# Information Theory and Coding

1. **Course number and name:** 020TICES5 Information Theory and Coding

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours

3. **Instructor's or course coordinator's name:** Hadi Sawaya

4. **Text book:**
   a. **Other supplemental materials:**
      Professor textbook and course material

5. **Specific course information**
   a. **Catalog description:**
      This course introduces the limits of possible in digital communications systems and the techniques that can be used to approach these limits. The course covers the basics of information theory like the information associated to an event, entropy, mutual information, data processing theorem, source coding, Huffman codes, channel capacity and the channel coding theorem. The course covers also the channel coding technics used to improve the performance of a communications system like block codes, the algebraic structure of cyclic codes, BCH codes, Reed Solomon codes, convolutional codes, LDPC and turbo codes.

   b. **Prerequisites:** 020CONES3 Analog and digital communications

   c. **Required:** Elective for CCE students; required for CCE telecommunication networks option students

6. **Specific goals for the course**
   a. **Specific outcomes of instruction:**
      Measure and analyze the quantity of information associated to events or random variables.
      Determine the limits of communications systems in terms of source and channel coding.
      Examine linear bloc codes and the algebraic structures used in the construction and in the decoding of cyclic codes.
      Calculate the error probability of a channel coding system with hard or soft decoding.
      Describe the coding technics used in composite codes like LDPC and turbo codes that can reach the channel capacity.

   b. **KPI addressed by the course:**

| KPI | a1 | a2 | k1 | k2 | k3 |
|---|---|---|---|---|---|
| Covered | | x | x | x | x |

| | | | | | |
|---|---|---|---|---|---|
| Assessed | x | x | x | x | x |
| Give Feedback | x | x | | | |

**7. Topics and approximate lecture hours:**

Introduction to information theory, information associated to an event, entropy, joint entropy, conditional entropy, mutual information, relationship between entropy and mutual information, the Venn diagram, chain rules for entropy and mutual information, Log sum inequality, Markov chains, data processing theorem, entropy of continuous random variables. (4 lectures)

Data compression, example of codes, Kraft-Macmillan inequality, source coding and entropy, Huffman codes. (2 lectures)

Channels, channel coding, channel capacity and the general random coding theorem. (3 lectures)

Introduction to channel coding and to the basic concepts of block codes like Hamming distance and the minimum Hamming distance of a block codes, Hard decoding and performance over a binary symmetric channel, soft decoding and performance over a Gaussian channel with a BPSK input. (2 lectures)

Linear block codes, generator matrix, parity check matrix, singleton bound, Syndrome table and decoding over a binary symmetric channel, examples of linear bloc codes, Recall of arithmetic structures, vector Space, Galois field, cyclic codes, BCH codes, Peterson decoding algorithm, Reed Solomon codes. (6 lectures)

Convolution codes, structure, Trellis diagram, state diagram, transfer function calculation, Recursive Systematic convolutional codes. (3 lectures)

Introduction to composite codes, LDPC codes, Tanner graph, Iterative decoding of LDPC codes over an erasure channel, Soft-Input Soft-Output decoding, A posteriori probability and Log likelihood ratio, Iterative decoding of LDPC codes over a Gaussian channel, encoding and iterative decoding of turbo codes. (4 lectures)

Introduction to coded modulations, Trellis coded modulations, Bit-Interleaved coded modulations. (2 lectures)

Performance of a channel coding system over Gaussian and Rayleigh channels: Matlab simulation. (2 lectures)