Homework #1, EECS 206, F03. Due **Fri. Sept. 12**, by 4:30 PM

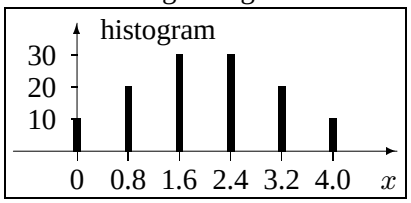
## Notes

- Review/coverage of the basic materials in Homework #1 will occur during Monday and Wednesday lectures.
- 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.

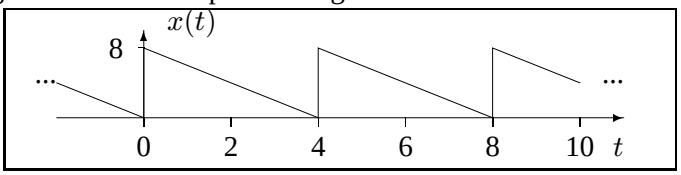
| | **Characteristic** | | | |
|---|---|---|---|---|
| **Operation** | min/max | duration | energy | mean |
| Time shift | N | | | |
| Time scale | N | | | |
| Time reversal | N | | | |
| Amplitude shift | Y | | | |
| Amplitude scale | Y | | | |

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.