Homework #1, EECS 451, W04. Due **Fri. Jan. 16**, in class

0. [0] (a) To enroll in this class (and to have this homework graded) you must complete the one-page student information form and sign the "Statement of Informed Participation." If you did not get a copy in class, then print it out from the web site `http://www.eecs.umich.edu/~fessler/course/451`

   (b) We are forming an email list for this class, where we can send announcements, corrections to homework problems, etc. To add yourself to the list, send an email to `eecs451-request@eecs.umich.edu` with the word `subscribe` in the *subject* line.

   (c) Honor code: `http://www.engin.umich.edu/org/ehc/`

Skill Problems

Skill problems emphasize the basic concepts and problem solving skills that are required to learn this material at a passing level.

1. [0] Concept(s): ***periodicity of sinusoids, fundamental period, least common multiple***
   Determine whether each of the following signals is periodic, and if so, determine its fundamental period.
   (a) [0] $x_\mathrm{a}(t) = 7\cos(5t + \pi/6)$
   (b) [0] $x[n] = 7\cos(5n + \pi/6)$
   (c) [0] $x[n] = 7\,\mathrm{e}^{\jmath(n/6-\pi)}$
   (d) [0] $x[n] = \cos(n/8)\cos(\pi n/8)$
   (e) [0] $x[n] = \cos(\pi n/2) - \sin(\pi n/8) + 3\cos(\pi n/4 + \pi/3)$
   (f) [0] $x_\mathrm{a}(t) = \cos(2\pi 200t) + \cos(2\pi 500t) + \cos(2\pi 50t)$

2. [0] Concept(s): **MATLAB** ***plots, sinusoids, sampling***
   Consider the sinusoidal signal $x_\mathrm{a}(t) = 3\sin(100\pi t)$, where "$t$" is in seconds.
   (a) [0] Use MATLAB to plot $x_\mathrm{a}(t)$ for $0 \leq t \leq 30$ms.
   For full credit in *all* problems in this course, label axes and clearly title your graphs.
   (b) [0] The signal $x_\mathrm{a}(t)$ is sampled at rate $F_\mathrm{s} = 300$ Hz to form a discrete-time signal $x[n]$. Determine the (fundamental) period of $x[n]$.
   (c) [0] Find the *maximum* sampling rate F_s such that all sample values $x[n]$ are zero.
   (d) [0] Use `stem` to plot one period of $x[n]$ on the same figure as you plotted $x_\mathrm{a}(t)$.

3. [15] Text 1.10a-c. Concept(s): ***quantization and sampling***
   Hint: $F_\mathrm{s} \neq 10$kHz. For part (c), express in radians/sample.

4. [20] Concept(s): ***sound, sampling rates***
   Download and execute the m-file `chirp1.m` from the course web page. You will hear a sound (assuming that you are wearing headphones plugged into a computer with a sound card...).
   (See the "Brief Introduction to MATLAB" document for more detail about the `sound` command, or just type `help sound` in MATLAB.)
   (a) [5] Describe in one sentence the sound you hear (without using the word "chirp").
   (b) [5] Create a new file `chirp2.m` based on `chirp1.m`, in which the final frequency is 5000 Hz rather than 3000 Hz. Execute your `chirp2.m`.
   (For any such problems, turn in your mfile.)
   (c) [5] Describe in one sentence the sound you hear. (Did you expect this?)
   (d) [5] Explain briefly what happened. (Briefly means one, maybe two, sentences.)

5. [10] Concept(s): ***quantization***
   Load and play the signal $x[n]$ in `krushchv.mat`. Download the quantization function `qtize.m` and compute a 512-level quantized signal $y[n]$ from $x[n]$ using `y=qtize(s,512)`. Listen to $y[n]$. Repeat the quantization and listening for 256, 64, 16, 8, 4, 3, and 2 levels.
   (a) [0] When does the quantization noise become audible?
   (b) [5] How many bits/sample are required for each of the above quantization levels?
   (c) [0] Is the 2-level quantization still intelligible?
   (d) [5] Explain why the 2-level quantization sounds better than the 3-level quantization.

6. [0] Concept(s): ***downsampling, aliasing***
   (a) [0] Rerun `chirp1.m` and replay the generate signal $x[n]$ with `sound`.
   (b) [0] Consider a system that is described by the downsampling operation $y[n] = x[2n]$, where $x[n]$ denotes the input and $y[n]$ denotes the output. Generate $y[n]$ from the given signal $x[n]$. (You can do this *without* a loop if you understand MATLAB indexing well. If not, ask!)
   (c) [0] Play $y[n]$ with `sound(yn, Fs/2)`. Describe briefly the difference in sound between $x[n]$ and $y[n]$. Did you expect this result?

Mastery Problems

Mastery problems require integration of concepts across the course (particularly later in the course), or involve derivations. An ability to solve these types of problems is expected of students who wish to excel in this subject. Like real-world problems, these problems usually do not have corresponding examples that can be simply followed step by step. Instead, one must synthesize the concepts learned.

(There will be some of these on future assignments.)