In this project, you will write a report on a topic of your choice in information theory that we did not directly cover in the lectures, but for which we did cover the necessary background to be able to learn the topic via additional reading. A topic list is given below. The rules/guidelines are as follows:

- Projects may be done **individually** or **in pairs**, with the latter having a higher expected length/effort. If done in pairs, you should **also include a brief summary of who did what** as an appendix.
- The report length is **6 to 8 pages** if individual, or **10 to 14 pages** for a two-person project.
- This page count is using similar font, margins, and spacing to the present document. This page count **excludes** the cover page, reference list, and figures/tables (so the body of the report may be longer than the above if, e.g., the space of the figures/tables included takes up several pages). You may also choose to put 1 or 2 proofs (or other material that isn't too central) in an appendix even if they go beyond the page counts above.
- Writing in LaTeX can help your document look more professional (sample LaTeX files have been uploaded), but this is by no means required.
- Your report should be clearly written in a manner that would be accessible/understandable to other students. You may assume that the reader is familiar with the material covered in the lectures (e.g., you can use notation like $H(X)$ and $I(X;Y)$ without defining it).
- Writing should be in an academic style, such as that you would see in a textbook, research paper, etc. There is no fixed structure to the report, but you may wish to initially briefly introduce the background, then spend the bulk of the report including details of the relevant techniques, discussions, theorems, proofs, etc., and then end with a brief conclusion. **A sample report has been uploaded.**
- If you want to write on a topic not listed in the suggested topics below, please first check with me via email ( ) for approval.
- The due date is **Friday April 7th** (Week 12) at 11:59pm. You should upload your report (named in the form **A1234567 ArithmeticCodes.pdf** with your student number and topic substituted) and any supplementary files (if any) to Canvas. For paired projects, please arrange for one student to upload, and for the other to upload the same file ending in **(...) DUPLICATE.pdf**
- Your report must be **entirely written in your own words**. Any reports too similar to the textbook, to another students' report, or to other existing tests may be (potentially significantly) penalized.

Automated writing tools are similarly not allowed. If you use any images, quotes, etc. from existing sources, please make sure they are clearly cited. (Note: For mathematical analyses and proofs, most individual equations wouldn't warrant a citation, but an entire proof that you followed should be cited.) **Turnitin will be used.**

- If your report includes practical techniques/algorithms, then you may also wish to include an implementation or simple experiments, but this is by no means required. **If you do so, please also upload a .zip file of your code, and use comments or a README to make completely clear which parts of the code you wrote vs. took from existing solutions.** (Using parts of existing code is OK, but doing so without proper acknowledgment is not.) Code that is mostly/entirely existing will not be considered as significant compared to a solution you wrote yourself.

Suggested Topics

If you would like to write on a topic not listed here, please first email me for approval. It is suggested that students only choose an advanced topic if they feel confident. Chapter references below are referring to the textbook by Cover/Thomas, but students are encouraged to read on their topic in more than one source. Feel free to email me if you need suggestions for such sources. Note that both Cover/Thomas and MacKay's textbooks in PDF format can be found easily via a Google search.

Standard topics:

- Sources with memory and entropy rate (Chapter 4)
- Information theory and gambling (Chapter 6)
- Lempel-Ziv compression (Chapter 13)
- Simple codes for communication with feedback (e.g., Horstein and Schalkwijk-Kailath schemes; see Chapter 17 of "Network Information Theory" (El Gamal / Kim))
- **(Please avoid Arithemitic Coding, as it is the topic of the sample report)**

Slightly advanced topics:

- Lossy compression and rate-distortion theory (Chapter 10)
- Information theory and statistics (Chapter 11)
- The maximum entropy principle (Chapter 12)
- Kolmogorov complexity (Chapter 14)
- Network information theory problem(s), such as multiple-access or Slepian-Wolf (Chapter 15)
- Reed-Solomon codes (e.g., `https://tomverbeure.github.io/2022/08/07/Reed-Solomon.html`)

Advanced topics (please email to discuss first):

- Polar codes (e.g., `https://www.youtube.com/watch?v=VhyoZSB9g0w`)
- Posterior matching for communication with feedback (e.g., `https://arxiv.org/abs/0909.4828`)
- Zero-error capacity (e.g., see Shannon's 1956 paper "The Zero-Error Capacity of a Noisy Channel")
- Information-theoretic limits of other statistical problems (e.g., statistical estimation, machine learning, or problems in theoretical computer science)

Regardless of the topic, please focus on the information theory aspects. Other perspectives "far" from information theory could be mentioned for comparison purposes, but should not be the main focus.

Assessment Criteria *(Rough Guide Only)*

The assessment criteria are roughly as follows (25 marks total):

1. **Material and its presentation [approx. 12 Marks]**
   - Material presented is correct and clear
   - Report shows a good understanding of the topic
   - Report would be accessible to other students
   - Appropriate balance of breadth and depth
   - Interesting discussions and connections with other topics (when suitable)
2. **Writing quality [approx. 8 Marks]**
   - Suitable academic writing style
   - Appropriate report structure
   - Logical/pedagogical flow of material
   - Grammatical correctness
   - Clear notation and definitions
3. **Effort [approx. 5 Marks]**
   - Depth of material
   - Evidence of diligence in reading, ideally from more than one source
   - Quality of figures, tables, etc. (if any)
   - (Optional) Selection of an advanced topic
   - (Optional) Inclusion of suitable algorithm implementations, numerical findings, etc. (But please see the dot point earlier in the document regarding the use of existing code.)