The University of Texas at Austin
Dept. of Electrical and Computer Engineering
Midterm #1

Date: October 5, 2017 Course: EE 313 Evans

Name: ____
Last, First

- The exam is scheduled to last 75 minutes.
- Open books and open notes. You may refer to your homework assignments and the homework solution sets.
- Calculators are allowed.
- You may use any standalone computer system, i.e. one that is not connected to a network.
- ***Please disable all wireless connections on your calculator(s) and computer system(s).***
- Please turn off all cell phones.
- No headphones are allowed.
- All work should be performed on the midterm exam. If more space is needed, then use the backs of the pages.
- **Fully justify your answers.** If you decide to quote text from a source, please give the quote, page number and source citation.

Problem	*Point Value*	*Your score*	*Topic*
1	21		Sampling Sinusoids
2	21		Fourier Series
3	21		Child of Fourier Series
4	18		Spectrograms
5	19		Potpourri
Total	100		

Problem 1.1 *Sampling Sinusoids*. 21 points.

Consider the sinusoidal signal $x(t) = \cos(2\,\pi\, f_0\, t)$ for continuous-time frequency f_0.

We then sample $x(t)$ at a sampling rate f_s to produce a discrete-time signal $x[n]$.

(a) Derive the formula for $x[n]$. *6 points.*

(b) Based on your answer in part (a), give a formula for the discrete-time frequency $\hat{\omega}_0$ of $x[n]$ in terms of the continuous-time frequency f_0 and sampling rate f_s. *6 points.*

(c) Plot the spectrum of $x[n]$ over discrete-time frequencies from -3π rad/sample to 3π rad/sample, assuming that the sampling theorem has been satisfied, i.e. $f_s > 2\, f_0$. *9 points.*

Problem 1.2 *Fourier Series.* 21 points.

An A major chord on the Western scale consists of notes A, C# and E being played at the same time. The signal corresponding to an A major chord would be

$$x(t) = \cos(2\,\pi\, f_A\, t) + \cos(2\,\pi\, f_{C\#}\, t) + \cos(2\,\pi\, f_E\, t)$$

For the note frequencies, please use $f_A = 440$ Hz, $f_{C\#} = 550$ Hz and $f_E = 660$ Hz.

Consider the Fourier series synthesis formula

$$x(t) = \sum_{k=-N}^{N} a_k e^{j2\pi(k f_0)t}$$

(a) What is the fundamental frequency for the three notes? *6 points.*

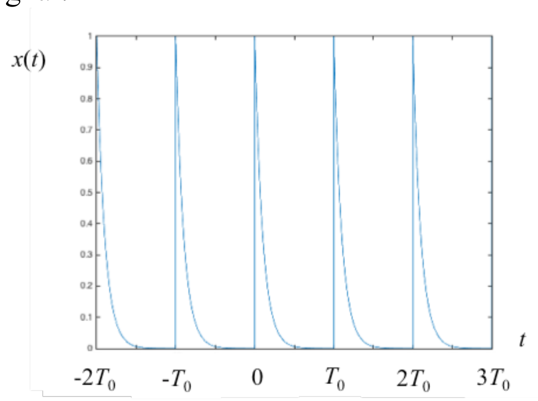
(b) Give the value for the Fourier series coefficient a_0. *3 points.*

(c) What is the value of N? *3 points.*

(d) Give the values for all the Fourier series coefficients a_k for $k = -N, \ldots, 0, \ldots, N$. *9 points.*

Problem 1.3. *Child of Fourier Series.* 21 points**.**

Consider the following periodic signal:



Over one period of time $0 \le t < T_0$, where $T_0 = 10$ seconds,

$$x(t) = e^{-t}$$

Compute the Fourier series coefficients using

$$a_k = \frac{1}{T_0}\int_0^{T_0} x(t)e^{-j2\pi(kf_0)t}dt$$

For the value of $x(t)$ at $t = T_0 = 10$ seconds, please use $x(T_0) = e^{-T_0} = e^{-10}$

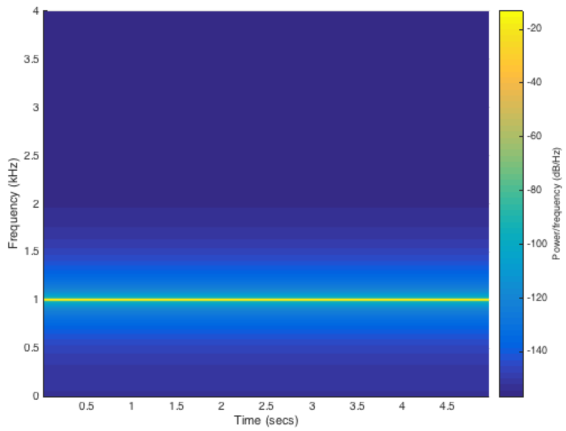
Problem 1.4 *Spectrograms.* 18 points.

For each spectrogram below, give a formula for the signal in either continuous time or discrete time.

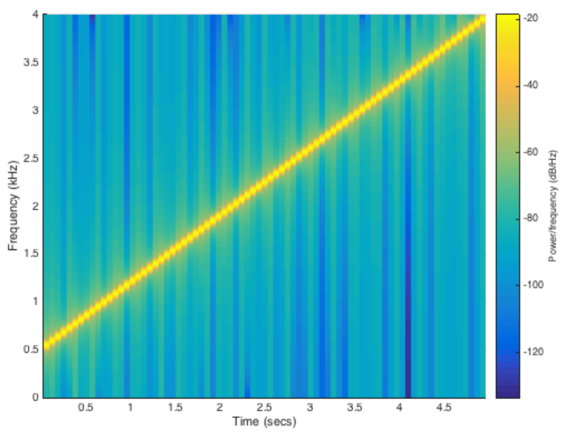
Each signal was sampled at a sampling rate of f_s = 8 kHz for 5 seconds.

Each spectrogram used a 1024-point window and a shift of 512 samples.

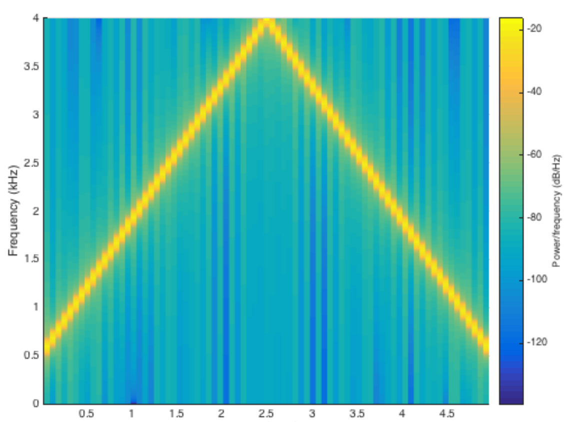
(a)



(b)

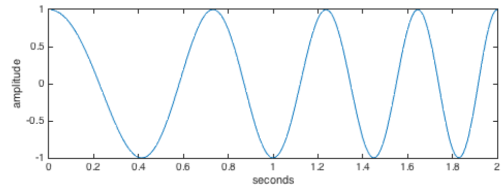


(c)



Problem 1.5. *Potpourri.* 19 points.

(a) An example of a sinusoidal signal whose primary frequency component is varying with time is shown on the right.



Describe a time-domain only method to determine the primary frequency component as it varies over time. *9 points*.

(b) While standing outside on campus, you make a voice call on a cell phone. The person you called answers. As you're talking, the voice level slowly fades in and out, but the call does not drop. To get a better voice connection, would it be better to hang up and call again, or is it better to walk while talking? Why? Please give an answer based on the material covered in class. *10 points*.