ARIZONA STATE UNIVERSITY

GENERAL STUDIES COURSE PROPOSAL COVER FORM

Course information:

*Copy and paste **current** course information from Class Search/Course Catalog.*

Academic Unit: **College of Health Solutions** Department: **School for the Science of Health Care Delivery**

Subject: **HCD** Number: **300** Title: **Biostatistics** Units: **3**

Is this a cross-listed course? (Choose one)
If yes, please identify course(s): **PBH 300**

Is this a shared course? (choose one) If so, list all academic units offering this course: **Public Health and SHCD**

Course description:
Biostatistics and its use in health and health services research. Familiarize students with statistical concepts and methods to analyze and interpret data and conceptually addresses statistical theory. Introduces SPSS software to analyze large data sets.

Requested designation: Mathematical Studies-CS

*Note- a **separate** proposal is required for each designation requested*

Eligibility:

Permanent numbered courses must have completed the university's review and approval process.
For the rules governing approval of omnibus courses, contact Phyllis.Lucie@asu.edu or Lauren.Leo@asu.edu.

Submission deadlines dates are as follow:

For Fall 2015 Effective Date: October 9, 2014 For Spring 2016 Effective Date: March 19, 2015

Area(s) proposed course will serve:

A single course may be proposed for more than one core or awareness area. A course may satisfy a core area requirement and more than one awareness area requirements concurrently, but may not satisfy requirements in two core areas simultaneously, even if approved for those areas. With departmental consent, an approved General Studies course may be counted toward both the General Studies requirement and the major program of study.

Checklists for general studies designations:

Complete and attach the appropriate checklist

- Literacy and Critical Inquiry core courses (L)
- Mathematics core courses (MA)
- Computer/statistics/quantitative applications core courses (CS)
- Humanities, Arts and Design core courses (HU)
- Social-Behavioral Sciences core courses (SB)
- Natural Sciences core courses (SQ/SG)
- Cultural Diversity in the United States courses (C)
- Global Awareness courses (G)
- Historical Awareness courses (H)

A complete proposal should include:

- ☒ Signed General Studies Program Course Proposal Cover Form
- ☒ Criteria Checklist for the area
- ☒ Course Catalog description
- ☒ Course Syllabus
- ☒ Copy of Table of Contents from the textbook and list of required readings/books

Respectfully request that proposals are submitted electronically with all files compiled into one PDF. If necessary, a hard copy of the proposal will be accepted.

Contact information:

Name: Kate Lehman Phone: 602-496-0241

Mail code: 3020 E-mail: Kate.Lehman@asu.edu

Department Chair/Director approval: *(Required)*

Chair/Director name (Typed): Natalie Landman Date: 8/5/14

Rev. 1/94, 4/95, 7/98, 4/00, 1/02, 10/08, 11/11/ 12/11, 7/12, 5/14

ARIZONA STATE UNIVERSITY

Chair/Director (Signature):

Arizona State University Criteria Checklist for

MATHEMATICAL STUDIES [CS]

Rationale and Objectives

The **Mathematical Studies** requirement is intended to ensure that students have skill in basic mathematics, can use mathematical analysis in their chosen fields, and can understand how computers can make mathematical analysis more powerful and efficient. The **Mathematical Studies** requirement is completed by satisfying both the **Mathematics [MA]** requirement and the **Computer/Statistics/Quantitative Applications [CS]** requirement explained below.

The **Mathematics [MA]** requirement, which ensures the acquisition of essential skill in basic mathematics, requires the student to complete a course in College Mathematics, College Algebra, or Pre-calculus; or demonstrate a higher level of skill by completing a mathematics course for which a course in the above three categories is a prerequisite.

The **Computer/Statistics/Quantitative Applications [CS]** requirement, which ensures skill in real world problem solving and analysis, requires the student to complete a course that uses some combination of computers, statistics, and/or mathematics.* Computer usage is encouraged but not required in statistics and quantitative applications courses. At a minimum, such courses should include multiple demonstrations of how computers can be used to perform the analyses more efficiently.

*CS does *not* stand for computer science in this context; the "S" stands for statistics. Courses in computer science must meet the criteria stated for CS courses.

Revised April 2014

Proposer: Please complete the following section and attach appropriate documentation.

ASU--[CS] CRITERIA

A COMPUTER/STATISTICS/QUANTITATIVE APPLICATIONS [CS] COURSE MUST SATISFY ONE OF THE FOLLOWING CRITERIA: 1, 2, OR 3

YES	NO		Identify Documentation Submitted
		1. Computer applications*: courses must satisfy both **a** and **b**:	
☐	☐	**a.** Course involves the use of computer programming languages or software programs for quantitative analysis, algorithmic design, modeling, simulation, animation, or statistics.	
		b. Course requires students to analyze and implement procedures that are applicable to at least one of the following problem domains **(check those applicable)**:	
☐	☐	i. Spreadsheet analysis, systems analysis and design, and decision support systems.	
☐	☐	ii. Graphic/artistic design using computers.	
☐	☐	iii. Music design using computer software.	
☐	☐	iv. Modeling, making extensive use of computer simulation.	
☐	☐	v. Statistics studies stressing the use of computer software.	
☐	☐	vi. Algorithmic design and computational thinking.	

***The **computer applications** requirement **cannot** be satisfied by a course, the content of which is restricted primarily to word processing or report preparation skills, the study of the social impact of computers, or methodologies to select software packages for specific applications. Courses that emphasize the use of a computer software package are acceptable only if students are required to understand, at an appropriate level, the theoretical principles embodied in the operation of the software and are required to construct, test, and implement procedures that use the software to accomplish tasks in the applicable problem domains. Courses that involve the learning of a computer programming language are acceptable only if they also include a substantial introduction to applications to one of the listed problem domains.

YES	NO		Identify Documentation Submitted
		2. Statistical applications: courses must satisfy **a**, **b,** and **c**.	
☒	☐	**a.** Course has a minimum mathematical prerequisite of College Mathematics, College Algebra, or Pre-calculus**,** or a course already approved as satisfying the MA requirement.	syllabus prerequisites section
		b. The course must be focused principally on developing knowledge in statistical inference and include coverage of all of the following:	
☒	☐	i. Design of a statistical study.	See blue highlighted areas
☒	☐	ii. Summarization and interpretation of data.	See gray highlighted areas
☒	☐	iii. Methods of sampling.	See blue highlighted areas
☒	☐	iv. Standard probability models.	See purple highlighted areas
☒	☐	v. Statistical estimation	See yellow highlighted areas
☒	☐	vi. Hypothesis testing.	See blue highlighted areas
☒	☐	vii. Regression or correlation analysis.	See gray highlighted areas
☒	☐	**c.** The course must include multiple demonstrations of how computers can be used to perform statistical analysis more efficiently, if use of computers to carry out the analysis is not required. .	See yellow and green highlighted areas

YES	NO		Identify Documentation Submitted
		3. Quantitative applications: courses must satisfy **a**, **b, and c:**.	
☐	☐	**a.** Course has a minimum mathematical prerequisite of College Mathematics, College Algebra, or Pre-calculus**,** or a course already approved as satisfying the MA requirement.	
		b. The course must be focused principally on the use of mathematical models in quantitative analysis and decision making. Examples of such models are:	
☐	☐	i. Linear programming.	
☐	☐	ii. Goal programming.	
☐	☐	iii. Integer programming.	
☐	☐	iv. Inventory models.	
☐	☐	v. Decision theory.	
☐	☐	vi. Simulation and Monte Carlo methods.	
☐	☐	vii. Other (explanation must be attached).	
☐	☐	**c.** The course must include multiple demonstrations of how computers can be used to perform the above applications more efficiently, if use of computers is not required by students.	

Course Prefix	Number	Title	General Studies Designation
HCD	300	Biostatistics	

Explain in detail which student activities correspond to the specific designation criteria. Please use the following organizer to explain how the criteria are being met.

Criteria (from checksheet)	How course meets spirit (contextualize specific examples in next column)	Please provide detailed evidence of how course meets criteria (i.e., where in syllabus)
minimum math prerequisite	course requires student to have completed the MA prior to taking the course	Prerequisite listed on page one of the syllabus
course focused on developing statistical inference	covers probability theory, the difference between correlation and causality, study design and methods of sampling, testing of hypotheses, how to interpret regression and summary data.	see highlighted colors on syllabus
Use of computers in statistical analysis	The course uses SPSS to run the data and the students use it in their assignments and are tested on it.	See yellow and green highlighted areas.

School for the Science of Health Care Delivery

ARIZONA STATE UNIVERSITY

HCD 300: Biostatistics

Faculty
Staff

Module/Course Placement
Spring 2014 / Session A or B
Day/Time TBD
Classroom TBD
Cross listed as PBH 300

Prerequisites or Co-Requisites
Completion of MA requirement with a C or better and minimum of 45 hours; credit is allowed for only HCD 300 or PBH 300.

Catalog Description
This course serves as an introduction biostatistics and its use in health and health services research. The course will familiarize students with statistical concepts and methods to analyze and interpret data and will address statistical theory conceptually. Students will also be introduced to SPSS software to analyze large data sets.

Credit Hours
3 credit hours

Methods of Instruction
This course includes didactic instruction, in-class learning activities and examples, and SPSS software.

Module/Course Objectives
Upon completion of this course, the student will be able to:

1. Describe the role of biostatistics in health, public health and health services research;
2. Understand the difference between correlation and causation;
3. Identify different experimental and sampling designs and discuss the stregnths and weanknesses of each;
4. Understand the rules of probability;
5. Describe sampling distributions and compute descriptive statistics;
6. Perform various methods of hypothesis testing and identify significant vs non-significant results;
7. Identify when particular stastical methods are appropriately used;
8. Use SPSS software to perform statistical methods discussed in the course

Module/Course Requirements (Assignments)
Students are responsible for completing the following assignments for this course:

1. Midterm exam:
Students will take an in-class midterm exam at the end of week 5. The exam will consist of computation problems and short answers covering content through week 4.

2. Final exam:
Students will take an in-class final exam on the last day of class. The exam will consist of computation problems and short answer questions covering all course content. Students will also be required to answer a set of questions using SPSS.

3. Homework Assignments:
There will be 7 homework assignments throughout the course. The assigments will consist of problems from the textbook, covering course content from the previous week. Assignments will be distributed at the beginning of each week and will be due at the start of class the following week.
DUE EACH WEEK

4. In Class SPSS Excercises:
There will be 4 SPSS excercises completed in-class. Following a demonstration by the instructor, students will be given a set of problems to complete using SPSS. Students are permitted to callaboate but each student must submit his/her own set of questions.

Methods of Evaluation

1.	Midterm exam	100 points
2.	Final exam	150 points
3.	Homework assingments (7 @ 20 points each)	140 points
4.	In-class SPSS excercises (4 @ 15 points each)	60 points
	Total	450 points

Final grades will be distributed as follows:

97% - 100% = **A+**	93% - 96.9% = **A**
90% - 92.9% = **A-**	87% - 89.9% = **B+**
83% - 86.9% = **B**	80% - 82.9% = **B-**
77% - 79.9% = **C+**	70% - 76.9% = **C**
60% - 69.9% = **D**	Less than 59.9% = **E**

Topical Outline

Week 1
Topics: 1) Course overview, introductions and 2) Distributions and Relationships
Reading assignments: Moore, McCabe, Craig Ch. 1, 2

Week 2
Topics: 1) Producing data – experimental designs, sampling and 2) Probability
Reading assignments: Moore, McCabe, Craig Ch. 3, 4
Homework assignment 1 due

Week 3
Topics: 1) Sampling distributions and 2) Introduction to inference
Reading assignments: Moore, McCabe, Craig Ch. 5, 6
Homework assignment 2 due

Week 4
Topic: 1) Inference for the mean of a population and 2) Comparing two means
Reading assignments: Moore, McCabe, Craig Ch. 7.1, 7.2
Activities: In-class SPSS exercise
Homework assignment 3 due

Week 5
Topics: 1) Inference for a single proportion and 2) Mid-term exam
Reading assignments: Moore, McCabe, Craig Ch. Chapter 8.1
Activities: In-class SPSS excercise
Homework assignment 4 due

Week 6
Topic: 1) Comparing 2 proportions and 2) Introduction to Analysis of Variance
Reading assignments: Moore, McCabe, Craig Ch. 8.2, 9.1
Activities: In-class SPSS exercise
Homework assignment 5 due

Week 7
Topics: 1) Analysis of Variance and 2) Introduction to simple linear regression
Reading assignments: Moore, McCabe, Craig Ch. 9.2, 9.3, 10.1
Activities: In-class SPSS exercise
Homework assignment 6 due

Week 8
Topics: 1) Course Content Review and 2) Final Exam
Homework assignment 7 due

Materials

Introduction to the Practice of Statistics (6^{th})
Author(s): Moore, McCabe, Craig and W.H. Freeman and Company, 2009

Health Sciences librarians:
Kevin Pardon: Kevin.Pardon@asu.edu
Virginia Pannabecker: Virginia.Pannabecker@asu.edu

Expectations of Faculty

Faculty will be available for student questions and/or discussion during office hours and by appointment. Faculty will answer all student emails and phone calls within a 24-hour time frame (or one working day). Faculty will model professional behavior in and out of the classroom, and treat all students respectfully.

Faculty will:
1. Explain the course structure and objectives at the beginning of the session.
2. Provide a course syllabus and course schedule at the beginning of the session, and oversee administration of evaluation tools and methods.
3. Facilitate the identification of useful learning resources.
4. Provide a respectful and safe learning environment.
5. Provide meaningful feedback to learners.
6. Assure that all learners have equal opportunity to achieve the course objectives.

Expectations of Students

1. Come prepared for each session, with thought provoking questions, an open mind, and the desire to make each session truly meaningful for yourself and your peers.
2. Discuss and debate ideas with the faculty and your colleagues in a respectful and professional manner.
3. Turn off cell phones during class time.
4. Submit assignments on time.

5. Attend class, ask questions and don't hesitate to visit me during office hours.

Accommodations Students with disabilities who need accommodations in this module/course are encouraged to make their requests to faculty at the beginning of the semester either during office hours or by appointment.

Note: Prior to receiving disability accommodations, verification of eligibility from the Disability Resource Center (DRC) is required. The DRC is located in University Center, 411 N. Central Avenue, Suite 160. DRC staff can also be reached at: 602-496-4321 (V), 602-496-0378 (TTY), and at: Disability-Q. Their hours are 8:00 AM to 5:00 PM, Monday through Friday. Eligibility and documentation policies can be viewed at: http://www.asu.edu/drc. *Disability information is confidential.*

Academic Conduct
All students are held to the ABOR Student Code of Conduct, found at:
https://eoss.asu.edu/dos/srr/codeofconduct

All students are held to the ASU Student Academic Integrity Policy, found at:
https://provost.asu.edu/sites/default/files/AcademicIntegrityPolicyPDF.pdf

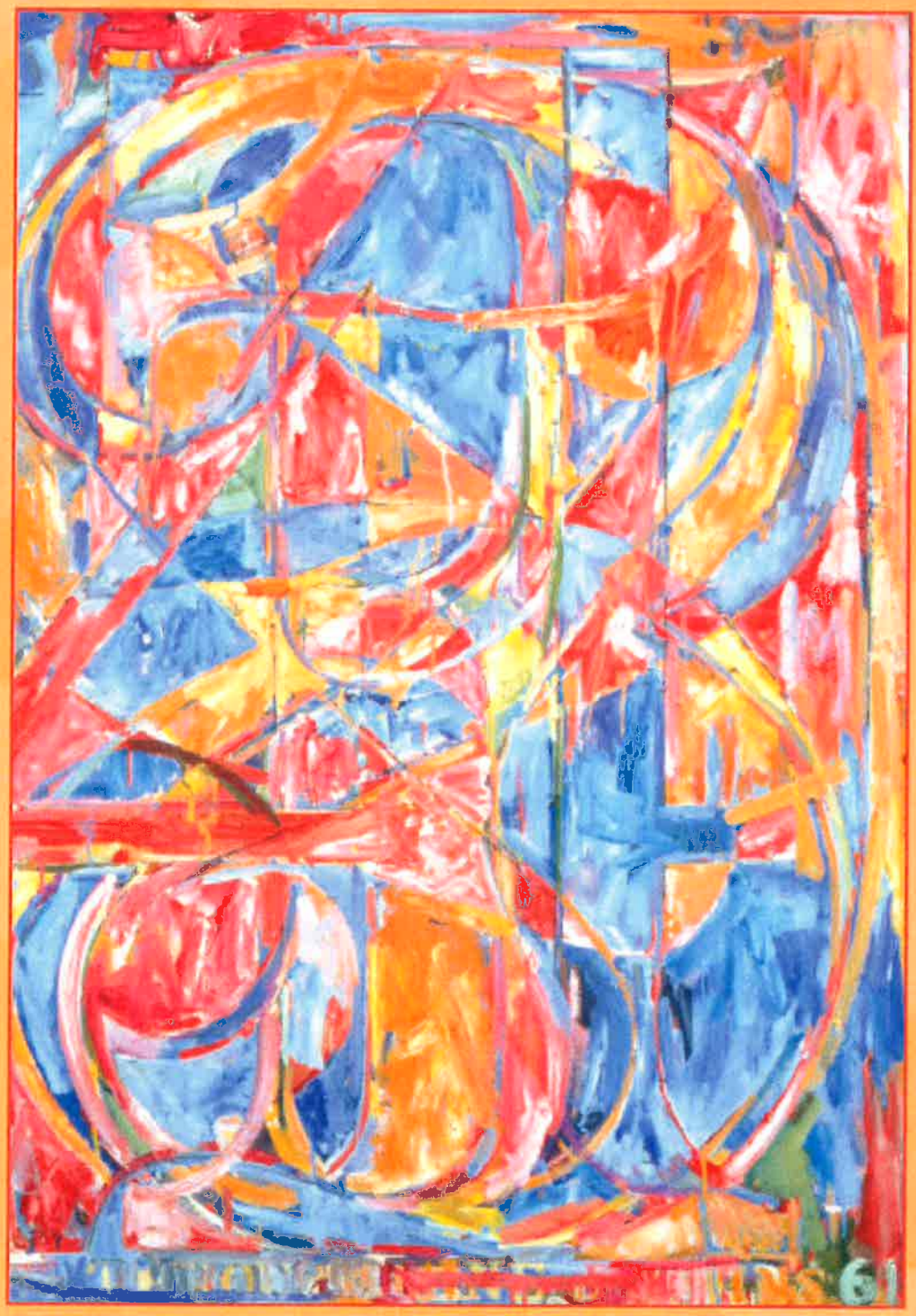
All students are held to the ASU Policies and Procedures, found at:
https://eoss.asu.edu/dos/srr/PoliciesAndProcedures

Copyright
Module/course content, including lectures and written materials distributed to the class, are under copyright protection.

Module/course content, including lectures, are copyrighted material and students may not sell notes taken during the conduct of the course.

Information in the syllabus may be subject to change with reasonable advance notice.

INTRODUCTION TO THE PRACTICE OF STATISTICS



SIXTH EDITION

MOORE
McCABE
CRAIG

Brief Contents

To Teachers: *About This Book* xv
To Students: *What Is Statistics?* xxv
About the Authors xxix
Data Table Index xxxi
Beyond the Basics Index xxxiii

PART I Looking at Data

CHAPTER 1: Looking at Data—Distributions 1

CHAPTER 2: Looking at Data—Relationships 83

CHAPTER 3: Producing Data 171

PART II Probability and Inference

CHAPTER 4: Probability: The Study of Randomness 237

CHAPTER 5: Sampling Distributions 311

CHAPTER 6: Introduction to Inference 353

CHAPTER 7: Inference for Distributions 417

CHAPTER 8: Inference for Proportions 487

PART III Topics in Inference

CHAPTER 9: Analysis of Two-Way Tables 525

CHAPTER 10: Inference for Regression 559

CHAPTER 11: Multiple Regression 607

CHAPTER 12: One-Way Analysis of Variance 637

CHAPTER 13: Two-Way Analysis of Variance 683

Companion Chapters (on the IPS Web site www.whfreeman.com/ips6e and CD-ROM)

CHAPTER 14: Logistic Regression 14-1

CHAPTER 15: Nonparametric Tests 15-1

CHAPTER 16: Bootstrap Methods and Permutation Tests 16-1

CHAPTER 17: Statistics for Quality: Control and Capability 17-1

Data Appendix D-1
Tables T-1
Answers to Odd-Numbered Exercises A-1
Notes and Data Sources N-1
Photo Credits C-1
Index I-1

Contents

To Teachers: *About This Book* xv
To Students: *What Is Statistics?* xxv
About the Authors xxix
Data Table Index xxxi
Beyond the Basics Index xxxiii

PART I Looking at Data

CHAPTER 1
Looking at Data—Distributions 1

Introduction 1
Variables 2
Measurement: know your variables 5

1.1 Displaying Distributions with Graphs 6
Graphs for categorical variables 6
Data analysis in action: don't hang up on me 7
Stemplots 9
Histograms 12
Examining distributions 15
Dealing with outliers 17
Time plots 18
Beyond the basics: decomposing time series* 19
Section 1.1 Summary 22
Section 1.1 Exercises 22

1.2 Describing Distributions with Numbers 30
Measuring center: the mean 30
Measuring center: the median 32
Mean versus median 34
Measuring spread: the quartiles 34
The five-number summary and boxplots 36
The 1.5 × *IQR* rule for suspected outliers 38
Measuring spread: the standard deviation 40
Properties of the standard deviation 42
Choosing measures of center and spread 43
Changing the unit of measurement 45
Section 1.2 Summary 47
Section 1.2 Exercises 48

1.3 Density Curves and Normal Distributions 53
Density curves 55
Measuring center and spread for density curves 56
Normal distributions 58
The 68–95–99.7 rule 59
Standardizing observations 61
Normal distribution calculations 62
Using the standard Normal table 64
Inverse Normal calculations 66
Normal quantile plots 68
Beyond the basics: density estimation 71
Section 1.3 Summary 71
Section 1.3 Exercises 72
Chapter 1 Exercises 76

CHAPTER 2
Looking at Data—Relationships 83

Introduction 83
Examining relationships 84

2.1 Scatterplots 86
Interpreting scatterplots 88
Adding categorical variables to scatterplots 89
More examples of scatterplots 90
Beyond the basics: scatterplot smoothers 92
Categorical explanatory variables 93
Section 2.1 Summary 94
Section 2.1 Exercises 95

2.2 Correlation 101
The correlation *r* 102
Properties of correlation 102
Section 2.2 Summary 105
Section 2.2 Exercises 105

2.3 Least-Squares Regression 108
Fitting a line to data 110
Prediction 111
Least-squares regression 112
Interpreting the regression line 115

Sections marked with an asterisk are optional.

Correlation and regression 115
*Understanding r^2 118
Beyond the basics: transforming relationships 119
Section 2.3 Summary 121
Section 2.3 Exercises 122

2.4 Cautions about Correlation and Regression 125
Residuals 126
Outliers and influential observations 129
Beware the lurking variable 132
Beware correlations based on averaged data 135
The restricted-range problem 135
Beyond the basics: data mining 136
Section 2.4 Summary 137
Section 2.4 Exercises 137

2.5 Data Analysis for Two-Way Tables 142
The two-way table 142
Joint distribution 144
Marginal distributions 145
Describing relations in two-way tables 146
Conditional distributions 146
Simpson's paradox 148
The perils of aggregation 151
Section 2.5 Summary 151
Section 2.5 Exercises 152

2.6 The Question of Causation 154
Explaining association: causation 154
Explaining association: common response 155
Explaining association: confounding 156
Establishing causation 157
Section 2.6 Summary 159
Section 2.6 Exercises 159
Chapter 2 Exercises 161

CHAPTER 3
Producing Data 171

Introduction 171
Anecdotal data 171
Available data 172
Sample surveys and experiments 173

3.1 Design of Experiments 178
Comparative experiments 180
Randomization 181
Randomized comparative experiments 183
How to randomize 184
Cautions about experimentation 188
Matched pairs designs 189
Block designs 190
Section 3.1 Summary 191
Section 3.1 Exercises 192

3.2 Sampling Design 197
Simple random samples 200
Stratified samples 202
Multistage samples 203
Cautions about sample surveys 204
Section 3.2 Summary 207
Section 3.2 Exercises 208

3.3 Toward Statistical Inference 212
Sampling variability 213
Sampling distributions 214
Bias and variability 217
Sampling from large populations 219
Why randomize? 219
Beyond the basics: capture-recapture sampling 220
Section 3.3 Summary 221
Section 3.3 Exercises 221

3.4 Ethics 224
Institutional review boards 225
Informed consent 226
Confidentiality 227
Clinical trials 228
Behavioral and social science experiments 230
Section 3.4 Summary 232
Section 3.4 Exercises 232
Chapter 3 Exercises 234

PART II Probability and Inference

CHAPTER 4
Probability: The Study of Randomness 237

Introduction 237

4.1 Randomness 237
The language of probability 239
Thinking about randomness 240

The uses of probability 241
Section 4.1 Summary 241
Section 4.1 Exercises 241

4.2 Probability Models 242
Sample spaces 243
Probability rules 245
Assigning probabilities: finite number of outcomes 248
Assigning probabilities: equally likely outcomes 249
Independence and the multiplication rule 251
Applying the probability rules 254
Section 4.2 Summary 255
Section 4.2 Exercises 255

4.3 Random Variables 258
Discrete random variables 259
Continuous random variables 263
Normal distributions as probability distributions 265
Section 4.3 Summary 267
Section 4.3 Exercises 267

4.4 Means and Variances of Random Variables 270
The mean of a random variable 270
Statistical estimation and the law of large numbers 273
Thinking about the law of large numbers 275
Beyond the basics: more laws of large numbers 277
Rules for means 277
The variance of a random variable 279
Rules for variances and standard deviations 281
Section 4.4 Summary 285
Section 4.4 Exercises 286

4.5 General Probability Rules* 289
General addition rules 290
Conditional probability 293
General multiplication rules 298
Tree diagrams 299
Bayes's rule 301
Independence again 302
Section 4.5 Summary 302
Section 4.5 Exercises 303
Chapter 4 Exercises 307

CHAPTER 5
Sampling Distributions 311

Introduction 311

5.1 Sampling Distributions for Counts and Proportions 313
The binomial distributions for sample counts 314
Binomial distributions in statistical sampling 315
Finding binomial probabilities: software and tables 316
Binomial mean and standard deviation 319
Sample proportions 321
Normal approximation for counts and proportions 322
The continuity correction* 326
Binomial formula* 327
Section 5.1 Summary 330
Section 5.1 Exercises 331

5.2 The Sampling Distribution of a Sample Mean 335
The mean and standard deviation of $\bar{x}$ 337
The central limit theorem 339
A few more facts 343
Beyond the basics: Weibull distributions 344
Section 5.2 Summary 346
Section 5.2 Exercises 348
Chapter 5 Exercises 350

CHAPTER 6
Introduction to Inference 353

Introduction 353
Overview of inference 354

6.1 Estimating with Confidence 356
Statistical confidence 356
Confidence intervals 358
Confidence interval for a population mean 360
How confidence intervals behave 363
Choosing the sample size 364
Some cautions 366
Beyond the basics: the bootstrap 368
Section 6.1 Summary 368
Section 6.1 Exercises 369

6.2 Tests of Significance 372
The reasoning of significance tests 372

Stating hypotheses 374
Test statistics 376
P-values 377
Statistical significance 379
Tests for a population mean 382
Two-sided significance tests and confidence intervals 386
P-values versus fixed α 388
Section 6.2 Summary 390
Section 6.2 Exercises 390

6.3 Use and Abuse of Tests 394
Choosing a level of significance 395
What statistical significance does not mean 396
Don't ignore lack of significance 397
Statistical inference is not valid for all sets of data 398
Beware of searching for significance 398
Section 6.3 Summary 399
Section 6.3 Exercises 399

6.4 Power and Inference as a Decision* 401
Power 401
Increasing the power 405
Inference as decision* 406
Two types of error 406
Error probabilities 407
The common practice of testing hypotheses 409
Section 6.4 Summary 410
Section 6.4 Exercises 410
Chapter 6 Exercises 412

CHAPTER 7
Inference for Distributions 417

Introduction 417

7.1 Inference for the Mean of a Population 418
The *t* distributions 418
The one-sample *t* confidence interval 420
The one-sample *t* test 422
Matched pairs *t* procedures 428
Robustness of the *t* procedures 432
The power of the *t* test* 433
Inference for non-Normal populations* 435
Section 7.1 Summary 440
Section 7.1 Exercises 441

7.2 Comparing Two Means 447
The two-sample *z* statistic 448
The two-sample *t* procedures 450
The two-sample *t* significance test 451
The two-sample *t* confidence interval 454
Robustness of the two-sample procedures 456
Inference for small samples 457
Software approximation for the degrees of freedom* 460
The pooled two-sample *t* procedures* 461
Section 7.2 Summary 466
Section 7.2 Exercises 467

7.3 Optional Topics in Comparing Distributions* 473
Inference for population spread 473
The *F* test for equality of spread 474
Robustness of Normal inference procedures 476
The power of the two-sample *t* test 477
Section 7.3 Summary 479
Section 7.3 Exercises 479
Chapter 7 Exercises 481

CHAPTER 8
Inference for Proportions 487

Introduction 487

8.1 Inference for a Single Proportion 488
Large-sample confidence interval for a single proportion 488
Beyond the basics: the plus four confidence interval for a single proportion 491
Significance test for a single proportion 493
Confidence intervals provide additional information 496
Choosing a sample size 498
Section 8.1 Summary 501
Section 8.1 Exercises 502

8.2 Comparing Two Proportions 505
Large-sample confidence interval for a difference in proportions 506
Beyond the basics: plus four confidence interval for a difference in proportions 509
Significance test for a difference in proportions 511
Beyond the basics: relative risk 515
Section 8.2 Summary 516
Section 8.2 Exercises 517
Chapter 8 Exercises 519

PART III Topics in Inference

CHAPTER 9
Analysis of Two-Way Tables 525

Introduction 525

9.1 Inference for Two-Way Tables 526
- The hypothesis: no association 529
- Expected cell counts 529
- The chi-square test 530
- The chi-square test and the z test 533
- Beyond the basics: meta-analysis 534
- Section 9.1 Summary 536

9.2 Formulas and Models for Two-Way Tables* 536
- Computations 536
- Computing conditional distributions 537
- Computing expected cell counts 540
- The X^2 statistic and its P-value 540
- Models for two-way tables 541
- Concluding remarks 544
- Section 9.2 Summary 545

9.3 Goodness of Fit* 545
- Section 9.3 Summary 548
- Chapter 9 Exercises 548

CHAPTER 10
Inference for Regression 559

Introduction 559

10.1 Simple Linear Regression 560
- Statistical model for linear regression 560
- Data for simple linear regression 561
- Estimating the regression parameters 565
- Confidence intervals and significance tests 570
- Confidence intervals for mean response 572
- Prediction intervals 574
- Beyond the basics: nonlinear regression 576
- Section 10.1 Summary 578

10.2 More Detail about Simple Linear Regression* 579
- Analysis of variance for regression 579
- The ANOVA F test 581
- Calculations for regression inference 583
- Inference for correlation 590
- Section 10.2 Summary 593
- Chapter 10 Exercises 594

CHAPTER 11
Multiple Regression 607

Introduction 607

11.1 Inference for Multiple Regression 607
- Population multiple regression equation 607
- Data for multiple regression 608
- Multiple linear regression model 609
- Estimation of the multiple regression parameters 610
- Confidence intervals and significance tests for regression coefficients 611
- ANOVA table for multiple regression 612
- Squared multiple correlation R^2 613

11.2 A Case Study 615
- Preliminary analysis 615
- Relationships between pairs of variables 616
- Regression on high school grades 618
- Interpretation of results 619
- Residuals 620
- Refining the model 621
- Regression on SAT scores 622
- Regression using all variables 623
- Test for a collection of regression coefficients 623
- Beyond the basics: multiple logistic regression 625
- Chapter 11 Summary 627
- Chapter 11 Exercises 628

CHAPTER 12
One-Way Analysis of Variance 637

Introduction 637

12.1 Inference for One-Way Analysis of Variance 638
- Data for one-way ANOVA 638
- Comparing means 639
- The two-sample t statistic 640
- An overview of ANOVA 641
- The ANOVA model 644
- Estimates of population parameters 646
- Testing hypotheses in one-way ANOVA 648
- The ANOVA table 649
- The F test 652

12.2 Comparing the Means 655
Contrasts 655
Multiple comparisons 661
Software 665
Power* 666
Section 12.2 Summary 669
Chapter 12 Exercises 670

CHAPTER 13
Two-Way Analysis of Variance 683

Introduction 683

13.1 The Two-Way ANOVA Model 684
Advantages of two-way ANOVA 684
The two-way ANOVA model 688
Main effects and interactions 689

13.2 Inference for Two-Way ANOVA 694
The ANOVA table for two-way ANOVA 694
Section 13.2 Summary 695
Chapter 13 Exercises 699

Companion Chapters for the IPS Web site www.whfreeman.com/ips6e and CD-ROM)

CHAPTER 14
Logistic Regression 14-1

Introduction 14-1

14.1 The Logistic Regression Model 14-1
Binomial distributions and odds 14-2
Odds for two samples 14-3
Model for logistic regression 14-4
Fitting and interpreting the logistic regression model 14-6

14.2 Inference for Logistic Regression 14-8
Confidence intervals and significance tests 14-8
Multiple logistic regression 14-14
Section 14.2 Summary 14-16
Chapter 14 Exercises 14-17
Chapter 14 Notes 14-23

CHAPTER 15
Nonparametric Tests 15-1

Introduction 15-1

15.1 The Wilcoxon Rank Sum Test 15-3
The rank transformation 15-4
The Wilcoxon rank sum test 15-5
The Normal approximation 15-7
What hypotheses does Wilcoxon test? 15-8
Ties 15-10
Rank, *t*, and permutation tests 15-12
Section 15.1 Summary 15-14
Section 15.1 Exercises 15-15

15.2 The Wilcoxon Signed Rank Test 15-17
The Normal approximation 15-20
Ties 15-21
Section 15.2 Summary 15-23
Section 15.2 Exercises 15-23

15.3 The Kruskal-Wallis Test* 15-26
Hypotheses and assumptions 15-28
The Kruskal-Wallis test 15-28
Section 15.3 Summary 15-30
Section 15.3 Exercises 15-31
Chapter 15 Exercises 15-33
Chapter 15 Notes 15-35

CHAPTER 16
Bootstrap Methods and Permutation Tests 16-1

Introduction 16-1
Software 16-2

16.1 The Bootstrap Idea 16-3
The big idea: resampling and the bootstrap distribution 16-4
Thinking about the bootstrap idea 16-9
Using software 16-10
Section 16.1 Summary 16-11
Section 16.1 Exercises 16-11

16.2 First Steps in Using the Bootstrap 16-13
Bootstrap *t* confidence intervals 16-13
Bootstrapping to compare two groups 16-17
Beyond the basics: the bootstrap for a scatterplot smoother 16-20
Section 16.2 Summary 16-21
Section 16.2 Exercises 16-22

16.3 How Accurate Is a Bootstrap Distribution?* 16-24
Bootstrapping small samples 16-26
Bootstrapping a sample median 16-28
Section 16.3 Summary 16-28
Section 16.3 Exercises 16-30

16.4 Bootstrap Confidence Intervals 16-30
Bootstrap percentile confidence intervals 16-31
More accurate bootstrap confidence intervals: BCa and tilting 16-32
Confidence intervals for the correlation 16-35
Section 16.4 Summary 16-38
Section 16.4 Exercises 16-38

16.5 Significance Testing Using Permutation Tests 16-41
Using software 16-45
Permutation tests in practice 16-45
Permutation tests in other settings 16-49
Section 16.5 Summary 16-52
Section 16.5 Exercises 16-52
Chapter 16 Exercises 16-56
Chapter 16 Notes 16-59

CHAPTER 17
Statistics for Quality: Control and Capability 17-1

Introduction 17-1
Use of data to assess quality 17-2

17.1 Processes and Statistical Process Control 17-3
Describing processes 17-3
Statistical process control 17-6
$\bar{x}$ charts for process monitoring 17-8
s charts for process monitoring 17-12
Section 17.1 Summary 17-17
Section 17.1 Exercises 17-17

17.2 Using Control Charts 17-21
$\bar{x}$ and R charts 17-22
Additional out-of-control rules 17-23
Setting up control charts 17-25
Comments on statistical control 17-30
Don't confuse control with capability! 17-33
Section 17.2 Summary 17-34
Section 17.2 Exercises 17-35

17.3 Process Capability Indexes* 17-39
The capability indexes C_p and C_{pk} 17-41
Cautions about capability indexes 17-44
Section 17.3 Summary 17-45
Section 17.3 Exercises 17-46

17.4 Control Charts for Sample Proportions 17-49
Control limits for p charts 17-50
Section 17.4 Summary 17-54
Section 17.4 Exercises 17-54
Chapter 17 Exercises 17-56
Chapter 17 Notes 17-57

Data Appendix D-1
Tables T-1
Answers to Odd-Numbered Exercises A-1
Notes and Data Sources N-1
Photo Credits C-1
Index I-1