Index

• **Symbols** •

! sign, 331

• **A** •

addition rule, 31–32, 34–35
“and,” 38
answers, checking, 319–321
approximating binomial distribution
with normal distribution, 188–192
at least, 21
at most, 21
auto insurance probability example, 11

• **B** •

backwards normal problems
fish length example, 181–186
overview, 180–181
returning to X units, using Z-formula
solved for X, 185–186
setting up, 181–183
using Z table backward, 183–185
finding Z given greater-than probability, 184–185
finding Z given less-than probability, 183–184
overview, 183
bank entry example, 248
basketball free throw example
contingency table, 68–73
expected value of variance formulas, 271–272
geometric distribution, 256
negative binomial probability formula, 266–268, 270
whether 50-50 situation, 17
basketball tournament example, 16
Bayes’ Theorem
blood test example, 60, 63
finding posterior probability with, 60–64
formalizing Bayes’ Theorem, 61–62
overview, 60–61
setting up tree diagram and putting in probabilities, 62
grocery example, 56
restaurant example, 61–63, 64
beads in jar example, 154
between-values probabilities
and cdf, 142–143
for an exponential, 305–307
BINGO, 121–124
overview, 121
probability of winning, 123–124
ways to win, 121–123
binomial distribution
approximating with normal distribution
coin example, 197–200
determining if n is large enough, 192–193
finding mean and standard deviation
to put in Z-formula, 193
identifying when you need to, 187–188
making continuity correction, 194–197
overview, 187, 192
why normal approximation works
when n is large enough, 188–192
beads in jar example, 154
cdf of, table, 333–336
choosing geometric distribution over, 253–254
coin flip example, 152–157, 163
comparing and contrasting with
negative binomial distribution, 262–263
expected value of binomial, 165
binomial distribution (continued)
finding probabilities for binomial,
  155–164
  with cdf, 160–164
  overview, 155
  with pmf, 155–160
negative
  applying expected value and variance formulas, 271–272
  applying negative binomial pmf, 265–269
  checking off conditions for, 262
  comparing and contrasting with geometric and binomial models, 262–263
  developing negative binomial probability formula, 264–265
  expected value of, 269–270
  overview, 261
  recognizing, 261–263
  variance and standard deviation of, 270–271
overview, 151
versus Poisson distribution, 237
recognizing
  checking binomial conditions step by step, 152–153
  overview, 151–152
  spotting variable that isn’t binomial, 153–154
  traffic light example, 157–158, 161
  variance and standard deviation of binomial, 166
birdfeeder example, 14, 15
birth and death process, 309
birth rates, 235
birthday problem, 103
blood test example, 60, 63
Bonferroni approach, 230
brackets, 22
branches, in tree diagrams, 48

• C •
calculus, 301
capture-recapture technique, 282
car insurance example, 11
cards example. See also Poker hands combinations, 92–93, 101
independence or exclusivity, 37
mutually exclusive events, 35–36
carpet blemish example, 241, 242, 244–245
cdf. See cumulative distribution function
cells, 69
center, of normal distribution, 168–170
Central Limit Theorem (CLT)
  applied to sample mean, 215
  applied to sample proportion, 217–218
  applied to sample total, 210–211
die-rolling example, 207–214,
  216–217, 219
  main results of, 205–206
overview, 205
  why works, 206–206
chance, concept of, 10
checking answers, 319–321
checking conditions, 317
classical approach to probability
die-roll example, 13
random processes, 14
refrigerator-repair example, 14
CLT. See Central Limit Theorem
coin-flipping example
  approximate binomials, 188
  binomial conditions, 152–154
  binomial probabilities, 156–157, 163
  independent events, 51
  mutually exclusive events, 35
  normal approximation to binomial,
    193, 197–200
patterns, 18
symmetric situations, 191
columns, in contingency tables, 69
columns bet, 117, 120
combinations
cards example, 92–102
comic book example, 102
committee-choosing example, 100–101
confusing with permutations, 330–331
finding probabilities involving
  calculating probabilities for poker hands, 101–102
  choosing with restrictions, 100–101
  grouping and regrouping, 102
  overview, 100
lottery example, 92–93
overview, 88
and Pascal’s Triangle, 90–91
probability problems involving
  overview, 91
  picking items in any order with no repeats allowed, 92
  picking items in any order with repeats allowed, 92–93
  splitting objects or individuals into two groups, 91
  seating arrangement example, 91
  solving combination problems, 89
comic book example, 102
committee-choosing example
  combinations, 100–101
  hypergeometric distribution, 274–282
  represented by tree diagram, 52–56
complement probabilities, 26–27
complement rule, 29–30, 178
complements, 23, 35
complex problems, finding probabilities
  for with Venn diagrams
  answering “exactly one” question, 47
  answering “neither” question, 46–47
  overview, 45
  setting up diagram, 45–46
computer game example, 298
conditional probabilities, 24
die-roll example, 27
identifying, 38
organizing with tree diagrams
  connecting tree’s branches to rules of probability, 53–54
  for dependent events, 52–53
  for independent events, 51
  overview, 51
confidence intervals
  assessing cost of probably, 224–225
  creating for p, 222–223
die-roll probability example, 225
dog “debris” example, 222
figuring with Z table, 223–224
interpreting with probability, 225
overview, 221–222
Consumer Reports magazine, and relative frequency approach, 15
contingency tables
  basket ball free throw example, 68–73
  checking for independence of two events, 74–75
  finding and interpreting probabilities within
    calculating marginal probabilities, 71–72
    figuring joint probabilities, 71
    identifying conditional probabilities, 72–73
    overview, 70
organizing
  adding row, column, and grand totals, 70
  defining sample space, 68
  inserting data, 69
  overview, 67–68
  setting up rows and columns, 69
  overview, 67
continuous distribution, 167, 190
continuous random variables, 133
continuous uniform distribution
corraling cumulative probabilities,
  using F(x), 294–296
determining density function for,
  287–290
building general form of f(x), 287–288
finding f(x) given a and b, 288–289
finding value of b given f(x), 289–290
overview, 287
drawing up probabilities for, 290–294
finding greater-than probabilities,
  292–293
finding less-than probabilities,
  291–292
finding probabilities between two
  values, 293–294
overview, 290
expected value of, 297
overview, 285–286
variance and standard deviation of,
  297–298
corner bet, 119, 120
countably infinite sample spaces, 20
counting rules
combinations
  finding probabilities involving,
    100–102
  overview, 88
  and Pascal’s Triangle, 90–91
probability problems involving, 91–93
solving combination problems, 89
studying through poker hands, 93–99
overview, 77
permutations
  finding probabilities involving
    permutations, 86–88
  overview, 78
  permutation problems with added
    restrictions, 82–86
  unraveling permutation, 78–82
crosspatch pattern, in Venn diagrams, 43
cumulative distribution function (cdf)
of binomial distribution, 333–336
determining probability mass function
  (pmf) given cdf, 143–144
die-rolling example, 138–139
of discrete uniform, 149–150
finding probabilities for binomial with,
  160–164
finding probabilities with, 141–143
graphing, 140–141
interpreting, 139
overview, 138–139
of Poisson distribution
carpet blemish example, 241, 242
figuring greater-than probabilities,
  241–242
figuring less-than or equal-to
  probabilities, 241
figuring probabilities between two
  values, 242
overview, 240
of Z distribution, 338–339

• D •
data insertion, in contingency tables, 69
data snoopers, 230
dauber, 122
de Moivre, Abraham, 204
death rates, 235
decisions, investigating and making with
  probability
  confidence intervals
    assessing cost of probably, 224–225
    creating for p, 222–223
  interpreting with probability, 225
  overview, 221–222
hypothesis testing
  accepting probability of making wrong
    decision, 229–230
  and data snoopers, 230
overview, 226
putting p in probability with
p-values, 228
testing probability, 226–227
overview, 221
quality control, 231–232
definitions. See terminology
DeMorgan’s Laws, 43
density function
determining for continuous uniform
distribution
building general form of f(x), 287–288
finding f(x) given a and b, 288–289
finding value of b given f(x), 289–290
overview, 287
for exponential distribution,
identifying, 300–301
density function of X, 286
dependence, checking for, 75
dependent events, organizing
probabilities for, 52–53
diagrams
tree
for finding probabilities for complex
events, 54–56
limitations of, 54
organizing conditional probabilities
with, 51–54
overview, 47–48
and restaurant probability
problem, 62
setting up for finding marginal
probability using LTP, 58
showing multi-stage outcomes with,
49–50
Venn
finding probabilities beyond those
given, 40–41
finding probabilities for complex
problems with, 45–47
limitations of, 44
organizing and visualizing
relationships, 41–42
overview, 40
proving intermediate rules about sets,
42–44
die-rolling example, 23
Central Limit Theorem (CLT), 207–214,
216–217, 219
checking independence of two events,
32–33
classical approach to probability, 13
complement rule, 29–30
conditional probability, 27
confidence intervals, 225
cumulative distribution function (cdf),
138–139
expected value of random variable, 145
geometric distribution, 255, 258
hypothesis testing, 226
margin of probability, 25
multiplication rule for independent
events, 34
negative binomial probability formula,
264–265
pmf of discrete uniform example, 149
probability distribution, 133–134
probability mappings for single die, 25
p-values, 228
represented by Venn diagram, 42
sample spaces, 20, 21
discrete random variables
calculating variance of, 147–148
finding expected value of, 145–146
finding standard deviation of, 148
probability distribution of
defining random variable, 132–133
finding and using probability
distribution, 133–138
discrete uniform distribution
cdf of, 149–150
expected value of, 150
overview, 148
pmf of, 149
standard deviation of, 150
variance of, 150
disease-testing evaluation, using conditional probabilities with, 28
distribution. See probability distribution
Doctrine of Chances, The, 204
dog “debris” example
confidence intervals, 222
hypothesis testing, 226
domain of X, 286
dozens bet, 117, 120

• E •
empty sets, 22
endpoints, 22
envelope choosing example, 277–279
equal-to probabilities
and cdf, 141–142
and cdf of the Poisson, 241
using binomial cdf to find, 162–163
error, margin of. See margin of error
events
complements of, 23
dependent, organizing probabilities for,
  52–53
independent
  distinguishing from mutually exclusive, 36–38
  organizing probabilities for, 51
multiple, independence in
  checking with definition, 32–33
  overview, 32
  utilizing multiplication rule for independent events, 33–34
mutually exclusive
  distinguishing from independent events, 36–38
  overview, 34
  recognizing, 34–35
  simplifying addition rule with, 34–35
  overview, 21–22
relationships between, represented by Venn diagrams, 41
eyeveryday life, probability in, 11–12

“exactly one” question, 47
expected value
  of binomial, 165
  of continuous uniform distribution, 297
  of discrete random variable, 145–146
  of discrete uniform, 150
  of exponential distribution, 307–308
  gaming, 104
  of geometric distribution, 258–259
  of negative binomial distribution, 269–270
  of Poisson distribution, 243
  of random variable, 145, 146
  of variance formulas, 271–272
exponential distribution
  expected value of, 307–308
  finding between-values probability for, 305–307
  finding greater-than probability for, 304–305
  finding less-than probability for, 302–304
grocery-line example, 304–305, 306–308
help desk example, 307
identifying density function for, 300–301
overview, 299–300
relating Poisson and exponential distributions, 309–310
variance and standard deviation of, 308–309

• F •
factorials, 78, 79
false alarms, 229
50-50 proposition, 17
finite samples spaces, 20
fishing examples
  handling backwards normal problems, 181–183, 185–186
  hypergeometric distribution, 282
  probabilities for normal distribution, 173–174
five-number bet, 119, 120
formulas, writing down, 316–317
frequencies, relative, 14–15

• G •
g conditional probabilities, 72–73
  gaming
    BINGO, 121–124
    overview, 121
    probability of winning, 123–124
    ways to win, 121–123
  expected value, 104
  famous birthday problem, 126–127
  knowing what you’re up against, 125
  lottery
    figuring odds, 107
    finding expected value of ticket, 107–111
    overview, 105
    probability of winning, 105–106
  odds, 104
  overview, 103
  roulette wheel
    chances and expected payouts on, 119–120
    developing strategy for, 120–121
    overview, 116–117
  placing inside bet, 119
  placing outside bet, 117–118
slot machines
  average payout, 111–112
  myths about, 113–114
  overview, 111
  strategy for, 114–115
geometric distribution
  basketball free throw example, 256
  choosing over binomial and Poisson, 253–254
  compared to negative binomial distribution, 262–263
  die-rolling example, 255, 258
  expected value of, 258–259
  finding probabilities for using pmf
    applying geometric probabilities, 256–257
    building pmf for geometric, 255
    overview, 254–255
    meeting conditions for, 252
    overview, 251–252
  student counting example, 254
  variance and standard deviation of, 259–260
  grand totals, in contingency tables, 70
  graphing
    binomial cdf, 164
    cumulative distribution function (cdf), 140–141
    greater-than probabilities
      and cdf of the Poisson, 241–242
      and continuous uniform distribution, 292–293
    for exponential, 304–305
    finding Z given a greater-than probability, 184–185
  general discussion, 141–142
  overview, 21
  quiz grading example, 292
  using binomial cdf to find, 163
  for Z, 178–179
grocery example
  Bayes’ Theorum, 56
  exponential distribution, 304–305, 306–308
  grouping, 102

• H •
helpdesk example
  exponential distribution, 307
  pmf of Poisson, 238
histograms
  plotting distribution of discrete random variable, 135–136
  relative frequency histograms, 135, 158–160
hot streaks, 113
house edge, 108
hurricane prediction, 16
hypergeometric distribution
committee-choosing example, 274–282
conditions for, 274–275
envelope choosing example, 277–279
expected value of, 281
finding probabilities for
breaking down boundary conditions for X, 277–279
finding and using pmf to calculate probabilities, 279–280
overview, 275
setting up hypergeometric pmf, 275–277
fish pond example, 282
overview, 273
variance and standard deviation of, 281–282
hypothesis testing
accepting probability of making wrong decision, 229–230
and data snoopers, 230
die-rolling example, 226
dog “debris” example, 226
overview, 226
putting p in probability with p-values, 228
testing probability, 226–227

I

independence
assuming, 331–332
card deck example, 37
coin flip example, 51
distinguishing from mutually exclusive events, 36–38
in multiple events
checking with definition, 32–33
overview, 32
utilizing multiplication rule for independent events, 33–34
organizing probabilities for, 51
in two events
checking for, 74–75
die-roll example, 32–33
inequalities, 21
information, organizing, 315–316
instant lottery game example, 10–11
insurance example, 11
integration by parts, 308
intermediate rules about sets, proving, 42–44
interpreting probabilities, 10–11
interpreting results, 321
intersection (joint) probabilities, 23, 26, 30–31, 38, 54
interval notation, 22
intervals, 20
intuition, 17

J

joint (intersection) probabilities, 23, 26, 30–31, 38, 54
joint probabilities, 31, 71

L

law of averages, 114
Law of Total Probability, finding marginal probability using
finding total probability, 59–60
formalizing Law of Total Probability, 57–58
overview, 57
plugging in probabilities, 58–59
restaurant example, 58–60
setting up tree diagram, 58
less-than probabilities
and cdf of the Poisson, 241
and continuous uniform distribution, 291–292
finding for an exponential, 302–304
finding Z given a less-than probability, 183–184
overview, 21
quiz grading example, 291
using binomial cdf to find, 162–163
using cdf to find, 141–142
for Z, 178
long-term average amount, gaming, 104
long-term percentages, 10
lottery
combinations, 92–93
expected value of ticket
overview, 107
pick-three, 107–108
Powerball, 108–111
figuring odds, 107
overview, 105
probability of winning
overview, 105
pick three, 105
Powerball, 106
low-high bet, 117, 120

- M -
mapping out probabilities. See tree diagrams
margin of error (MOE), 16, 222–224
marginal probabilities
calculating, 71–72
finding using Law of Total Probability
formalizing LTP, 57–58
overview, 57
plugging in probabilities, 58–59
putting probabilities together to find
total probability, 59–60
setting up tree diagram, 58
overview, 25
and tree diagrams, 53
marginal totals, 70
medication example, 11
misconceptions
overview, 17
thinking in 50-50 terms, 17
thinking that patterns can’t occur, 18
mistakes
applying wrong probability
distribution, 328–329
assuming independence, 331–332
being “on a roll,” 326
confusing permutations and
combinations, 330–331
forgetting probability must be between
zero and one, 323–324
giving every situation 50-50 chance,
326–327
leaving probability model conditions
unchecked, 329–330
misinterpreting small probabilities, 324
overview, 323
switching conditional probabilities
around, 327–328
thinking that sequence can’t win,
325–326
using probability for short-term
predictions, 325
MOE (margin of error), 16, 222–224
multiple events, independence in
checking with definition, 32–33
overview, 32
utilizing multiplication rule for, 33–34
multiplication rule, 30–31, 32, 34,
105–106, 126
multi-stage outcomes, showing with tree
diagrams, 49–50
mutually exclusive events
card deck example, 35–36
coin flip example, 35
distinguishing from independent
events, 36–38
overview, 34
recognizing, 34–35
simplifying addition rule with, 34–35
• **N** •

negative binomial distribution
  - applying expected value and variance formulas, 271–272
  - applying negative binomial pmf, 265–269
  - basketball free throw example, 266–268, 270
  - checking off conditions for, 262
  - compared with geometric and binomial models, 262–263
  - developing negative binomial probability formula, 264–265
  - die-roll example, 264–265
  - expected value of, 269–270
  - overview, 261
  - recognizing, 261–263
  - variance and standard deviation of, 270–271

“neither” question, 46–47

n-factorial, 156

normal distribution
  - approximating binomial with coin flip example, 193, 197–200
  - determining if n is large enough, 192–193
  - finding mean and standard deviation to put in Z-formula, 193
  - identifying when you need to, 187–188
  - making continuity correction, 194–197
  - overview, 187, 192
  - why normal approximation works when n is large enough, 188–192

approximating Poisson distribution with
  - completing steps for, 248–250
  - overview, 245
  - satisfying conditions for, 246–247

center, 168–170

finding and using probabilities for getting picture, 173

overview, 172–173

translating problem into probability notation, 173–174

using Z table, 176–180

using Z-formula, 174–175

handling backwards normal problems
  - overview, 180–181
  - returning to X units, using Z-formula solved for X, 185–186
  - setting up backwards normal problem, 181–183

using Z table backward, 183–185

overview, 167

shape, 168–170

spread, 168–170

standard normal (Z) distribution
  - changing from X units to Z units, 171–172
  - overview, 170
  - standard scores, 170–171

normal table, 337–339

not less than, 21

not more than, 21

notation, 19, 24–25, 68

null hypothesis, 226

null sets, 22

number-picking example, 18

• **O** •

odd-even bet, 117, 120

odds, difference from probability, 9

“of,” 38

opposites, complement rule for, 29–30

“or,” 38

order of operations, 318

organizing information, 315–316

organizing relationships, 41–42

outcomes, sample spaces
  - countably infinite, 20
  - finite, 20

overview, 19–20

subsets of. See events

uncountably infinite, 20
Index

\[ p \]

parameter, 300
parentheses, 318
Pascal’s Triangle, 90–91
patterns, 18
penny slot machines, 115
percentages, long-term, 10
permutations
   confusing with combinations, 330–331
   finding probabilities involving, 86–88
   overview, 78
   prize example, 89
   problems with added restrictions, 82–86
   seating arrangement example, 78–84, 87–88
   unraveling, 78–82
phone call example, 20–21
pick-three lottery
   finding expected value of ticket, 107–108
   probability of winning, 105
picturing probabilities. See tree diagrams; Venn diagrams
pizza orders example, 49–50
pmf. See probability mass function
Poisson, Simeon Denis, 235
Poisson distribution
   approximating with normal
   completing steps for, 248–250
   overview, 245
   satisfying conditions for using normal approximation, 246–247
bank entry example, 248
versus binomial, 237
carpet blemish example, 244–245
cdf of
   figuring greater-than probabilities, 241–242
   figuring less-than or equal-to probabilities, 241
   figuring probabilities between two values, 242
   overview, 240
   table, 341
   changing units over time or space, 244–245
   choosing geometric distribution over, 253–254
   identifying expected value and variance of, 243
   meeting conditions for Poisson model, 236
   overview, 235
   pmf of, 238–239
poker hands
   calculating probabilities for, 101–102
   studying complex combinations through
   figuring number of ways to draw each hand, 95–99
   overview, 93–94
   ranking poker hands, 94–95
political affiliation example, 11
Powerball lottery
   finding expected value of ticket, 108–111
   probability of winning, 106
   prize example, 89
   probability, defined, 9
probability density function, 168, 169
probability distribution. See also
   binomial distribution; continuous uniform distribution; cumulative distribution function (cdf); normal distribution; Poisson distribution
   calculating variance of discrete random variable, 147–148
die-roll probability example, 133–134
of discrete random variable
   defining random variable, 132–133
   finding and using probability distribution, 133–138
probability distribution, of discrete random variable (continued)
finding expected value, 145–146
finding standard deviation, 148
overview, 131–132
discrete uniform distribution, 148–150
exponential distribution
expected value of, 307–308
finding between-values probability for, 305–307
finding greater-than probability for, 304–305
finding less-than probability for, 302–304
grocery-line example, 304–305, 306–308
help desk example, 307
identifying density function for, 300–301
overview, 299–300
relating Poisson and exponential distributions, 309–310
variance and standard deviation of, 308–309
geometric distribution
basketball free throw example, 256
choosing over binomial and Poisson, 253–254
compared to negative binomial distribution, 262–263
die-rolling example, 255, 258
expected value of, 258–259
finding probabilities for using pmf, 254–257
meeting conditions for, 252
overview, 251–252
student counting example, 254
variance and standard deviation of, 259–260
hypergeometric distribution
committee-choosing example, 274–282
conditions for, 274–275
envelope choosing example, 277–279
expected value of, 281
finding probabilities for, 275–279
fish pond example, 282
overview, 273
variance and standard deviation of, 281–282
negative binomial distribution
applying expected value and variance formulas, 271–272
applying negative binomial pmf, 265–269
basketball free throw example, 266–268, 270
checking off conditions for, 262
compared with geometric and binomial models, 262–263
developing negative binomial probability formula, 264–265
die-roll example, 264–265
expected value of, 269–270
overview, 261
recognizing, 261–263
variance and standard deviation of, 270–271
overview, 131, 144–145
sampling distributions
overview, 201–202
rollercoaster example, 203–204
of sample mean, $\bar{X}$, 214–217
of sample proportion, $\hat{p}$, 217–219
of sample total (t), 210–214
surveying, 202–205
uniform distribution, 298
probability mass function (pmf)
determining, given cdf, 143–144
of discrete uniform, 149
finding probabilities for binomial using, 155–160
<table>
<thead>
<tr>
<th>Finding Probabilities for Geometric Distribution Using</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying Geometric Probabilities, 256–257</td>
</tr>
<tr>
<td>Building PMF for Geometric, 255 Overview, 254–255</td>
</tr>
<tr>
<td>Hypergeometric, 279–280</td>
</tr>
<tr>
<td>Negative Binomial PMF, 265–269</td>
</tr>
<tr>
<td>Of Poisson Distribution, 238–239</td>
</tr>
<tr>
<td>Probability Notation, 19, 24–25, 68</td>
</tr>
<tr>
<td>P-Values, 228</td>
</tr>
</tbody>
</table>

| Quality Control, 231–232, 269 |
| Queuing Theory, 309 |
| Quiz Grading Example |
| Greater-Than Probabilities, 292 |
| Less-Than Probabilities, 291 |

| Random Numbers, 18, 298 |
| Random Processes, 10, 14, 19 |
| Random Variables |
| Continuous, 133 |
| Discrete |
| Calculating Variance of, 147–148 |
| Finding Expected Value of, 145–146 |
| Finding Standard Deviation of, 148 |
| Probability Distribution of, 132–138 |
| Red-Black Bet, 117, 120 |
| Reference Tables |
| Binomial Table, 333–336 |
| Normal Table, 337–339 |
| Overview, 333 |
| Poisson Table, 340–341 |
| Refrigerator-Repair Example, 14 |
| Refrigerator-Sales Example, 146 |
| Relationships Between Events, 41 |
| Relative Frequencies, 14–15 |
| Relative Frequency Histograms, 135, 158–160 |
| Restaurant Example |
| Bayes' Theorum, 61–63, 64 |
| Law of Total Probability, 58–60 |
| Results, Interpreting, 321 |
| Revell, Ashley, 121 |
| Review Sheets, 321–322 |
| Rollercoaster Example, 203–204 |
| Roulette Wheel |
| Chances and Expected Payouts On, 119–120 |
| Developing Strategy For, 120–121 |
| Overview, 116–117 |
| Placing Inside Bet, 119 |
| Placing Outside Bet, 117–118 |
| Round Brackets, 22 |
| Rounding Off, 318 |
| Rows, In Contingency Tables, 69–70 |
| Rules of Probability |
| Addition Rule For Unions, 31–32 |
| Complement Rule For Opposites, 29–30 |
| Connecting Tree Diagram's Branches To, 53–54 |
| Multiplication Rule For Intersections, 30–31 |
| Overview, 29 |
| Ryan, Mark, 301, 304, 305, 307 |

| Saddle Points, 168–169 |
| Sample Spaces |
| Countably Infinite, 20 |
| Die-Rolling Example, 20, 21 |
| Finite, 20 |
| Overview, 19–20 |
| Phone Call Example, 20, 21 |
| Subsets Of. See Events |
| Uncountably Infinite, 20 |
sampling distributions
overview, 201–202
rollercoaster example, 203–204
of sample mean, $X$
   CLT applied to sample mean, 215
   finding probabilities for $X$ with CLT, 216–217
   overview, 214
of sample proportion, $\hat{p}$
   CLT applied to sample proportion, 217–218
   finding probabilities for $\hat{p}$ with CLT, 218–219
   overview, 217
of sample total (t)
   CLT applied to sample total, 210–211
   finding probabilities for $t$ with CLT, 211–214
   overview, 210
surveying
   and Central Limit Theorem, 204–205
   lining up possibilities with sampling distribution, 202–204
   overview, 202
   setting up your sample statistic, 202
seating arrangement example
combinations, 91
permutations, 78–84, 87–88
set notation
complements, 23
empty sets, 22
events, 21–22
intersections, 23
overview, 19
sample spaces, 19–20
unions, 23
sets
defined, 20
intermediate rules about, proving, 42–44
and Venn diagrams, 40
shape, of normal distribution, 168–170
significance level, 227
simulations, 15–16
“sing” example, 86–87
skewed situations, 188, 190–192
slot machines
   average payout, 111–112
   myths about, 113–114
   overview, 111
   strategy for, 114–115
solving probability problems, steps for calculating with confidence, 318
   checking answer, 319–321
   checking conditions, 317
   getting into problem, 314
   interpreting results, 321
   making review sheet, 321–322
   organizing information, 315–316
   overview, 313
   showing work, 319
   understanding question, 314–315
   writing down needed formulas, 316–317
split bet, 119, 120
spread, of normal distribution, 168–170
square brackets, 22
standard deviation
   of binomial, 166
   of continuous uniform distribution, 297–298
   of discrete random variable, 148
   of discrete uniform, 150
   of exponential distribution, 308–309
   of geometric distribution, 259–260
   of hypergeometric distribution, 281–282
   of negative binomial distribution, 270–271
standard error, 211, 215
standard normal (Z) distribution
   changing from X units to Z units, 171–172
   overview, 170
   standard scores, 170–171
statistics, 15
storm prediction, 16
straight bet, 119, 120
street bet, 119, 120
student-counting example, 254
subjective approach to probability, 13
subsets of sample spaces. See events
surrender rule, 120
surveys, 199
symmetric situations, 188, 189–190, 191

d • T •
tables. See contingency tables
terminology
• complement probabilities, 26–27
• conditional probabilities
  overview, 27
  solving conditional probabilities with
  formula, 27–28
  solving conditional probabilities
  without formula, 27
• definition of probability, 9
• independence in multiple events
  checking with definition, 32–33
  overview, 32
  utilizing multiplication rule for
  independent events, 33–34
• intersection (joint) probabilities, 26
• marginal probabilities, 25
• mutually exclusive events
  distinguishing from independent
  events, 36–38
  overview, 34
  recognizing, 34–35
  simplifying addition rule with, 34–35
  overview, 19
• probability notation, 24–25
• rules of probability
  addition rule for unions, 31–32
  complement rule for opposites, 29–30
  multiplication rule for intersections,
  30–31
  overview, 29
set notation
• complements, 23
• empty sets, 22
• events, 21–22
• intersections, 23
• overview, 19
• sample spaces, 19–20
• unions, 23
• union probabilities, 26
• test statistic, 227
testing. See hypothesis testing
totals, in contingency tables, 70
traffic light example
• binomial probabilities, 157–158, 161
• mutually exclusive events, 34
• represented by Venn diagram, 45–47
tree diagrams
• for finding probabilities for complex
  events
• example 1: probability of choosing
  exactly one female, 55
• example 2: probability of choosing at
  least one female, 55–56
• example 3: probability that both people
  you choose have same gender, 56
• overview, 54–55
• limitations of, 54
• organizing conditional probabilities with
  connecting tree’s branches to rules of
  probability, 53–54
• organizing probabilities for dependent
  events, 52–53
• organizing probabilities for
  independent events, 51
• overview, 51
• overview, 47–48
• and restaurant probability problem, 62
• setting up for finding marginal
  probability using LTP, 58
• showing multi-stage outcomes with,
  49–50
• Type I errors, in hypothesis testing, 229
• Type II errors, in hypothesis testing, 229
• **U** •

u substitution, 300
uncountably infinite sample spaces, 20
uniform distribution, 298
unions, 23, 24, 26, 31–32, 38

• **V** •

variables
continuous random, 133
discrete random
calculating variance of, 147–148
finding expected value of, 145–146
finding standard deviation of, 148
probability distribution of, 132–138
effect on predictions, 16
variance
of continuous uniform distribution, 297–298
of discrete random variable, 147–148
of discrete uniform, 150
of exponential distribution, 308–309
of geometric distribution, 259–260
of hypergeometric distribution, 281–282
of negative binomial distribution, 270–271
of Poisson distribution, 243
variance of binomial, 166
Venn diagrams
finding probabilities beyond those
given, 40–41
finding probabilities for complex
problems
answering “exactly one” question, 47
answering “neither” question, 46–47
overview, 45
setting up diagram, 45–46
limitations of, 44
organizing and visualizing
relationships, 41–42
overview, 40
proving intermediate rules about sets,
42–44
sets, 40
subsets, 40
video game example, 298
visualizing relationships. See tree
diagrams; Venn diagrams
void in set, 22

• **W** •

weather prediction, 16
Wizard of Odds Web site, 124

• **Z** •

z distribution, cdf of, 338–339
z scores, 170–171
Z table
figuring confidence intervals with,
223–224
using backward
finding Z given greater-than
probability, 184–185
finding Z given less-than probability,
183–184
overview, 183
using to find probability
greater-than probabilities for Z,
178–179
intersecting rows and columns of Z
table, 176–178
less-than probabilities for Z, 178
overview, 176
between probabilities for Z, 179–180
z values, 170–171
Z-formula, 174–175