1. **B.** $\sin(3n)$ just multiplies $x[n]$. Don't confuse with $\sin(3x[n])$.
   But $y[n-1] = \sin(3n-3)x[n-1] \neq \sin(3n)x[n-1]$, so NOT TI.

2. **C.** $y[n] = x[n]x[n-2] \rightarrow y[n-D] = x[n-D]x[n-2-D]$ for any D, so TI.
   Doubling input quadruples output, so NOT linear.

3. **A.** Constant coefficients and delays everywhere, so LTI.

4. **C.** $\{2,3,4\} = \{1,1,1\} + \{1,2,3\} \rightarrow \underline{\overline{|LTI|}} \rightarrow \{2,1,1,-1\} + \{2,3,4,-3\}$.

5. **D.** $\{5,7,9\} = 3\{1,1,1\} + 2\{1,2,3\} \rightarrow \underline{\overline{|LTI|}} \rightarrow 3\{2,1,1,-1\} + 2\{2,3,4,-3\}$.

6. **B.** $\{0,1,2\} = \{1,2,3\} - \{1,1,1\} \rightarrow \underline{\overline{|LTI|}} \rightarrow \{2,3,4,-3\} - \{2,1,1,-1\} = \{0,2,3,-2\}$.
   Using time-invariance (new wrinkle), $\{1,2,0\} \rightarrow \underline{\overline{|LTI|}} \rightarrow \{2,3,-2,0\}$.
   $\{0,0,3\} = \{1,2,3\} - \{1,2,0\} \rightarrow \underline{\overline{|LTI|}} \rightarrow \{2,3,4,-3\} - \{2,3,-2,0\} = \{0,0,6,-3\}$.
   $\{1,0,0\} \rightarrow \underline{\overline{|LTI|}} \rightarrow \{2,-1\} \rightarrow$ B. OR: Try all five answers.

7. **E.** $H(e^{j\pi/2}) = 1 + e^{-j\pi/2} = 1 - j = \sqrt{2}e^{-j\pi/4} \rightarrow \sqrt{2}\cos(\frac{\pi}{2} - \frac{\pi}{4})$.

8. **E.** $H(e^{j\omega}) = 1 + e^{-j\omega} = 0$ if $\omega = \pi$. OR: $x[n] = \cos(\pi n) = (-1)^n \rightarrow y[n] = 0$.

9. **C.** $\{(1)(3), (1)(4)+(2)(3), (2)(4)\} = \{3,10,8\}$. Either you got it or not.

10. **C.** At $t = 0.001n$, periodic $\rightarrow \cos(2\pi 300t) = \cos(0.6\pi n) = \cos(2.6\pi n) = \cos(2\pi 1300t)$
    A. Even $\rightarrow = \cos(-0.6\pi n) = \cos(1.4\pi n) = \cos(2\pi 700t)$.

11. **B.** At $t = n/200$, get $2.5\cos(\pi n) + 10\sin(5\pi n) + 11\cos(7.5\pi n + \frac{\pi}{2})$.
    Components at $\omega = \pi, 7.5\pi = -0.5\pi$ only, since $\sin(5\pi n) = 0$.

12. **A.** $h[n] = (0.8)^n u[n]$ (note upper limit of sum), so C AND S.

13. **D.** Causal input$\rightarrow$noncausal output ($\delta[n+1]$) and $e^{2(n-1)} \rightarrow \infty \rightarrow$NOT C NOT S.

14. **B.** Since LTI, $h[n] = 10^{-6}\cos(2\pi 0.1(n-200))u[n-10200] = 0$ for $n < 0$, so C.
    But $\sum_{n=10200}^{\infty} |\cos(2\pi 0.1(n-200))| \rightarrow \infty$, so NOT S.

15. **B.** Input has length=3; output has length=5=3+3-1$\rightarrow$ $h[n]$ has length=3 or infinity.
    So it *has* to be B. OR: Try each one; only B works.

16. **B.** Can IMMEDIATELY eliminate all but B,D ($h[n]$ has wrong length). B true.

17. **E.** Real $x[n]$ with period=25$\rightarrow$ $X(20) = X(5)^* \rightarrow$ E true.
    Don't confuse *phase* $\pi/2$ in $e^{j\pi/2}$ with *frequency* $2\pi\frac{5}{25} = 0.4\pi$.
    $x[n] = 2e^{j\pi/2}e^{j2\pi\frac{5n}{25}} + 2e^{-j\pi/2}e^{j2\pi\frac{20n}{25}} = 4\cos(0.4\pi n + \frac{\pi}{2})$.

18. **B.** $\cos(2\pi\frac{m}{N})$ and $\cos(2\pi\frac{n}{N})$ have correlation=0 if $m \neq n$.
    $\cos(2\pi\frac{m}{N})$ and $\sin(2\pi\frac{n}{N})$ have correlation=0 *even if* $m = n$.
    We're going to keep asking this correlation question until you all get it right!

19. **D.** Only D is true (note $|Y(k)| = |X(k)|$). Watch sign (B vs. D).

20. **A.** $2\pi\frac{10}{25} = 0.8\pi$, so A is true. Other answers involve *amplitude*.

21. Scaling of frequency axis (even by 3500) was only -1 or -2. Looking for the following: (a) Spectrum of sampled signal is *periodic*; (b) 2000 Hz sinusoid is *aliased*. Scoring for various possible answers is shown below.

22. $y[n+N] = \sum h[i]x[n+N-i] = \sum h[i]x[n-i] = y[n]$ since $x[n]$ is periodic. Hence $y[n]$ is periodic with period N. There are other ways to do this.

EXAM SCORES BY LECTURE SECTION–SEE WHERE YOU STAND

#1: $92, 91, 90^2, 88^3, 86, 84^2, 83^2, 82, 79, 78^2, 77^2, 76, 74, 73^3, 71^4, 70^4, 69^2, 67^2, 66, 65^6,$
$64^2, 63^3, 62^2, 60, 58, 56^2, 54, 53, 51^2, 49^2, 48, 46, 45, 44, 43, 41, 40, 34, 32, 30, 29, 28^2.$
Mean: 64.5 #: 72.

#2: $96, 93, 92^4, 90^2, 89^3, 88, 87, 86^2, 85^5, 81^3, 80, 78, 76^2, 75^4, 74^2, 73, 72, 71^2, 69^5, 68^4, 67^2, 66^2, 65$
$64^4, 62, 61^3, 60^2, 59^3, 58^3, 57, 56, 55, 54, 53, 52^2, 51, 50, 49^2, 48^2, 47, 46^2, 45, 41, 32, 31^2, 28, 27.$
Mean: 67.0 #: 90. (Excludes two taking late.)

Comments: Well, we *did* promise you that we would make this exam harder! We were true to our word. Recall it's how you compare to everyone else that counts.

Biggest surprise: Trouble with linearity and causality (supposed to be easy). If an input zero before time T results in an output having a nonzero value before T, then the system HAS to be noncausal, since it reacted to the input before it was there!