Homework #2, EECS 206, W03. Due **Fri. Jan. 17**, by 11:30AM

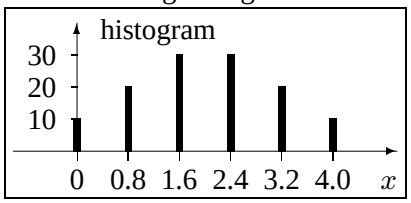
Notes

- Review the policies on HW1! (Except, now you turn in HW in 2420 EECS, which is open 24/7.)
- Reading: all of "Part 1" lecture notes.

Skill Problems

1. [50] Concept(s): ***signal characteristics: energy, mean, average power, RMS value***
   For each of the following signals, determine the energy [3], the mean value [3], the average power [4], and the RMS value [0]. Hints: sketching the signals will help, and look at the "useful formulas" page.
   (a) [0] $x_1(t) = \begin{cases} \cos\left(2\pi\frac{1}{T_0}t\right), & t \geq 0 \\ 0, & \text{otherwise.} \end{cases}$
   Answer: $\mathrm{E}(x_1) = \infty$, $\mathrm{M}(x_1) = 0$, $\mathrm{MS}(x_1) = 1/2$, $\mathrm{RMS}(x_1) = 1/\sqrt{2}$
   (b) [10] $x_2(t) = \begin{cases} 1, & 0 < t < 1 \\ 1 - |t-5|, & |t-5| \leq 1 \\ 0, & \text{otherwise.} \end{cases}$
   (c) [10] $x_3(t) = \begin{cases} \cos^2\left(2\pi\frac{1}{T_0}t\right), & 0 \leq t \leq T_0 \\ 0, & \text{otherwise.} \end{cases}$ Hint: look for $\cos^2$ in the list of useful formulas.
   Hint: $\mathrm{RMS}(x_3) = \sqrt{3/8}$. (But do not use this to solve for other values.)
   (d) [10] $x_4(t) = 7 + 3\mathrm{e}^{-2|t|}$
   (e) [10] $y_1[n] = \cos\left(\frac{2\pi}{4}n\right)$
   (f) [10] $y_2[n] = \begin{cases} 1 + (1/3)^n, & n \geq 0, \\ 0, & \text{otherwise} \end{cases}$

2. [20] Concept(s): ***signal value distributions / histograms***
   (a) [10] Determine the signal value distribution of signal $x[n] = \sin\left(\frac{2\pi}{8}n\right)$.
   Hint: use one period and sketch the limit as the number of histogram bins increases.
   (b) [10] A discrete-time signal $x[n]$ has the following histogram.



   Determine the mean value $\mathrm{M}(x)$ and standard deviation $\sigma(x)$ of this signal.
   Hint: see if your values make sense in light of the center and "spread" of the histogram.
   (c) [0] Determine the signal value distribution of signal $x(t) = \begin{cases} 3, & |t| \leq 1 \\ -2, & 5 < |t| \leq 7. \end{cases}$
   (Think about what happens as the number of signal samples increases, and express your singular value distribution using proportions.)

3. [20] Concept(s): ***periodicity, fundamental period, least common multiple***
   Determine whether each of the following signals is periodic, and if so, determine its fundamental period.
   (a) [0] $x_1(t) = \cos(\sqrt{2}\pi t)$. Answer: periodic with fundamental period $T_1 = \sqrt{2}$.
   (b) [5] $x_2(t) = \cos(2\pi 200t) + \cos(2\pi 500t) + \cos(2\pi 50t)$
   (c) [5] $x_3(t) = \cos(2\pi 200t) + \cos(500t)$
   (d) [0] $y_1[n] = \cos\left(\frac{\pi}{5}n\right)$. Answer: periodic with fundamental period $T_1 = 10$.
   (e) [0] $y_2[n] = \cos(7\pi n)$. Hint: sketch it! (The period is *not* $2/7$.)
   (f) [5] $y_3[n] = \cos(\sqrt{2}\pi n)$
   (g) [5] $y_4[n] = y_1[n] + y_2[n]$, where $y_1[n]$ and $y_2[n]$ are as defined in preceding parts.

4. [10] Concept(s): ***signal operations: amplitude shift/scale and time shift/scale***
Consider the following signal: $x(t) = \begin{cases} 1 - t/3, & |t| \leq 3 \\ 0, & \text{otherwise.} \end{cases}$
(a) [5] Sketch $y(t) = 3 + 7x(t/2)$ carefully.
(b) [5] Sketch $z(t) = x\left(\frac{3-t}{2}\right)$ carefully.

5. [45] Concept(s): ***effects of signal operations on signal characteristics***
Make a table like the following and complete it. For each entry in the table, write Y if the operation could affect the characteristic or N if it cannot. (The first column is completed for you.) If you are unsure, write "U" instead. For this problem, only your table will be graded, not your work.
Scoring: 3 points for each correct answer, 0 points for wrong answer, except 1 point for each U.

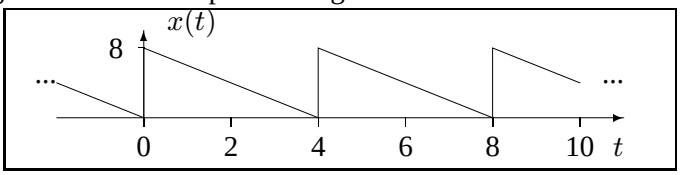
	Characteristic			
Operation	min/max	duration	energy	mean
Time shift	N			
Time scale	N			
Time reversal	N			
Amplitude shift	Y			
Amplitude scale	Y			

6. [20] Concept(s): ***Using* MATLAB**
Download the MATLAB file `periodic.mat`, using the link on the class website just below the link to this homework set. This file contains a vector called `signal1` that is a segment of a nearly periodic signal.
(a) [0] Start MATLAB, then load `periodic.mat` by typing `load periodic` at the MATLAB prompt. (You will need to understand MATLAB's "path" settings for this to work.)
(b) [5] Determine the length of the vector `signal1`.
(c) [5] Determine its maximum and minimum values.
(d) [10] Determine, approximately, the period of this approximately periodic discrete-time signal. Explain briefly how you determined the value.
For each part, show the MATLAB command(s) that you used. (Handwritten is fine.)

Mastery Problems

7. [25] (a) [10] Determine the mean value and average power of the signal $x_1(t) = a + b\cos(2\pi f t)$.
(b) [5] Find a signal $x_2(t)$ that has $\mathrm{M}(x) = 5$ and $\mathrm{MS}(x) = 50$.
(c) [10] Find a signal $x(t)$ that has duration = 5, $\mathrm{E}(x) = 45$, and $\mathrm{M}(x) = 3$.

8. [10] Concept(s): ***combining time-scaling and periodicity***
Let $x(t)$ be the following continuous-time periodic signal.



Determine a period T of the signal $y(t) = x(t) + x(2t/3 - 1) + x(7t)$.
(Determining whether your answer is the fundamental period is optional.)

Optional Extra Credit Problems

No help will be given in office hours prior to the due date for extra credit problems.

9. [10] An engineer working on a digital satellite communications system was asked by her boss to find a signal $x(t)$ that has mean value = 5 and average power = 20.
Should her boss take a refresher course in signal characteristics? Explain.