ECSE 305 - Fall 2010
Probability and Random Signals I (3 cr.)

Senate on January 29, 2003 approved a resolution on academic integrity, which requires that the following reminder to students be printed on every course outline:

McGILL UNIVERSITY VALUES ACADEMIC INTEGRITY. THEREFORE ALL STUDENTS MUST UNDERSTAND THE MEANING AND CONSEQUENCES OF CHEATING, PLAGIARISM AND OTHER ACADEMIC OFFENCES UNDER THE CODE OF STUDENT CONDUCT AND DISCIPLINARY PROCEDURES (see http://www.mcgill.ca/integrity for more information).

General Information:

Instructor:

- Prof. Benoît Champagne
- Office: McConnell Engineering Building, Room 756
- Tel: (514) 398-5701
- Email: benoit.champagne@mcgill.ca

- Office Hours:
  - Monday & Wednesday from 1:30 to 3:30pm
  - Otherwise by appointment

Lectures:

- Monday, Wednesday and Friday: from 12:30 to 13:30
- Location: Room ENGMC 13
- **Lectures will start on Wednesday, September 1st, 2010**

Tutorials:

- There are two tutorial sections for this course:
  - CRN497 (Sec003): Friday, 09:30 to 11:30, ENGTR 1090
  - CRN498 (Sec004): Monday, 09:30 to 11:30, ENGTR 1080
- **The tutorials will begin on Friday September 10.**
- During each tutorial, the responsible TA will solve representative problems related to material recently covered in class.

Teaching Assistants:

Name	***Office***	***Main Duty***	***Email***
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Course Description:

Prerequisite:

- ECSE-303 (Signals and Systems I) or ECSE-306 (Fundamentals of Signals and Systems).
- No previous exposure to probability is assumed.

Objectives:

- The course is intended as an introduction to the mathematical theory and applications of probability and random signals for students in electrical, computer and software engineering. It aims to develop fundamental concepts and methods of this field and, through a variety of examples, illustrate some of their applications.
- After successfully completing the course, students should be well prepared to take on more advanced courses in such fields as communications systems, artificial intelligence, computer network, control engineering and signal processing.

List of Topics:

Part I: *Fundamental concepts (~9 hours)*

- *Introduction*: Determinism and randomness in science, regularity and relative frequency, goals of probability, axiomatic approach.
- *Background material*: Review of set theory: terminology, set operations, and sigma-algebra. Combinatorial analysis: counting principles, permutations, combinations, related results.
- *The probability model*: Random experiment, sample space and events, axioms of probability, basic theorems and properties, finite, countably infinite and uncountably infinite probability spaces.
- *Conditional probability and independence*: Definition and interpretation of conditional probability, basic theorems (laws of multiplication, total probability and Bayes' formula), statistical independence.

Part II: Random variables (~12 hours)

- *Introduction to random variables:* Definition, cumulative distribution function, basic types of random variables.
- *Discrete random variables*: Probability mass function, expectation and variance. Special discrete distributions: Bernoulli, binomial, Poisson and some others. Function of a discrete random variable.
- *Continuous random variables*: Probability density functions, expectation and variances. Special continuous distributions: uniform, normal, exponential, and some others. Function of a continuous random variable.
- *Moments:* Unifying framework for discrete and continuous random variables, moment generating function, characteristic function, Markov and Chebyshev inequalities.

Part III: Jointly distributed random variables (~9 hours)

- *Bivariate distributions:* Bivariate distribution and density functions, independent random variables, conditional distributions and densities.
- *Multivariate distributions:* Extension of above to multivariate distributions, random vectors and matrix notations, function of a random vector.
- *Expectations and variance:* Expected values of sum of random variables, covariance, correlation, conditioning on random variables, study of multivariate normal distribution.
- *Limit theorems*: Moment-generating functions, sums of independent random variables, law of large numbers, central limit theorem.

Part IV: Introduction to random signals (~8 hours)

- *Introduction to random signals:* definition, discrete and continuous cases, 2nd order characterization, stationarity, covariance function.
- *Stationary random signals:* practical motivation, power spectral density, Wiener-Khinchin *relations*, white noise, linear filtering.
- *Poisson processes:* Counting process, definition of the Poisson process, properties of interarrival time.

Course Material:

WEB Support:

- The course web page on McGill University's *my*Courses (WebCT Vista) will be used extensively to post course related information (e.g. course outline, class notes, problem sets, exam solutions, etc.). Please consult regularly.

Class Notes and related material:

- A complete set of class notes will be available (free of charge ☺) on the course Web page, along with any additional lecture slides.
- These notes are organized in Chapters that closely follow the above topics. They are self-sufficient in terms of textual explanations for the course: i.e. they cover all aspects of the theory and contain a number of selected examples. However, for students who wish to better develop their ability to solve problems and drill questions, they should be supplemented with one of the two references below.

Course Textbooks:

There are no required textbook for the course; however students may find the following two references very useful. Copies have been ordered at the McGill Bookstore; a few copies will be put on reserve at the Schulich Library.

- S. Ghahramani: *Fundamentals of Probability, with Stochastic Processes*, *3rd Edition*, Prentice Hall, 2005, ISBN 0-13-145340-8.
  http://www.pearsonhighered.com/educator/academic/product/0,3110,0131453408,00.html

This textbook is well written and covers most of the material (except for Part IV). It contains many solved examples and extensive lists of additional problems for each chapter. Students who like to study from a traditional text (as opposed to more concise notes) will appreciate it.

- H. Hsu: *Schaum's Outline: Probability, Random Variables, & Random Processes*, ***2nd Edition***, McGraw-Hill, **2010**, ISBN 0071632891
  http://www.mhprofessional.com/product.php?cat=145&isbn=0071632891&cat=145
  While the coverage of the theory is concise, this book contains many solved problems, which the students usually find very useful. The course material is included in the first 6 chapters of the book, while the remaining 3 chapters cover more advanced material.

Old Exams:

- A limited subset of midterms and final exams previously given in 305 will be made available on the course Web page.
- These should be consulted by the students prior to examinations.

Other Related Textbooks:

There are many textbooks covering probability and random signals at the level of this course. A selected subset of such textbooks, with an emphasis on electrical engineering in the choice and presentation of material, includes:

- J. A. Gubner, *Probability and Random Processes for Electrical and Computer Engineers,* Cambridge University Press, 2006.
- C. W. Hesltrom: *Probability and Stochastic Processes for Engineers*, Prentice Hall, 1991.
- A. Leon-Garcia, *Probability and Random Processes for Electrical Engineering,* 3rd Edition, Addison-Wesley, 2008.
- A. Papoulis and S. U. Pillai, *Probability, Random Variables and Stochastic Processes, 4th Ed.*, McGraw Hill, 2002.
- H. Stark and J. W. Woods, *Probability and Random Processes with Applications to Signal Processing, 3rd Ed.,* Prentice Hall, 2002.
- Y. Viniotis, *Probability and Random Processes for Electrical Engineers*, McGraw-Hill, 1998.

Other introductory texts targeting a more general audience include:

- S. Ross, A First Course in Probability, 6th Ed., Prentice Hall, 2002.
- G. F. Grimmett, and D. R. Stirzaker: *Probability and Random Processes, 3rd Ed.,* Oxford University Press, 2001.

More advanced treatments of the material can be found in:

- J. S. Rosenthal, *A First Look at Rigorous Probability theory*, World Sc., 2000.
- S. M. Ross, *Introduction to Probability Models, 7th Ed.*, Academic Press, 2000.
- K. S. Trivedi, *Probability and Statistics with Reliability, Queuing and Computer Science Applications, 2nd Ed.*, Wiley, 2002.
- E. Wong, *Stochastic Processes in Information and Dynamical Systems,* McGraw Hill, 1971.

Some interesting links:

- The Probability Web: http://www.mathcs.carleton.edu/probweb/probweb.html
- Virtual Laboratory in Probability and Statistics: http://www.ds.unifi.it/VL/VL_EN/index.html

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Homework and Evaluation:

Problem sets:

- Weekly problem sets will be posted on the course Web page.
- Experimenting with a new approach this year, these will not be marked but instead, solutions will be posted on the Web within a week.
- The purpose here is to help students develop confidence and ability in problem solving. Some problems are likely to be more challenging, in which case group discussion with other students is encouraged.
- Attempting to solve all the problems and understanding their solutions are of paramount importance as a preparation for the midterm and final exams.

Midterm examinations:

- There will be 2 midterm examinations, 50 minutes in duration, and held during normal class time:
  - **Midterm #1**: Friday, October 8, 2010
  - **Midterm #2**: Friday, November 12, 2010
- This will be of the CLOSED BOOK type; only the faculty standard calculator will be allowed (NO crib sheet).
- Consult the course Web page for additional information on the specific material covered by these exams.

Final examination:

- There will be a final examination, 3 hours in duration (date and time to be announced by the Faculty)
- This will be of the CLOSED BOOK type; only the faculty standard calculator will be allowed (NO crib sheet).
- The final examination will cover all the material included in the class notes and/or seen in class during the term.
- Consult the course Web page for additional information.

Marking scheme:

Midterm #1	20%
Midterm #2	20%
Final examination	60%

Marking Policy (Midterms):

- **There will not be any make-up exam** for students who miss a Midterm.
- Students who miss a midterm due to illness **should notify the instructor within a week** of the examination and provide him with an adequate **medical certificate** stating the date and nature of the illness.
- Under presentation of a proper certificate, and only in this case, the mark for the missed examination will be computed from that obtained at the final.
- Students who miss a midterm for unjustified reasons (e.g.: no medical certificate, going to the exam at the wrong time or on the wrong day, etc.) will get a mark of zero.
- Any request for reevaluation of a Midterm must be made within a week of its return by contacting the instructor.
- Marked Midterms that have not been picked up after two weeks of their return will be discarded.