

COMMUNICATION THEORY AND ENGINEERING

Master of Science in Electronic Engineering, first year
As taught in the first semester of Academic Year 2025-2026

Instructor: Prof. Jocelyn Fiorina, Prof. Luca De Nardis
Website for the course: <http://acts.ing.uniroma1.it/~lucadn/comel2.php>

COURSE MEETING TIMES

2 sessions/week

COURSE OVERVIEW

Communication Theory and Engineering is a course of 9 credits that offers an introduction to the quantitative theory of information and its application to communication systems engineering. One of the goals is to provide some insight into the fundamental concepts of information representation, such as entropy, capacity, channel coding, and into source coding, with particular focus on speech and image.

COURSE PREREQUISITES

Fundamentals of probability theory; This is important because from the beginning we assume solid knowledge of probability. Signals and systems; students who did not take a class on signals and systems at the undergraduate level are advised to take the online course: "Signals and Systems" MITOPENCOURSEWARE, Massachusetts Institute of Technology, Instructor: Prof. Alan V. Oppenheim, <https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/>

REQUIREMENTS AND GRADING

Certificate of the MATLAB course "MATLAB Fundamentals"
Written (50%) and oral (50%) exam

COURSE TEXTBOOK AND READING MATERIAL

In addition to the lecture notes, students may find the following texts to be of use.
Cover, Thomas, and Joy Thomas (2006). *Elements of Information Theory*. 2nd ed. New York, NY, USA: Wiley-Interscience, 2006. ISBN: 9780471241959. *Recommended Reading*
Rabiner Lawrence R. and Schafer Ronald W. (2007), "Introduction to Digital Speech Processing", Foundations and Trends® in Signal Processing: Vol. 1: No. 1–2, pp 1-194. <http://dx.doi.org/10.1561/20000000001>
Free copy downloadable after registration. *Recommended Reading*
Proakis John G., Salehi Masoud, Bauch Gerhard (2013). *Contemporary Communication Systems Using MATLAB*, 3rd ed. Stamford, CT, USA: Cengage Learning US, 2013. ISBN 9780495082514. *Recommended Reading*

COURSE TOPICS

Information theory

Statistical measure of information. Entropy. Conditional entropy and joint entropy. Relative entropy. Distance of Kullback-Leiber.

Asymptotic Equipartition Property (AEP)

Discrete channel capacity. Continuous channel capacity. Theoretical limits of modulation.

Channel coding

Error correction codes. Block codes. Parity check codes and Hamming codes. Hamming distance.

Soft and hard decoding and performance analysis. The perfect code. Code gain. Parity check matrix. Syndrome. Cyclic codes, BCH codes, Reed-Solomon codes. Convolutional codes. Generator polynomial.

Source coding: speech and image

Speech. Production model. Frequency analysis of speech. Spectrogram. Digital representation of speech signals and telephone speech.

Quantization noise, signal-to-quantization noise. Uniform and non-uniform quantization. Adaptive and differential quantization.

Standards: Waveform coding, PCM, DPCM, ADPCM, ADM. Parametric coding LPC, GSM, MP3

Image. Representation of still black and white and coloured images. Aspect ratio. Luminance and chrominance. Still image sampling.

Moving images sampling. Digital representation of moving images.

Standards: NTSC, SECAM, PAL, DVD, MPEG-2 Part 2 (H262) e MPEG-4 Part 10 (H264), DVB-T/DVB-T2, ATSC, DTMB, ISDB-T, Full HD, Super HD

Application of theory using MATLAB

Throughout the course the theoretical material will be supplemented by practice work sessions addressing specific design and performance analysis problems and a variety of exercises that may be solved on a personal computer using MATLAB.

The practice work sessions material is available on the website of the course and form an integral part of the course topics.
