
Contents

1	Why probability and statistics?	1
1.1	Biometry: iris recognition	1
1.2	Killer football	3
1.3	Cars and goats: the Monty Hall dilemma	4
1.4	The space shuttle <i>Challenger</i>	5
1.5	Statistics versus intelligence agencies	7
1.6	The speed of light	9
2	Outcomes, events, and probability	13
2.1	Sample spaces	13
2.2	Events	14
2.3	Probability	16
2.4	Products of sample spaces	18
2.5	An infinite sample space	19
2.6	Solutions to the quick exercises	21
2.7	Exercises	21
3	Conditional probability and independence	25
3.1	Conditional probability	25
3.2	The multiplication rule	27
3.3	The law of total probability and Bayes' rule	30
3.4	Independence	32
3.5	Solutions to the quick exercises	35
3.6	Exercises	37

4	Discrete random variables	41
4.1	Random variables	41
4.2	The probability distribution of a discrete random variable	43
4.3	The Bernoulli and binomial distributions	45
4.4	The geometric distribution	48
4.5	Solutions to the quick exercises	50
4.6	Exercises	51
5	Continuous random variables	57
5.1	Probability density functions	57
5.2	The uniform distribution	60
5.3	The exponential distribution	61
5.4	The Pareto distribution	63
5.5	The normal distribution	64
5.6	Quantiles	65
5.7	Solutions to the quick exercises	67
5.8	Exercises	68
6	Simulation	71
6.1	What is simulation?	71
6.2	Generating realizations of random variables	72
6.3	Comparing two jury rules	75
6.4	The single-server queue	80
6.5	Solutions to the quick exercises	84
6.6	Exercises	85
7	Expectation and variance	89
7.1	Expected values	89
7.2	Three examples	93
7.3	The change-of-variable formula	94
7.4	Variance	96
7.5	Solutions to the quick exercises	99
7.6	Exercises	99
8	Computations with random variables	103
8.1	Transforming discrete random variables	103
8.2	Transforming continuous random variables	104
8.3	Jensen's inequality	106

8.4	Extremes	108
8.5	Solutions to the quick exercises	110
8.6	Exercises	111
9	Joint distributions and independence	115
9.1	Joint distributions of discrete random variables	115
9.2	Joint distributions of continuous random variables	118
9.3	More than two random variables	122
9.4	Independent random variables	124
9.5	Propagation of independence	125
9.6	Solutions to the quick exercises	126
9.7	Exercises	127
10	Covariance and correlation	135
10.1	Expectation and joint distributions	135
10.2	Covariance	138
10.3	The correlation coefficient	141
10.4	Solutions to the quick exercises	143
10.5	Exercises	144
11	More computations with more random variables	151
11.1	Sums of discrete random variables	151
11.2	Sums of continuous random variables	154
11.3	Product and quotient of two random variables	159
11.4	Solutions to the quick exercises	162
11.5	Exercises	163
12	The Poisson process	167
12.1	Random points	167
12.2	Taking a closer look at random arrivals	168
12.3	The one-dimensional Poisson process	171
12.4	Higher-dimensional Poisson processes	173
12.5	Solutions to the quick exercises	176
12.6	Exercises	176
13	The law of large numbers	181
13.1	Averages vary less	181
13.2	Chebyshev's inequality	183

13.3	The law of large numbers	185
13.4	Consequences of the law of large numbers	188
13.5	Solutions to the quick exercises	191
13.6	Exercises	191
14	The central limit theorem	195
14.1	Standardizing averages	195
14.2	Applications of the central limit theorem	199
14.3	Solutions to the quick exercises	202
14.4	Exercises	203
15	Exploratory data analysis: graphical summaries	207
15.1	Example: the Old Faithful data	207
15.2	Histograms	209
15.3	Kernel density estimates	212
15.4	The empirical distribution function	219
15.5	Scatterplot	221
15.6	Solutions to the quick exercises	225
15.7	Exercises	226
16	Exploratory data analysis: numerical summaries	231
16.1	The center of a dataset	231
16.2	The amount of variability of a dataset	233
16.3	Empirical quantiles, quartiles, and the IQR	234
16.4	The box-and-whisker plot	236
16.5	Solutions to the quick exercises	238
16.6	Exercises	240
17	Basic statistical models	245
17.1	Random samples and statistical models	245
17.2	Distribution features and sample statistics	248
17.3	Estimating features of the “true” distribution	253
17.4	The linear regression model	256
17.5	Solutions to the quick exercises	259
17.6	Exercises	259

18 The bootstrap	269
18.1 The bootstrap principle	269
18.2 The empirical bootstrap	272
18.3 The parametric bootstrap	276
18.4 Solutions to the quick exercises	279
18.5 Exercises	280
19 Unbiased estimators	285
19.1 Estimators	285
19.2 Investigating the behavior of an estimator	287
19.3 The sampling distribution and unbiasedness	288
19.4 Unbiased estimators for expectation and variance	292
19.5 Solutions to the quick exercises	294
19.6 Exercises	294
20 Efficiency and mean squared error	299
20.1 Estimating the number of German tanks	299
20.2 Variance of an estimator	302
20.3 Mean squared error	305
20.4 Solutions to the quick exercises	307
20.5 Exercises	307
21 Maximum likelihood	313
21.1 Why a general principle?	313
21.2 The maximum likelihood principle	314
21.3 Likelihood and loglikelihood	316
21.4 Properties of maximum likelihood estimators	321
21.5 Solutions to the quick exercises	322
21.6 Exercises	323
22 The method of least squares	329
22.1 Least squares estimation and regression	329
22.2 Residuals	332
22.3 Relation with maximum likelihood	335
22.4 Solutions to the quick exercises	336
22.5 Exercises	337

23 Confidence intervals for the mean	341
23.1 General principle	341
23.2 Normal data	345
23.3 Bootstrap confidence intervals	350
23.4 Large samples	353
23.5 Solutions to the quick exercises	355
23.6 Exercises	356
24 More on confidence intervals	361
24.1 The probability of success	361
24.2 Is there a general method?	364
24.3 One-sided confidence intervals	366
24.4 Determining the sample size	367
24.5 Solutions to the quick exercises	368
24.6 Exercises	369
25 Testing hypotheses: essentials	373
25.1 Null hypothesis and test statistic	373
25.2 Tail probabilities	376
25.3 Type I and type II errors	377
25.4 Solutions to the quick exercises	379
25.5 Exercises	380
26 Testing hypotheses: elaboration	383
26.1 Significance level	383
26.2 Critical region and critical values	386
26.3 Type II error	390
26.4 Relation with confidence intervals	392
26.5 Solutions to the quick exercises	393
26.6 Exercises	394
27 The t-test	399
27.1 Monitoring the production of ball bearings	399
27.2 The one-sample t -test	401
27.3 The t -test in a regression setting	405
27.4 Solutions to the quick exercises	409
27.5 Exercises	410

28 Comparing two samples	415
28.1 Is dry drilling faster than wet drilling?	415
28.2 Two samples with equal variances	416
28.3 Two samples with unequal variances	419
28.4 Large samples	422
28.5 Solutions to the quick exercises	424
28.6 Exercises	424
A Summary of distributions	429
B Tables of the normal and t-distributions	431
C Answers to selected exercises	435
D Full solutions to selected exercises	445
References	475
List of symbols	477
Index	479

<http://www.springer.com/978-1-85233-896-1>

A Modern Introduction to Probability and Statistics

Understanding Why and How

Dekking, F.M.; Kraaikamp, C.; Lopuhaä, H.P.; Meester, L.E.

2005, XVI, 488 p. 120 illus. With online files/update.,

Hardcover

ISBN: 978-1-85233-896-1