SOLUTIONS

30318451

RED

ECEn 380: Signals & Systems

Fall 2015

Professors Neal Bangerter and Brian Jeffs

Midterm #2

November 17 – 20, 2015

- 3 hour time limit
- Open book, open notes (electronic books and/or notes or book on a tablet allowed)
- Calculators allowed (okay to use tablet or e-book as calculator)
- **IMPORTANT: The exam is double sided, per testing center requirements**

- The exam consists entirely of multiple choice questions. **Please provide all answers on the scantron bubble sheet.**

- You are welcome to use extra scratch paper for your work, but please include it when you hand in the exam.

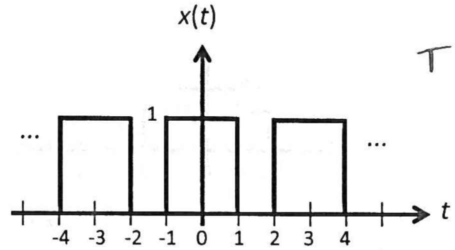
- There are 33 questions and 100 points possible in the exam. The first problem is worth 4 points, and all remaining problems are worth 3 points each.

- **PLEASE NOTE:** The problems are not ordered in terms of difficulty. For example, if you really understand sampling and the Chapter 7 material, the second half of the exam may be significantly easier for you than the first half of the exam. You may want to skip difficult problems on your first pass through the test, and come back to them after you have answered all of the problems that are easy for you.

- Manage your time carefully! Skip more difficult problems on your first pass through the exam, and return to them later (time permitting).

If you feel that something in the exam is not clear, please state your assumptions and work the problem based on those assumptions.

1. Find the Fourier series coefficients x_n of the following periodic function $x(t)$: (4 points)



$T = 3$

(a) $x_n = \dfrac{\sin(\frac{2\pi}{3}n)}{\pi n}$ for all n

(b) $x_n = \begin{cases} \dfrac{1-e^{-jn\frac{2\pi}{3}}}{j2\pi n}, & n \neq 0 \\ \dfrac{2}{3}, & n = 0 \end{cases}$

(c) $x_n = \begin{cases} \dfrac{1-e^{-jn\frac{2\pi}{3}}}{j2\pi n/3}, & n \neq 0 \\ 1, & n = 0 \end{cases}$

$\boxed{\text{(d)}}$ $x_n = \begin{cases} \dfrac{\sin(\frac{2\pi}{3}n)}{\pi n}, & n \neq 0 \\ \dfrac{2}{3}, & n = 0 \end{cases}$

(e) $x_n = \begin{cases} \dfrac{1-e^{-jn\frac{1}{3}}}{jn}, & n \neq 0 \\ \dfrac{2}{3}, & n = 0 \end{cases}$

$$X_n = \frac{1}{3}\int_{-1}^{1} e^{-j\frac{2\pi}{3}nt}\,dt$$

FOR $n \neq 0$:

$$= \frac{1}{3}\left.\frac{e^{-j\frac{2\pi}{3}nt}}{-j\frac{2\pi}{3}n}\right|_{-1}^{1}$$

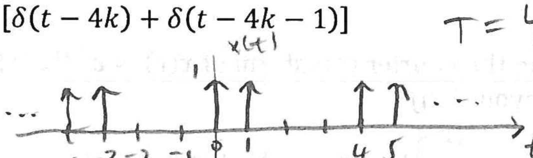
$$= \frac{e^{j\frac{2\pi}{3}n} - e^{-j\frac{2\pi}{3}n}}{j2\pi n}$$

$$X_n = \begin{cases} \dfrac{\sin(\frac{2\pi}{3}n)}{\pi n}, & n \neq 0 \\ \dfrac{2}{3}, & n = 0 \end{cases}$$

2. Find the Fourier series coefficients x_n of the following periodic function $x(t)$:

$$x(t) = \sum_{k=-\infty}^{\infty} [\delta(t-4k) + \delta(t-4k-1)]$$

$T = 4$



(a) $x_n = \dfrac{1+e^{-jn\pi}}{4}$ for all n

(b) $x_n = \dfrac{e^{jn\frac{\pi}{2}}+e^{jn\pi}}{5}$ for all n

$\boxed{\text{(c)}}$ $x_n = \dfrac{(-j)^n+1}{4}$ for all n

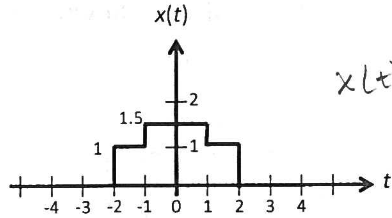
(d) $x_n = \dfrac{(-j)^n+(-1)^n}{4}$ for all n

$$X_n = \frac{1}{4}\int_{0^-}^{1^+} [\delta(t) + \delta(t-1)]\, e^{-j\frac{2\pi}{4}nt}\,dt$$

$$= \frac{1}{4}\left[1 + (e^{-j\frac{\pi}{2}})^n\right]$$

$$= \frac{1}{4}\left[(-j)^n + 1\right]$$

3. Find the Fourier transform $X(j\omega)$ of the following function $x(t)$:



$$x(t) = \text{rect}\left(\frac{t}{4}\right) + \frac{1}{2}\text{rect}\left(\frac{t}{2}\right)$$

(a) $2\sin(2\omega) + \sin(\omega)$

(b) $\frac{2\sin(2\omega)+2\sin(\omega)}{\omega}$

$\boxed{\text{(c)}}$ $\frac{2\sin(2\omega)+\sin(\omega)}{\omega}$

(d) $\frac{\sin(2\omega)+\sin(\omega)}{\omega}$

$$X(\omega) = 4\,\text{sinc}\left(\frac{4\omega}{2}\right) + \frac{1}{2}\cdot 2\,\text{sinc}\left(\frac{2\omega}{2}\right)$$

$$= 4\,\text{sinc}(2\omega) + \text{sinc}(\omega)$$

$$= 4\frac{\sin(2\omega)}{2\omega} + \frac{\sin(\omega)}{\omega}$$

$$= \frac{2\sin(2\omega) + \sin(\omega)}{\omega}$$

$$\text{sinc}(\theta) \equiv \frac{\sin(\theta)}{\theta}$$

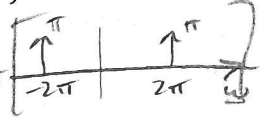
4. Find the Fourier transform of $x(t) = \cos(2\pi t)e^{-4t}\,u(t)$.

(a) $\frac{\pi}{4+j(\omega-2\pi)} + \frac{\pi}{4+j(\omega+2\pi)}$

$\boxed{\text{(b)}}$ $\frac{1}{2}\left[\frac{1}{4+j(\omega-2\pi)} + \frac{1}{4+j(\omega+2\pi)}\right]$

(c) $\frac{\pi\delta(\omega-2\pi)}{4+j2\pi} + \frac{\pi\delta(\omega+2\pi)}{4-j2\pi}$

(d) $\frac{1}{2j}\left[\frac{1}{4+j(\omega-2\pi)} - \frac{1}{4+j(\omega+2\pi)}\right]$

$X(\omega) = \frac{1}{2\pi}$  $* \left(\frac{1}{4+j\omega}\right)$

$$\boxed{= \frac{1}{2}\left[\frac{1}{4+j(\omega-2\pi)} + \frac{1}{4+j(\omega+2\pi)}\right]}$$

5. Find the Fourier transform of $x(t) = e^{-4t}u(t) * \cos(2\pi t)$ (where the * denotes convolution).

$\boxed{\text{(a)}}$ $\frac{\pi\delta(\omega-2\pi)}{4+j2\pi} + \frac{\pi\delta(\omega+2\pi)}{4-j2\pi}$

(b) $\frac{1}{2}\left[\frac{1}{4+j(\omega-2\pi)} + \frac{1}{4+j(\omega+2\pi)}\right]$

(c) $\frac{1}{2}\left[\frac{\delta(\omega-2\pi)}{4+j2\pi} + \frac{\delta(\omega+2\pi)}{4-j2\pi}\right]$

(d) $\frac{\pi\delta(\omega-2\pi)}{4j-2\pi} + \frac{\pi\delta(\omega+2\pi)}{4j+2\pi}$

$$X(\omega) = \left(\frac{1}{4+j\omega}\right)\left[\pi\,\delta(\omega-2\pi) + \pi\,\delta(\omega+2\pi)\right]$$

$$= \boxed{\frac{\pi}{4+2\pi j}\delta(\omega-2\pi) + \frac{\pi\,\delta(\omega+2\pi)}{4-2\pi j}}$$

6. Find the **inverse** Fourier transform of $X(j\omega) = \text{rect}(\frac{\omega}{2}) + \text{rect}(\omega)$.

(a) $x(t) = \frac{\sin(t)}{\pi t} + \frac{2\sin(2t)}{\pi t}$

$$x(t) = \frac{\sin(t)}{\pi t} + \frac{\sin(\frac{1}{2}t)}{\pi t}$$

$\boxed{\text{(b)}}$ $x(t) = \frac{\sin(t)+\sin(\frac{1}{2}t)}{\pi t}$

(c) $x(t) = \frac{\sin(t)}{\pi t} + \frac{\sin(2t)}{\pi t}$

$$x(t) = \boxed{\frac{\sin(t)+\sin(\frac{1}{2}t)}{\pi t}}$$

(d) $x(t) = \frac{\cos(t)+\cos(2t)}{j\pi t}$

(e) $x(t) = \frac{\text{sinc}(\omega_0 t)}{\pi}$

(f) $x(t) = \frac{2\sin(\omega_0 t)}{t}$

7. Find the signal $x(t)$ if its Fourier transform $X(j\omega) = \frac{d^2}{d\omega^2}\left[\frac{\sin(\omega)}{\omega}\right]$.

(a) $\frac{t^2}{2}\text{rect}\left(\frac{t}{2}\right)$

$$\frac{1}{2}\text{rect}\left(\frac{t}{2}\right) \xleftrightarrow{\mathcal{F}} \frac{\sin(\omega)}{\omega} = \text{sinc}(\omega)$$

(b) $-\frac{t^2}{2j}\text{rect}\left(\frac{t}{2}\right)$

DERIVATIVES IN ω

(c) $\frac{t}{j}\text{rect}\left(\frac{t}{2}\right)$

POP OUT $\frac{t}{j}$ IN TIME DOMAIN! TABLE 5-7, PROPERTY 9

$\boxed{\text{(d)}}$ $-\frac{t^2}{2}\text{rect}\left(\frac{t}{2}\right)$

$$\boxed{\left(\frac{t}{j}\right)^2 \frac{1}{2}\text{rect}\left(\frac{t}{2}\right)} \xleftrightarrow{\mathcal{F}} \frac{d^2}{d\omega^2}\frac{\sin(\omega)}{(\omega)}$$

(e) $t\,\text{rect}(t)$

8. Suppose the Fourier transform of a signal $x(t)$ is $X(j\omega)$. What is the Fourier transform of $x(5 - 2t)$?

(a) $\frac{1}{2}X\left(j\frac{\omega}{2}\right)$

$$x(t) \xleftrightarrow{\mathcal{F}} X(\omega)$$

(b) $\frac{e^{-j5\omega}}{2}X\left(-j\frac{\omega}{2}\right)$

$$x_1(t) = x(-2t) \xleftrightarrow{\mathcal{F}} \frac{1}{2}X\left(-\frac{\omega}{2}\right)$$

(c) $e^{-j5\omega}X\left(j\frac{\omega}{2}\right)$

$$x_2(t) = x_1\left(t - \frac{5}{2}\right)$$
$$= x\left(-2\left(t-\frac{5}{2}\right)\right) \xleftrightarrow{\mathcal{F}} \boxed{\frac{1}{2}e^{-j\frac{5}{2}\omega}X\left(-\frac{\omega}{2}\right)}$$
$$= x(5-2t)$$

(d) $2e^{-j\frac{5}{2}\omega}X(j2\omega)$

(e) $-\frac{e^{-j\frac{5}{2}\omega}}{2}X\left(-j\frac{\omega}{2}\right)$

$\boxed{\text{(f)}}$ $\frac{e^{-j\frac{5}{2}\omega}}{2}X\left(-j\frac{\omega}{2}\right)$

9. $[1 + 2\cos(40\pi t)]\frac{\sin(20\pi t)}{\pi t}$ is equal to which of the following? **HINT:** You don't need any trig identities to solve this! Just look at it in the frequency domain.

(a) $\frac{\sin(20\pi t)}{\pi t}$

(b) $\frac{2\sin(20\pi t)\cos^2(20\pi t)}{\pi t}$

$\boxed{\text{(c)}}$ $\frac{\sin(60\pi t)}{\pi t}$

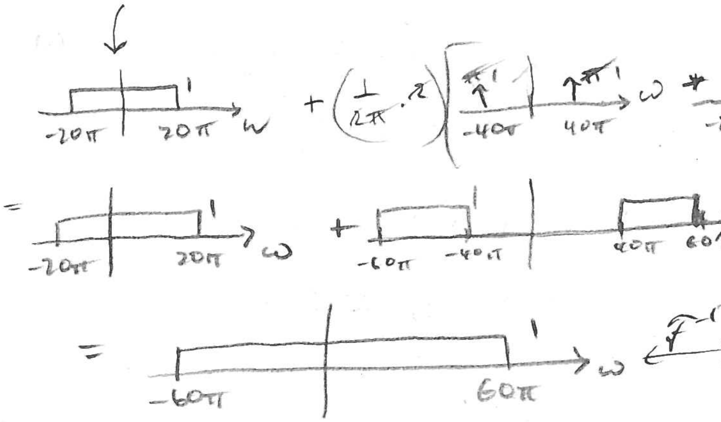
(d) $\frac{2\sin(60\pi t)}{t}$

(e) $\text{rect}\left(\frac{t}{60\pi}\right)$

(f) $\text{rect}(40\pi t)$

(g) $\text{rect}(60\pi t)$

$= \frac{\sin(20\pi t)}{\pi t} + \frac{2\cos(40\pi t)\sin(20\pi t)}{\pi t}$



$\xleftrightarrow{\mathcal{F}^{-1}} \boxed{\frac{\sin(60\pi t)}{\pi t}}$

10. A real-valued signal $x(t)$ is known to be even. Which of the following could be its Fourier Transform?

EITHER / BOTH CORRECT

$\boxed{\text{(a)}}$ $e^{j\pi t} + e^{-j\pi t}$ $= 2\cos(\pi t)$ ← REAL & EVEN!

(b) $-\frac{\omega^2}{2j}\text{rect}\left(\frac{\omega}{2}\right)$ ← COMPLEX

$\boxed{\text{(c)}}$ $\frac{\sin(20\pi\omega)}{\pi\omega}$ ← REAL & EVEN!

(d) $\frac{\cos(\omega)+\cos(2\omega)}{j\pi\omega}$ ← COMPLEX!

(e) $\frac{1}{2}\left[\frac{1}{4+j(\omega-2\pi)} + \frac{1}{4+j(\omega+2\pi)}\right]$ ← COMPLEX!

11. Suppose the Fourier transform of a signal $x(t)$ is $X(j\omega) = \frac{e^{2j\omega}}{3+j\omega}$. What is the Fourier transform of $\frac{d}{dt}x(t-2)$?

(a) $\frac{\omega^2}{3+j\omega}$

(b) $\frac{-\omega^2}{3+j\omega}$

$\boxed{\text{(c)}}$ $\frac{j\omega}{3+j\omega}$

(d) $\frac{-\omega^2 e^{-2j\omega}}{3+j\omega}$

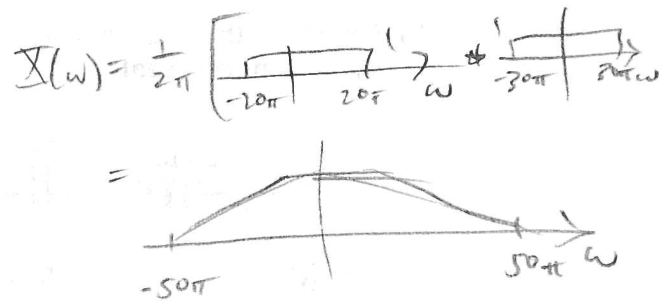
(e) $\frac{1}{3+j\omega}$

$x(t) \longleftrightarrow \frac{e^{2j\omega}}{3+j\omega}$

$x(t-2) \longleftrightarrow \frac{e^{-j2\omega}e^{2j\omega}}{3+j\omega} = \frac{1}{3+j\omega}$

$\frac{d}{dt}x(t-2) \longleftrightarrow \boxed{\frac{j\omega}{3+j\omega}}$

12. Is the signal $x(t) = \frac{\sin(20\pi t)\sin(30\pi t)}{(\pi t)^2}$ band limited? If so, what is the value of B such that $X(f) = 0$ for all $|f| > B$?

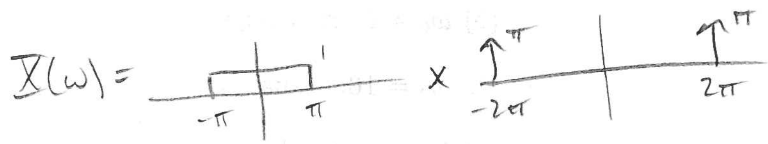


(a) $x(t)$ is not band limited
$\boxed{\text{(b)}}$ $x(t)$ is band limited, with $B = 25$ Hz
(c) $x(t)$ is band limited, with $B = 30$ Hz
(d) $x(t)$ is band limited, with $B = 35$ Hz
(e) $x(t)$ is band limited, with $B = 40$ Hz
(f) $x(t)$ is band limited, with $B = 20\pi$ Hz
(g) $x(t)$ is band limited, with $B = 30\pi$ Hz
(h) $x(t)$ is band limited, with $B = 50\pi$ Hz

13. Compute the total energy of the signal $\frac{\sin(\pi t)}{\pi t} * \cos(2\pi t)$ (where the * denotes convolution).

$\boxed{\text{(a) } \cancel{0}}$
(b) 1
(c) 2
(d) π
(e) 2π
(f) π^2
(g) $2\pi^2$
(h) $4\pi^2$

$x(t) = \frac{\sin(\pi t)}{\pi t} * \cos(2\pi t)$



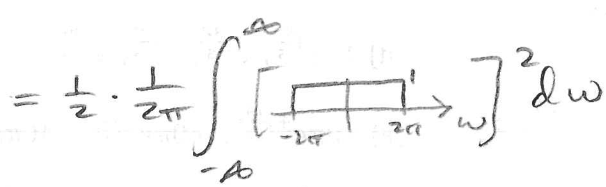
$= 0 \, !$

SO $x(t) = 0$ AND ENERGY IS 0!

14. Evaluate the following integral:

$$\int_0^{\infty} \left[\frac{\sin(2\pi t)}{(\pi t)}\right]^2 dt = \frac{1}{2}\int_{-\infty}^{\infty}\left[\frac{\sin(2\pi t)}{\pi t}\right]^2 dt$$

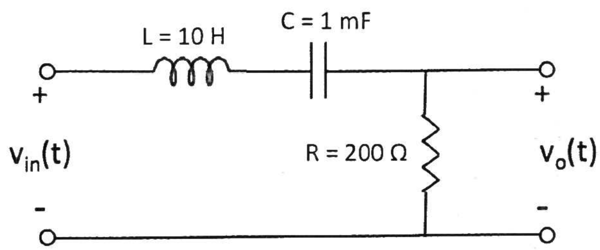
NOTE: Pay special attention to the bounds of integration, and try to think of an easy way to do this problem.



$$= \frac{1}{4\pi}\int_{-2\pi}^{2\pi} 1 \cdot d\omega = \frac{1}{4\pi}\cdot 4\pi = \boxed{1}$$

(a) 0
(b) 1/4
(c) 1/2
(d) 2/3
$\boxed{\text{(e)}}$ 1
(f) 3
(g) π
(h) 2π
(i) $\pi/2$

15. Determine the frequency ω_0 at which the frequency response $H(j\omega)$ of the following circuit is **purely real**.



$V_o = V_{in} \cdot \frac{R}{R + Z_L + Z_C}$

$H(\omega) = \frac{V_o}{V_{in}} = \frac{R}{R + \frac{1}{j\omega C} + j\omega L}$

(a) $\omega_0 = 0$ radians/s

(b) $\omega_0 = 5$ radians/s

(c) $\omega_0 = 8$ radians/s

$\boxed{\text{(d)}}$ $\omega_0 = 10$ radians/s

(e) $\omega_0 = 20$ radians/s

(f) $\omega_0 = 100$ radians/s

(g) None of the above

H(ω) IS PURELY REAL WHEN IMAGINARY PART = 0!

$\frac{1}{j\omega C} + j\omega L = 0$

$j\omega L = -\frac{1}{j\omega C}$

$j\omega L = \frac{j}{\omega C}$

$\omega^2 = \frac{1}{LC}$

$\omega = \sqrt{\frac{1}{LC}}$

$\omega = \sqrt{\frac{1}{(10\,H)(1\times10^{-3}F)}} = \sqrt{\frac{1}{.01}} = \sqrt{100} = \boxed{10}$

16. Which of the following are the pole locations of a fifth order Butterworth low-pass filter with a corner frequency of 20 cycles/second?

$f_c = 20$ Hz

$\omega_c = 40\pi$ rad/s.

(a) $-20,\ 20e^{j\frac{3}{5}\pi},\ 20e^{j\frac{4}{5}\pi},\ 20e^{j\frac{6}{5}\pi},\ 20e^{j\frac{7}{5}\pi}$

(b) $-1,\ e^{j\frac{3}{5}\pi},\ e^{j\frac{4}{5}\pi},\ e^{j\frac{6}{5}\pi},\ e^{j\frac{7}{5}\pi}$

(c) $40\pi,\ 40\pi e^{j\frac{2\pi}{5}},\ 40\pi e^{j\frac{4\pi}{5}},\ 40\pi e^{j\frac{6\pi}{5}},\ 40\pi e^{j\frac{8\pi}{5}}$

(d) $1,\ e^{j\frac{2\pi}{5}},\ e^{j\frac{4\pi}{5}},\ e^{j\frac{6\pi}{5}},\ e^{j\frac{8\pi}{5}}$

(e) $40\pi e^{\pm j\frac{19}{20}\pi},\ 40\pi e^{\pm j\frac{17}{20}\pi},\ 40\pi e^{\pm j\frac{15}{20}\pi},\ 40\pi e^{\pm j\frac{13}{20}\pi},\ 40\pi e^{\pm j\frac{11}{20}\pi}$

(f) $e^{\pm j\frac{19}{20}\pi},\ e^{\pm j\frac{17}{20}\pi},\ e^{\pm j\frac{15}{20}\pi},\ e^{\pm j\frac{13}{20}\pi},\ e^{\pm j\frac{11}{20}\pi}$

$\boxed{\text{(g)}}$ $-40\pi,\ 40\pi e^{j\frac{3}{5}\pi},\ 40\pi e^{j\frac{4}{5}\pi},\ 40\pi e^{j\frac{6}{5}\pi},\ 40\pi e^{j\frac{7}{5}\pi}$

(h) None of the above

17. What is the transfer function of the fifth order Buttterworth filter of the previous problem? **NOTE:** Remember that there can be an arbitrary scaling constant on the transfer function of the filter, depending on what the filter's passband gain is. We have chosen the constant so that the DC gain of the filter is 1.

(a) $H(s) = \dfrac{1}{s^5-20s^4+60s^3-40s^2+10s-50}$

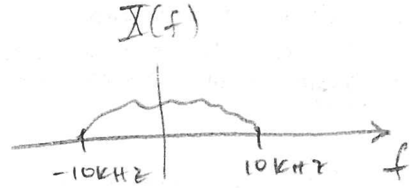
(b) $H(s) = \dfrac{(40\pi)^5}{(s+40\pi)(s-40\pi e^{j\frac{3}{5}\pi})(s-40\pi e^{j\frac{4}{5}\pi})(s-40\pi e^{j\frac{6}{5}\pi})(s-40\pi e^{j\frac{7}{5}\pi})}$

(c) $H(s) = \dfrac{(40\pi)^5}{(s-40\pi)(s-40\pi e^{j\frac{3}{5}\pi})(s-40\pi e^{j\frac{4}{5}\pi})(s-40\pi e^{j\frac{6}{5}\pi})(s-40\pi e^{j\frac{7}{5}\pi})}$

(d) $H(s) = \dfrac{1}{(s-1)(s-e^{j\frac{3}{5}\pi})(s-e^{j\frac{4}{5}\pi})(s-e^{j\frac{6}{5}\pi})(s-e^{j\frac{7}{5}\pi})}$

(e) None of the above

For **problems 18 – 21**, assume that a signal **$x(t)$ is band limited to 10 kHz**. That is, assume that $X(f) = 0$ for all $|f| > 10$ kHz.



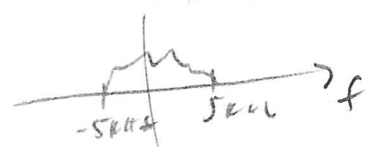
18. What is the Nyquist sampling rate for $x(t)$?

(a) 5 kHz
(b) 10 kHz
(c) 15 kHz
(d) 20 kHz
(e) 10π kHz
(f) 20π kHz
(g) 40π kHz
(h) None of the above

LINEAR PHASE, NO EFFECT ON WIDTH IN FREQUENCY

19. What is the Nyquist sampling rate for $x(t/2 + 5)$?

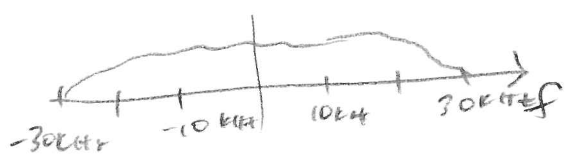
STRETCHED IN t ⇒ COMPRESSED IN f



(a) 5 kHz
(b) 10 kHz
(c) 20 kHz
(d) 40 kHz
(e) 40π kHz
(f) 80π kHz
(g) None of the above

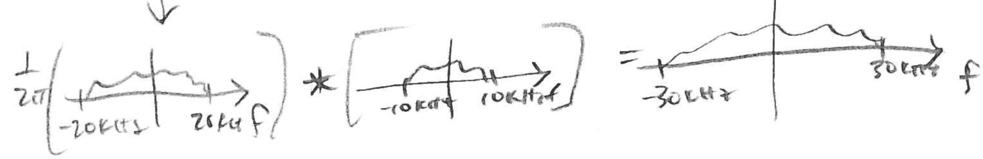
20. What is the Nyquist sampling rate for $\frac{d^2}{dt^2}x(3t)$?

COMPRESSED IN t ⇒ STRETCHED IN f



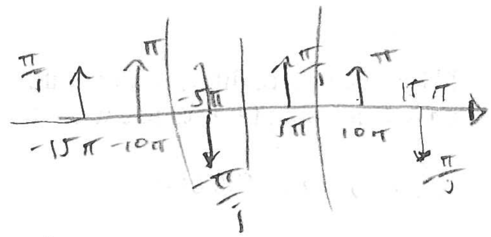
(a) 5 kHz
(b) 10 kHz
(c) 20 kHz
(d) 40 kHz
(e) 60 kHz
(f) 10π kHz
(g) 30π kHz
(h) None of the above

21. What is the Nyquist sampling rate for $x(2t)x(t)$?



(a) 10 kHz
(b) 20 kHz
(c) 30 kHz
(d) 60 kHz
(e) 20π kHz
(f) 40π kHz
(g) 60π kHz
(h) None of the above

22. The signal $x(t) = \cos(10\pi t) - \sin(15\pi t)$ is delta-train (impulse-train) sampled at a rate of 10 samples/s and then passed through an ideal low-pass filter with a cut-off frequency of 4 Hz. Which of the following could be the output?



(a) $\sin(5\pi t)$

(b) $1 - \sin(5\pi t)$

(c) $1 + \sin(5\pi t)$

(d) $\cos(10\pi t)$

(e) 0

(f) None of the above

For the following **two problems**, assume that you have a continuous-time to discrete-time converter capable of sampling at a rate of **64,000 samples/s**, but that you are recording audio and **don't want to keep any frequencies above 16 kHz.** However, you do want to get as faithful a representation as you can of all frequencies less than 16 kHz.

23. If I could build an **ideal** filter, what would be the best choice for the impulse response $h(t)$ of an anti-aliasing filter to use with this system?

(a) $h(t) = rect(20{,}000\pi t)$

(b) $h(t) = \frac{\sin(20{,}000\pi t)}{\pi t}$

(c) $h(t) = rect(80{,}000\pi t)$

(d) $h(t) = \frac{\sin(80{,}000\pi t)}{\pi t}$

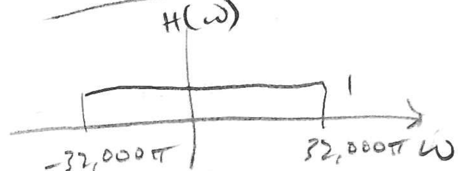
(e) $h(t) = \frac{\sin(48{,}000\pi t)}{\pi t}$

(f) $h(t) = rect(64{,}000\pi t)$

(g) $h(t) = rect(32{,}000\pi t)$

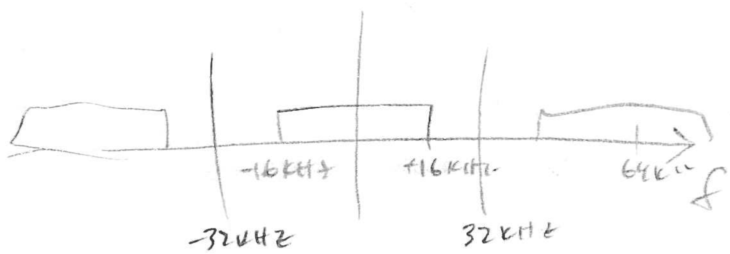
(h) $h(t) = \frac{\sin(32{,}000\pi t)}{\pi t}$

WANT TO FILTER OUT
BELOW 16kHz ! OR 32,000π rad/s



$\mathcal{F}^{-1}$

$h(t) = \frac{\sin(32{,}000\pi t)}{\pi t}$



24. As you know, to reconstruct a delta-train sampled signal, we pass it through a low-pass reconstruction filter. You have the following filters available. Which would be the **best** choice for your reconstruction filter?

(a) A 4th order Butterworth low-pass filter with a corner frequency of 64 kHz.

(b) A 4th order Butterworth low-pass filter with a corner frequency of 32 kHz.

(c) A 4th order Butterworth low-pass filter with a corner frequency of 16 kHz.

(d) A 4th order Butterworth low-pass filter with a corner frequency of 8 kHz.

(e) An 8th order Butterworth low-pass filter with a corner frequency of 64 kHz.

(f) An 8th order Butterworth low-pass filter with a corner frequency of 32 kHz.

(g) An 8th order Butterworth low-pass filter with a corner frequency of 16 kHz.

(h) An 8th order Butterworth low-pass filter with a corner frequency of 8 kHz.

25. What is the fundamental period of $x[n] = (2 + j)e^{0.16\pi n - 3}$?

$0.16\pi N_0 =$ INTEGER MULTIPLE OF 2π

$\frac{16}{100}\pi N_0 = 2\pi n$

$N_0 = \frac{200}{16} n$, NEED $n = 2$

$N_0 = 25$

(a) 100 samples
(b) 32 samples
(c) 25 samples
(d) $x[n]$ is not periodic, and thus does not have a fundamental period
(e) None of the above

ACCEPTED EITHER

TYPO.

26. What is the fundamental angular frequency of $x[n] = \sin(3 - 0.16\pi n)$?

$\frac{16}{100}\pi n \Rightarrow N_0 = 25$

$\Omega_0 = \frac{2\pi}{N_0} = \frac{2\pi}{25}$

(a) 0.16π rad/sample
(b) 0.08π rad/sample
(c) 4π rad/sample
(d) $x[n]$ is not periodic, and thus does not have a fundamental period
(e) None of the above

27. What is the fundamental period of $x[n] = \sin[0.16n + 1] + \cos[0.08n + 3]$?

NOT PERIODIC

NOT PERIODIC!

(a) 200 samples
(b) 100 samples
(c) 40 samples
(d) 25π samples
(e) $x[n]$ is not periodic, and thus does not have a fundamental period
(f) None of the above

28. Given: $h[n] = 5\delta[n] + 2\delta[n-1] + 3\delta[n-2]$ and

$$x[n] * h[n] = 5\delta[n] + 16\delta[n-1] + 34\delta[n-2] + 32\delta[n-3] + 21\delta[n-4]$$

which of the following is $x[n]$?

$\underline{5}$ 2 3

c b $\underline{a}$

$\underline{5}$ 16 34 32 21

(a) $x[n] = 5\delta[n] + 7\delta[n-1] + 8\delta[n-2]$

(b) $x[n] = 5\delta[n] + 6\delta[n-1] + 7\delta[n-2]$

(c) $x[n] = 5\delta[n] + 6\delta[n-1] + 6\delta[n-2]$

(d) None of the above

$5a = 5$ $a = 1$

$2a + 5b = 16$ $5c + 2b + 3a =$

$2 + 5b = 16$

$5b = 14$

$b = \frac{14}{5}$

29. Compute the following convolution: $\{1, \underline{3}, -2\} * \{2, \underline{7}, 1\}$

(a) $\{2, 13, \underline{18}, -11, -2\}$

(b) $\{2, \underline{13}, 18, -11, -2\}$

(c) $\{\underline{2}, 13, 18, -11, -2\}$

(d) $\{1, 10, \underline{21}, -8, -4\}$

(e) $\{1, \underline{10}, 21, -8, -4\}$

(f) $\{\underline{1}, 10, 21, -8, -4\}$

(g) None of the above

1 $\underline{3}$ -2

1 $\underline{7}$ 2

$\{2$ 13 $\underline{18}$ -11 $-2\}$

30. A discrete-time LTI system has unit impulse response $h[n] = \{\underline{2}, 0, 0, 1, 0, 0\}$. What is the output of the system if the input is $x[n] = \{4, 3, \underline{2}, 1\}$?

(a) $\{2, 4, \underline{6}, 9, 2, 3, 4\}$

(b) $\{2, \underline{4}, 6, 9, 2, 3, 4\}$

(c) $\{2, 4, 6, 8, 2, 3, 4\}$

(d) $\{8, 6, \underline{4}, 6, 3, 2, 1\}$

(e) $\{\underline{8}, 6, 4, 6, 3, 2, 1\}$

(f) None of the above

$\underline{2}$ 0 0 1

1 $\underline{2}$ 3 4

$\{8$ 6 $\underline{4}$ 6 3 2 $1\}$

31. Consider the discrete-time system described by the following input/output relationship:

$$y[n] + 7y[n-2] + 3y[n-3] = 2nx[n] - 3x[n-1] + 3x[n-2]$$

(a) This system is linear, but not time invariant.

(b) This system is not linear, but it is time invariant.

(c) This system is neither linear nor time invariant.

(d) This system is both linear and time invariant.

(e) Not enough information is given to determine whether the system is linear and/or time invariant.

LINEAR

BUT NOT TIME INVARIANT!

32. Consider the discrete-time system described by the following input/output relationship:

$$y[n] = \begin{cases} x[n], & n < 0 \\ -x[n], & n \geq 0 \end{cases}$$

LINEAR,

NOT TIME INVARIANT!

(a) This system is linear, but not time invariant.

(b) This system is not linear, but it is time invariant.

(c) This system is neither linear nor time invariant.

(d) This system is both linear and time invariant.

(e) Not enough information is given to determine whether the system is linear and/or time invariant.

33. What is the z-Transform of $x[n] = \{\underline{3},\ 0,\ 2,\ 1\}$? (Yes, the correct answer is there...)

(a) $3 + 2z^2 + z^3$

(b) $3z^3 + 2z + 1$

(c) $3 + 2z^2 + z^3$

(d) $\frac{3z^3+2z+1}{z^3}$

$$X(z) = 3 + 0z^{-1} + 2z^{-2} + z^{-3}$$

$$= 3 + 2z^{-2} + z^{-3}$$

$$= \frac{3z^3 + 2z + 1}{z^3}$$