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# CSC 310 - Information Theory

Fall 2009

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## Course Outline

*This document mostly contains information given in CSC 310 webpage. The website and Bulletin Board contain handouts, announcements, hints to exercises etc. Both are updated approximately once per week.*

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**Teaching assistant:** Ilya Sutskever

**Lectures:** Monday & Wednesday 10-11am, SS 2111.

**Tutorial:** Friday 10-11am, SS 2111.

**Office hours:** Monday 11-12.30pm or by appointment.

**Primary textbook:** *Information and Coding Theory*, by Jones and Jones, Springer.

**Web-page:** <http://www.cs.toronto.edu/~papakons/teaching/csc310/>

**Bulletin Board:** <https://csc.cdf.toronto.edu/bb/YaBB.pl?board=CSC310H1F>

## 1 Course description, objectives & prerequisites

This course is an introduction to Information and Coding Theory. The nature of the course is mathematical, the exposition follows a Definition-Lemma-Theorem style, coupled with appropriate intuition and real-world applications. This theory has immediate applications on how data can be compressed, communicated over noisy channels, how and to what extent error-correction can happen, and it also affects parts of secure communication. Moreover, the same communication framework models in unexpected ways other real-life and mathematical situations. For example, this mathematical machinery finds surprising applications to proofs of statements seemingly unrelated to information/communication, e.g. under the framework of Kolmogorov Complexity. *The primary goal of the course is to deliver a simple and clear message regarding the rigorous development of the basic theory.* Occasionally, students will be provided with appropriate sources and they will be asked to identify and think about applications of theory.

Prerequisite material for this course is a minimal but *firm* understanding of Discrete Probability and elementary enumerating principles, Linear Algebra, and of course Calculus. We also require only very few things (a couple of definitions) from Abstract Algebra. If you covered the prerequisite with MAT224 (instead of MAT240) then you are expected to individually prepare the very limited material required from Abstract Algebra. The course begins with a test (on the second week of classes) which corresponds to a little less than 20% of your final grade, on these prerequisites. The test will consist of simple questions, but there is an emphasis on proofs (i.e. avoid using for your preparation texts dedicated to calculations). The first two lectures and the first tutorial will briefly revise parts of the relevant material. Also, you can check with the instructor on an individual basis. Any decision to waive course prerequisites depends entirely on your performance in this test.

## 2 Grading

For due and test dates please check the course website.

The final grade is calculated as follows:

- **Assignments (25%):** 2 assignments each worths 12.5%.
- **Tests (75%):** 4 tests each worths 18.75%. In particular, 3 tests will be one-hour long (during tutorials) and one final exam which will last for 3-4 hours. Note that the final, although longer, takes the same percentage as any other test. You must score  $\geq 40/100$  in the final exam to pass the course.

No scaling to the grades will be applied. To that end, and taking into account the way the current grading scheme works (e.g. the fact that you may have poorer performance in one of the tests, or you wish to increase the percentage of the assignments), students can “scale” their grade by *working for the course*:

1. If your grade in each of the four tests is  $\geq 50/100$ , then we will only count the best three graded tests of yours. That is, the 75% of your grade corresponds to the average of these three tests (and not to the average of all four tests).
2. There will be designated points in time (mentioned in your problem sets), such that if you pass-in parts of your assignment reports during these times (earlier to the actual deadline) you will receive bonus.
3. If you type the whole assignment report in L<sup>A</sup>T<sub>E</sub>X then you will receive an extra 10% in your actual assignment grade. In this case, the only part of your assignment that can be handwritten are the figures.

## 3 Website and Bulletin Board

Students are responsible to visit CSC310’s website and bulletin board at least once per week. In both places you will find handouts and announcements regarding 310. Everything mentioned in the website and the bulletin board is part of the course; i.e. *it is considered taught material* (and in particular it will be tested). You are strongly encouraged to make use of the Bulletin Board; e.g. by posting your questions there.

## 4 How to study from the textbook & Report preparation

The style and the material presented in the Jones & Jones text is closely related to what we will be doing in class. Your text is simple, small, free of annoying details and long philosophical discussions. This comes at the expense that there isn’t much of intuition and applications. Note that in most cases this style is preferable for a first course in Information Theory. I’ll also supplement the core material with more applications by using a free text (consult with the course website) with many examples. You are not going to be tested on these examples.

Information and coding theory is a mathematical subject and as such the way to study is the same as for any other course in e.g. linear algebra or calculus. That is, *you must repeat the proofs we do during lectures and work out most of the questions at the end of each chapter (all questions are answered in the text)*. In addition, Information Theory has immediate applications. In this sense, *every proof* you will see tells us a story about a practical situation. You must spend enough time thinking about at least one concrete story each theorem together with its proof tells us about engineering or computer science.

Your assignment reports should have the same rigor as every other course with mathematical content. Please, don’t write essays instead of proofs. In particular, do not use vague arguments, over-restrictive (e.g. “trying to prove” a general case by an example), and do not appeal to real-world analogs. The style of your text

(the style in which proofs are presented) has the appropriate form; i.e. if you have a question whether your report is rigorous enough then check for similar situations in your text (your assignment questions will be such that you can check similar stuff).

If a question deserves a complicated answer then include a clearly marked “general idea/proof idea” paragraph (this in particular helps you to obtain part marks).

## 5 Collaboration & remarking requests

- The assignments should be done individually by each student. You are not only allowed but also encouraged to form study groups. Your assignment report must be prepared solely by you (avoid plagiarism).  
Definition of what type of collaboration is *not* considered plagiarism: during your meetings to collaborate for an assignment (i) no electronic collaboration is allowed (you can only meet in person), (ii) you should not discuss the very details of the solutions, and (iii) *you are not allowed to take any transcript out of your meeting*; i.e. you cannot take with you any notes or any form of electronic record. Then, you let some time (e.g. one hour) pass in between this meeting and you starting preparing your report. This is the only acceptable form of collaboration. Anything else, violating (i) or (ii) or (iii), is an academic offense.
- Every assignment comes with a cover page. Please, fill-in every field and sign the cover page in the designated area. Mention every person you collaborated with, otherwise you must write ”Collaborators: none”.
- No late assignments accepted (solutions circulated immediately after the deadline). If there is an acceptable and well-documented reason I will arrange for redistribution of marks on an individual basis.
- Remarking requests: Every remarking request should be addressed directly to the instructor of the course at most one week after your grade becomes available. You should attach an extra cover page mentioning the reason for remarking.

## 6 Related readings

Here is a list of texts related to this course. Please note that using any other source apart from the recommended texts (see below) requires contacting the instructor in advance. A short description for each of these references can be found in the course webpage <http://www.cs.toronto.edu/~papakons/teaching/csc310/texts.html>.

- **Information Theory, Inference and Learning Algorithms**, by MacKay (*freely available*), Cambridge University Press.
- **Elements of Information Theory**, by Cover and Thomas, Wiley.
- **An Introduction to Probability Theory and Its Applications, Vol. 1**, by Feller, Wiley.
- **Linear Algebra (3rd edition)**, by Lang, Springer.
- **Abstract Algebra (3rd edition)**, by Dummit and Foote, Wiley.
- **Introduction to Coding Theory**, by Lint, Springer.
- **An Introduction to Kolmogorov Complexity and Its Applications (3rd edition)**, by Li and Vitaniy, Springer.