Exam preparation

The exam will consist of:

- 2 practical exercises (2 x 10 points)
- 6-8 theoretical questions (total 20 points).

You have to acquire a total of 30 points for maximum grade 10, from the total 40 points available. So you can get maximum grade by solving 2 Exercises (20p) + half of theory (10p), or 1 Exercise (10p) + full Theory (20p), whichever is better. There will be 3 points “din oficiu”(i.e. “punctul din oficiu”) included.

The final grade = (exam (3 to 30p) + lab grade (1 to 10) + homework grade (1 to 10)) / 5

Practical exercises

Exercises will be very similar to the problems solved at the laboratory, in the homeworks, and the examples given during the lectures. Pay attention also to the examples on cyclic coding, which we did during the last lectures, but were never included in the laboratories or homeworks.

Theoretical subjects syllabus

The following list contains an overview of the subjects we covered during the lectures.

This list is for information only. The theoretical subjects at the exam will not be formulated identical to how they are listed here, but will consist of various questions from among all the curriculum.

Part I: Discrete Information Sources

- Definitions of: discrete memoryless source, information of a particular event, entropy of a memoryless source, efficiency, redundancy of a source. Examples. Entropy of a binary source (with figure).
- Properties of entropy, with proofs (3 properties: non-negative, maximum, diversification). The proof of the second property only for the particular case of a source with two messages (as we did in the lecture).
- Definition and entropy of a N-th order extension source, with proof of the theorem
- Sources with memory: definitions (state of a source , transition, transition matrix, ergodic property), and calculation of the entropy of ergodic sources with memory.

Part II: Discrete Transmission Channels

- Definition of a discrete transmission channel, definitions of the terms (discrete, memoryless, stationary)
- Matrices and entropies, and all the relations between them:
    - The joint probability matrix and joint entropy
    - Marginal distributions and their entropies
    - The channel matrix and the average error H(Y|X)

  - The equivocation matrix and the equivocation H(X|Y)
- Mutual information: definition, equation, properties (three properties, without proofs)
- Particular types of communication channels: zero equivocation, zero average error, uniform with respect to the input, uniform with respect to the output, symmetric
- Definition of channel capacity and its relevance in Shannon's channel coding theorem. Efficiency and redundancy of a channel.

Part III: Source Coding

- Definition of a code, average length, efficiency and redundancy of a code
- Definition of non-singular, uniquely decodable and instantaneous code. Examples. Relation between them (instantaneous codes are uniquely decodable, with proof)
- Kraft inequality theorem (with proof). McMillan theorem (no proof).
- Optimal codes: optimal values of the lengths (no proofs), minimal average length is equal to entropy.
- Shannon coding and average length of a Shannon code (with proof).
- Shannon's first theorem (with proof).
- Shannon-Fano coding and examples.
- Huffman coding and examples.

Chapter IV: Error Control Coding

- Definitions: error correcting code, block code, linear code, coding rate, t-error-detecting code, t-error-correcting code, systematic code, cyclic code
- Modeling the errors on a channel with the module-2 arithmetic
- Shannon's channel coding theorem
- Definition of Hamming distance and its properties. Minimum Hamming distance of a code.
- Nearest neighbor decoding. Number of errors that can be detected or corrected depending on dH_min (with proof).
- Generator and parity-check matrices: what they are used for, relation between them for systematic codes.
- Conditions on matrix [H] for error detection and correction
- Hamming codes: definition, example of matrix [H], properties, coding rate
- SECDED Hamming codes
- Cyclic codes: definition, proof of the cyclic property
- Generator polynomial: definition, properties
- Coding and decoding of cyclic codes with polynomials ("the mathematical way")
- Coding and decoding of cyclic codes with binary strings and XOR ("the programming way") - just the examples, not the full algorithms SIMPLE / TABLE included on the slides.
- Systematic cyclic encoder circuit: schematic, operation, showing that it outputs the desired codeword

Note: "No proof" means that you should only state the theorem / definition / property, without any proof. "With proof" means I expect the proof to be included, as we did in the lectures.