Name: Key

Section: 1111

EE432 Fall 2008 Exam 1

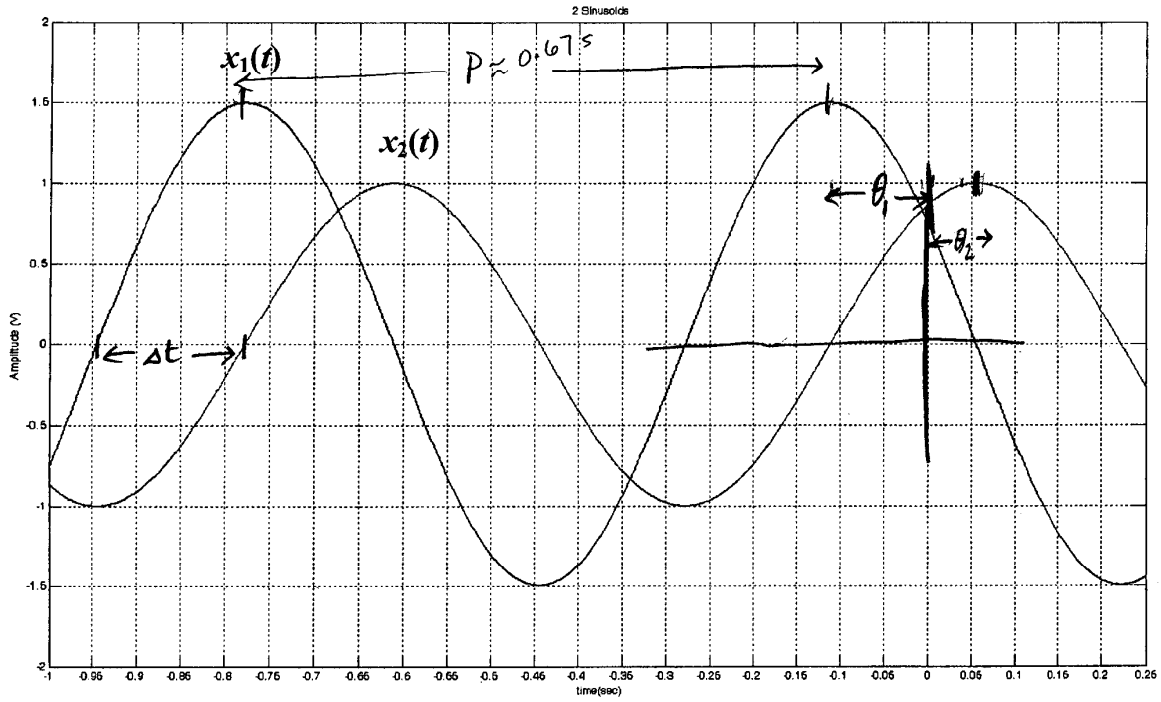
Problem	Possible Points	Score
1	20	
2	20	
3	20	
4	15	
5	25	
Total	100	

- Turn this in Wednesday, 9/24 at the beginning of class.
- This is an open book, open notes and open computer exam. USE ONLY YOUR COURSE NOTES (including the Etter/Ives book draft handouts for Chapter 1 and 2), and MATLAB HELP.
- You ***must show your work*** to get full credit for problems.
- Label your plots carefully, and use comments in code where needed.

- If you are stuck on a problem, you may ask for guidance…but it might cost you in points. You ask your question, and I will let you know how much it will cost. Then you can agree to obtain the guidance for the specified number of points off of your final score, if you wish.

EE432: Digital Signal Processing-Exam 1 Fall 2008

1. (20 pts) In the plot below, there are two sinusoids with the same frequency. Note that the time axis runs from -1 sec to 0.25 sec in 0.05 sec increments. Using this plot, answer the following questions.



(3) a. What is the frequency of the two sinusoids ?

$P = 0.67$ sec $\Rightarrow f = \boxed{1.5 \text{ Hz}}$

(5) b. What is the phase difference between the two sinusoids in radians? In degrees? In seconds?

0.17s

$\Delta t \approx 0.17s$

$\frac{.17}{.67} = \frac{\theta}{2\pi}$

$\Delta t = \boxed{0.17s}$

$\theta = \boxed{1.594 \text{ radians}}$

$\theta^\circ = 1.594 \text{ rad} \frac{180^\circ}{\pi \text{ rad}} = \boxed{91^\circ}$

EE432: Digital Signal Processing-Exam 1 Fall 2008

(3) c. What is the average power in each of the sinusoids?

for $x_1(t)$: $P_{x_1} = \frac{A^2}{2} = \frac{1.5^2}{2} = \boxed{1.125W}$

for $x_2(t)$: $P_{x_2} = \frac{A^2}{2} = \frac{1^2}{2} = \boxed{0.5W}$

(6) d. Write an equation for each of the sinusoids in terms of a cosine.

From plot, x_1 is shifted left of phase $= 0°$, ≈ 0.12 s

$\frac{.12}{.67} = \frac{\theta_1}{2\pi}$, $\theta_1 = 1.125$ rad.

$\boxed{x_1(t) = 1.5\cos(2\pi 1.5t + 1.125)}$

From plot, x_2 is shifted right 0.06 s.

$\frac{.05}{.67} = \frac{\theta_2}{2\pi}$, $\theta_2 = 0.469$ rad

$\boxed{x_2(t) = 1.0\cos(2\pi 1.5t - 0.469)}$

(3) e. What would be the value of each sinusoid at time t = 0.5 sec?

$x_1(0.5) = 1.5\cos(2\pi 1.5(0.5) + 1.125) = \boxed{1.3534}$

$x_2(0.5) = 1.0\cos(2\pi 1.5(.5) - 0.469) = \boxed{-0.452}$

EE432: Digital Signal Processing-Exam 1 Fall 2008

2. (20 pts) In Project 3, you wrote a function that normalized an input signal to always fall somewhere in the range from −1 to +1. In Quiz 3 and in the text, you figured out how to normalize an input signal to fall between 0 and +1. Write a MATLAB function that will take in an input signal, and normalize it to whatever range the user wants. Usage:

```
>> y=normalize_exam1(x, new_xmin, new_xmax);
```

Here, *x* is the input signal, and y is the output signal. If we assume that the original signal x had a minimum value of *xmin* and a maximum value of *xmax*, then the values of y will fall in the range from *new_xmin* to *new_xmax*. Example: if x is in the range [-1, 1], then normalize_exam1(x,-2,3) should take x and change the values linearly so they fall in the range from [-2, 3].

a. If `x = [1 2 3 4 5]`, what are the values of y for `y=normalize_exam1(x,0,1)`?

[0 .25 .50 .75 1.0]

b. If `x = [1 2 3 4 5]`, what are the values of y for `y=normalize_exam1(x,-3,10)`?

[-3 .25 3.5 6.75 10]

c. Run the following commands and <u>print</u> your results. Important: if you run and rerun the *randn* function, we will not get the same results unless you run the `randn('state',0)` command first! So for this exam, to test your function, **<u>ALWAYS</u>** run all of the below commands.

```
>> randn('state',0)
>> x=randn(10,1)*2-1.3;
>> y=normalize_exam1(ans,-33,45.8);
>> [x y]
```

d. Print out and turn in the well-commented code for your *normalize_exam1* function.

```
randn('state',0)
x=randn(10,1)*2-1.3;
y=normalize_exam1(x,-33,45.8);
[x y]

ans =

   -2.1651    1.0143
   -4.6312  -33.0000
   -1.0493   16.4046
   -0.7246   20.8831
   -3.5929  -18.6796
    1.0818   45.8000
    1.0783   45.7517
   -1.3753   11.9090
   -0.6454   21.9759
   -0.9507   17.7648
```

```
function y=normalize_exam1(x,xmin_new,xmax_new)
% first normalize to 0,1
y=(x-min(x))/(max(x)-min(x));
% expand the range to the desired range
y=y*(xmax_new-xmin_new);
% set the range of values using the new xmin
y=y+xmin_new;
```

3. (20 pts) Short answers.

(4) a. What is the expected average power in a noise signal consisting of 100,000 Gaussian random numbers that have a zero mean and standard deviation of 1.8?

$P_n = \sigma^2 = 1.8^2 = \boxed{3.24\,W}$

(4) b. What would you expect the plot of the autocorrelation function of the noise signal in part (a) to look like? Be specific.

delta function at origin, height = avg Pwr = 3.24

(4) c.. What is the overall period of the digital signal $x_n = 18\cos\left(\frac{2\pi n}{40} - 1.65\right) - 4\sin\left(\frac{\pi n}{17} + \frac{\pi}{10}\right)$.

P_1 $\quad$ $\frac{2\pi n}{34}$ P_2

$P_0 = LCM(P_1, P_2) = LCM(40, 34)$

$= \boxed{680}$

d.. Midn Johnny B. Goode has processed a digital speech signal of himself singing the Star Spangled Banner for a lab. In his lab report, he makes the following statements. Does each of the statements below make sense? Why or why not.

(2) (1) He claims that there is absolutely no background noise in his recording.

False - in a real recording, there is always background noise - electrical noise, speaker noise, sounds in background.

(2) (2) He states that the average power of his signal is –3 milliwatts.

False - avg power is always ≥ 0

(2) (3) He states that there is no unvoiced speech in the signal. If this is not true, give an example from the song.

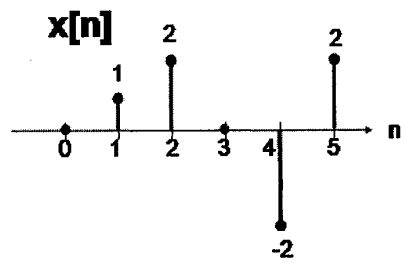
False - song is not only vowels
ex: "c" in "can"

(2) (4) He claims that if you plotted the autocorrelation function of this signal x_k, the peak value only occurs at $r_{xx}(1000)$.

False - $r_{xx}(0)$ always is the peak value, although that peak value can occur elsewhere.

EE432: Digital Signal Processing-Exam 1 Fall 2008

4. (20 pts) A digital signal is shown to the right.



a. Calculate the autocorrelation function of this signal (by hand). Note: all of the other values you cannot see are equal to zero.

$r_{xx}(0)$

0	1	2	0	-2	2
0	1	2	0	-2	2
	1	4		4	4

$r_{xx}(0) = \frac{13}{6}$

$r_{xx}(1)$

0	1	2	0	-2	2
1	2	0	-2	2	
0	2	0	0	-4	

$r_{xx}(1) = \frac{-2}{5}$

$r_{xx}(2)$

0	1	2	0	-2	2
2	0	-2	2		
0	0	-4	0		

$r_{xx}(2) = \frac{-4}{4} = -1$

$r_{xx}(3)$

0	1	2	0	-2	2
0	-2	2			
0	-2	4			

$r_{xx}(3) = \frac{2}{3}$

$r_{xx}(4)$

0	1	2	0	-2	2
-2	2				
0	2				

$r_{xx}(4) = \frac{2}{2} = 1$

$r_{xx}(5)$

0	1	2	0	-2	2
2					
0					

$r_{xx}(5) = 0$

$r_{xx}(-1) = r_{xx}(1) - 0.4$
$r_{xx}(-2) = r_{xx}(2) - 1$
$r_{xx}(-3) = r_{xx}(3) = 2/3$
$r_{xx}(-4) = r_{xx}(4) = 1$
$r_{xx}(-5) = r_{xx}(5) = 0$

b. What is the average power of this signal?

$r_{xx}(0) = \boxed{\frac{13}{6}}$

(3)

EE432: Digital Signal Processing-Exam 1 Fall 2008

5. (25 pts) Download the file from the course website (under the *Exams* link) called exam1.dat. The file is supposed to represent a series of weather measurements for a 1 hour period, at 3 minute intervals starting at minute 0. The columns of the data represent:

Column 1: minutes since measurements started
Column 2: air temperature (°F)
Column 3: wind speed (mph)
Column 4: air pressure (mm)

Write a single m-file that allows you to answer the following questions. Name this m-file <your last name>.m (for example, Midn Lau would call his: Lau.m. Email me your single m-file. Do NOT write or use any MATLAB functions that you have already written.

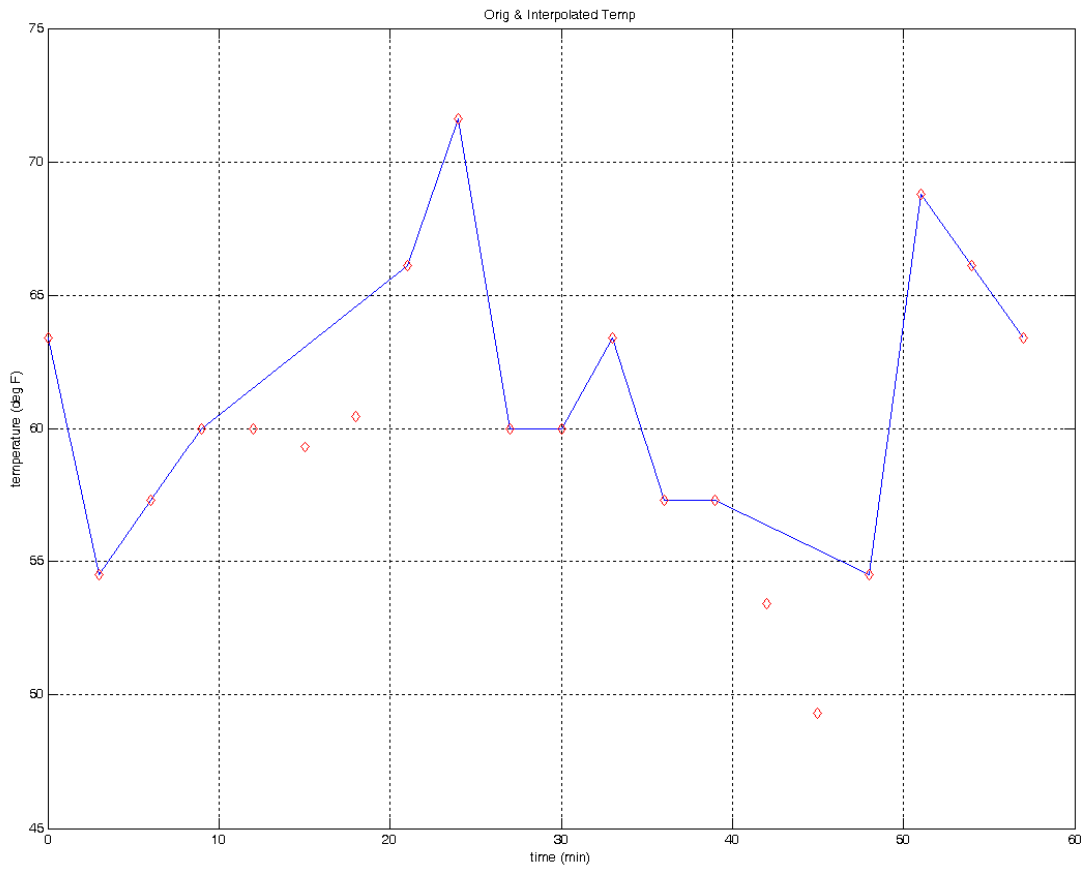
The way I will grade this is that I will run your m-file on my computer and see your results. If you call any non-built-in MATLAB functions, your file will NOT run on my computer.

a. Load the file into MATLAB. State the command you used to load the data, and the variable's name in the workspace. Note that the file is NOT complete (missing readings).

b. Use interpolation (spline method) to fill in the missing data. Remember that there should be 60 minutes worth of measurements (covering a 1 hr period only).

c. Calculate the average value and standard deviation of the temperature, wind speed and air pressure AFTER performing interpolation. Have these values display on the command line using an *fprintf* statement for each (one *fprintf* for temperature, one for wind speed and one for air pressure). As an example, the following might be displayed for temperature:

>> Temperature: mean is 45.5848 deg. F, std is 3.332 deg F

d. Create a single plot which shows the original temperature data (a blue line) and the interpolated temperature data (in red diamonds only—no line). Be sure to label the axes properly, turn the grid lines on, and give the plot a suitable title.

```
load exam1.dat
t=exam1(:,1);
temp=exam1(:,2);
ws=exam1(:,3);
pr=exam1(:,4);
ti=(0:3:57);

new_temp=interp1(t,temp,ti,'spline');
figure(1),plot(t,temp),hold on,plot(ti,new_temp,'rd'),
xlabel('time (min)'),ylabel('temperature (deg F)'),title('Orig & Interpolated
Temp')
grid on, hold off
```