TCOM 500: Modern Telecommunications
Prof. Paris

Solution for HW 1

1. All calculations are shown in the table below:

		x(t) = 5*cos(2π 50 t)*exp(-50t)		N=	8	
				A_{in} =	5	
t	x(t)	$y(t)=x(t)/A_{in}*(2^{(N-1)}-1)$	$y_q(t)=round(y(t))$	$x_q(t)=y_q(t)*A_{in}/(2^{(N-1)}-1)$	Quantization Error	Binary
0	5.0000	127.0000	127.0000	5.0000	0.0000	01111111
0.01	-3.0327	-77.0294	-77.0000	-3.0315	0.0012	11001101
0.02	1.8394	46.7207	47.0000	1.8504	0.0110	00101111
0.03	-1.1157	-28.3375	-28.0000	-1.1024	0.0133	10011100
0.04	0.6767	17.1876	17.0000	0.6693	0.0074	00010001

The largest possible quantization error occurs when y(t) is right between two integer values (e.g, y(t)=17.5 is midway between 17 and 18). In that case, the quantization error will be $0.5*A_{in}/(2^{(N-1)}-1)$. For N=8 and A_{in}=5, the maximum error is 0.0196.

2. The questions in this problem are fairly straightforward to answer with the help of the parametric search form that Analog Devices provides. This form is on-line at http://www.analog.com/dynamic/parametric/scResultsDisplay.asp?SearchType=PSS&ProductLine=ADC&la=en.
   - Highest sampling rate: 300MSPS (part number: AD9211-300)
   - Highest resolution: 24 bits (multiple parts)
   - To determine how price varies with resolution, set '#of Inputs" to 1 and "Output Data Format" to "Par" in the parametric table. This limits the number of products significantly; then, sort the "Throughput Rate" in increasing order.
     For 100KSPS, there are really only two available resolutions: 16 bits and 18 bits. The former cost between $7.54 and $12.14 depending on power consumption and packaging. The 18 bit ADC costs $19.43.
     The relatively small number of options reflects that audio applications generally require 16 bits of resolution or better.
   - For the radio ADCs, set "Output Data Format" to "Par" and "Throughput Rate" to >=10 MSPS. Sort the resulting list in increasing order of "Throughput Rate". Selected devices are listed in the table below.
     For radio applications, 8 and 10 bit ADCs are most widely used and are least expensive. Higher resolution ADCs at these sampling rates incur a significant premium.

Resolution	# of inputs	Sample Rate (MSPS)	Price	Part Number
8	1	32	$2.18	AD9280
10	1	20	$2.53	AD9200
12	1	10	$6.12	AD9220
14	1	10	$18.37	AD9240

3. The parametric search form for DA converters is at http://www.analog.com/dynamic/parametric/scResultsDisplay.asp?SearchType=PSS&ProductLine=DAC&la=en.

   - Highest update rate: 2.5 GSPS (part number: AD9739)
   - Highest resolution: 18 bits (2 devices)
   - DACs for audio applications are listed separately at http://www.analog.com/en/digital-to-analog-converters/audio-da-converters/products/index.html. Most of these devices use 24 bits at a sampling rate of 192KHz. They don't vary significantly in price and are generally mass market products.
   - For the radio DACs, set "Input Format" to "Par" and "Throughput Rate" to >=10 MSPS. Sort the resulting list in increasing order of "Throughput Rate". Selected devices are listed in the table below.
     For radio applications, 8, 10, and 12 bit DACs are most widely used and are least expensive. Higher resolution ADCs at these sampling rates incur a significant premium.

Resolution	Sample Rate (MSPS)	Price	Part Number
8	20.4	$1.52	AD5424
10	20.4	$2.42	AD5433
12	20.4	$2.58	AD5445
14	125	$7.54	AD9754
16	250	$16.09	AD9747