The University of Queensland
School of Information Technology & Electrical Engineering

COMS3100/7100 Introduction to Communications

Tutorial 1

These exercises relate to material in Lectures 2 & 3 (and Lecture 4 for the last question), but also CCR, ch. 2–3.

Attempt the starred questions (★) ahead of the tutorial: these are the questions that will be considered in class. You are encouraged to attempt the other questions also. Although answers will not be provided for them, your tutor and lecturer will be happy to discuss your answers during consultation times (or in tutorials if time permits).

Exercises:

1.1 The Shannon Limit for Communications Systems is $C = B\log_2\left(1 + \frac{S}{N}\right)$

★ (a) What is the minimum bandwidth required to handle CD quality audio (44kbps) for a 20dB SNR channel. (Note: SNR (dB) = $10\ \log_{10}\frac{S}{N}$)

(b) What would be the capacity of a system without noise?

1.2 Sketch the following signals:

★ (a) $x(t) = \dfrac{\sin t}{t}$,

(b) $x(t) = \dfrac{1}{1 + \frac{1}{2}e^{jt}}$,

(c) $x[n] = \cos\{\pi n/2 + \pi\}$,

★ (d) $x[n] = \{1 + j\}^n$.

For each of the signals, determine whether it is periodic and, if so, the fundamental period, as well as whether it is a power signal, an energy signal, or neither.

1.3 Suppose a signal $x(t)$ is conjugate symmetric. Determine whether the following signals are even or odd:

(a) $\mathrm{Re}\{x(t)\}$,

(b) $\mathrm{Im}\{x(t)\}$,

(c) $|x(t)|$,

(d) $\angle x(t)$.

Repeat under the assumption that $x(t)$ is conjugate antisymmetric instead.

★ 1.4 The voltage across a $50\ \Omega$ resistive load is the positive portion of a cosine wave where one of periods is

$$V(t) = \begin{cases} 10\cos\{2\pi f_0 t\} & -T_0/4 < t < T_0/4, \\ 0 & T_0/4 \le t \le 3T_0/4, \end{cases}$$

$T_0 = 4$ sec and $f_0 = 1/T_0$.

(a) Sketch the voltage and current waveforms.

(b) Evaluate the DC values for the voltage and current.

(c) Find the RMS values for the voltage and current. *Hint*: $\cos^2 x = \frac{1}{2}\{1 + \cos 2x\}$.

(d) Find the average power dissipated in the load. *Hint*: express P_{ave} in terms of V_{rms} and I_{rms}.

(e) Find the normalised average power dissipated in the load.

(f) What is the normalised average power in dBW?

1.5 A signal $w(t)$ consists of the sum of two sinusoidal waveforms:

$$w(t) = 3\sin\{50\pi t - \pi/3\} + 4\cos\{50\pi t\}.$$

Since both sinusoidal waveforms have the same frequency, then $w(t)$ can be written in the more compact form $w(t) = A\cos\{100\pi t + \varphi\}$. Determine A and φ.

1.6 For each of the following systems, determine if it is:

- memoryless,
- causal,
- invertible,
- stable,
- linear,
- time-invariant.

★ (a) Square: $H\{x(t)\} = x^2(t)$.

(b) Central difference: $H\{x[n]\} = \frac{1}{2}\{x[n+1] - x[n-1]\}$.

1.7 For each of the following impulse responses of LTI systems, determine whether the system is

- memoryless,
- causal,
- stable.

(a) $h(t) = \delta(t + t_0) + \delta(t + t_1)$, where t_0 and t_1 are constants,

★ (b) $h[n] = u[n]\cos\{\pi n\}$.

1.8 Evaluate the following convolutions:

(a) $y(t) = \Pi(\{t-2\}/4) * h(t)$ where $h(t) = 3\delta(t-2) + 2\delta(t-4)$,

♣ (b) $y[n] = w_1[n] * w_2[n]$ where $w_1[n] = u[n+5] - u[n-5]$ and $w_2[n] = 2^{-n}u[n]$.