Problem Set #9

1. *(*6points) **Entropy:**

   Estimate the number of bits of information (entropy) in each of the following observations. Briey justify your answers.

   (a) The day of the maximum temperature in Princeton in the coming July.

   (b) Whether or not it snows in Princeton on the day in part (a).

   (c) A random persons birthday.

   (d) Among 10 twenty-year-old students, whether or not any of them were born on the same day.

   (e) Among 23 twenty-year-old students, whether or not any of them were born on the same day. (search online for birthday problem for a hint)

   (f) Among 40 twenty-year-old students, whether or not any of them were born on the same day.

2. *(*6 points) **SNR from quantization:**

   (a) Suppose a signal with values $x[n]\ \epsilon\ [-1, 1]$ is uniformly quantized with b bits. Calculate the signal-to-noise ratio (SNR) of the quantized signal (power of the signal divided by power of the noise). For simplicity, assume that the samples x[n] are uniformly distributed on the range $[-1, 1]$.

   (b) Its common to measure ratios of powers on a log-scale using decibels, especially for signal-to-noise ratios. A decibel (1dB) is $10log_{10}$ of the ratio. Calculate the SNR of the quantized signal in dB. What is the value of each quantization bit in terms of dB?

3. *(*6points) **Group Delay:**

   Consider an LTI system with impulse response $h(t) = 5e^{-10t}u(t)$. What delay would a narrow-band signal of frequency 1 experience? What about frequency 1,000?