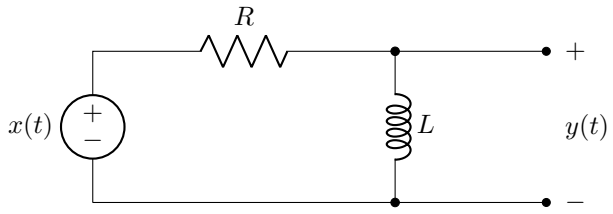
UCSD ECE 45
Final Exam
Summer Session 1 2022
Part 1

Problem 1:

Consider the following sinusoidal steady-state circuit, with a 6 Ohm resistor and a 3 Henry inductor. If $x(t)$ is the input signal and $y(t)$ is the output signal, then what is the frequency response $H(\omega)$ of this circuit when $\omega = 2$?



(a) $(1+j)/2$

(b) $(1-j)/2$

(c) $(1+j)$

(d) $(1-j)$

(e) $(1+j)/3$

(f) $(1-j)/3$

(g) $(1+j)/6$

(h) $(1-j)/6$

(i) None of these

Problem 2:

Suppose $f(t) = \sum_{n=-\infty}^{\infty} \frac{e^{3jnt}}{1+n^2}$. If G_n are the (exponential form) Fourier series coefficients of $g(t) = \frac{d}{dt}f(t)$, then what is G_2 ?

(a) $6j/5$

(b) $3j/5$

(c) $2j/5$

(d) $j/5$

(e) $6/5$

(f) $3/5$

(g) $2/5$

(h) $1/5$

(i) None of these

Problem 3:

Suppose the output from an LTI system is $2je^{3jt} + e^{-2jt}$ when the input is $-e^{3jt} + 2e^{-2jt}$. What is the output from the same system when the input is $2e^{3jt} - je^{-2jt}$?

(a) $-4je^{3jt} - (j/2)e^{-2jt}$

(b) $4je^{3jt} + (j/2)e^{-2jt}$

(c) $je^{3jt} - 2je^{-2jt}$

(d) $-je^{3jt} + 2je^{-2jt}$

(e) $-4e^{3jt} - (1/2)e^{-2jt}$

(f) $4e^{3jt} + (1/2)e^{-2jt}$

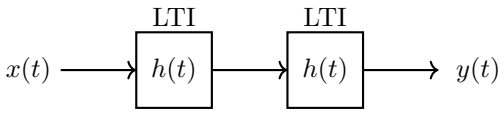
(g) $e^{3jt} - 2e^{-2jt}$

(h) $-e^{3jt} + 2e^{-2jt}$

(i) None of these

Problem 4:

Consider the cascade of two LTI systems shown below, with input $x(t)$ and output $y(t)$. If the impulse response of each of these LTI systems is $h(t) = \text{rect}(t)$, then what is the output $y(t)$ when the input is $x(t) = \delta(t)$?



(a) $\begin{cases} t+1 & \text{if } -1 < t \leq 0 \\ 1-t & \text{if } 0 < t \leq 1 \\ 0 & \text{else} \end{cases}$

(b) $\begin{cases} t & \text{if } 0 < t \leq 1 \\ 2-t & \text{if } 1 < t \leq 2 \\ 0 & \text{else} \end{cases}$

(c) $\begin{cases} 2(t+1) & \text{if } -1 < t \leq 0 \\ 2(1-t) & \text{if } 0 < t \leq 1 \\ 0 & \text{else} \end{cases}$

(d) $\begin{cases} 2t & \text{if } 0 < t \leq 1 \\ 2(2-t) & \text{if } 1 < t \leq 2 \\ 0 & \text{else} \end{cases}$

(e) $\begin{cases} 2t+1 & \text{if } -1/2 < t \leq 0 \\ 1-2t & \text{if } 0 < t \leq 1/2 \\ 0 & \text{else} \end{cases}$

(f) $\text{rect}(t)$

(g) $2\text{rect}(t)$

(h) $\delta(t)$

(i) None of these

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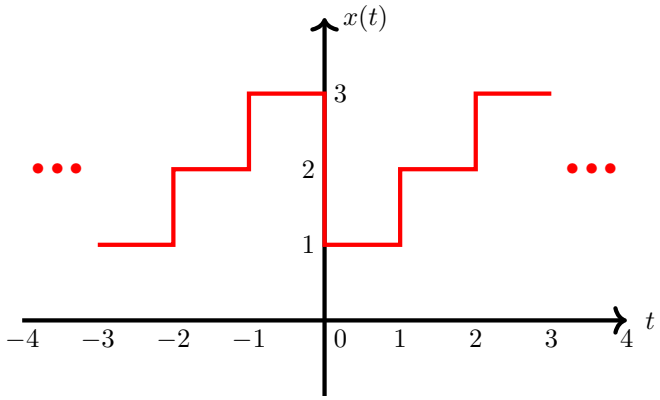
Problem 5:

Two periods of a periodic function $x(t)$ are drawn below. If $x(t)$ is the input to an LTI system with frequency response $H(\omega)$, where $H(\omega) = 2$ if $2.5 < |\omega| < 4$ and $H(\omega) = 0$ otherwise, then what is the output $y(t)$?



(a) None of these

(b) $2(1 + \cos(3t))$

(c) $2(1 - \cos(3t))$

(d) $2\cos(3t)$

(e) $-2\cos(3t)$

(f) $2\cos(2\pi t/3)$

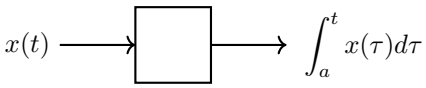
(g) $-2\cos(2\pi t/3)$

(h) $2(1 + \cos(2\pi t/3))$

(i) $2(1 - \cos(2\pi t/3))$

Problem 6:

Consider the system shown below. For what values of a is the system linear and time-invariant?



(a) None of these values

(b) All of these values

(c) 0

(d) 1

(e) -1

(f) 2

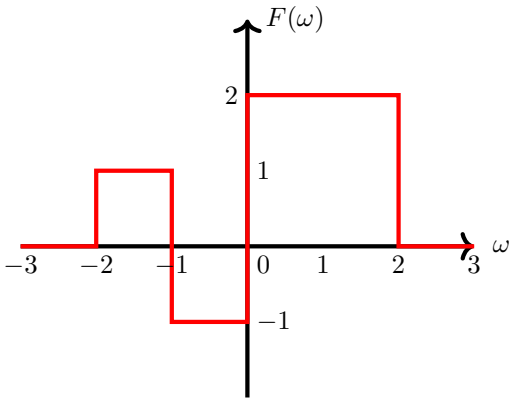
(g) -2

(h) 3

(i) -3

Problem 7:

Suppose $F(\omega)$ (shown below) is the Fourier transform of $f(t)$. What is $\int_{-\infty}^{\infty} |f(t)|^2 dt$?



(a) $5/\pi$

(b) $10/\pi$

(c) $3/\pi$

(d) $6/\pi$

(e) $4/\pi$

(f) $2/\pi$

(g) 10

(h) 6

(i) 4

(j) 0

(k) None of these

Problem 8:

Suppose when $x(t)$ is the input to an LTI system with impulse response $h(t) = \text{sinc}(4t)$, the output is $y(t) = \text{sinc}(3t)$. If $X(\omega)$ is the Fourier transform of $x(t)$, then what is $X(1)$?

(a) $4/3$

(b) $3/4$

(c) 3

(d) 4

(e) $4\pi/3$

(f) $3\pi/4$

(g) $\pi/4$

(h) $\pi/3$

(i) None of these

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Problem 9:

What is $\int_{-4}^{1} \frac{\cos(\pi t)\delta(t+2)e^{j\pi t}}{e^{\pi t}} dt$?

(a) $e^{2\pi}$

(b) $e^{-2\pi}$

(c) 0

(d) 1

(e) $e^{2\pi}\delta(t+2)$

(f) $e^{-2\pi}\delta(t+2)$

(g) $\delta(t+2)$

(h) None of these

Problem 10:

Suppose $X(\omega)$ is the Fourier transform of $x(t) = 2\text{rect}(t/3)$. What is $X(\pi)$?

(a) $-4/\pi$

(b) $4/\pi$

(c) -6

(d) 6

(e) $-2/\pi$

(f) $2/\pi$

(g) -3

(h) 3

(i) None of these

Problem 11:

If $s(t) = \sum_{n=-\infty}^{\infty} \delta(t-(2n+1))$, and $S(\omega)$ is the Fourier transform of $s(t)$, then what is $\int_{-1}^{7} |S(\omega)| d\omega$?

(a) 3π

(b) 3

(c) 2π

(d) 2

(e) 4π

(f) 4

(g) 5π

(h) 5

(i) 6π

(j) 6

(k) None of these

Problem 12:

Suppose $f(t) = \sum_{n=-1}^{1} F_n e^{jnt}$ and $F_{-1} = 2j$ and $F_0 = -3$. If $\int_{-4\pi/3}^{2\pi/3} |f(t)|^2 dt = 28\pi$, then which of the following could be F_1 ?

(a) $-j$

(b) π

(c) 3π

(d) $\sqrt{2}j$

(e) 2

(f) -3

(g) 7

(h) $9j$

(i) None of these

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Problem 13:

Suppose $f(t)$ has Fourier transform $F(\omega) = \text{rect}(\omega - 9) + \text{rect}(\omega + 9)$. If $G(\omega)$ is the Fourier transform of $g(t) = f(-t/3)$, then what is $G(\pi)$?

(a) 3

(b) 3π

(c) π

(d) 0

(e) $-\pi$

(f) $-\pi/3$

(g) -3

(h) $\pi/3$

(i) $1/3$

(j) None of these

Problem 14:

What is the Fourier transform of $e^{-4t}u(t) * 1$?

(a) $\frac{\pi}{2}\delta(\omega)$

(b) $\frac{\pi}{2}$

(c) $\frac{1}{4}\delta(\omega)$

(d) $\frac{1}{4}$

(e) $\frac{\pi}{4}\delta(\omega)$

(f) $\frac{\pi}{4}$

(g) $\frac{1}{2}\delta(\omega)$

(h) $\frac{1}{2}$

(i) None of these

Problem 15:

Let $f(t) = |\cos(t)|$, and let F_n be the (exponential form) Fourier series coefficients for $f(t)$. What is F_0 ?

(a) $2/\pi$

(b) 2

(c) 2π

(d) $4/\pi$

(e) 4

(f) 4π

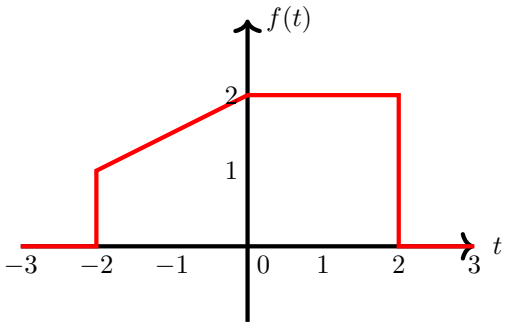
(g) $\pi/2$

(h) $\pi/4$

(i) None of these

Problem 16:

If $f(t)$ (shown below) has Fourier transform $F(\omega)$, then what is the Fourier transform of $F(t)$ when $\omega = 1$?



(a) 3π

(b) 4π

(c) 2

(d) 1

(e) $3/2$

(f) 2π

(g) π

(h) $2/\pi$

(i) $4/\pi$

(j) $1/\pi$

(k) 0

(l) None of these

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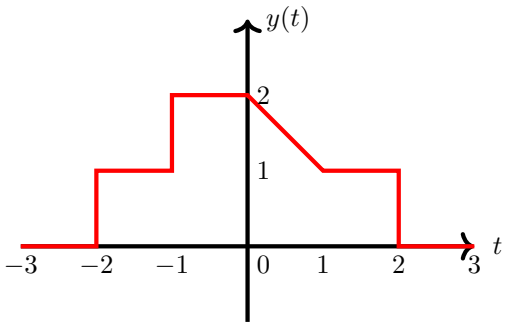
Problem 17:

If $y(t) = x(t) * h(t)$ (drawn below), then what is the value of the signal $x(t+3) * h(t-2)$ when $t = -1/2$?



(a) $3/2$

(b) $1/2$

(c) $-1/2$

(d) 1

(e) 2

(f) 0

(g) $2/3$

(h) -1

(i) None of these

Problem 18:

Suppose $f(t) = \sum_{n=-3}^{3} F_n e^{2jnt}$, where $F_n = (-2)^n e^{j\pi n}$. If $F(\omega)$ is the Fourier transform of $f(t)$, then what is $\int_3^7 F(\omega) d\omega$?

(a) 24π

(b) -8π

(c) 24

(d) 8

(e) 8π

(f) 12

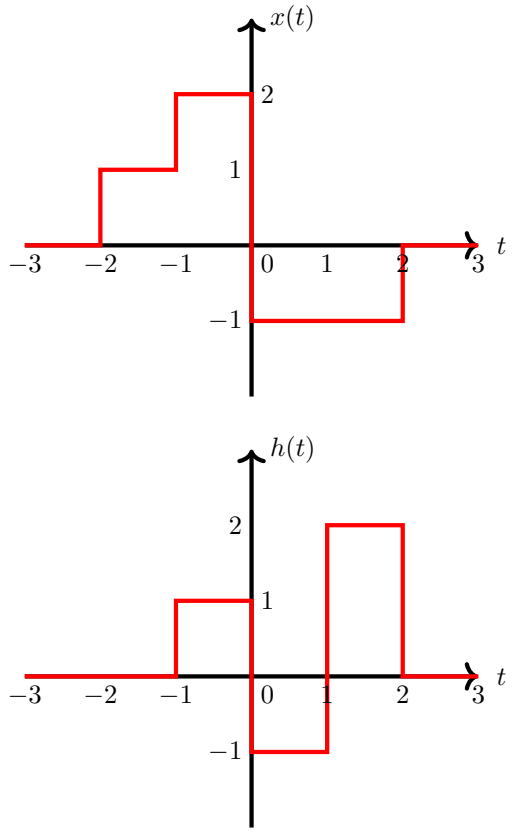
(g) -4

(h) 4π

(i) None of these

Problem 19:

If $x(t)$ (drawn below) is the input to an LTI system with impulse response $h(t)$ (drawn below), then what is the output $y(t)$ when $t = 1$?



(a) 4

(b) 5

(c) 3

(d) 2

(e) 1

(f) 0

(g) -1

(h) -2

(i) -3

(j) None of these

Problem 20:

If $x(t) = e^{2t} * u(t)$, then what is $x(3)$?

(a) $e^6/2$

(b) $e^{-6}/2$

(c) $2e^6$

(d) e^6

(e) e^{-6}

(f) $e^6 - 1$

(g) $e^6 - 2$

(h) $e^{-6} - 1$

(i) None of these

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Problem 21:

For which values of a is $\text{sinc}(at)$ NOT bandlimited?

(a) None of these values

(b) All of these values

(c) 0

(d) 1

(e) 2

(f) 3

(g) -1

(h) π

(i) $\pi/2$

Problem 22:

Suppose $X(\omega) = \text{rect}(\omega/2)$ is the input to an LTI system with frequency response $H(\omega) = \sum_{n=-\infty}^{\infty} \delta(\omega - \pi n)$ and $Y(\omega)$ is the output. If $y(t)$ is the inverse Fourier transform of $Y(\omega)$, then what is $y(3)$?

(a) $1/(2\pi)$

(b) $1/\pi$

(c) 1

(d) 2π

(e) π

(f) $1/(3\pi)$

(g) 3π

(h) 3

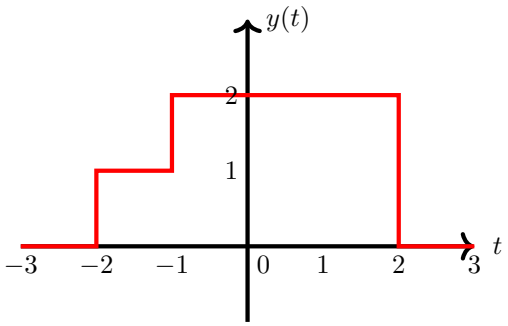
(i) 2

(j) 0

(k) None of these

Problem 23:

Suppose that when $x(t) = u(t+3)$ is the input to an LTI system with impulse response $h(t)$, the output is $y(t)$ (drawn below). What is $h(t)$?



(a) $\delta(t-1) + \delta(t-2) - 2\delta(t-5)$

(b) $\delta(t+2) + \delta(t+1) - 2\delta(t-2)$

(c) $\delta(t+5) + \delta(t+4) - 2\delta(t+1)$

(d) $u(t-1) + u(t-2) - 2u(t-5)$

(e) $u(t+2) + u(t+1) - 2u(t-2)$

(f) $u(t+5) + u(t+4) - 2u(t+1)$

(g) None of these

Problem 24:

If $F(\omega) = \text{rect}(\omega)$ and $G(\omega) = \sum_{n=-4}^{4} \delta(\omega - 2n)$, then what is $\int_{-\infty}^{\infty} |f(t)g(t)|^2 dt$?

(a) $9/(2\pi)^3$

(b) $1/\pi^3$

(c) $9/(2\pi)^2$

(d) $2/\pi^2$

(e) $9/(2\pi)$

(f) $4/\pi$

(g) 9

(h) 8

(i) 8π

(j) None of these

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Problem 25:

What is the period of $f(t) = |e^{j4|t|}| + e^{j5t} + e^{j6t}$?

(a) 2π

(b) π

(c) $2\pi/5$

(d) $2\pi/6$

(e) $\pi/15$

(f) $\pi/5$

(g) $\pi/6$

(h) 5

(i) 6

(j) 30

(k) 1

(l) $f(t)$ is not periodic

(m) None of these

Problem 26:

If $x(t) = \cos(t)\cos(2t)$ is the input to an LTI system with impulse response $H(\omega)$, where $H(\omega) = 1$ if $1.5 < |\omega| < 4$ and $H(\omega) = 0$ otherwise, then what is the output time signal?

(a) $\cos(3t)/2$

(b) $\cos(3t)$

(c) $\cos(2t)/2$

(d) $\cos(2t)$

(e) $\pi\cos(3t)$

(f) $\pi\cos(2t)$

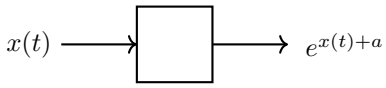
(g) 0

(h) $\cos(t)$

(i) None of these

Problem 27:

Consider the system shown below. For what value(s) of a is the system linear and time-invariant?



(a) None of these values

(b) All of these values

(c) 1

(d) 2

(e) 3

(f) πj

(g) $2\pi j$

(h) π

(i) 2π

Problem 28:

What is the Laplace transform of $u(2022t - 6)$? (No need to find the region of convergence.)

(a) $e^{-s/337}/s$

(b) $-e^{-s/337}/s$

(c) $e^{-s/2022}/s$

(d) $-e^{-s/2022}/s$

(e) $e^{-s/6}/s$

(f) $-e^{-s/6}/s$

(g) $1/s$

(h) $-1/s$

(i) None of these

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Problem 29:

What is the limit as t goes to infinity of e^{45jt} ?

(a) None of these

(b) 1

(c) e^{45j}

(d) e^{-45j}

(e) π

(f) -1

(g) $-\pi$

(h) 0

(i) ∞

Problem 30:

What is the inverse Laplace transform of $X(s) = 3/(s+2)+2/(s-4)$ if $X(s)$ exists when $s = -3+2j$?

(a) $-\Big(3e^{-2t} + 2e^{4t}\Big)u(-t)$

(b) $\Big(3e^{-2t} + 2e^{4t}\Big)u(-t)$

(c) $-\Big(3e^{-2t} + 2e^{4t}\Big)u(t)$

(d) $\Big(3e^{-2t} + 2e^{4t}\Big)u(t)$

(e) $-3e^{-2t}u(-t) + 2e^{4t}u(t)$

(f) $3e^{-2t}u(-t) - 2e^{4t}u(t)$

(g) $-3e^{-2t}u(t) + 2e^{4t}u(-t)$

(h) $3e^{-2t}u(t) - 2e^{4t}u(-t)$

(i) None of these

Problem 31:

Suppose $x(t)$ is the inverse Laplace transform of $3/(s - j - 2)$ and the Fourier transform of $x(t)$ exists. What is $x(-\pi)$?

(a) $3/e^{2\pi}$

(b) $3e^{2\pi}$

(c) $-3/e^{2\pi}$

(d) $-3e^{2\pi}$

(e) $3/e^{4\pi}$

(f) $3e^{4\pi}$

(g) 3

(h) -3

(i) 0

(j) None of these

Problem 32:

Suppose $x(t) = \text{sinc}(2022t)$ and $h(t) = \text{sinc}(45t)$. If $x(t)\cos(45t)$ is the input to an LTI system with impulse response $h(t)$, then what is the output?

(a) $\frac{\pi}{2022}\text{sinc}(45t)$

(b) $\text{sinc}(45t)$

(c) $\frac{\pi}{45}\text{sinc}(2022t)$

(d) $\text{sinc}(2022t)$

(e) $\frac{\pi^2}{45 \cdot 2022}$

(f) $\frac{\pi^2}{45 \cdot 2022}\text{sinc}(45t)$

(g) $\frac{\pi^2}{45 \cdot 2022}\text{sinc}(2022t)$

(h) $\frac{\pi}{2022}$

(i) $\frac{\pi}{45}$

(j) None of these

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Problem 33:

What is the phasor of $4\sin(\pi/3 + 3t)$?

(a) $4e^{-j\pi/6}$

(b) $4e^{j\pi/6}$

(c) $4e^{5j\pi/6}$

(d) $4e^{-5j\pi/6}$

(e) $4e^{j\pi/3}$

(f) $4e^{-j\pi/3}$

(g) $4e^{2j\pi/3}$

(h) $4e^{-2j\pi/3}$

(i) None of these

Problem 34:

If $x(t)$ has Laplace transform $X(s) = 2j/(s+3)$, then what is the Laplace transform of $x^*(t)$ evaluated at $s = 2 + j$?

(a) $-2j/(5+j)$

(b) $2j/(5+j)$

(c) $-2j/(5-j)$

(d) $2j/(5-j)$

(e) $2j$

(f) $-2j$

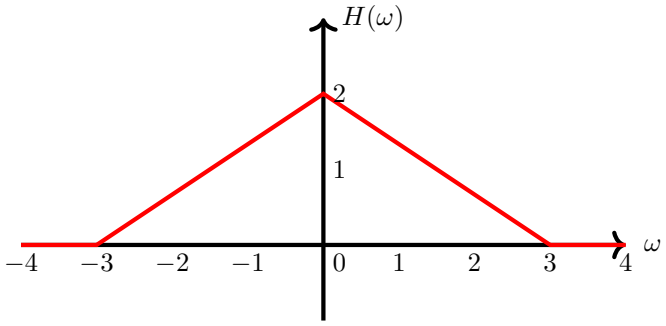
(g) $5-j$

(h) $5+j$

(i) None of these

Problem 35:

Suppose $f(t)$ is a periodic function that can be written as $f(t) = \sum_{n=-\infty}^{\infty} \frac{e^{3jnt/2}}{2+n^2}$. If $f(t)$ is the input to an LTI system with frequency response $H(\omega)$ shown below, then what is the output $y(t)$?



(a) $1 + \frac{2}{3}\cos(3t/2)$

(b) $2 + \frac{2}{3}\cos(3t/2)$

(c) $1 + \frac{1}{3}\cos(3t/2)$

(d) $2 + \frac{1}{3}\cos(3t/2)$

(e) 1

(f) 2

(g) $\frac{2}{3}\cos(3t/2)$

(h) $\frac{1}{3}\cos(3t/2)$

(i) None of these

Problem 36:

What is the Fourier transform of $e^{-5|t|-t}$ when $\omega = 2$?

(a) $\frac{-5}{-14+2j}$

(b) $\frac{5}{-14+2j}$

(c) $\frac{-5}{-7+j}$

(d) $\frac{5}{-7+j}$

(e) $\frac{5}{21}$

(f) $\frac{-5}{21}$

(g) $\frac{10}{21}$

(h) $\frac{-10}{21}$

(i) None of these