EE 221: Signal Analysis & Systems
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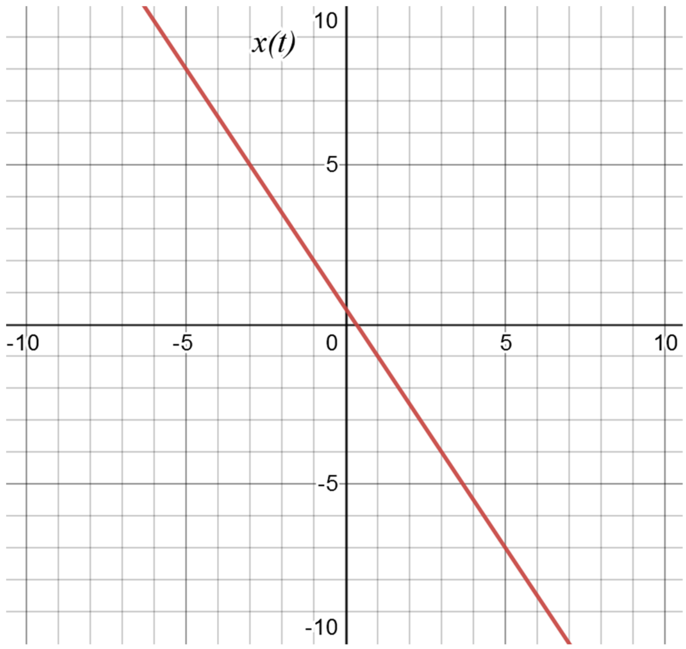
Signal Classification: Practice Problems

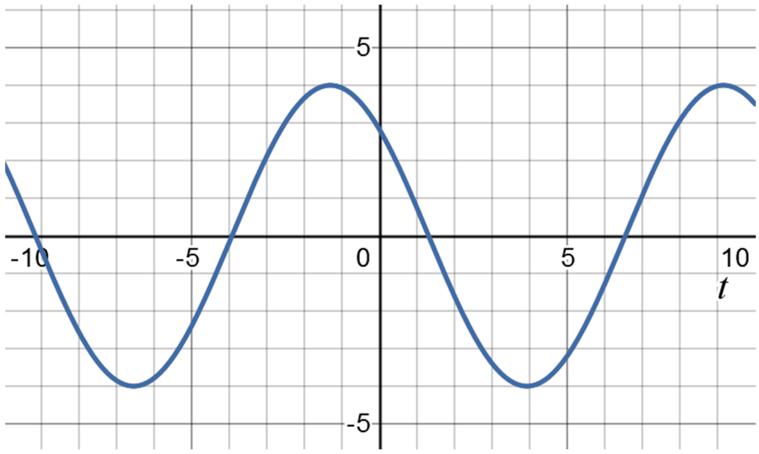
Q1. Given two points $(t_1, x_1) = (-1, 2)$ and $(t_2, x_2) = (2, -2.5)$ on a linear line: **(a)** write the equation of the line, **(b)** determine the slope, **(c)** determine the y-intercept, **(d)** sketch the line by hand, **(e)** is this linear line deterministic or random signal? and **(f)** is this linear line periodic or aperiodic signal?

Q1. Answer.
(a) $x(t) = -1.5t + 0.5$,
(b) $m = -1.5$,
(c) $b = 0.5$,
(d) see figure to the right,
(e) deterministic signal,
(f) aperiodic signal.



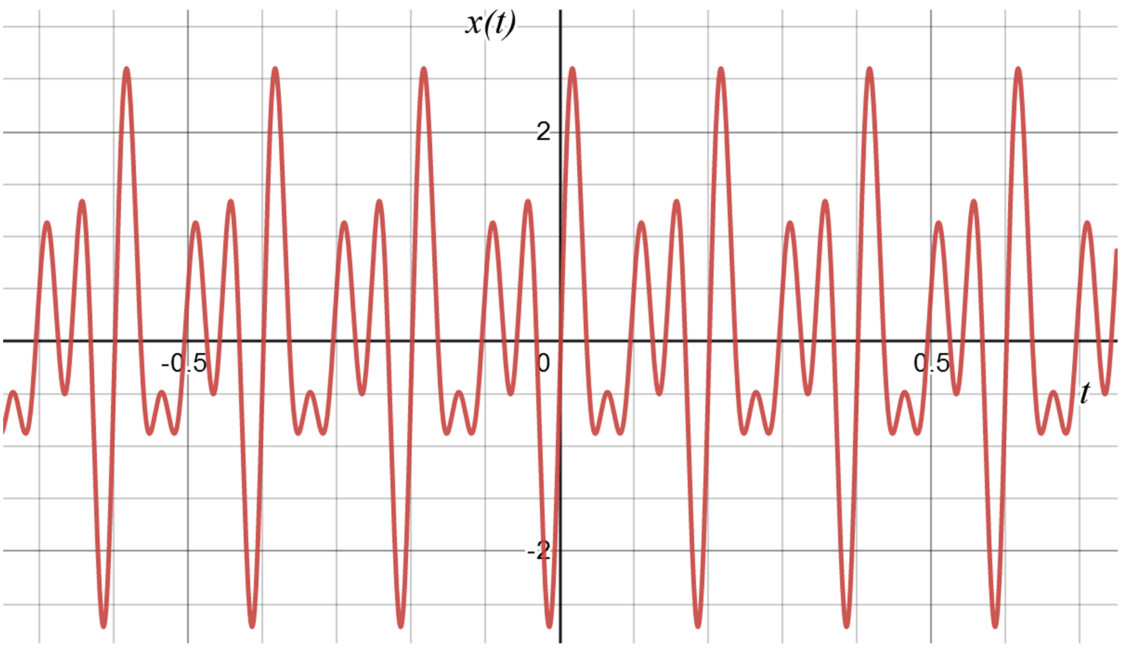
Q2. For the signal $x(t) = 4\cos(0.6t + \pi/4) = 4\cos(0.6t + 0.785)$: **(a)** write the equation in terms of sin function, **(b)** determine the fundamental period of the signal, **(c)** sketch the signal by hand, **(d)** determine the average power in the signal, **(e)** determine the average of the signal (celled its DC value and found as $\lim_{T\to\infty} \frac{1}{T}\int_{-T/2}^{T/2} x(t)dt$), **(f)** determine the total energy in the signal, **(g)** is this signal periodic or aperiodic signal? and **(h)** is this signal energy or power signal?

Q2. Answer.
(a) $x(t) = 4\sin(0.6t + 3\pi/4)$,
(b) $T_0 = 10.472$ second,
(c) see figure to the right,
(d) $P_x = 4^2/2 = 8$ Watt,
(e) DC $= 0$ Volt,
(f) $E_x = \infty$ Joule,
(g) periodic signal,
(h) power signal.



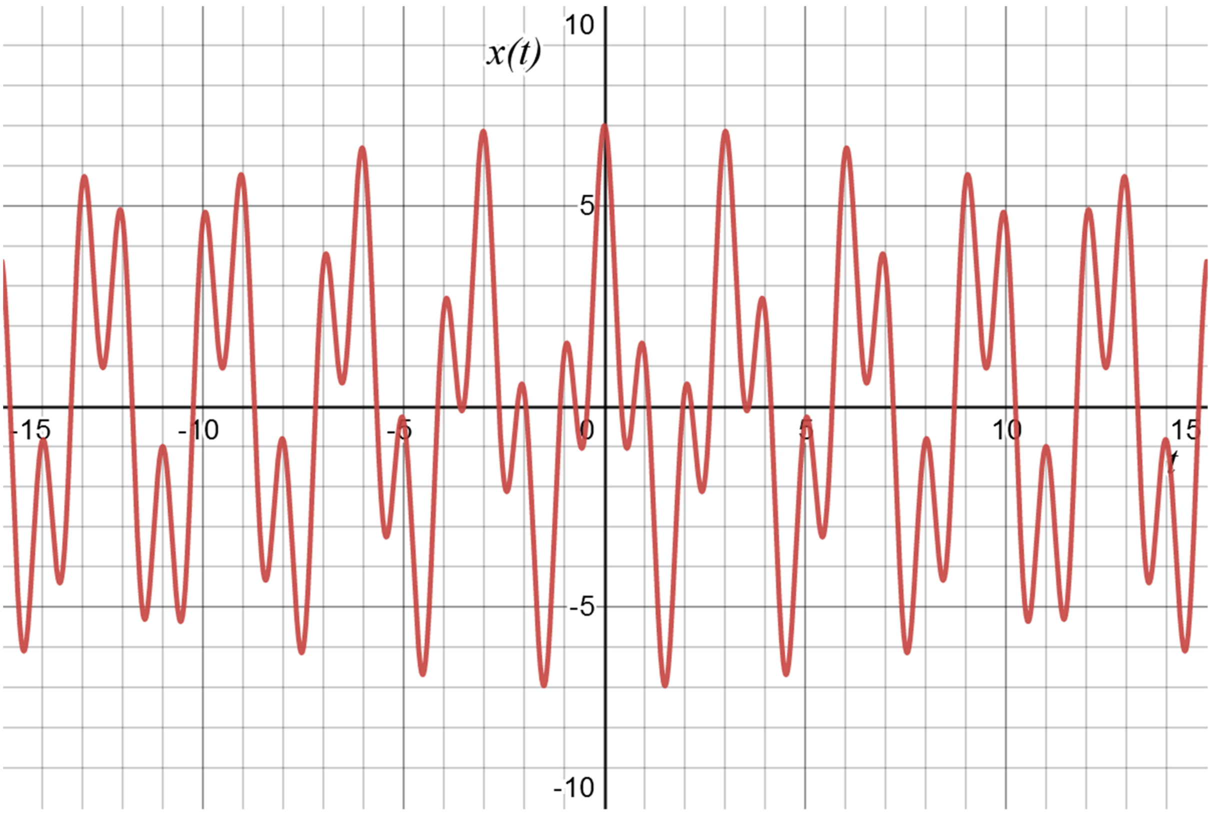
Q3. For the signal $x(t)$ that results from the addition of three periodic signals $x(t) = \sin(20\pi\, t) + \sin(30\pi\, t - 30°) + \sin(40\pi\, t)$: **(a)** use a graphing calculator to plot the signal $x(t)$, **(b)** is this signal periodic or aperiodic signal? **(c)** determine the fundamental period of the signal $x(t)$ from the plot, **(d)** determine the fundamental angular frequency of the signal $x(t)$, **(e)** what is the relationship between the fundamental frequency of the sum $x(t)$ and the frequencies of the three constituent signals?

Q3. Answer.
(a) see figure below, **(b)** periodic signal, **(c)** from figure, we see that $T_0 = 0.2$ second, **(d)** $\omega_0 = 2\pi/0.2 = 10\pi$ rad/s, **(e)** greatest common divisor (gcd).



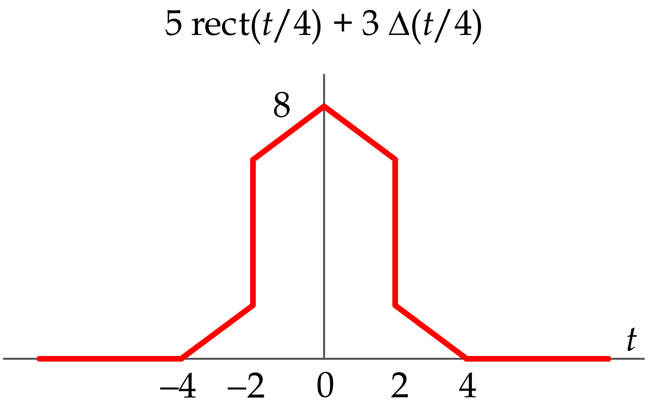
Q4. For the signal $x(t)$ that results from the addition of two periodic signals $x(t) = 4\cos(2\,t) + 3\cos(2\pi\,t)$: **(a)** use a graphing calculator to plot the signal $x(t)$, **(b)** is this signal $x(t)$ periodic or aperiodic signal? **(c)** explain why, **(d)** is this signal $x(t)$ even or odd signal? **(e)** explain why.

Q4. Answer.
(a) see figure below,
(b) aperiodic signal,
(c) think about the relationship between the constituent frequencies 2 rad/s and 2π rad/s, can you explain the relationship?
(d) even signal,
(e) notice that the two cosine signals, called $x_1(t)$ and $x_2(t)$, are both even signals, so they satisfy $x_1(-t) = x_1(t)$ and $x_2(-t) = x_2(t)$, which leads to $x(-t) = x_1(-t) + x_2(-t) = x_1(t) + x_2(t) = x(t)$, thus completing the proof.



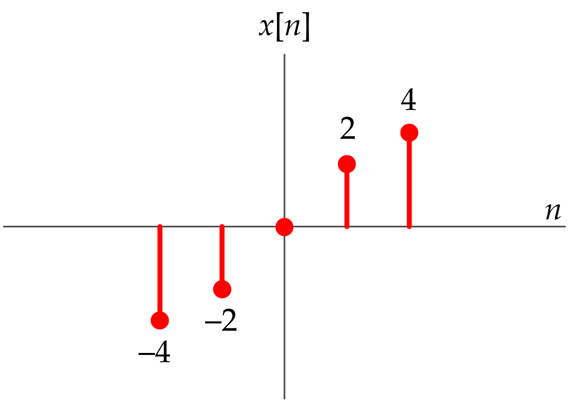
Q5. For the signal $x(t) = 5\,\mathrm{rect}(t/4) + 3\,\Delta(t/4)$: **(a)** sketch the signal $x(t)$ by hand (Hint: draw each part separately, then add them up), **(b)** is this signal $x(t)$ periodic or aperiodic signal? **(c)** determine the width of this signal $x(t)$, **(d)** determine the value of $x(t)$ at time $t = 0$, **(e)** determine the value of $x(t)$ at time $t = 0.5$, **(f)** determine the value of $x(t)$ at time $t = 1$, **(g)** determine the value of $x(t)$ at time $t = 3$, **(h)** determine the value of $x(t)$ at time $t = 5$, **(i)** determine the value of $\int_{-\infty}^{\infty} x(t)dt$.

Q5. Answer.



(a) see figure to the right,
(b) aperiodic signal,
(c) 8 seconds,
(d) $x(t) = 5 + 3 = 8$,
(e) $x(t) = 5 + 2.625 = 7.625$,
(f) $x(t) = 5 + 2.25 = 7.25$,
(g) $x(t) = 0 + 0.75 = 0.75$,
(h) $x(t) = 0 + 0 = 0$,
(h) We can write the equation for each line and perform integration under the line, or we can simply find the area under the rectangular shape and triangular shape and add them up to get $\int_{-\infty}^{\infty} x(t)dt = W_r H_r + \frac{1}{2} W_t H_t = 4 \times 5 + \frac{1}{2} \times 8 \times 3 = 20 + 12 = 32$.

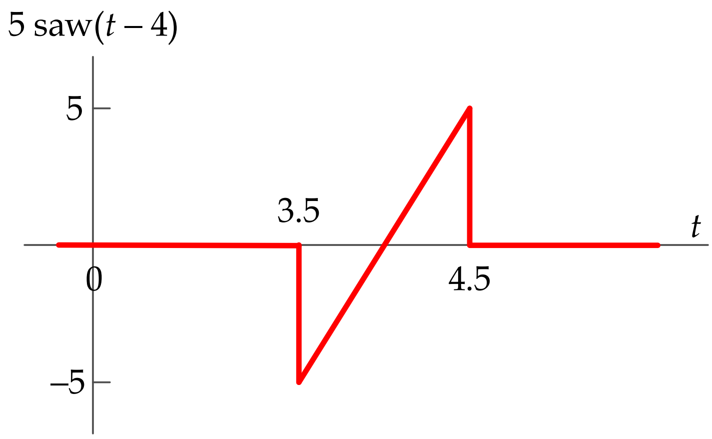
Q6. For the signal $x[n]$ shown: **(a)** is this signal continuous-time or discrete-time signal? **(b)** is this signal analog or digital signal? **(c)** is this signal energy or power signal? **(d)** determine the total energy in the signal, **(e)** determine the average power in the signal.



Q6. Answer.
(a) discrete-time signal,
(b) analog and digital signals are typically continuous-time, so this signal is neither analog nor digital,
(c) energy signal,
(d) $E_x = 40$ Joule,
(e) $P_x = 0$ Watt,

Q7. For the signal $x(t) = 5\,\mathrm{saw}(t-4)$: **(a)** sketch the signal $x(t)$ by hand, **(b)** is this signal $x(t)$ periodic or aperiodic signal? **(c)** is this signal energy or power signal? **(d)** determine the total energy in the signal (Hint: write the equation for the signal then integrate the square of that function over the appropriate limits), **(e)** does the signal $y(t) = 5\,\mathrm{saw}(t)$ have similar total energy to $x(t)$? and is it easier to evaluate the energy for $y(t)$ compared to $x(t)$? what are your conclusions **(f)** determine the average power in the signal $x(t)$.

Q7. Answer.
(a) see figure to the right,
(b) aperiodic signal,
(c) energy signal,
(d) $E_x = 8.3333$ Joule,
(e) yes, $E_y = E_x$, and the equation for the linear line is easier to write and square for $y(t)$ compared to the shifted version $x(t)$.



This means we have a shortcut that we can used to calculate (total energy, average power or average value), since a time shift does not affect the answer.
(f) $P_x = 0$ Watt.