ELG5375: Digital Communications

Lecture 1

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ELG5375: Digital Communications

- **Instructor:** Dr. Sergey Loyka, CBY A608
- **Course web page:** `http://www.site.uottawa.ca/~sloyka/` (lecture slides, assignments, announcements and other info will be posted there)
- **Lectures:** Mon. 2:30PM - 5:20PM, CRX C307
- **Office hours:** Wed. 6-7pm. Ask questions during or after lectures (some time will be allocated).
- **Prior knowledge**: signals & systems (Fourier analysis, impulse/frequency response etc.), probability & stochastic processes, basic communications, all at undergrad level.

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- **Purpose:** First graduate-level course on digital communications. Introduces fundamental principles and techniques for the analysis and design of modern digital communication systems (physical layer). Both noiseless and noisy analyses are included.
- The course will focus on communication engineering (insights, understanding, applications) rather than on mathematics. The latter will be used as a tool for the former. Modern approaches/techniques will be emphasized.
- **Calendar description:** Elements of communication theory and information theory applied to digital communications systems. Characterization of noise and channel models. Analysis of digital data transmission techniques for additive Gaussian noise channels. Efficient modulation and coding for reliable transmission.

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Topics to be covered:

- Introduction. Main parameters & performance metrics. Historical perspective. Examples.
- Review of signals & systems, Fourier analysis, sampling theorem. Signal spectra, bandwidth, energy- and power-type signals. Power/energy spectral densities (PSD/ESD).
- Baseband systems: pulse-amplitude modulation (PAM), signaling over band-limited channels, intersymbol interference (ISI) & Nyquist criterion for zero-ISI. ESD/PSD of PAM. Data rate, bandwidth, spectral efficiency. M-PAM.
- Optimal receivers for noisy channels. Binary hypothesis testing. Signal-space analysis, sufficient statistics. Matched filter. The MAP and ML receivers for AWGN channel. Error rate performance.

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Topics to be covered:

- Bandpass (RF) systems. Carrier modulation: BPSK, QPSK, QAM. Signal spectra, bandwidth and performance. Link budget analysis. Multiple-access (multi-user) techniques. OFDM and MIMO systems.
- Introduction to information theory. Fundamental limits. Channel capacity. Source and channel coding.
- Topics of current research activities.

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Marking scheme:

- Assignments + mini-projects: 50%
- Final exam: 50%
- Lots of bonus points to everybody who takes active part in the course.
- Final exam: will be scheduled by the university; 3h, open book.

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Textbook: there is no single textbook to cover all topics in an ideal way :(The following books will be used (all available in the library).

Main books:

1. S. Haykin, Digital Communication Systems, Wiley, 2014. - well-written and easy to read; emphasizes insights and understanding, with many explanations and examples; includes some of modern topics as well.

2. J.M. Wozencraft, I.M. Jacobs, Principles of Communication Engineering, Wiley: New York, 1965. - a masterpiece in this area (has not been surpassed so far); exceptionally-well written; includes all fundamental principles as well as a review of signals & systems, Fourier analysis, probability & stochastic processes. Strongly recommended read.

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Additional references:

3. S. Haykin, Communication Systems, 4th Ed, Wiley, 2001.

4. R.E. Ziemer, W.H. Tranter, Principles of Communications, Wiley, 2009.

5. D. Tse, P. Viswanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005. - the best book on wireless communications.

6. T.M. Cover, J.A. Thomas, Elements of Information Theory, John Wiley & Sons, 2006. - the best book on information theory.

7. R.G. Gallager, Principles of Digital Communication, Cambridge University Press, 2012. - based on a course taught at MIT.

8. B. Rimoldi, Principles of Digital Communication, Cambridge University Press, 2016. - based on a course taught at EPFL.

9. A. Lapidoth, A Foundation in Digital Communication, Cambridge University Press, 2017. - very detailed/rigorous but mathematically demanding; based on a course taught at ETH.

How to Study: Learning Efficiency Pyramid

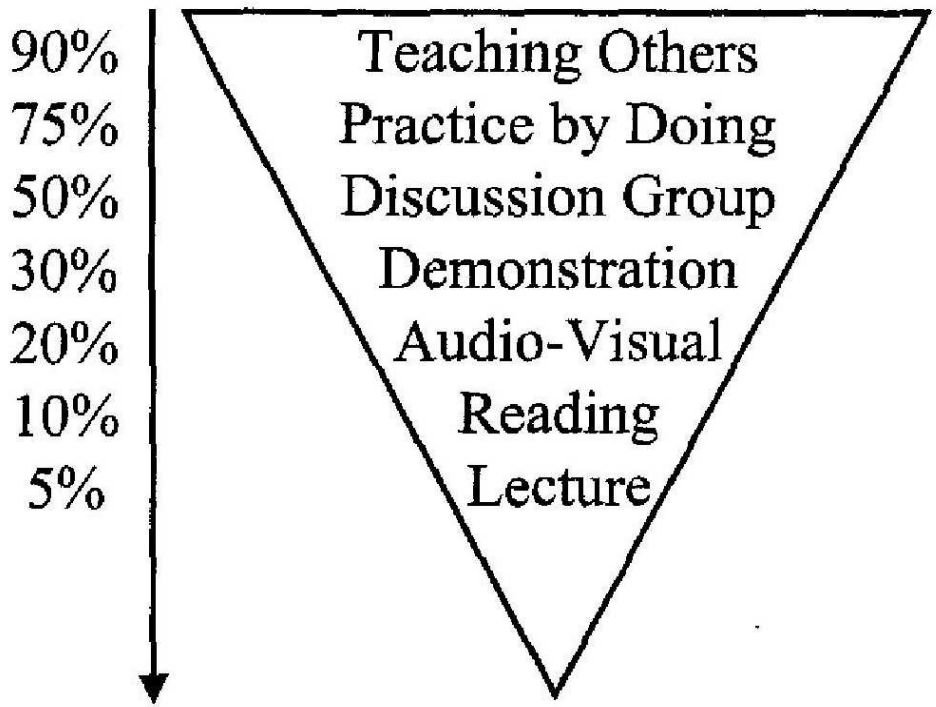

Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.

How to Study

- "Tell me and I'll forget; show me and I may remember; involve me and I'll understand.'" – old Chinese proverb.
- "I hear, I forget; I see, I remember; I do, I understand".
- "No pain, no gain" – common wisdom.

How to Study

Learning efficiency pyramid is a good guideline!

- Reading is necessary, but taken alone is not efficient
- Solving problems: "practice by doing" is much more efficient
- Examples, assignments, end-of-chapter problems
- Group discussions
  - help provided you contribute something
- Systematic study during the semester
  - is a key to a success.
  - do not leave everything to the last day/night before exams!
- Lectures
  - should be supplemented by the items above
- There is no substitute for active learning! "Seat and watch" approach does not work!