AMS 131: Introduction to Probability Theory

Tentative syllabus and reading list: Spring 2019

The textbook for this class (abbreviated in what follows as DS) is

DeGroot MH, Schervish MJ (2012). *Probability and Statistics* (4th edition). Boston: Addison-Wesley.

Lecture Number	Date	Topics	Reading (DS sections; * optional)
1	2 Apr	Random samples from populations (IID and SRS); the Equally-Likely Model; experiments; events; sample space; Venn diagrams; set theory (part 1); duality between sets and true/false propositions; cardinality (orders of infinity)	1.1–1.4, 1.6
2	4 Apr	Probability rules for **and**, **or**, and **not**; conditional probability and independence; mutually exclusive; experiments, events, sample spaces, set theory; partitions; Kolmogorov probability axioms; permutations and combinations	1.5, 1.7–1.8
3	9 Apr	Binomial coefficients, factorials, Gamma function; multinomial coefficients; conditional probability; Law of Total Probability; independence (Bayesian and frequentist concepts)	1.9–1.12
4	11 Apr	Bayes's Theorem for events; basic ideas of Bayesian statistics (prior, posterior, likelihood information); random variables and their distributions (discrete, continuous, mixed); probability mass functions (PMFs); histograms	2.1–2.3, 2.4*, 2.5, 3.1–3.2
5	16 Apr	Bernoulli and Binomial distributions; continuous random variables, Uniform(a, b) distribution; probability density functions (PDFs); cumulative distribution functions (CDFs) basic shapes of distributions	3.3
6	18 Apr	Exponential distribution; quantiles and percentiles; measures of center of a distribution (median); measures of spread (interquartile range); bivariate distributions; joint PMFs and PDFs; marginal distributions; Poisson distribution and process	3.5
7	23 Apr	Bivariate and marginal CDFs; independence of random variables; conditional probability distributions; Bayesian statistical inference	3.4, 3.6
8	25 Apr	Multivariate distributions: discrete joint PMFs; computing marginal distributions; multivariate Law of Total Probability; conditional independence	3.7
9	30 Apr	Functions of a random variable; probability integral transform; generation of pseudo-random numbers; the Monte-Carlo method; distribution of functions of two or more random variables; convolution of probability distributions	3.8–3.9, 3.11

Lecture Number	Date	Topics	Reading (DS sections; * optional)
10	2 May	Multivariate linear transformations of random variables; expectation (expected value, mean) of a random variable	4.1
11	7 May	Expectation pathologies; expectation of a function of a random variable; Law of the Unconscious Statistician; Jensen's inequality; variance and standard deviation	4.2–4.3
12	9 May	Moments of a random variable; skewness and kurtosis; moment-generating function; mean versus median	4.4–4.5
13	14 May	Prediction; (root) mean squared error and mean absolute error; covariance; converting to standard units; correlation; Cauchy-Schwartz inequality; conditional expectation; double-expectation theorem	4.6–4.7
14	16 May	Conditional variance; utility and Bayesian decision theory; maximization of expected utility; summary of useful univariate discrete distributions (Bernoulli, Binomial, Hypergeometric, Poisson)	4.8–4.9, 5.1–5.4
15	21 May	Summary of useful discrete distributions (Negative Binomial); Poisson process; Summary of useful continuous distributions (Normal [Gaussian]); standard deviation; Empirical Rule; Normal approximation to discrete distribution	5.5, 5.6
16	23 May	Sample mean; unbiased estimation; standard error; summary of useful continuous distributions (Lognormal, Gamma); memoryless property of Exponential distribution, survival (reliability) function, hazard function	5.7
17	28 May	Summary of useful continuous distributions (Beta); Multivariate distributions (Multinomial, bivariate Normal); scatterplots; simple linear regression	5.8–5.11
18	30 May	Large random samples: sample mean, Markov and Chebyshev inequalities, convergence in probability, Weak Law of Large Numbers, Central Limit Theorem, convergence in distribution, the Delta method; statistical inference: confidence intervals and posterior distributions	6.1–6.3, 7.1–7.6, 8.5
19	4 Jun	The Continuity Correction; stochastic processes; Markov chains: time series, state space, transition probabilities, time-homogeneity, stochastic matrix	6.4–6.5, 3.10
20	6 Jun	Random walk, absorbing state, equilibrium (stationary) distribution, initial distribution, eigenanalysis to obtain transition matrix	—

Mon 27 May 2019 is the only holiday this quarter; the only effect this will have on AMS 131 is that there will (probably) be no office hours that day.

Please note also that with the loss of 200 minutes of lecture time (under the relatively recent class schedule), we may need to have a make-up lecture; more on this toward the end of the quarter.