CUHK (SZ)
Course Outline

1. Course Identity

A. Course as listed in CUHK (SZ)

The information in this block should be exactly as approved by CUHK Senate. In case there are any differences, please explain in the table below.

Course code	MAT3350
Course title (English)	Selected Topics in Information Theory
Course title (Chinese)	信息论专题
Units	3
Description (English)	Techniques and concepts from information theory and coding theory are fundamentals of many areas in information technologies. A systematic training of information theory and coding theory can benefit students for doing researches related to information and data. This course covers the basic topics of information theory and some coding techniques, and provides connections of these theories/techniques to problems in statistics, big data processing and machine learning.
Description (Chinese)	

B. Corresponding course in CUHK

Please give details of the *closest* corresponding course in CUHK (as approved by CUHK Senate and listed in course list). If the course in SZ maps to more than one course in CUHK, please make multiple copies of the block below.

Course code	ENGG5301
Course title (English)	Information Theory
Course title (Chinese)	
Units	3
Description (English)	Introduction. Shannon's information measures. Entropy rate of a stationary process. The source coding theorem. Kraft inequality. Huffman code. Redundancy of a prefix code. The channel coding theorem. Rate-distortion theory. Universal data compression.
Description (Chinese)	

Course code	ENGG5200
Course title (English)	Channel Coding and Modulation
Course title (Chinese)	
Units	
Description (English)	This course covers classic and new channel coding, and related modulation schemes. Topics include Reed-Solomon codes,

	convolutional codes, concatenated codes, low-density parity-check (LDPC) codes, and optionally, OFDM, MIMO, and network coding.
Description (Chinese)	

2. Prerequisites / Co-requisites

Please state prerequisites and co-requisites, in terms of courses in CUHK (SZ)* or any other requirements (e.g., having taken certain subjects in high school).

(* Because course codes may not yet be stable, please provide both course code and course tile.)

A. Prerequisites

STA2001 Probability and Statistics I
MAT2040 Linear Algebra

B. Co-requisites

None

3. Learning Outcomes

Knowledge:

- Understand the basic Shannon information measures, including entropy, mutual information, relative entropy and their properties and relations.
- Understand the fundamental mathematical models for data compression, communication and security.
- Learn Shannon's theory on data compression, communication and security.
- Learn the basic coding theory and techniques.

Skills:

- Be able to use the information measures in research and various applications.
- Model and formulate new problems in various research areas, in particular data science and machine learning, using information theory related approaches.
- Use information theoretic concepts in thinking, analysis and arguments of new problems.
- Use coding techniques in solving research and engineering problems.

Value:

- Equipped with the knowledge of information/coding theory, students will be able to communicate with others rigorously concerning information related matters in science, engineering and daily life.
- Use the knowledge of information/coding theory to better understand the systems and research problems related to information, e.g., Internet, 5G, IoT, big data, AI and so on.

- Be aware of the impact of information/coding theory on information technologies and learn the importance of theoretical research for solving practical problems.

4. Course syllabus

- Entropy, joint entropy, conditional entropy, mutual information, information divergence.
- Chain rules, Jensen's inequality, log sum inequality, data-processing inequality, Fano's inequality.
- Asymptotic equipartition property, source coding theorem, data compression, Kraft inequality, Huffman codes, arithmetic codes, Lempel-Ziv codes.
- Discrete memoryless channel, channel capacity, channel coding theorem, jointly typical sequences, converse.
- Fountain codes, LDPC codes, message passing, polar codes.
- Quantization, rate distortion theorem
- Information theoretic security, wiretap channel, secret key agreement.
- Introduction of algebraic coding, Humming codes.

5. Assessment Scheme

Component/ method	**% weight**
Assignments	25%
Course Projects	25%
Final Exam	50%

6. Grade descriptor

Grade	**Overall course**
A	• Achieve all the learning outcomes in this course. • Deep understanding of the subjects learnt in the course. • Be able to apply the principles in solving problems in novel situations, in a manner that would surpass the normal expectation. • Has the ability to express the synthesis of ideas or application in a clear and cogent manner.
A-	• Achieve almost all the learning outcomes in this course. • Very good understanding of the subjects learnt in the course. • Be able to apply the principles or subject matter learnt in the course to familiar and standard situations in a manner that is logical and comprehensive. • Has the ability to express the knowledge or application with clarity.

Grade	Overall course
B	• Achieve a very good part of the learning outcomes in this course. • Good understanding of most subjects learnt in the course. • Be able to state and partially apply the principles or subject matter learnt in the course to most (but not all) familiar and standard situations in a manner that is usually logically persuasive. • Has the ability to express the knowledge or application in a satisfactory and unambiguous way.
C	• Achieve a good part of the learning outcomes in this course. • Sufficient understanding of the subjects learnt in the course. • Be able to state and apply the principles or subject matter learnt in the course to most (but not all) familiar and standard situations in a manner that is not incorrect but is somewhat fragmented. • Has the ability to express the separate pieces of knowledge in an unambiguous way.
D	• Achieve a reasonable part of the learning outcomes in this course. • Basic understanding of the subjects learnt in the course. • Be able to state and sometimes apply the principles or subject matter learnt in the course to some simple and familiar situations in a manner that is broadly correct in its essentials. • Has the ability to state the knowledge or application in simple terms.
F	• Poor understanding of the subjects learnt in the course. • Not be able to state nor apply the principles or subject matter learnt in the course to simple and familiar situations.

7. Feedback for evaluation

8. Reading

A. Required

- Thomas M. Cover and Joy A. Thomas. *Elements of Information Theory*. John Wiley & Sons, Inc, 2nd edition, 2006.

B. Recommended

- MacKay. *Information Theory, Inference and Learning Algorithms*, Cambridge University Press, 2003.

- Raymond W. Yeung. *Information Theory and Network Coding*. Springer, 2008.
- Abbas El Gammal and Young-Han Kim. *Network Information Theory*. Cambridge, 2011.
- F. J. MacWilliams and N.J.A. Sloane. *The Theory of Error-Correcting Codes*. North-Holland, 2007.
- Tom Richardson and Rüdiger Urbanke. *Modern Coding Theory*. Cambridge, 2008.
- Christopher M. Bishop. *Pattern Recognition and Machine Learning*. Springer, 2006.

9. Course components

Activity	**Hours/week**
Lecture	3 hours per week

10. Indicative teaching plan

Week	**Content/ topic/ activity**
1	Entropy, joint entropy, conditional entropy, mutual information, chain rules
2	Information divergence, Jensen's inequality, log sum inequality, Markov chains, data-processing inequality
3	Asymptotic equipartition property, type, source coding theorem
4	data compression, entropy rate, Kraft inequality, Huffman codes
5	Arithmetic codes, Lempel-Ziv codes
6	Discrete memoryless channel, channel capacity, channel coding theorem
7	Achievability, jointly typical sequences, Fano's inequality, converse
8	Introduction of algebraic coding, Humming codes, Reed-Solomon codes
9	Fountain codes, LDPC codes
10	Graphical model, message passing
11	polar codes
12	Quantization, rate distortion theorem
13	Information-theoretic secrecy, wiretap channel, secret key agreement
14	Project presentation

11. Implementation plan (2017–18)

The implementation plan may vary from year to year. Please indicate expected enrolment, and number of sections.

[Example: 150 students for lecture (x 2); 30 students for tutorials (x 10)]

30 students for lecture (x1)

12. Approval

Has the course title been included in the programme submission approved by CUHK Senate? Are there any differences?

Yes.

Have the details (as in this document) been approved at School or other level in CUHK (SZ)?

No.

13. Any other information

No.

14. Version date

Version number	001
As of (date)	24 December 2018

Please save file as XXXxxxx v-nnn yymmdd

XXXxxxx = course code, e.g., MAT1212
nn = version number, e.g., 001 for version 1
yymmdd = date of this version, e.g., 131210