5, & 2 < t < 3 \end{cases}$$



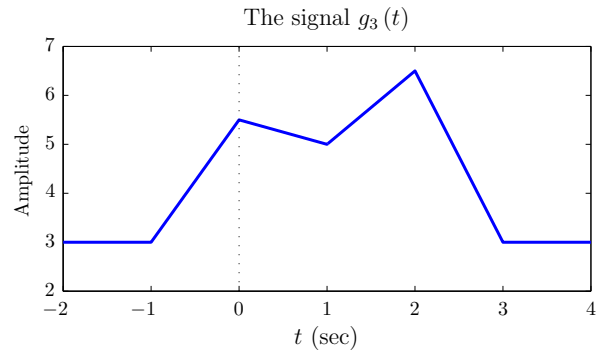
b.

$$g_2(t) = \begin{cases} 0, & t < -1 \text{ or } t > 3 \\ 3t^2 + 6t + 3, & -1 < t < 0 \\ 1.5t^2 - 4.5t + 3, & 0 < t < 1 \\ -1.5t + 1.5, & 1 < t < 2 \\ -1.5t^2 + 9t - 13.5, & 2 < t < 3 \end{cases}$$



c.

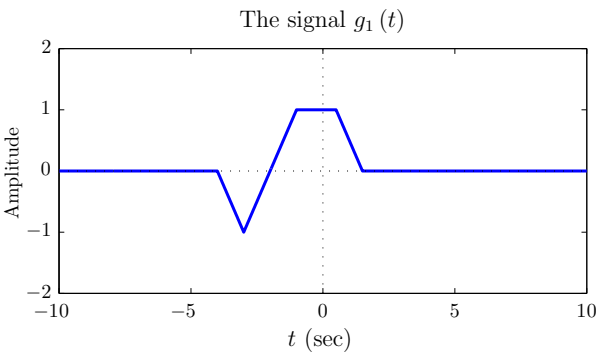
$$g_3(t) = \begin{cases} 3, & t < -1 \text{ or } t > 3 \\ 2.5t + 5.5, & -1 < t < 0 \\ -0.5t + 5.5, & 0 < t < 1 \\ 1.5t + 3.5, & 1 < t < 2 \\ -3.5t + 13.5, & 2 < t < 3 \end{cases}$$



1.4.

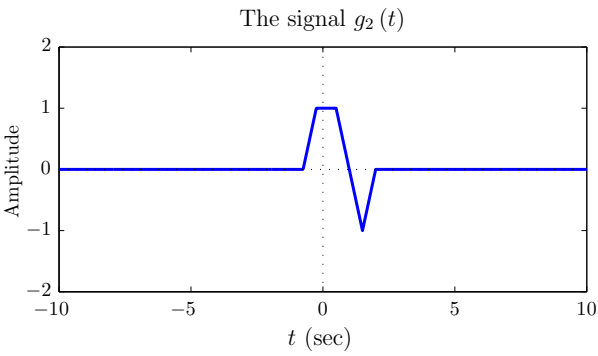
a.

Time reversal
 $g_1(t) = x(-t)$



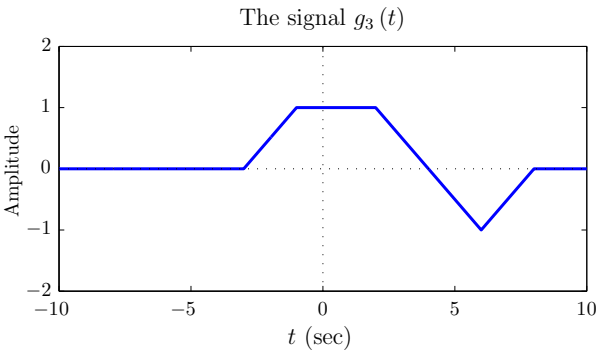
b.

Time scaling
 $g_2(t) = x(2t)$



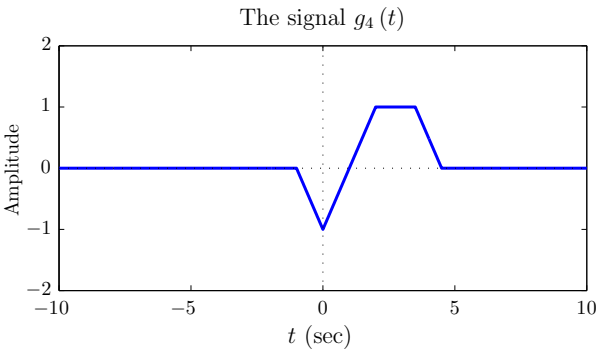
c.

Time scaling
 $g_3(t) = x\left(\frac{t}{2}\right)$



d.

Step 1: Time reversal
 $g_{4a}(t) = x(-t)$
Step 2: Time shifting
 $g_4(t) = g_{4a}(t-3) = x(-t+3)$



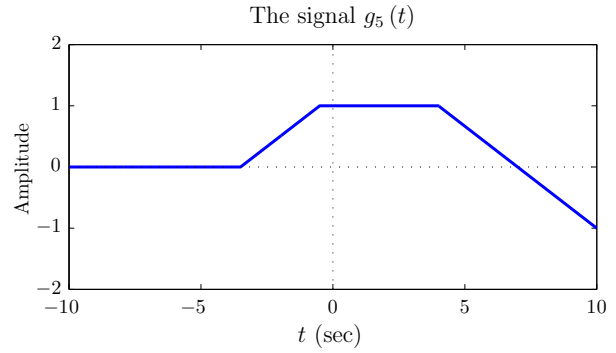
e.

Step 1: Time scaling

$$g_{5a}(t) = x\left(\frac{t}{3}\right)$$

Step 2: Time shifting

$$g_5(t) = g_{5a}(t-1) = x\left(\frac{(t-1)}{3}\right)$$



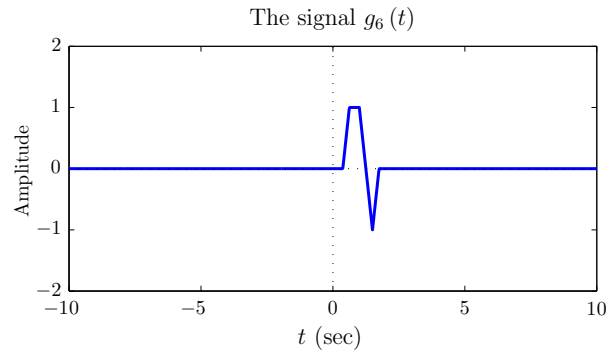
f.

Step 1: Time scaling

$$g_{6a}(t) = x(4t)$$

Step 2: Time shifting

$$g_6(t) = g_{6a}(t-3/4) = x(4t-3)$$



g.

Step 1: Time scaling

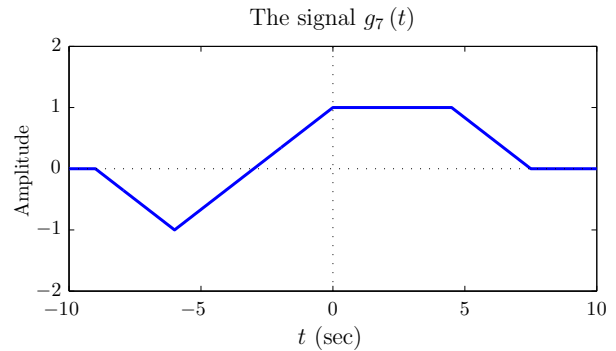
$$g_{7a}(t) = x\left(\frac{t}{3}\right)$$

Step 2: Time reversal

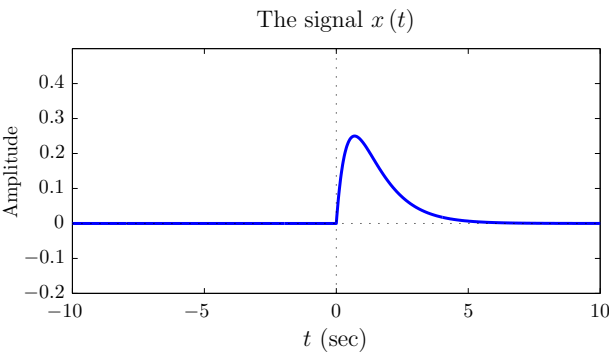
$$g_{7b}(t) = g_{7a}(-t) = x\left(-\frac{t}{3}\right)$$

Step 3: Time shifting

$$g_y(t) = g_{7b}(t-3) = x\left(1-\frac{t}{3}\right)$$



1.5.



a.

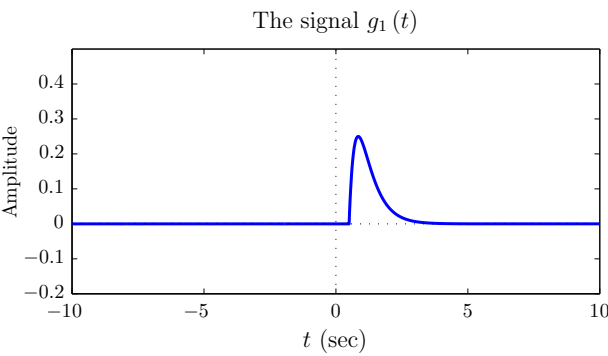
$$g_1(t) = x(2t - 1)$$

Step 1: Time scaling

$$g_{1a}(t) = x(2t)$$

Step 2: Time shifting

$$g_1(t) = g_{1a}(t - 0.5) = x(2t - 1)$$



b.

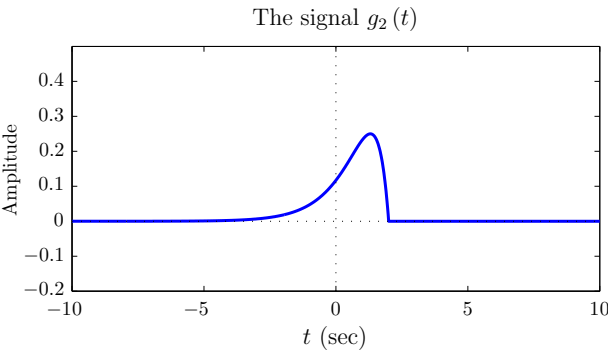
$$g_2(t) = x(-t + 2)$$

Step 1: Time reversal

$$g_{2a}(t) = x(-t)$$

Step 2: Time shifting

$$g_2(t) = g_{2a}(t - 2) = x(-t + 2)$$



c.

$$g_3(t) = x(-3t + 5)$$

Step 1: Time scaling

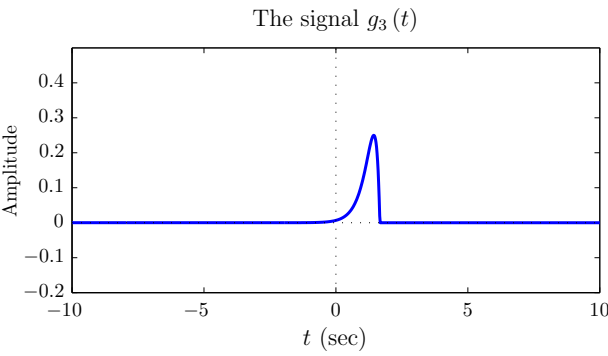
$$g_{3a}(t) = x(3t)$$

Step 2: Time reversal

$$g_{3b}(t) = g_{3a}(-t) = x(-3t)$$

Step 3: Time shifting

$$g_3(t) = g_{3b}(t - 5/3) = x(-3t + 5)$$



d.

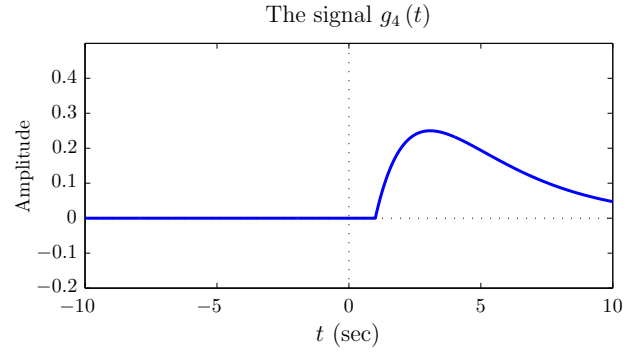
$$g_4(t) = x\left(\frac{t-1}{3}\right)$$

Step 1: Time scaling

$$g_{4a}(t) = x\left(\frac{t}{3}\right)$$

Step 2: Time shifting

$$g_4(t) = g_{4a}(t-1) = x\left(\frac{t-1}{3}\right)$$



1.6.

Let $q(t)$ be a rectangular pulse with height $1/a$ and width a .

$$q(t) = \frac{1}{a} \Pi\left(\frac{t}{a}\right)$$

and the unit-impulse function can be obtained through

$$\delta(t) = \lim_{a \rightarrow \infty} [q(t)] = \lim_{a \rightarrow \infty} \left[\frac{1}{a} \Pi\left(\frac{t}{a}\right) \right]$$

It follows that

$$\delta(bt) = \lim_{a \rightarrow \infty} [q(bt)] = \lim_{a \rightarrow \infty} \left[\frac{1}{a} \Pi\left(\frac{bt}{a}\right) \right]$$

Let $\tilde{a} = a/b$ so that

$$\frac{1}{a} \Pi\left(\frac{bt}{a}\right) = \frac{1}{\tilde{a}b} \Pi\left(\frac{t}{\tilde{a}}\right)$$

Therefore

$$\begin{aligned} \delta(bt) &= \lim_{a \rightarrow \infty} \left[\frac{1}{\tilde{a}b} \Pi\left(\frac{t}{\tilde{a}}\right) \right] \\ &= \frac{1}{b} \lim_{a \rightarrow \infty} \left[\frac{1}{\tilde{a}} \Pi\left(\frac{t}{\tilde{a}}\right) \right] \\ &= \frac{1}{b} \delta(t) \end{aligned}$$

1.7.

Given that

$$q(t) = \frac{1}{a} \Pi\left(\frac{t}{a}\right) = \begin{cases} \frac{1}{a}, & -\frac{a}{2} < t < \frac{a}{2} \\ 0, & \text{otherwise} \end{cases}$$

the time shifted pulse $q(t - t_1)$ is

$$q(t - t_1) = \frac{1}{a} \Pi\left(\frac{t - t_1}{a}\right) = \begin{cases} \frac{1}{a}, & t_1 - \frac{a}{2} < t < t_1 + \frac{a}{2} \\ 0, & \text{otherwise} \end{cases}$$

and the integral can be written as

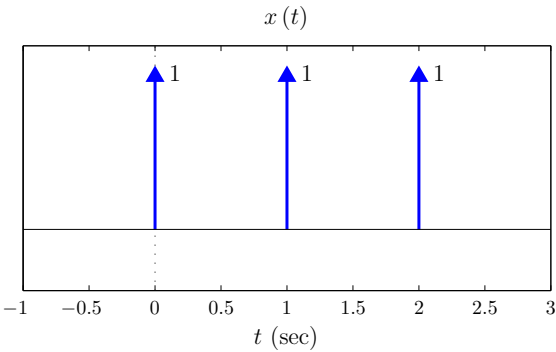
$$\int_{-\infty}^{\infty} f(t) q(t-t_1) dt = \frac{1}{a} \int_{t_1-a/2}^{t_1+a/2} f(t) dt$$

If $f(t)$ is continuous in the vicinity of $t = t_1$ then, for small values of a , the value of the integral above is approximately equal to the area of a rectangle with height equal to $f(t_1)$ and width equal to a , that is,

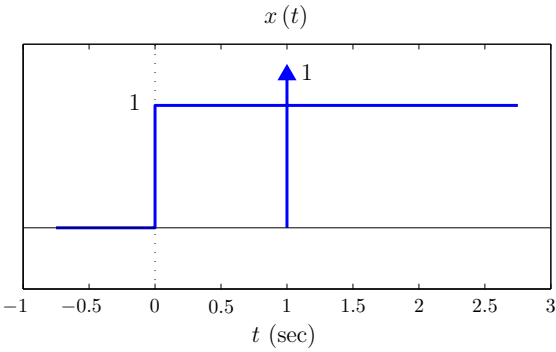
$$\frac{1}{a} \int_{t_1-a/2}^{t_1+a/2} f(t) dt \approx \frac{1}{a} [f(t_1) a] = f(t_1)$$

1.8.

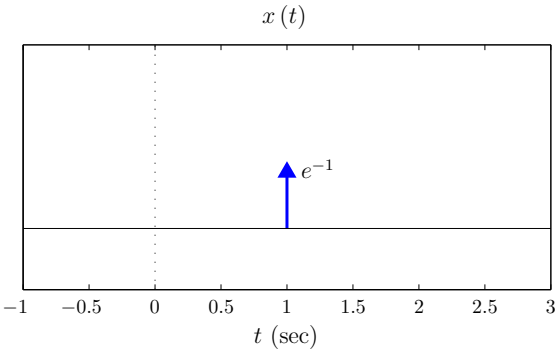
a.



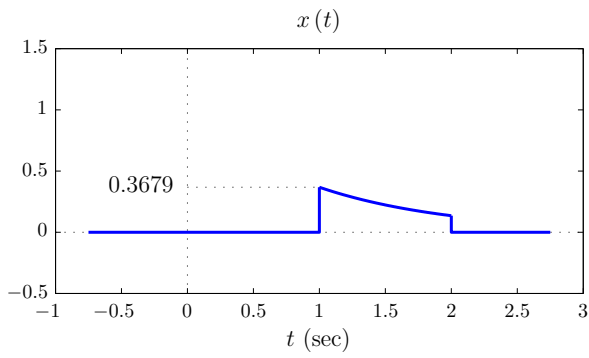
b.



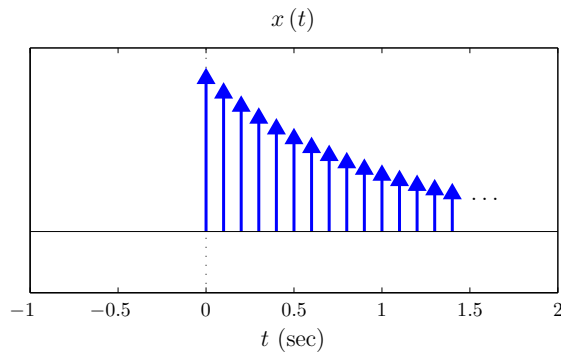
c.



d.

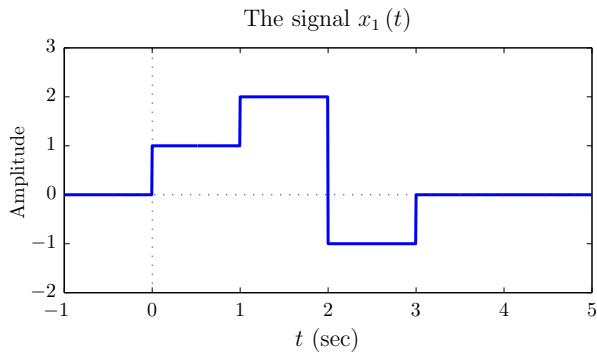


e.

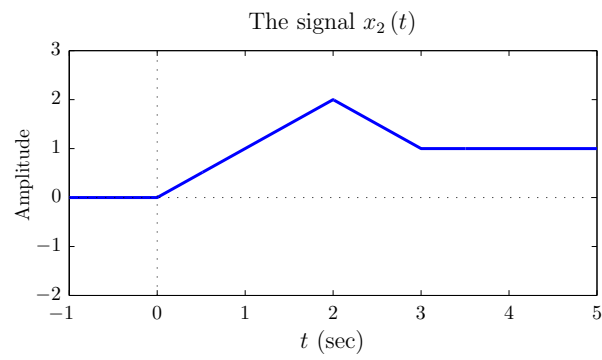


1.9.

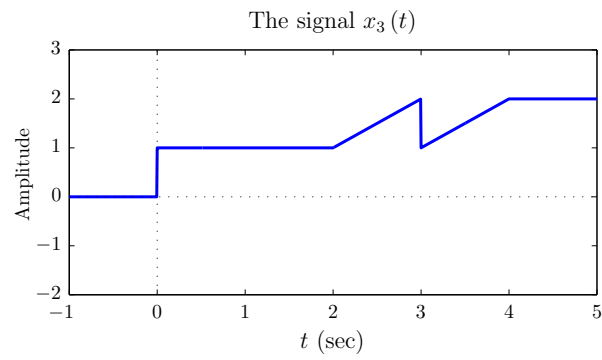
a.



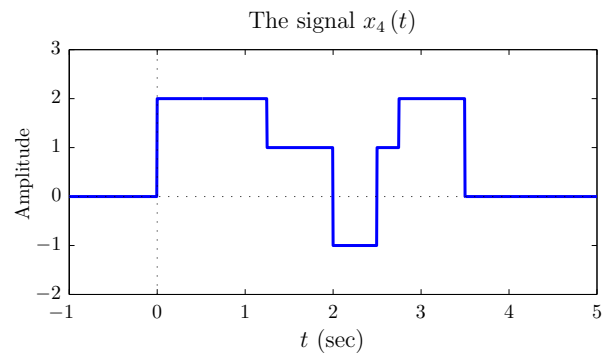
b.



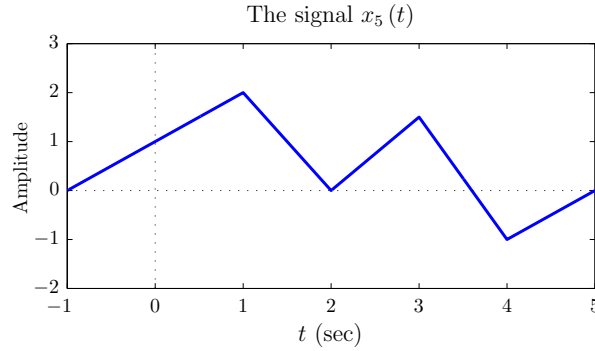
c.



d.



e.



1.10.

a. $x_a(t) = u(t+2) + 0.5u(t+1) - 2u(t-1.5) + 0.5u(t)$

b. $x_b(t) = 1.5u(t+1) - 2.5u(t) + u(t-1)$

1.11.

a. $x_a(t) = \Pi(t+1.5) + 1.5\Pi\left(\frac{t-0.25}{2.5}\right) - 0.5\Pi\left(\frac{t-2.25}{1.5}\right)$

b. $x_b(t) = 1.5\Pi(t+0.5) - \Pi(t-0.5)$

1.12.

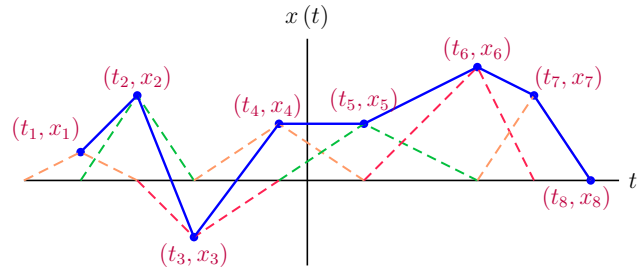
a. $x(t) = -r(t+1) + 3.5r(t) - 3r(t-1) - 0.5r(t-2) + r(t-3)$

b. $x(t) = -\Lambda(t) + 1.5\Lambda(t-1) + \Lambda(t-2)$

1.13.

For each data point (t_i, x_i) use a triangle $x_i \Lambda_s(t, a_i, b_i)$ with parameters $a_i = t_i - t_{i-1}$ and $b_i = t_{i+1} - t_i$. The signal $x(t)$ can be expressed as

$$\begin{aligned} x(t) &= \sum_i x_i \Lambda_s(t, a_i, b_i) \\ &= \sum_i x_i \Lambda_s(t, t_i - t_{i-1}, t_{i+1} - t_i) \end{aligned}$$



1.14.

Integration by parts:

$$\int_a^b u(t) dv(t) = u(t) v(t) \Big|_a^b - \int_a^b v(t) du(t)$$

Let $u(t) = f(t)$ and $dv(t) = \delta'(t) dt$:

$$\int_{-\infty}^{\infty} f(t) \delta'(t) dt = f(t) \delta(t) \Big|_{-\infty}^{\infty} - \int_{-\infty}^{\infty} \delta(t) f'(t) dt$$

Using the sifting property of the unit impulse function yields

$$\int_{-\infty}^{\infty} f(t) \delta'(t) dt = -f'(0)$$

1.15.

Using

$$u(t) = \begin{cases} 1, & t > 0 \\ 0, & t < 0 \end{cases} \quad \text{and} \quad u(-t) = \begin{cases} 1, & t < 0 \\ 0, & t > 0 \end{cases}$$

the signum function can be written as

$$\text{sgn}(t) = -u(-t) + u(t)$$

or as

$$\text{sgn}(t) = -1 + 2u(t)$$

1.16.

a.

$$e^{ja} = \cos(a) + j \sin(a)$$

$$e^{-ja} = \cos(a) - j \sin(a)$$

Therefore

$$\frac{1}{2} e^{ja} + \frac{1}{2} e^{-ja} = \cos(a)$$

b.

$$e^{ja} = \cos(a) + j \sin(a)$$

$$e^{-ja} = \cos(a) - j \sin(a)$$

Therefore

$$\frac{1}{2} e^{ja} - \frac{1}{2} e^{-ja} = j \sin(a) \quad \Rightarrow \quad \sin(a) = \frac{1}{2j} e^{ja} - \frac{1}{2j} e^{-ja}$$

c.

$$\frac{d}{da} \left[\frac{1}{2} e^{ja} + \frac{1}{2} e^{-ja} \right] = \frac{j}{2} e^{ja} - \frac{j}{2} e^{-ja} = -\frac{1}{2j} e^{ja} + \frac{j}{2j} e^{-ja} = -\sin(a)$$

d.

$$\begin{aligned} \cos(a+b) &= \frac{1}{2} e^{j(a+b)} + \frac{1}{2} e^{-j(a+b)} \\ &= \frac{1}{2} \left[e^{ja} e^{jb} + e^{-ja} e^{-jb} \right] \\ &= \frac{1}{2} \left[[\cos(a) + j \sin(a)] [\cos(b) + j \sin(b)] + [\cos(a) - j \sin(a)] [\cos(b) - j \sin(b)] \right] \\ &= \cos(a) \cos(b) - \sin(a) \sin(b) \end{aligned}$$

e.

$$\frac{d}{da} \left[\frac{1}{2} e^{ja} + \frac{1}{2} e^{-ja} \right] = \frac{j}{2} e^{ja} - \frac{j}{2} e^{-ja} = -\frac{1}{2j} e^{ja} + \frac{j}{2j} e^{-ja} = -\sin(a)$$

d.

$$\begin{aligned} \sin(a+b) &= \frac{1}{2j} e^{j(a+b)} - \frac{1}{2j} e^{-j(a+b)} \\ &= \frac{1}{2j} \left[e^{ja} e^{jb} - e^{-ja} e^{-jb} \right] \\ &= \frac{1}{2j} \left[[\cos(a) + j \sin(a)] [\cos(b) + j \sin(b)] - [\cos(a) - j \sin(a)] [\cos(b) - j \sin(b)] \right] \\ &= \sin(a) \cos(b) + \cos(a) \sin(b) \end{aligned}$$

f.

$$\begin{aligned} \cos^2(a) &= \left[\frac{1}{2} e^{ja} + \frac{1}{2} e^{-ja} \right]^2 \\ &= \frac{1}{4} e^{j2a} + \frac{1}{2} + \frac{1}{4} e^{-j2a} \\ &= \frac{1}{2} + \frac{1}{2} \cos(2a) \end{aligned}$$

1.17.

a. Periodic.

$$2\pi f_0 = 2 \quad \Rightarrow \quad f_0 = \frac{1}{\pi} \text{ Hz}, \quad T_0 = \frac{1}{f_0} = \pi \text{ sec}$$

b. Periodic.

$$2\pi f_0 = \sqrt{20} \quad \Rightarrow \quad f_0 = \frac{\sqrt{20}}{2\pi} = \frac{\sqrt{5}}{\pi} \text{ Hz}, \quad T_0 = \frac{1}{f_0} = \frac{\pi}{\sqrt{5}} \text{ sec}$$

c. Not periodic due to the factor $u(t)$.

d. Periodic.

$$2\pi f_0 = 3 \quad \Rightarrow \quad f_0 = \frac{3}{2\pi} \text{ Hz}, \quad T_0 = \frac{1}{f_0} = \frac{2\pi}{3} \text{ sec}$$

e. Not periodic due to the factor $e^{-|t|}$.

f. Not periodic.

g. Periodic.

$$x(t) = \cos(2t + \pi/10) + j \sin(2t + \pi/10)$$

$$2\pi f_0 = 2 \quad \Rightarrow \quad f_0 = \frac{1}{\pi} \text{ Hz}, \quad T_0 = \frac{1}{f_0} = \pi \text{ sec}$$

h. Not periodic.

1.18.

a.

$$f_1 = \frac{5}{2\pi} \text{ Hz}, \quad f_2 = \frac{5}{2\pi} \text{ Hz} \quad \Rightarrow \quad f_0 = \frac{5}{2\pi} \text{ Hz}, \quad T_0 = \frac{2\pi}{5} \text{ sec}$$

b.

$$f_1 = 5 \text{ Hz}, \quad f_2 = 15 \text{ Hz} \quad \Rightarrow \quad f_0 = 5 \text{ Hz}, \quad T_0 = \frac{1}{5} = 0.2 \text{ sec}$$

c.

$$f_1 = \frac{\sqrt{2}}{2\pi} \text{ Hz}, \quad f_2 = \frac{2}{2\pi} \text{ Hz}$$

For periodicity we require two integers m_1 and m_2 to be found such that

$$\frac{m_1}{f_1} = \frac{m_2}{f_2} \quad \Rightarrow \quad \frac{m_1}{\sqrt{2}} = \frac{m_2}{2}$$

No two integers can be found; therefore the signal is not periodic.

d.

$$f_1 = 22.5 \text{ Hz}, \quad f_2 = 27.5 \text{ Hz} \quad \Rightarrow \quad f_0 = 2.5 \text{ Hz}, \quad T_0 = \frac{1}{2.5} = 0.4 \text{ sec}$$

1.19.

a. The energy of the signal $x(t)$ is

$$E_x = \int_{-\infty}^{\infty} |x(t)|^2 dt < \infty$$

The energy of $g(t)$ is found as

$$E_g = \int_{-\infty}^{\infty} |g(t)|^2 dt = \int_{-\infty}^{\infty} |Ax(t)|^2 dt = |A|^2 \int_{-\infty}^{\infty} |x(t)|^2 dt$$

Thus we have

$$E_g = |A|^2 E_x$$

If $x(t)$ is an energy signal, $x(t)$ is also an energy signal.

b. The power in the signal $x(t)$ is

$$P_x = \langle |x(t)|^2 \rangle$$

The power in $g(t)$ is found as

$$P_g = \langle |g(t)|^2 \rangle = \langle |Ax(t)|^2 \rangle = |A|^2 \langle |x(t)|^2 \rangle$$

Thus we have

$$P_g = |A|^2 P_x$$

If $x(t)$ is a power signal, $x(t)$ is also a power signal.

1.20.

a. We will assume that parameters A and B are real-valued. Given that $E_x = \int_{-\infty}^{\infty} |x(t)|^2 dt$, attempting to compute the normalized energy of the signal $g(t)$ results in

$$E_g = \int_{-\infty}^{\infty} |Ax(t) + B|^2 dt$$

which does not converge for $B \neq 0$. Therefore $g(t)$ is a power signal.

b. The normalized average power in $g(t)$ is

$$\begin{aligned} P_g &= \langle |g(t)|^2 \rangle \\ &= \langle (Ax(t) + B)(Ax(t) + B)^* \rangle \\ &= A^2 \langle |x(t)|^2 \rangle + B^2 + 2AB \langle \operatorname{Re}\{x(t)\} \rangle \end{aligned}$$

Since $x(t)$ is an energy signal, we have

$$P_g = B^2$$

1.21.

a. The signal $x(t)$ can be written as

$$x(t) = e^{-2|t|} = \begin{cases} e^{2t}, & t < 0 \\ e^{-2t}, & t > 0 \end{cases}$$

The energy of the signal is

$$E_x = \int_{-\infty}^{\infty} |x(t)|^2 dt = \int_{-\infty}^0 e^{4t} dt + \int_0^{\infty} e^{-4t} dt = \frac{1}{2}$$

b.

$$E_x = \int_{-\infty}^{\infty} |e^{-2t}|^2 u(t) dt = \int_0^{\infty} e^{-4t} dt = \frac{1}{4}$$

c.

$$\begin{aligned} |x(t)|^2 &= |e^{-2t}|^2 |\cos(5t)|^2 u(t) \\ &= e^{-4t} \cos^2(5t) u(t) \end{aligned}$$

Remembering that

$$\cos^2(5t) = \frac{1}{2} + \frac{1}{2} \cos(10t)$$

we have

$$\begin{aligned} |x(t)|^2 &= \frac{1}{2} e^{-4t} u(t) + \frac{1}{2} e^{-4t} \cos(10t) u(t) \\ &= \frac{1}{2} e^{-4t} u(t) + \frac{1}{4} e^{-4t} e^{j10t} u(t) + \frac{1}{4} e^{-4t} e^{-j10t} u(t) \\ &= \frac{1}{2} e^{-4t} u(t) + \frac{1}{4} e^{(-4+j10)t} u(t) + \frac{1}{4} e^{(-4-j10)t} u(t) \end{aligned}$$

The normalized energy is

$$\begin{aligned} E_x &= \int_{-\infty}^{\infty} |x(t)|^2 dt \\ &= \frac{1}{2} \int_0^{\infty} e^{-4t} dt + \frac{1}{4} \int_0^{\infty} e^{(-4+j10)t} dt + \frac{1}{4} \int_0^{\infty} e^{(-4-j10)t} dt \\ &= \frac{1}{8} + \frac{1}{58} = 0.1422 \end{aligned}$$

1.22.

a.

$$x_a(t) = \begin{cases} 2t+2, & -1 < t < 0 \\ -t+2, & 0 < t < 1 \\ 1, & 1 < t < 2 \\ -t+3, & 2 < t < 3 \\ 0, & \text{otherwise} \end{cases}$$

$$E_x = \int_{-1}^0 (2t+2)^2 dt + \int_0^1 (-t+2)^2 dt + \int_1^2 (1)^2 dt + \int_2^3 (-t+3)^2 dt = 5$$

b.

$$x_b(t) = \begin{cases} 1.5t+1.5, & -1 < t < 0 \\ -1.5t+1.5, & 0 < t < 2 \\ 1.5t-4.5, & 2 < t < 3 \\ 0, & \text{otherwise} \end{cases}$$

$$E_x = \int_{-1}^0 (1.5t + 1.5)^2 dt + \int_0^2 (-1.5t + 1.5)^2 dt + \int_2^3 (1.5t - 4.5)^2 dt = 3$$

1.23.

a.

$$P_x = \langle |x(t)|^2 \rangle = \int_0^{0.5} (1)^2 dt = \frac{1}{3}$$

b.

$$P_x = \langle |x(t)|^2 \rangle = \int_0^1 t^2 dt = \left. \frac{t^3}{3} \right|_0^1 = 0.5$$

c.

$$P_x = \int_0^1 \sin^2(\pi t) dt = \int_0^1 \left(\frac{1}{2} - \frac{1}{2} \cos(2\pi t) \right) dt = \frac{1}{2}$$

1.24.

The two terms with the same frequency need to be combined. Consider that

$$A \cos(2\pi f_1 t + \theta) = A \cos(\theta) \cos(2\pi f_1 t) - A \sin(\theta) \sin(2\pi f_1 t)$$

Let $A \cos(\theta) = 2$ and $-A \sin(\theta) = 3$. Solving the two equations we get

$$A = 3.6056 \quad \text{and} \quad \theta = -0.9828 \text{ radians}$$

The signal is

$$x(t) = 3.6056 \cos(2\pi f_1 t - 0.9858) + 6 \cos(2\pi f_2 t)$$

and its RMS value is

$$x_{RMS} = \sqrt{\frac{3.6056^2}{2} + \frac{6^2}{2}} = 4.9497$$

1.25.

a. Even

b. Odd

c. Neither even nor odd

d. Even

e. Odd

f. Neither even nor odd

1.26.

a.

$$\int_{-\lambda}^{\lambda} x(t) dt = \int_{-\lambda}^0 x(t) dt + \int_0^{\lambda} x(t) dt$$

For the first integral, apply the variable change $t = -\alpha$ to obtain

$$\begin{aligned} \int_{-\lambda}^{\lambda} x(t) dt &= \int_{\lambda}^0 x(-\alpha) (-d\alpha) + \int_0^{\lambda} x(t) dt \\ &= - \int_{\lambda}^0 x(-\alpha) d\alpha + \int_0^{\lambda} x(t) dt \\ &= \int_0^{\lambda} x(-\alpha) d\alpha + \int_0^{\lambda} x(t) dt \end{aligned}$$

Since $x(t)$ is even, $x(-\alpha) = x(\alpha)$ and

$$\begin{aligned} \int_{-\lambda}^{\lambda} x(t) dt &= \int_0^{\lambda} x(\alpha) d\alpha + \int_0^{\lambda} x(t) dt \\ &= 2 \int_0^{\lambda} x(t) dt \end{aligned}$$

b. From part (a) we have

$$\int_{-\lambda}^{\lambda} x(t) dt = \int_0^{\lambda} x(-\alpha) d\alpha + \int_0^{\lambda} x(t) dt$$

Since $x(t)$ is odd, $x(-\alpha) = -x(\alpha)$ and

$$\begin{aligned} \int_{-\lambda}^{\lambda} x(t) dt &= - \int_0^{\lambda} x(\alpha) d\alpha + \int_0^{\lambda} x(t) dt \\ &= 0 \end{aligned}$$

1.27.

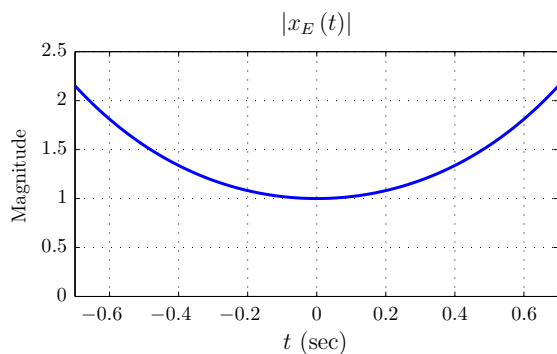
a. $x(-t) = x_1(-t) x_2(-t) = x_1(t) x_2(t) = x(t)$

b. $x(-t) = x_1(-t) x_2(-t) = [-x_1(t)] [-x_2(t)] = x_1(t) x_2(t) = x(t)$

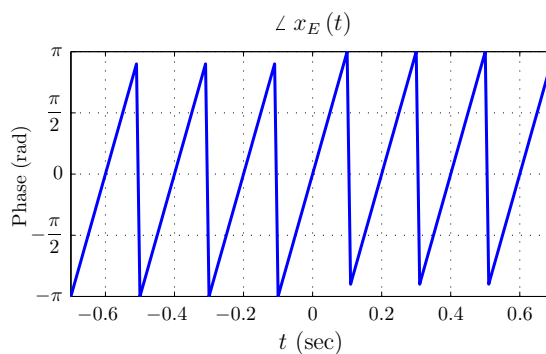
c. $x(-t) = x_1(-t) x_2(-t) = x_1(t) [-x_2(t)] = -x_1(t) x_2(t) = -x(t)$

1.28.

$$\begin{aligned} x_E(t) &= \frac{1}{2} e^{(-2+j10\pi)t} + \frac{1}{2} e^{(-2-j10\pi)(-t)} \\ &= \frac{1}{2} (e^{-2t} + e^{2t}) e^{j10\pi t} \end{aligned}$$

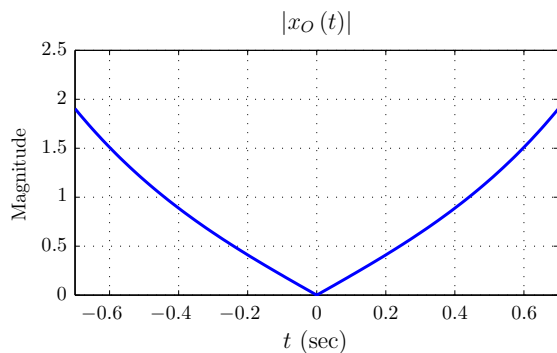


(a)

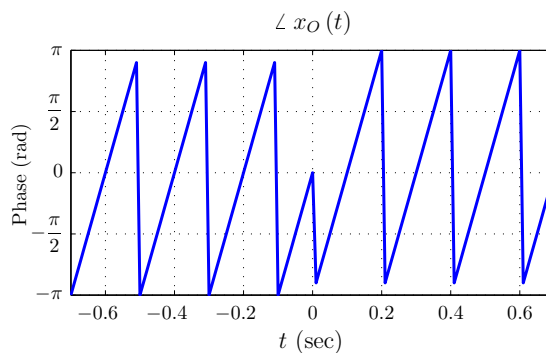


(b)

$$\begin{aligned} x_O(t) &= \frac{1}{2} e^{(-2+j10\pi)t} - \frac{1}{2} e^{(-2-j10\pi)(-t)} \\ &= \frac{1}{2} (e^{-2t} - e^{2t}) e^{j10\pi t} \end{aligned}$$



(c)



(d)

1.29.

a.

$$\begin{aligned} x_e(t) &= \frac{1}{2} e^{-5t} \sin(t) u(t) + \frac{1}{2} e^{5t} \sin(-t) u(-t) \\ &= \frac{1}{2} \sin(t) [e^{-5t} u(t) - e^{5t} u(-t)] \end{aligned}$$

$$\begin{aligned} x_o(t) &= \frac{1}{2} e^{-5t} \sin(t) u(t) - \frac{1}{2} e^{5t} \sin(-t) u(-t) \\ &= \frac{1}{2} \sin(t) [e^{-5t} u(t) + e^{5t} u(-t)] \end{aligned}$$

b.

$$\begin{aligned}x_e(t) &= \frac{1}{2} e^{-3|t|} \cos(t) + \frac{1}{2} e^{-3|-t|} \cos(-t) \\&= e^{-3|t|} \cos(t)\end{aligned}$$

$$\begin{aligned}x_o(t) &= \frac{1}{2} e^{-3|t|} \cos(t) - \frac{1}{2} e^{-3|-t|} \cos(-t) \\&= 0\end{aligned}$$

c.

$$\begin{aligned}x_e(t) &= \frac{1}{2} e^{-3|t|} \sin(t) + \frac{1}{2} e^{-3|-t|} \sin(-t) \\&= 0\end{aligned}$$

$$\begin{aligned}x_o(t) &= \frac{1}{2} e^{-3|t|} \sin(t) - \frac{1}{2} e^{-3|-t|} \sin(-t) \\&= e^{-3|t|} \sin(t)\end{aligned}$$

d.

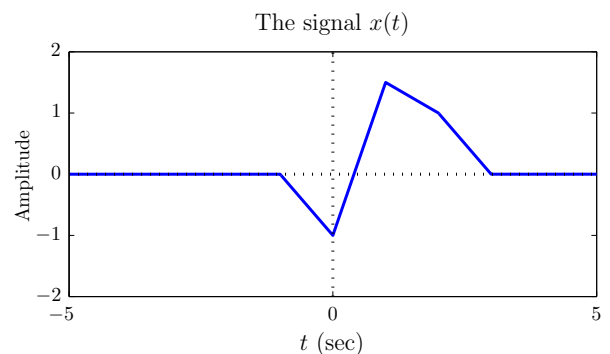
$$\begin{aligned}x_e(t) &= \frac{1}{2} (t e^{-3t} + 2) u(t) + \frac{1}{2} (-t e^{3t} + 2) u(-t) \\&= \frac{1}{2} t e^{-3t} u(t) - \frac{1}{2} t e^{3t} u(-t) + 1 \\x_o(t) &= \frac{1}{2} (t e^{-3t} + 2) u(t) - \frac{1}{2} (-t e^{3t} + 2) u(-t)\end{aligned}$$

e.

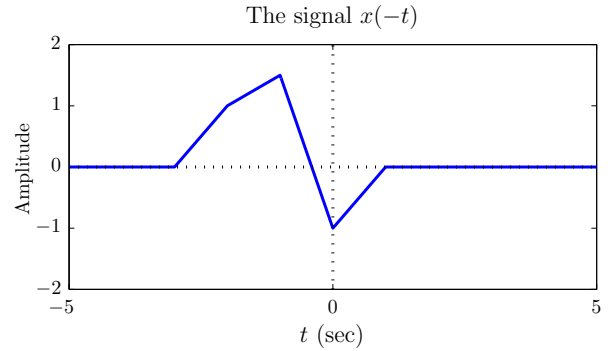
$$\begin{aligned}x_e(t) &= \frac{1}{2} e^{-2|t-1|} + \frac{1}{2} e^{-2|-t-1|} \\x_o(t) &= \frac{1}{2} e^{-2|t-1|} - \frac{1}{2} e^{-2|-t-1|}\end{aligned}$$

1.30.

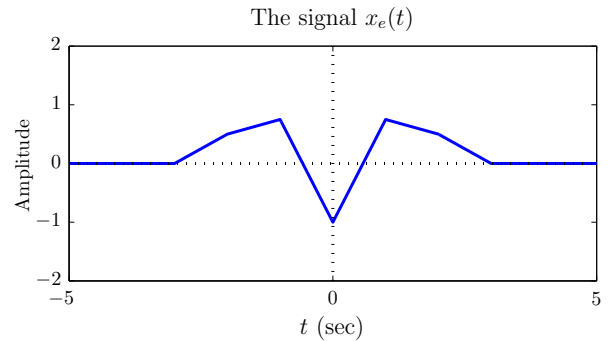
$$x(t) = \begin{cases} -t-1, & -1 < t < 0 \\ 2.5t-1, & 0 < t < 1 \\ -0.5t+2, & 1 < t < 2 \\ -t+3, & 2 < t < 3 \\ 0, & \text{otherwise} \end{cases}$$



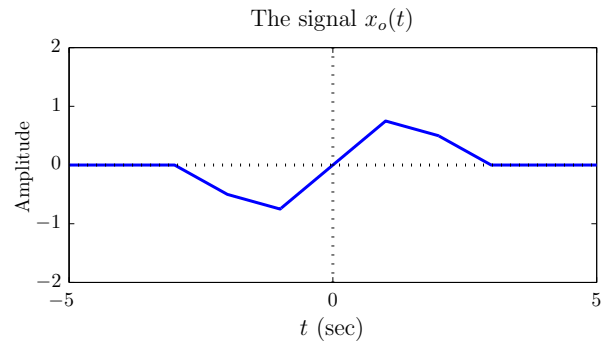
$$x(-t) = \begin{cases} t+3, & -3 < t < -2 \\ 0.5t+2, & -2 < t < -1 \\ -2.5t-1, & -1 < t < 0 \\ t-1, & 0 < t < 1 \\ 0, & \text{otherwise} \end{cases}$$



$$x_e(t) = \frac{x(t) + x(-t)}{2}$$



$$x_o(t) = \frac{x(t) - x(-t)}{2}$$



1.31.

a. $X = 3e^{j0^\circ}$, $\omega_0 = 200\pi$ rad/s

b. $x(t) = 7 \cos(100\pi t - \pi/2) \Rightarrow X = 7e^{-j\pi/2}$, $\omega_0 = 100\pi$ rad/s

c.

$$x(t) = 2 \cos(10\pi t - \pi/2) + 5 \cos(10\pi t + \pi)$$

$$X = 2e^{-j\pi/2} + 5e^{j\pi}$$

$$= 5.3852e^{-j2.7611}, \quad \omega_0 = 10\pi \text{ rad/s}$$