UCSD ECE 45
Final Exam
Spring 2022
Part 1

Problem 1:

What value of C would make the function $\cos(2Ct/\pi)$ periodic with period 2?

(a) $\pi^2/2$

(b) $\pi/2$

(c) π^2

(d) $\pi^2/4$

(e) $2/\pi^2$

(f) $2/\pi$

(g) $1/\pi^2$

(h) $4/\pi^2$

(i) 1

(j) 2

(k) 1/2

(l) $1/\pi$

(m) None of these

Problem 2:

Define three signals:

$$x(t) = \begin{cases} 3\sin(5t)\cos(6t)t^{-1} & \text{if } t \neq 0 \\ 7 & \text{if } t = 0 \end{cases}$$
$$y(t) = e^{jt} + e^{-jt}$$
$$z(t) = t^2 e^{-t^2+\pi j}.$$

Which of these statements is true?

(a) x, y, z are all even

(b) x, y are even, z is odd

(c) y, z are even, x is odd

(d) x, z are even, y is odd

(e) x, y are odd, z is even

(f) x, z are odd, y is even

(g) y, z are even, z is odd

(h) x, y are even, z is neither even nor odd

(i) x, z are even, y is neither even nor odd

(j) y, z are even, z is neither even nor odd

(k) y is even, z is odd, x is neither even nor odd

(l) None of x, y, z are either even or odd

(m) None of these

Problem 3:

If $x(t) = h(t) = 4e^{-4t}u(t)$, where $x(t)$ is the input to a linear, time-invariant system with impulse response $h(t)$, then the output of the system at $t = 2$ is:

(a) $32/e^8$

(b) $16/e^8$

(c) $8/e^8$

(d) $4/e^8$

(e) $32/e^4$

(f) $16/e^4$

(g) $8/e^4$

(h) $64/e^8$

(i) $4/e^4$

(j) $32e^8$

(k) $16e^8$

(l) $8e^8$

(m) None of these

Problem 4:

What is the Fourier transform of the signal $x(t)$ below when $\omega = \pi/36$?

$$x(t) = \begin{cases} 1 & \text{if } 0 < t < 12 \\ -1 & \text{if } -12 < t < 0 \\ 0 & \text{else} \end{cases}$$

(a) $-36j/\pi$

(b) $36j/\pi$

(c) $-36/\pi$

(d) $-j/\pi$

(e) $-36j$

(f) $-36j\pi$

(g) $-18j/\pi$

(h) $-6j/\pi$

(i) $36/\pi$

(j) $18j/\pi$

(k) $36j\pi$

(l) $6j/\pi$

(m) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 2

Problem 5:

What is the magnitude of the impedance of a 25 micro-farad capacitor at frequency 24 kHz?

(a) $5/(6\pi)$

(b) $5/(3\pi)$

(c) $5/(12\pi)$

(d) $10/(3\pi)$

(e) $5/3$

(f) $5/6$

(g) $25/(6\pi)$

(h) $6\pi/5$

(i) $5000/(6\pi)$

(j) $5/(6000\pi)$

(k) $2\pi/5$

(l) $\pi/6$

(m) None of these

Problem 6:

Suppose the output of a linear time-invariant system is $(e^{-2t} - e^{-3t})u(t)$ when the input is $\delta(t) - \delta(t-2)$, and the output is $e^{-3t}u(t)$ when the input is $\delta(t) + \delta(t-2)$. What is the impulse response of the system?

(a) $(1/2)e^{-2t}u(t)$

(b) $e^{-2t}u(t)$

(c) $2e^{-2t}u(t)$

(d) $(1/2)e^{-2t}$

(e) $e^{-t-1}u(t)$

(f) $e^{-3t-1}u(t)$

(g) $(1/2)e^{-3t}u(t)$

(h) $e^{-t}u(t)$

(i) $e^{-5t}u(t)$

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

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

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

(m) None of these

Problem 7:

Define the convolution $x(t) = 2 \cdot \text{rect}(t-5) * \text{rect}(3t)$. What is $\int_{-\infty}^{\infty} x(t)dt$?

(a) 2/3

(b) 1/3

(c) 4/3

(d) 3/2

(e) 1

(f) 2

(g) 3

(h) 3/4

(i) 1/6

(j) 0

(k) 1/2

(l) 6

(m) None of these

Problem 8:

Suppose the output of a linear time-invariant system is $e^{-2t}u(t)$ when the input is $e^{-3t}u(t)$, What is the impulse response of the system?

(a) $\delta(t) + e^{-2t}u(t)$

(b) $\delta(t) + e^{-3t}u(t)$

(c) $\delta(t) - e^{-2t}u(t)$

(d) $\delta(t) - e^{-3t}u(t)$

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

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

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

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

(i) $e^{-t}u(t)$

(j) $e^{t}u(t)$

(k) $e^{-5}u(t)$

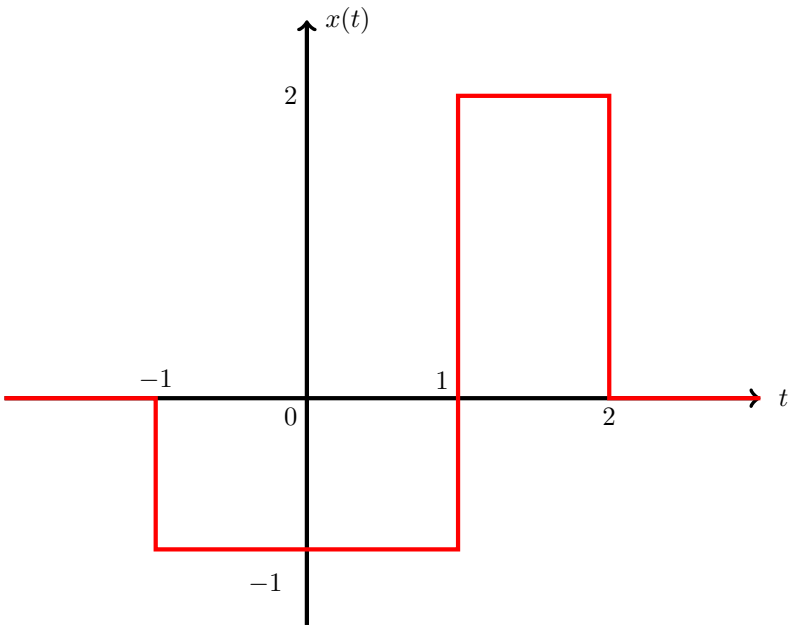
(l) $e^{-6t}u(t)$

(m) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 3

Problem 9:

If $x(t)$ is the red time signal shown below, and its Fourier transform is $X(\omega)$, then what is the value of $\int_{-\infty}^{\infty} X(\omega)d\omega$?



(a) -2π

(b) 2π

(c) π

(d) $-\pi$

(e) -2

(f) 2

(g) 1

(h) 0

(i) $-\pi/2$

(j) $-1/(2\pi)$

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

(l) $1/\pi$

(m) None of these

Problem 10:

Suppose system #1 produces an output $x(t)u(t)$ when its input is $x(t)$, and system #2 produces an output $x(t)u(-t)$ when its input is $x(t)$. Which of the following statements is true?

(a) System #1 is linear, not time-invariant.
System #2 is linear, not time-invariant.

(b) System #1 is linear, time-invariant
System #2 is linear, not time-invariant.

(c) System #1 is linear, not time-invariant.
System #2 is linear, time-invariant.

(d) System #1 is linear, time-invariant.
System #2 is linear, time-invariant.

(e) System #1 is linear, not time-invariant.
System #2 is not linear, not time-invariant.

(f) System #1 is linear, time-invariant.
System #2 is not linear, not time-invariant.

(g) System #1 is linear, not time-invariant.
System #2 is time-invariant, not linear.

(h) System #1 is linear, time-invariant.
System #2 is time-invariant, not linear.

(i) System #1 is not linear, not time-invariant.
System #2 is linear, not time-invariant.

(j) System #1 is time-invariant, not linear.
System #2 is linear, not time-invariant.

(k) System #1 is not linear, not time-invariant.
System #2 is linear, time-invariant.

(l) System #1 is time-invariant, not linear.
System #2 is linear, time-invariant.

(m) None of these

Problem 11:

What is the magnitude of the Fourier transform of the signal $x(t)$ defined below?

$$x(t) = \begin{cases} e^{-t} & \text{if } t > 2 \\ 0 & \text{else} \end{cases}$$

(a) $\frac{1}{e^2\sqrt{1+\omega^2}}$

(b) $\frac{e^2}{\sqrt{1+\omega^2}}$

(c) $\frac{1}{e^2\sqrt{1+\omega}}$

(d) $\frac{1}{\sqrt{1+\omega^2}}$

(e) $\frac{1}{e^2(1+\omega^2)}$

(f) $\frac{1}{1+\omega^2}$

(g) $e^2\sqrt{1+\omega^2}$

(h) $e^2(1+\omega^2)$

(i) $\sqrt{1+\omega^2}$

(j) $\frac{1}{1+j\omega}$

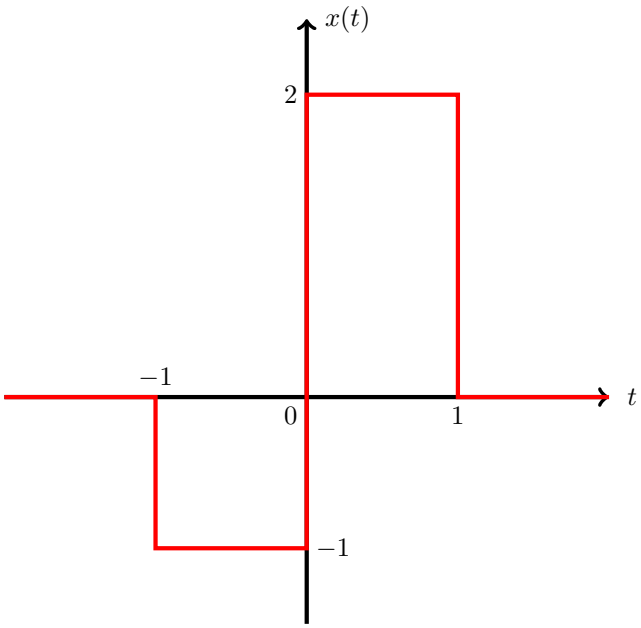
(k) $\frac{e^{-2}}{1+j\omega}$

(l) $\frac{2}{e^2\sqrt{1+\omega^2}}$

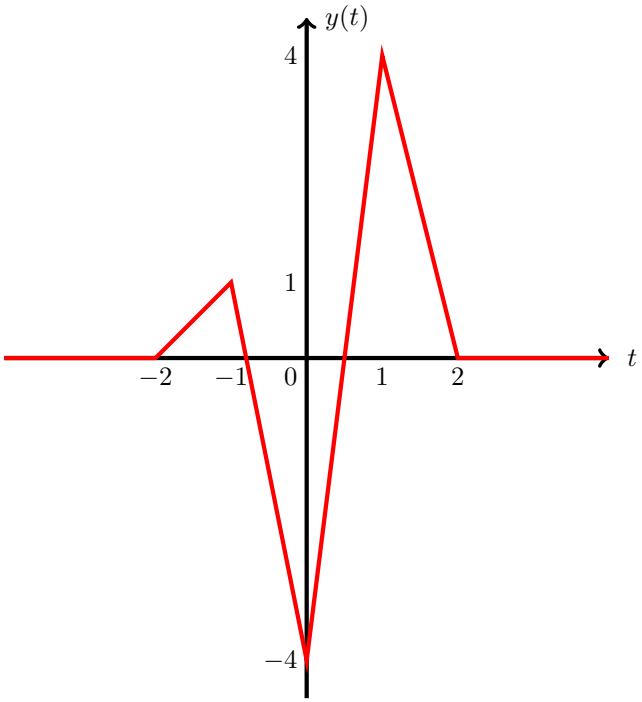
(m) None of these

Problem 12:

If $x(t)$ is the red time signal shown below, and $y(t) = x(t) * x(t)$, i.e. $x(t)$ convolved with itself, then which of the following time signals in red is $y(t)$?



(a)



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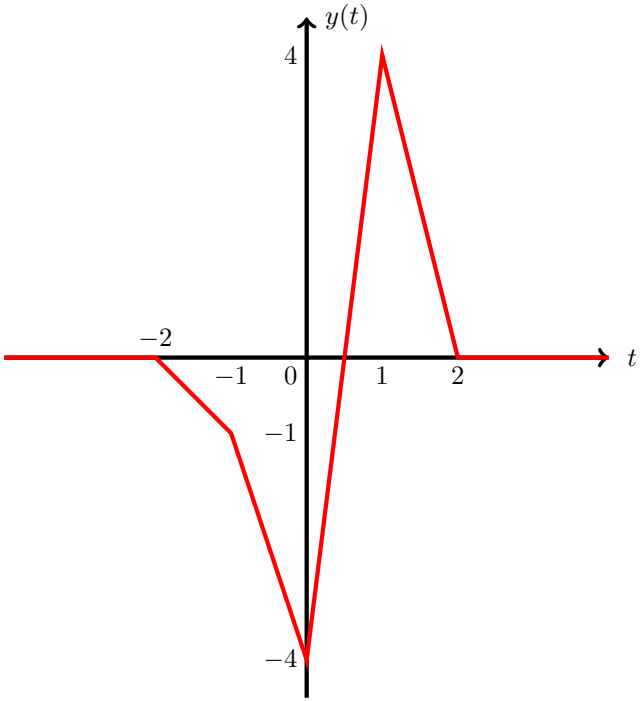

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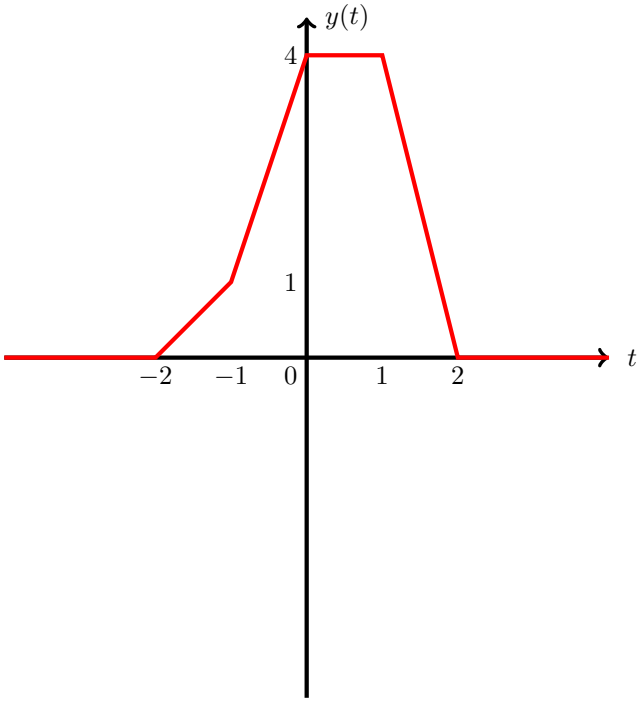
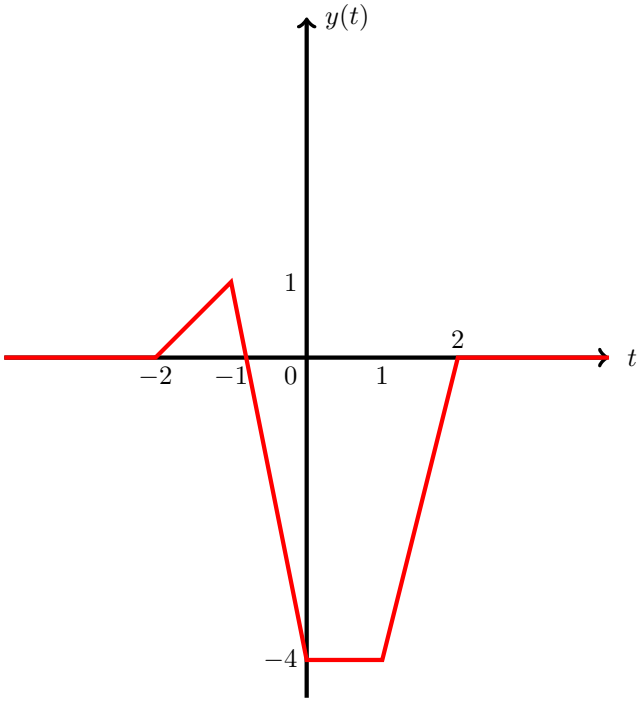
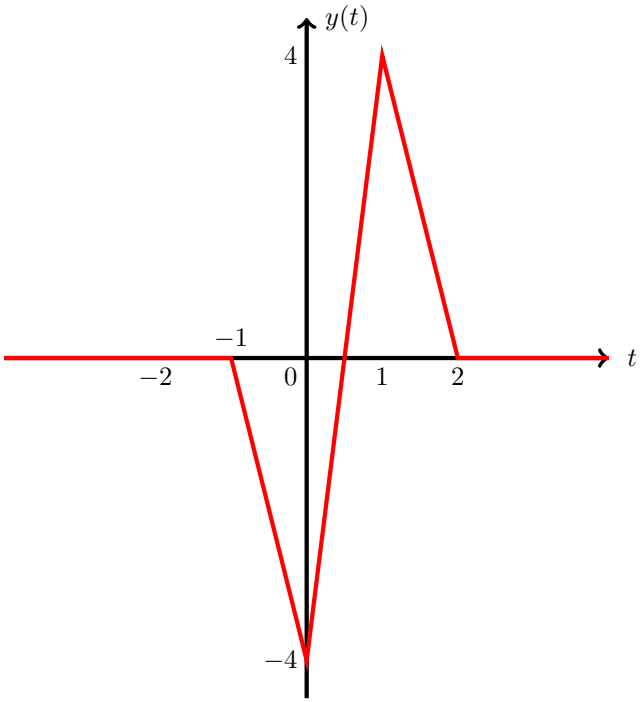


(d)

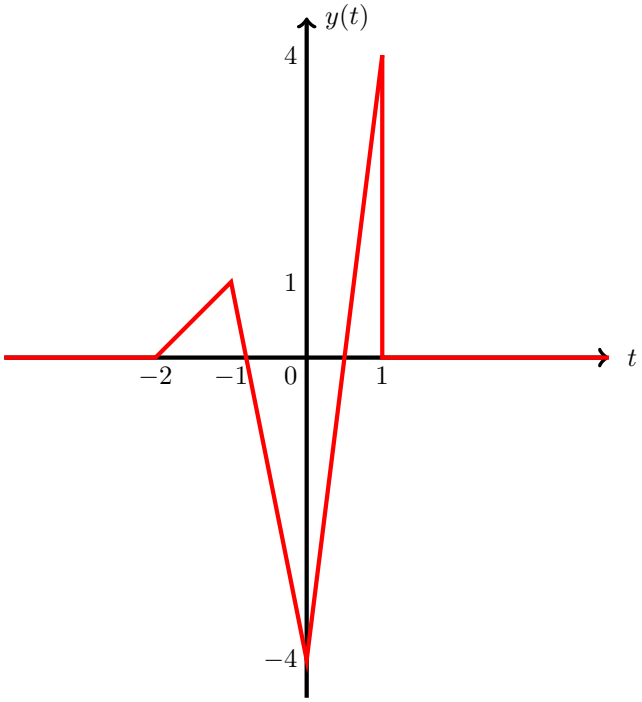
n



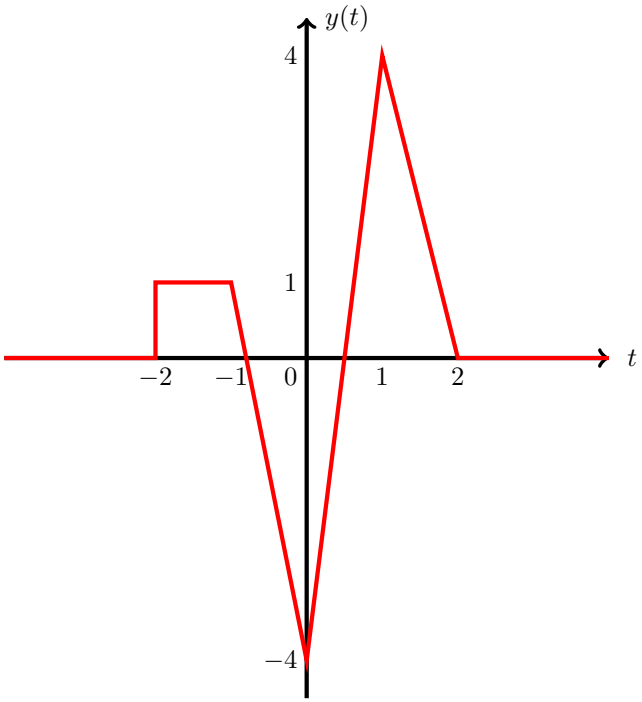
(e)



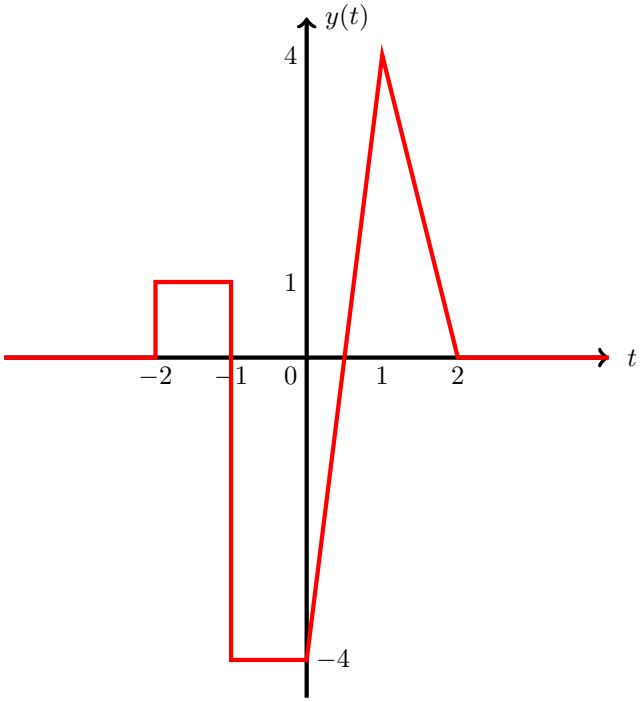
(f)



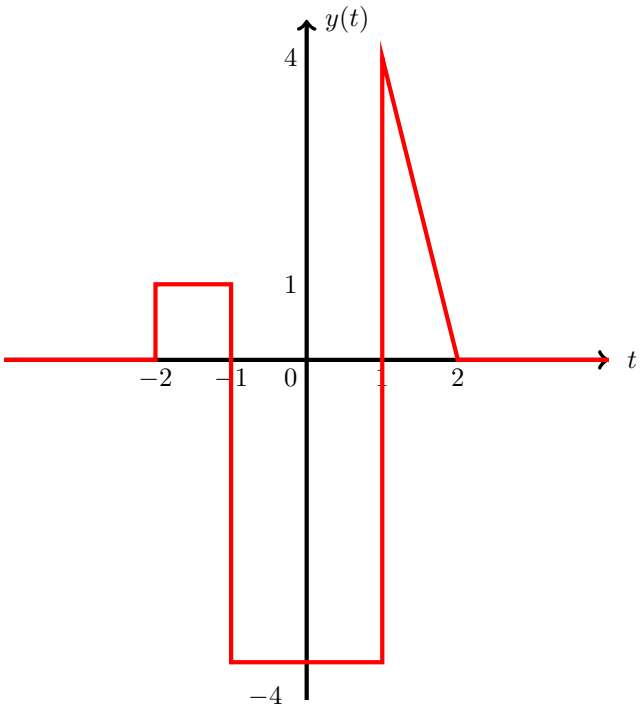
(g)



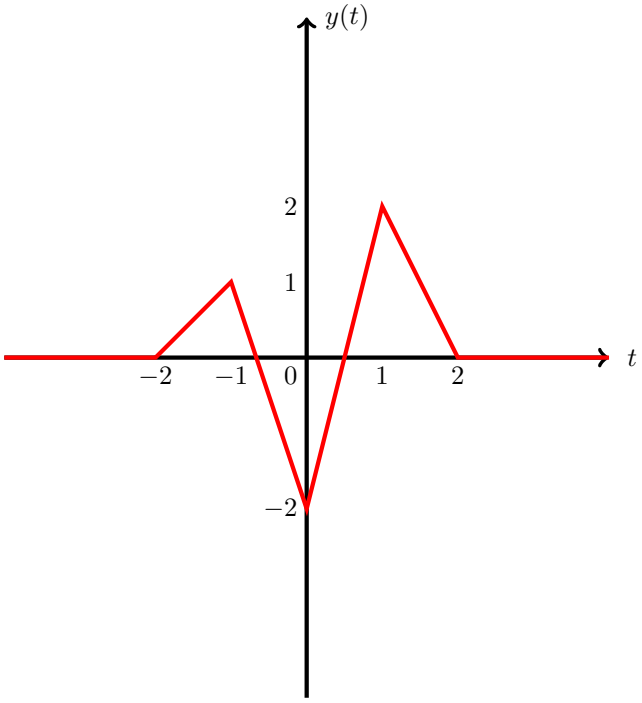
(h)



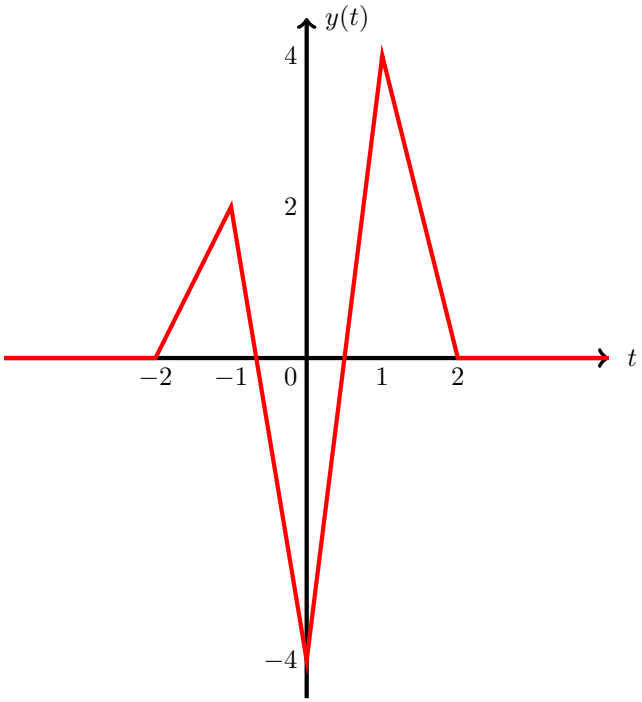
(i)



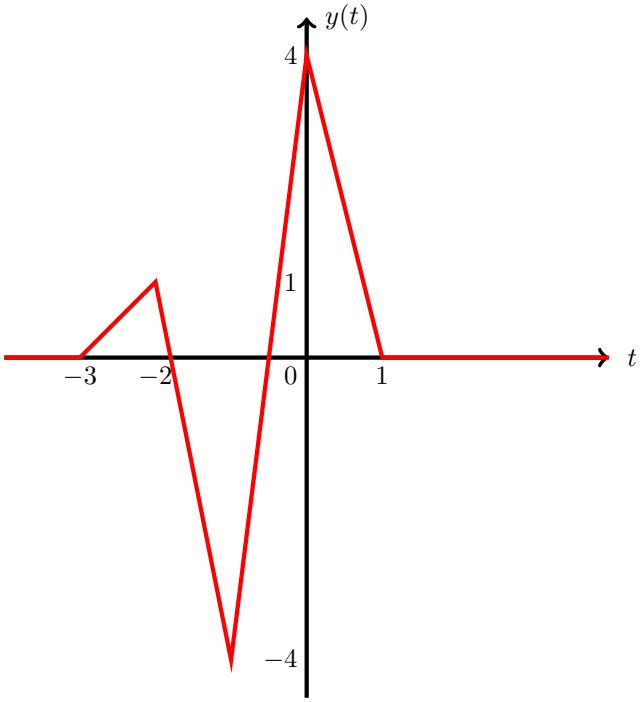
(j)



(k)



(l)



(m) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 4

Problem 13:

What is the value of the Fourier transform of $2u(t) - u(t-2) - u(t-5)$ at $\omega = 0$?

(a) 7

(b) 5

(c) 6

(d) 8

(e) 4

(f) 3

(g) 2

(h) 1

(i) 0

(j) 10

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

(l) $5/(2\pi)$

(m) None of these

Problem 14:

Define the convolution $x(t) = (2\delta(t-1) - \delta(t)) * (\delta(t-1) - 3\delta(t))$. What is $\int_{-\pi/2}^{\pi/2} x(t)dt$?

(a) -4

(b) -7

(c) -3

(d) 7

(e) 3

(f) 4

(g) 10

(h) 2

(i) -2

(j) 0

(k) 1

(l) -1

(m) None of these

Problem 15:

If the Laplace transform of $x(t)$ equals $X(s) = \frac{2}{s-2+3j}$ and exists at $s = \frac{1}{2} - 2j$, then what is $x(t)$ when $t = -1$?

(a) $-2e^{3j-2}$

(b) $2e^{3j-2}$

(c) $-e^{3j-2}$

(d) e^{3j-2}

(e) $-2e^{2-3j}$

(f) $2e^{2-3j}$

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

(h) $-2e^{3j}$

(i) $-2e^{-2}$

(j) $-2e^{2}$

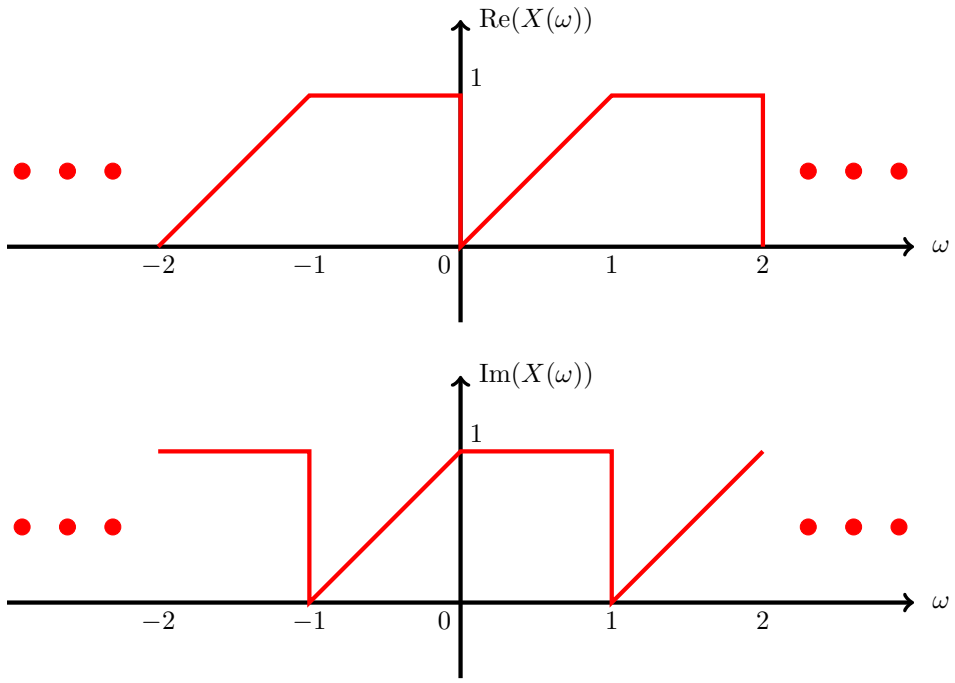
(k) $2e^{-2}$

(l) $2e^{3j}$

(m) None of these

Problem 16:

Suppose $x(t)$ is the input to a linear, time-invariant system with impulse response $h(t)$ and output $y(t)$. The Fourier transform of $x(t)$ is periodic in ω with period 2 and its real and imaginary parts are shown below. If the system's frequency response is $H(\omega) = \text{rect}(\omega - \frac{1}{2})$, then what is the Fourier transform of the output $y(t)$?



(a) $(\omega + j)(u(\omega) - u(\omega - 1))$

(b) $(\omega + 1)(u(\omega) - u(\omega - 1))$

(c) $(\omega + j)u(\omega)$

(d) $(\omega + 1)u(\omega)$

(e) $\omega(u(\omega) - u(\omega - 1))$

(f) $\omega u(\omega)$

(g) $u(\omega)$

(h) $(\omega + j)\text{rect}(\omega)$

(i) $(\omega + 1)\text{rect}(\omega)$

(j) $\text{rect}(\omega)$

(k) $\text{rect}(\omega - \frac{1}{2})$

(l) $\text{rect}(\omega + \frac{1}{2})$

(m) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 5

Problem 17:

What is the Fourier transform of $\frac{\delta(t+2)}{e^t}$?

(a) $e^{2(1+j\omega)}$

(b) $e^{2(1-j\omega)}$

(c) $e^{1+j\omega}$

(d) $e^{1-j\omega}$

(e) $e^{2(1+2j\omega)}$

(f) $e^{2(2+j\omega)}$

(g) $e^{-2(1+j\omega)}$

(h) $e^{2(-1+j\omega)}$

(i) $e^{2j\omega}$

(j) $e^{-2j\omega}$

(k) $e^{2\omega}$

(l) $e^{-2\omega}$

(m) None of these

Problem 18:

What is the period of the function $x(t) = 99999\cos(2t/\pi)\cos((\pi/3)2^{99999})$?

(a) π^2

(b) π

(c) $2\pi^2$

(d) $\pi^2/2$

(e) $\pi/2$

(f) $\pi^2/4$

(g) $\pi/4$

(h) $1/\pi^2$

(i) $2/\pi^2$

(j) $2/\pi$

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

(l) 99999π

(m) None of these

Problem 19:

What is the convolution of $x(t) = u(-t-1)$ with $y(t) = u(1-t)$ at $t = 1$?

(a) 0

(b) 1

(c) -1

(d) 2

(e) 3

(f) 4

(g) 5

(h) 6

(i) -2

(j) $1/2$

(k) ∞

(l) $1/4$

(m) None of these

Problem 20:

Suppose a periodic signal $x(t) = \sum_{n=0}^{\infty} e^{n(jt-1)}$ is the input to a linear time-invariant system whose frequency response is $H(\omega) = \text{rect}(\omega - 1)$. What is the real part of the output time signal?

(a) $\frac{\cos t}{e}$

(b) $\frac{\sin t}{e}$

(c) $\cos t$

(d) $\sin t$

(e) $e \cdot \cos t$

(f) $e \cdot \sin t$

(g) $1 + \frac{\cos t}{e}$

(h) $1 + \cos t$

(i) $1 + \frac{\sin t}{e}$

(j) $1 + \sin t$

(k) 1

(l) e^t

(m) e^{t-1}

(n) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 6

Problem 21:

What value of C would make the frequency of the function $\cos(t/C)$ equal to 10 Hertz ?

(a) $1/(20\pi)$

(b) $1/(10\pi)$

(c) $1/(5\pi)$

(d) $5/\pi$

(e) $10/\pi$

(f) $20/\pi$

(g) $\pi/10$

(h) $\pi/5$

(i) $\pi/20$

(j) 10

(k) 20

(l) 1/10

(m) 1/20

(n) None of these

Problem 22:

What is the Fourier transform of $x(t)$ when $\omega = 0$, if

$$x(t) = \begin{cases} 2 & \text{if } |t| < 2 \\ e^{-t} & \text{if } t > 3 \\ 0 & \text{else} \end{cases}$$

(a) $8 + e^{-3}$

(b) $4 + e^{-3}$

(c) $2 + e^{-3}$

(d) $4 - e^{3}$

(e) $8 + e^{3}$

(f) $4 + e^{3}$

(g) $2 + e^{3}$

(h) $8 - e^{-3}$

(i) $4 - e^{-3}$

(j) $2 - e^{-3}$

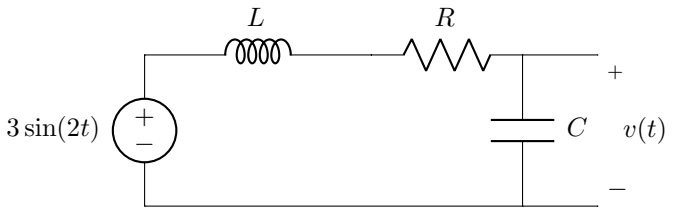
(k) $8 + e^{-2}$

(l) $8 + e^{-4}$

(m) None of these

Problem 23:

The circuit below is in sinusoidal steady state. The capacitor is 25 micro-farads, the inductor is 2 mega-henrys, and the resistor is 600 kilo-ohms. What is the phasor of the voltage $v(t)$?



(a) $\frac{3j}{199-30j}$

(b) $\frac{-3j}{199-30j}$

(c) $\frac{3j}{200-30j}$

(d) $\frac{-3j}{200-30j}$

(e) $\frac{3j}{199-90j}$

(f) $\frac{3j}{199+90j}$

(g) $\frac{j}{199-90j}$

(h) $\frac{j}{200-30j}$

(i) $\frac{30j}{199-30j}$

(j) $\frac{30}{199-30j}$

(k) $\frac{25j}{199-30j}$

(l) $\frac{15}{199-30j}$

(m) None of these

Problem 24:

Let $x(t)$ be a signal whose Fourier transform is

$$X(\omega) = \begin{cases} |\omega| & \text{if } 40 < |\omega| < 50 \\ 0 & \text{else} \end{cases}$$

and let $y(t) = x(t)\sin(20t)$. If $Y(\omega)$ is the Fourier transform of $y(t)$, then what is $Y(24)$?

(a) $22j$

(b) $44j$

(c) 22

(d) 44

(e) $-22j$

(f) $-44j$

(g) $24j$

(h) 24

(i) $-24j$

(j) 42

(k) 0

(l) 48

(m) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 7

Problem 25:

What does the convolution $\delta(t-10) * \delta(t+8) * u(t-2) * \delta(t+1) * \delta(t)$ equal?

(a) $u(t-3)$

(b) $u(t-4)$

(c) $u(t+4)$

(d) $u(t-2)$

(e) $u(t+3)$

(f) $u(t-5)$

(g) $u(t+1)$

(h) $u(t)$

(i) $\delta(t-3)$

(j) $\delta(t+1)$

(k) $\delta(t)$

(l) $\delta(t-2) + u(t+1)$

(m) None of these

Problem 26:

If $X(\omega)$ is the Fourier transform of $x(t) = \sum_{n=-\infty}^{\infty} \delta(t-2n)$, then what is $\int_{-5/2}^{15/2} X(\omega)d\omega$?

(a) 3π

(b) 2π

(c) π

(d) 4π

(e) 5π

(f) 3

(g) 4

(h) 2

(i) 1

(j) 0

(k) 10π

(l) 10

(m) None of these

Problem 27:

Define two signals:

$$x(t) = \begin{cases} 3\sin(5t)\cos(6t)t^{-1} & \text{if } t \neq 0 \\ 7 & \text{if } t = 0 \end{cases}$$
$$y(t) = e^{jt} + e^{-jt}$$

Which of these statements is true?

(a) x is bandlimited and not periodic. y is bandlimited and periodic.

(b) x is bandlimited and periodic. y is bandlimited and periodic.

(c) x is not bandlimited and not periodic. y is bandlimited and periodic.

(d) x is bandlimited and not periodic. y is periodic and not bandlimited.

(e) x is bandlimited and not periodic. y is bandlimited and not periodic.

(f) x is not bandlimited and not periodic. y is periodic and not bandlimited.

(g) x is not bandlimited and not periodic. y is bandlimited and not periodic.

(h) x is periodic and not bandlimited. y is bandlimited and periodic.

(i) x is bandlimited and periodic. y is bandlimited and not periodic.

(j) x is bandlimited and periodic. y is periodic and not bandlimited.

(k) x is not bandlimited and not periodic. y is bandlimited and not periodic.

(l) x is bandlimited and periodic. y is not bandlimited and not periodic.

(m) None of these

Problem 28:

If the Fourier transform of the signal

$$x(t) = \begin{cases} \sqrt{3t+4} & \text{if } 1 < t < 2 \\ 0 & \text{else} \end{cases}$$

is $X(\omega)$, then what is the value of $\int_{-\infty}^{\infty} |X(\omega)|^2 d\omega$?

(a) 17π

(b) $17\pi/2$

(c) 16π

(d) 17

(e) 34π

(f) 26π

(g) $17/\pi$

(h) $17/(2\pi)$

(i) 34

(j) $\pi/17$

(k) 12

(l) 16

(m) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 8

Problem 29:

What is the convolution of $\delta(t-1) - \delta(t) - \delta(t+1)$ and $\delta(t) - \delta(t+1)$?

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

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

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

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

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

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

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

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

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

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

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

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

(m) None of these

Problem 30:

If the impulse response of a linear time-invariant system is $h(t) = e^{-\pi jt/2}$, then what is the output of the system when the input is $\delta(t-1) - \delta(t+1)$?

(a) $2je^{-j\pi t/2}$

(b) $je^{-j\pi t/2}$

(c) $2je^{j\pi t/2}$

(d) $2je^{-j\pi t}$

(e) $2je^{-2j\pi t}$

(f) $4je^{-j\pi t/2}$

(g) $e^{-j\pi t/2}$

(h) $2e^{-j\pi t}$

(i) $2je^{j\pi t}$

(j) $je^{-j\pi t}$

(k) $2je^{-j\pi t/4}$

(l) $4je^{-j\pi t/4}$

(m) None of these

Problem 31:

The signal $x(t)$ is anti-causal and its bilateral Laplace transform is $\frac{1}{(2s+1)(s+1)}$. What is the value of $x(t)$ at time $t = -2$?

(a) $e(e-1)$

(b) $e(e+1)$

(c) $-e(e-1)$

(d) $2e(e-1)$

(e) $e(2e-1)$

(f) $e(e-2)$

(g) $-e(e-2)$

(h) $-e(2e-1)$

(i) e

(j) 0

(k) $\frac{1}{2e+1}$

(l) $\frac{1}{(2e+1)(e+1)}$

(m) None of these

Problem 32:

Let $p_1(t) = \sum_{n=-\infty}^{\infty} \delta(t-4n)$ and $p_2(t) = \sum_{n=-\infty}^{\infty} \delta(t-4n+2)$.
If $x(t) = \text{sinc}(3t)(p_1(t) + p_2(t))$, then what is $X(\omega)$ when $\omega = 2.9$?

(a) $\pi/3$

(b) $\pi/6$

(c) $2\pi/3$

(d) $\pi/12$

(e) $1/3$

(f) $1/6$

(g) $1/2$

(h) π

(i) 3π

(j) $6/\pi$

(k) $3/\pi$

(l) $2\pi^2/3$

(m) $\pi^2/3$

(n) None of these

UCSD ECE 45
Final Exam
Spring 2022
Part 9

Problem 33:

If a linear, time-invariant system with impulse response $\cos(t\pi/4)u(t-1)$ has input $\delta(t-2)$, what is the output at $t = 6$?

(a) -1

(b) 1

(c) $1/2$

(d) $-1/2$

(e) $\sqrt{2}/2$

(f) $-\sqrt{2}/2$

(g) 0

(h) $\sqrt{3}/2$

(i) $-\sqrt{3}/2$

(j) π

(k) $-\pi$

(l) $\pi/2$

(m) $\pi/4$

(n) None of these

Problem 34:

Suppose the input $x(t)$ and output $y(t)$ of an LTI system always satisfy the differential equation

$$\frac{dy(t)}{dt} = \frac{dx(t)}{dt} + 4x(t).$$

What is the magnitude of the frequency response of the system at $\omega = 1$?

(a) $\sqrt{17}$

(b) 17

(c) 4

(d) 16

(e) 8

(f) 1

(g) 2

(h) $2\sqrt{2}$

(i) 1/17

(j) 1/16

(k) 1/4

(l) 1/8

(m) None of these

Problem 35:

Let $x(t)$ be the convolution of $\delta(t-1)-\delta(t-2)$ with $\delta(t)+\text{rect}(t)$. What is $\int_{5/4}^{9/4} x(t)dt$?

(a) $-3/2$

(b) -1

(c) -3

(d) 4

(e) 6

(f) $3/2$

(g) $-3/4$

(h) $-5/8$

(i) $7/4$

(j) $5/4$

(k) $-7/8$

(l) 0

(m) None of these

Problem 36:

Suppose $f(t)$ is a periodic signal with period 1 and $f(t) = e^{-t}$ when $0 < \mathsf{t} \leq 1$. What is the magnitude of the coefficient F_2 of the exponential form of the Fourier Series for $f(t)$?

(a) $\frac{1-e^{-1}}{\sqrt{1+16\pi^2}}$

(b) $\frac{1-e^{-1}}{1+16\pi^2}$

(c) $\frac{1-e^{-1}}{\sqrt{1+4\pi^2}}$

(d) $\frac{1-e^{-1}}{\sqrt{1+2\pi^2}}$

(e) $\frac{1-e^{-1}}{\sqrt{1+16\pi}}$

(f) $\frac{1-e^{-1}}{\sqrt{1-16\pi^2}}$

(g) $\frac{1-e^{-1}}{\sqrt{1-4\pi^2}}$

(h) $\frac{1-e^{-1}}{\sqrt{1-16\pi}}$

(i) $\frac{1}{\sqrt{1+16\pi^2}}$

(j) $\frac{e^{-1}-1}{\sqrt{1+16\pi^2}}$

(k) $\frac{1-e}{\sqrt{1+16\pi^2}}$

(l) $\frac{1+e}{\sqrt{1+16\pi^2}}$

(m) None of these