

**Department of Electrical Engineering  
University of Southern California**

**EE 565 – INFORMATION THEORY AND COMPRESSION Spring 2019**

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**Instructor:** Urbashi Mitra, Professor  
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**Course Web Page:** DEN Blackboard [www.uscden.net](http://www.uscden.net)  
Contains homework, solutions, and relevant handouts. Course announcements, homework hints and modifications will be posted on this page – please check it regularly.

**Lectures:** MW 10:00 am - 11:50am, OHE 120

**Course Objectives:** Information theory answers two fundamental questions in communication and compression theories: What is the ultimate data compression (answer: the entropy  $H$ ), and what is the ultimate transmission rate of communication (answer: the channel capacity  $C$ ). This course covers fundamental theories and practical algorithms for both data compression and reliable communication. EE565 is designed as the entry point for graduate studies in information theory at the Viterbi School of Engineering at USC. At the completion of the subject, students will have mastered basic concepts and tools in information theory, and will be able to analyze a wide range of problems in data compression and data communication over noisy channels. They will also be able to design algorithms for data compression, and design error correction codes for data communication. Topics include: entropy and other information measures; variable and fixed-length lossless and lossy source codes; universal compression; applications to text and multimedia compression; channel capacity and the channel coding theorem; error-correcting codes and real channels; and applications to erasure channels and Gaussian channels.

**Prerequisites:** Probability theory and random variables, moments, transformations of random variables, *etc.* (EE 503).

**Other Requirements:** Basic computer skills (*i.e.* programming, plotting, random variable generation, familiarity with Matlab is helpful although not necessary), knowledge of convex functions and their properties, simple optimization, stationary points of functions, limits of sequences and series, *etc.*

**Text:** Elements of Information Theory, by T. M. Cover and J. A. Thomas, Wiley, 2nd edition, 2006.

**Grading:** (tentative) 20% Homework  
30% Midterm  
40% Final  
10% Project  
Final grades will be assigned by a combination of student score distribution (curve) and the discretion of the instructor.

**Exams:** **Midterm** (tentative) Wednesday, February 20, 2019, 10:00 am - 11:50am  
**Final** Wednesday, May 6, 2019, 8:00am-10:00am

**Office Hours:** TBD

Use of email to set up appointments encouraged: ubli@usc.edu. Attending office hours in person is encouraged.

**Late Policy:** Homework is due at 5pm on Wednesdays in the 565 box (EEB basement). No late homework will be accepted. A late assignment results in a zero grade.

**Make-up Material:** Homework assignment dates are non-negotiable. Your lowest homework score will be thrown out before computing final grades. No make-up exams will be given. In the case of a required business trip or a medical emergency, a signed letter from your supervisor or doctor is required. This letter must include the telephone number of your doctor or supervisor.

**Grade Adjustment:** If you dispute any scoring of a problem on an exam or homework set, you have **one week** from the date that the graded paper is **returned** to request a change in the grade. After this time, no further alterations will be considered. All requests for a change in grade must be submitted in writing to me.

**Attendance:** Lecture attendance is encouraged; many examples and applications not in the text will be covered in the lectures. The student is responsible for all assignments, changes of assignments, announcements, lecture notes *etc.* All such changes should be posted on the course web-site.

- References:**
1. Information Theory, Inference, and Learning Algorithms, D. Mackay, Cambridge University Press, 2003.
  2. A First Course in Information Theory, R. Yeung, Springer 2002.
  3. Principles of Digital Communication, R. Gallager, Cambridge University Press, 2008.

- Tentative weekly outline:**
1. Basic information measures (2.1-2.3)
  2. Properties of information measures; typicality (2.4-2.9,3.1-3.3)
  3. Lossless compression, Huffman coding (5.1-5.8)
  4. Universal compression (and learning); entropy rate; compression of stationary sources (13.1-13.2)
  5. Algorithms: arithmetic coding; Lempel-Ziv; Burrows-Wheeler (13.3-13.5)
  6. Binning; Slepian-Wolf coding (15.4,15.8)
  7. Point-to-point communications; channel capacity (7.1-7.7)
  8. Channel coding theorem for DMCs (7.8-7.10)
  9. Examples of error-correcting codes; decoding algorithms (7.11)
  10. Differential entropy; channel coding theorem for Gaussian channels (8.1-8.6,9.1-9.2)
  11. Bandlimited channels; parallel channels (9.3-9.4)
  12. Feedback (7.12-7.13, 9.6)
  13. Multiple-access channels (15.3)
  14. Broadcast channels (15.6)

15. (time permitting) Rate-Distortion Theory (10.1-10.5,10.8)

- Suggestions:**
1. Remember the big picture.
  2. Read the book and supplementary sources.
  3. Prepare your own summaries from texts and notes.
  4. Work as many problems as you can.

**Academic Conduct:** Plagiarism presenting someone else's ideas as your own, either verbatim or recast in your own words is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards <https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/><https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/>. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct/><http://policy.usc.edu/scientific-misconduct/>. Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity <http://equity.usc.edu/><http://equity.usc.edu/> or to the Department of Public Safety <http://capsnet.usc.edu/departement/departement-public-safety/online-forms/contact-us> <http://capsnet.usc.edu/departement/departement-public-safety/online-forms/contact-us>. This is important for the safety whole USC community. Another member of the university community such as a friend, classmate, advisor, or faculty member can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men <http://www.usc.edu/student-affairs/cwm/><http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage [sarc@usc.edu](mailto:sarc@usc.edu) describes reporting options and other resources.

**Students with Disabilities:** A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute <http://dornsife.usc.edu/ali/><http://dornsife.usc.edu/ali/>, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs [http://sait.usc.edu/academicsupport/centerprograms/dsp/home\\_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html) [http://sait.usc.edu/academicsupport/centerprograms/dsp/home\\_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html) provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information <http://emergency.usc.edu/will/><http://emergency.usc.edu/will/> will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.