

A	Bernoulli, James, 141
Acceptance, of hypothesis. See Hypothesis testing	Bernoulli parameter, maximum likelihood estimator of, 237–240
Additive property, of chi-square random	Bernoulli populations
variables, 264	hypothesis testing in, 329–336
Algebra of events, 56–57, 56f, 57f Analysis, of residuals, 384–386, 385–386f	testing equality of parameters in two of, 333–336
Analysis of variance (ANOVA), 445–476 introduction, 445–446	Bernoulli random variables, 141–148, 143f, 148f
one-way, 446, 448–459, 452t, 453f, 456t multiple comparisons of sample means,	confidence interval for mean of, 268–272, 272t
456–458	generation of, 639
with unequal sample sizes, 458–459 overview, 446–448 two-way, 446	hypergeometric random variables and, 157–158
hypothesis testing for, 464–468, 467t, 468f	sign test and, 522
interaction, 446, 469–476, 475t, 476f	signed rank test and, 526-527
introduction and parameter estimation,	Beta distribution, 282
460–463	Between samples sum of squares, 451-452, 454
ANOVA. See Analysis of variance	456t, 459
Approximately normal, 31, 31f	Bias, of estimators, 274
Assessment, of models, 384–386, 385–386f	Bimodal data set, 33, 34f
Assignable cause, 553	Binary output data, logistic regression models
Association, causation v., 39	for, 418–421, 418f
Associative law, 56–57	Binomial distribution function, computation of
Averaging notation, in two-way analysis of	147–148, 148f
variance, 461–462	Binomial distribution, hypothesis testing in, 329–336
	Binomial random variables, 141–148, 143f,
Balanced case, in one-way analysis of variance, 459	148f
Bar graph, 10, 10t, 11f	binomial distribution function, 147–148,
Bayes estimator, 236, 279–284	148f
Bayes' formula, 68-75, 69f	central limit theorem and, 212, 215–216,
Bayesian approach, 236, 604-606	216f
Behrens-Fisher problem, 324–325	generation of, 639–640
Bernoulli density function, 419	hypergeometric random variables and,
Bernoulli, Jacob, 5–6	158–160, 225–226

Binomial random variables (<i>continued</i>) Poisson random variables and, 150–153	Chi-square distribution, 188–193, 190f, 192f, 327–328, 607
sign test and, 522	gamma random variables and, 191-192, 192
Bootstrap method, 623–630	t-distribution and, 193–195, 193f, 194f
mean square error and, 627–628	Chi-square goodness of fit tests, history of, 6
population mean and, 623–624, 628–630	Chi-square random variables, 189, 190f
population variance and, 623–625	additive property of, 264
probability and, 629–630	estimators of variance from, 447–448
random variable generation, 627	F-distribution and, 195–196, 195f
Box plot, 27, 27f	mean and variance of, 192
Box-Muller method, 642	sample mean and variance distribution with,
_	222
C	Choosing, of normal prior, 283–284
Categorical data analysis, goodness of fit tests	Class boundaries, 15, 15f, 15t
and, 489–514	Class intervals, 14–15, 15f, 15t
critical region determination by simulation, 496–499, 498f	Classical approximation, for rank sum test, 535–537
dummy variables for, 416-418	Classical simulation, for rank sum test,
introduction, 489-490	537–539, 538f
Kolmogorov-Smirnov goodness of fit test for	Coefficient of determination, sample correlation
continuous data, 510–514, 511f	coefficient and, 382–384
tests of independence in contingency tables,	Coefficient of multiple determination, 411
501–505	Column factors
tests of independence in contingency tables	hypothesis testing for, 464–468, 467t, 468f
having fixed marginal totals, 505-510,	in two-way analysis of variance, 460
506f	deviation from grand mean due to, 462
tests when all parameters are specified,	row factor interaction with, 446, 469–476,
489–497, 493t, 498f	475t, 476f
tests when some parameters are unspecified,	Column sum of squares, 467t
499–501	Combinations, permutations and, 63
Causation, association v., 39	Combining, of unbiased estimators, 275–277
Central limit theorem, 210–219, 212–216f,	Common density function, independent
approximate distribution of sample mean,	variables and, 102–103
216–218	Commutative law, 56–57, 56f
binomial random variables and, 212,	Comparison, of sample means, 456–458
215–216, 216f	Complement
defined, 210	in sample space, 55
independent random variables, 226–227	in Venn diagram, 56–57, 56f, 57f
Monte Carlo study and, 643	Composite hypothesis, 298
probability mass function and, 212-215f	Computational identity, of sum of squares of
sample size needed, 218-219, 219f	residuals, 366
Chance variation, 553	Conditional densities, 106–107
Channel noise disturbance, 173	Conditional distributions, 104–107,
Chebyshev's inequality, 27–30, 29t	337–339
one-sided, 29–30	random numbers and, 164–166, 166f
random variables and, 128-131	Conditional probability, 65-68, 66f, 106
weak law of large numbers, 129	independent events and, 75–79
Chi-square approximation, 497–498	Poisson random variables and, 153-154
Chi-square density function, 188–193, 190f, 192f	Conditional probability density function, 280–281

Conditional probability mass function	for population mean 571 581
Conditional probability mass function, 105–106	for population mean, 571–581 moving-average, 571–573, 573t, 574f
Confidence, 235	variance, 562–565, 564f
	Control group, 164
Confidence interval. See also specific intervals,	Control limits
e.g. 95 Percent confidence interval for difference in means of two normal	for fraction defective, 566–567
distributions, 260–268, 262–263f,	for mean control charts, 555–557, 556f
	for moving-average, 572–573, 573t, 574f
266–267f, 260t, 268t for difference in population means, 456–458	for variance control charts, 563–564, 564f
	Controls, 336
for estimating unknown mean, 247–252	Correlation analysis, history of, 6
for exponential distribution in life testing, 594–596	Counting
	basic principles of, 60–63
for mean of Bernoulli random variable, 268–272, 272t	notation and terminology, 63–65
	Covariance, 121–122
for mean of exponential distribution, 272–273	Critical region, 298, 300
for normal mean with unknown variance,	for goodness of fit tests when all parameters
252–258, 256f	are specified, 490–491
one-sided lower, 249–250, 255–257, 256f,	one-sided, 307
260t, 261–265, 261–263f, 268t	simulation for determination of, 496-499,
one-sided upper, 249–250, 254–255, 260t,	498f
261, 265–268, 266–267f	Critical value, for determining independence of
prediction interval v., 381	characteristics of population member,
for regression parameters	504
α , 376–377	Cumulative distribution function, 91–93, 93f,
β , 371–372	96
in sequential testing for exponential	exponential random variables and, 177
distribution in life testing, 599–601	probability density function and, 94–95, 94f
two-sided, 248, 251, 255–257, 256f,	Cumulative sum control charts, 579–581
261–268, 262–263f, 266–267f	D
for unknown probability, 268-272, 272t	D
for variance of normal distribution, 259–260,	Data collection, descriptive statistics and, 1–2
260t	Data sets
Confidence interval estimators	describing, 9–17
of difference in means of two normal	frequency tables and graphs, 10, 10t, 11f,
distributions, 260-265, 262-263f	12f
for mean of exponential distribution, 272	grouped data, histograms, ogives, and stem
of mean response, 377–379, 411–413	and leaf plots, 14–17, 14t, 15f, 15t,
Contingency tables	16f, 18t
with fixed marginal totals, tests of	relative frequency tables and graphs, 10–14, 13–14f, 13t
independence in, 505–510, 506f	normal and skewed, 31–33, 31f, 32f, 34f
tests of independence in, 501-505	summarizing, 17–27
Continuous data, Kolmogorov–Smirnov	sample mean, sample median, and sample
goodness of fit test for, 510-514, 511f	mode, 17–22
Continuous random variables, 93-94, 640-643	sample percentiles and box plots, 24–27,
Control charts, 553	26t, 27f
fraction defective, 565-567	sample variance and sample standard
mean, 554-562, 556f, 564f	deviation, 22–24
case of unknown, 557-562, 559t	Defects, probability of, 329-337
number of defect, 567–570, 569t	DeMorgan's laws, 57

Density function. See also Probability density	Discrete random variables, 91-92
function	expectation and, 111, 111f
Bernoulli, 419	generation of, 638–640
chi-square, 188-193, 190f, 192f	probability mass function and, 92-93,
common, 102–103	638–640
conditional probability, 280-281	Dispersion parameter, 197
F, 195–196, 195f	Distribution
gamma distribution and, 186–188	binomial, hypothesis testing in, 329-336
joint, 236–237, 242, 244	chi-square, 188-193, 190f, 192f, 327-328,
joint probability, 99–101	607
of logistics distribution, 197	conditional, 337-339
normal, 168, 168f, 188, 189f	exponential, confidence interval for mean of,
posterior, 280, 284	272–273
random variables and, 112	F, 328–329
Rayleigh, 591	gamma, 595, 604–607
t, 193, 193f, 252, 253t	hypothesis testing for determining equality of
Weibull, 608, 609f	m population distributions, 508–509
Density, mode of, 284	of least squares estimators, 361-367, 368f,
Dependent events, 75–79, 78f	369f
Dependent variable. See Response variable	life, 245–247
DES. See Diethylstilbestrol	multivariate normal, 404
Descriptive statistics	normal
Chebyshev's inequality, 27–30, 29t	confidence interval for variance of,
data collection and, 1-2	259–260, 260t
describing data sets, 9-17	estimation of difference in means of,
frequency tables and graphs, 10, 10t, 11f,	260–268, 262–263f, 266–267f, 268t
12f	Poisson
grouped data, histograms, ogives, and stem	goodness of fit tests for, 499–501
and leaf plots, 14–17, 14t, 15f, 15t,	hypothesis testing concerning mean of,
16f, 18t	336–339
relative frequency tables and graphs,	variance in, 395–396
10–14, 13–14f, 13t	prior, 279–284, 604–606
history of, 7	probability, of estimator of mean response,
normal data sets, 31-34, 32f, 34f	377–378
paired data sets and the sample correlation	rate of, 590
coefficient, 34–41, 35t, 36f, 39f	of sample, goodness of fit tests for, 489–499,
summarizing data sets, 17–27	493t, 498f
sample mean, sample median, and sample	uniform, estimating mean of, 244–245
mode, 17–22	Distribution function. See also Cumulative
sample percentiles and box plots, 24–27,	distribution function; Probability
26t, 27f	distribution function
sample variance and sample standard	binomial, 147–148, 148f
deviation, 22–24	of continuous random variable, 640–641
Deviation from grand mean due to column j ,	empirical, 624–625
462	moment generating function and, 128
Deviation from grand mean due to row <i>i</i> , 462	of normal random variables, 170–171
Diethylstilbestrol (DES), 336	Poisson
Difference, in means of two normal	computation of, 155–156
distributions, 260–268, 262–263f,	number of defects and, 567–570, 569t
266–267f, 268t	probability and, 91–92
Discrete inverse transform method, 639-640	random variables and, 91-92, 624

of rank sum test, 531	confidence interval for variance of normal
signed rank test for, 525, 526f	distribution, 259–260, 260t
two-sample problem and, 531	hypothesis testing v., 310
Distribution results, summary of, 381–382	prediction, 257–258
Distributive law, 56–57, 57f	for unknown mean, 247–252
Doll, R., 17	Estimation
Dot notation, in two-way analysis of variance,	
461–462	of life distributions, 245–247
	of mean of uniform distribution, 244–245
Double-blind test, 164	of mean response, 411–413
Dummy variables, for categorical data, 416–418	of parameters, 235–284
	approximate confidence interval for mean
E	of Bernoulli random variable, 268–272,
Effect of column j, 470	272t
Effect of row i, 470	Bayes estimator, 236, 279–284
Empirical distribution function, 624–625	confidence interval for mean of
Empirical rule, 33–34	exponential distribution, 272-273
-	of difference in means of two normal
Entropy, 110	distributions, 260–268, 262–263f,
Equal variance, testing equality of means of two	266–267f, 268t
normal populations with, 324–325,	interval estimates, 235, 247–260, 310
325t	introduction, 235–236
Equality	
of m population distributions, hypothesis	of life distributions, 245–247
testing for, 508–509	maximum likelihood estimators, 235–247,
of means of two normal populations,	260, 284, 500
318–326, 319t, 321f, 323f, 325t	point estimator evaluation, 273–279
case of known variance, 318-320, 319t	for two-way analysis of variance, 460–463
case of unknown and equal variance,	Estimators
324–325, 325t	Bayes, 236, 279–284
case of unknown variance, 320-324, 321f,	bias of, 274
323f	confidence interval
hypothesis testing of, 318-326, 319t,	of difference in means of two normal
321f, 323f, 325t	distributions, 260-265, 262-263f
paired <i>t</i> -test, 325–326	for mean of exponential distribution, 272
of parameters in two Bernoulli populations,	of mean response, 377–379, 411–413
333–336	defined, 236
	of deviance from grand mean, 462–463
of population means, hypothesis testing of,	of grand mean, 462–463
446, 448–459, 452t, 453f, 456t	
of variance, of two normal populations,	least squares, 385
328–329	distribution of, 361–367, 368f, 369f
Error	in multiple linear regressions, 400–408,
mean square error of point estimators,	413–414
273–279	in polynomial regression, 397–399
type I, 298, 300	of regression parameters, 359-361, 361f,
type II, 298, 302–305, 304f	362f
Error sum of squares, 465, 467t	for Weibull distribution in life testing,
Estimated regression line, 360	610–612
Estimates	maximum likelihood, 235-247, 279
defined, 236	of Bernoulli parameter, 237-240
interval, 235, 247–260	of difference in means of two
confidence interval for normal mean with	normaldistributions, 260
unknown variance, 252–258, 256f	evaluation of, 277–278

Estimators (continued)	moment generating functions and, 177
for exponential distribution in life testing,	Poisson process, 181-183, 181f
593–594, 602–604	probability and, 179–180
least squares estimators as, 365–366	sample means for, 218-219, 219f
for life distributions, 245–247	Exponentially weighted moving-average control
in logistic regression models, 418	charts, 573–578, 575f, 578f
for mean of exponential distribution, 272	
of normal population, 242–244	F
of Poisson parameter, 240–241	Failure rate. See Hazard rate
in sequential testing for exponential	
distribution in life testing, 599, 601	F-density function, 195–196, 195f
for Weibull distribution in life testing,	F-distribution, 195–196, 195f, 328–329
608–610	Finite populations, sampling distributions from,
weighted least squares estimators as, 392	223–227
point	First quartile, 25–27
evaluation of, 273–279	Fisher, Ronald A., 6–7
for hypothesis testing, 299–300	Fisher-Irwin test, 335
of mean response, 377, 411	Fixed margins, contingency tables with, tests of
pooled, 261, 321	independence in, 505–510, 506f
unbiased, 274–279	Fraction defective control charts, 565–567
of variance, 447–448	Frequency interpretation
for one-way analysis of variance, 446,	of expectations, 108
448–459, 452t, 453f, 456t	probability, 53
for two-way analysis of variance, 464–467	Frequency tables and graphs, 10, 10t, 11f, 12f
for two-way analysis of variance with	frequency histogram, 16
interaction, 469–476, 475t, 476f	frequency polygon, 10, 10t, 12f
weighted least squares, 390-396, 395f	relative, 10–14, 13–14f, 13t
Evaluation, of point estimator, 273–279	sample mean and, 19–20, 22
Events, 54–55	sample median and, 20–22
algebra of, 56–57, 56f, 57f	sample mode and, 22
independent, 75–79, 78f	F-statistic, in two-way analysis of variance with
odds of, 59	interaction, 474, 475t
Expectation, 107–111, 111f	Future response, prediction interval of, 379–381
properties of, 111–118	in multiple linear regression, 411-416, 413t,
of a random variable function, 113–115	414f, 415f
of sums of random variables, 115–118	
Expected value. See Expectation	G
Exponential distribution	Galton, Francis, 6, 372–373
confidence interval for mean of, 272–273	Gamma density, 188, 189f
gamma distribution and, 188	· · · · · · · · · · · · · · · · · · ·
in life testing, 592–606, 598f	Gamma distribution, 595, 604–607
Bayesian approach, 604–606	Gamma function, 186–187
sequential testing, 598-602, 598f	Gamma random variables, 187–188, 189f
simulation testing with stopping at rth	chi-square distribution and, 191–192, 192f
failure, 592–598	Gauss, Karl Friedrich, 5–6
simulation testing with stopping by fixe	Generation
time, 602–604	of random numbers, 620–622
Poisson process and, 181–182	of random variables, 497, 627, 638–643
Exponential random variables, 177–185, 181f	Goodness of fit tests, 489–514
generation of, 641–642	critical region determination by simulation,
memoryless, 178	496–499, 498f

. 1 . /00 /00	C 1 1 C 1
introduction, 489–490	of independence of characteristics of
Kolmogorov–Smirnov goodness of fit test for	population member, 501–505
continuous data, 510–514, 511f	interval estimates v., 310
tests of independence in contingency tables, 501–505	introduction, 297
	of mean of normal population, 299–317,
tests of independence in contingency tables	301f, 304f, 311t, 313f, 315f, 317t
having fixed marginal totals, 505–510, 506f	case of known variance, 299–311, 301f,
tests when all parameters are specified,	304f, 311t
489–497, 493t, 498f	case of unknown variance, 311–317, 313f,
tests when some parameters are unspecified,	316f, 317t
499–501	for mean of Poisson distribution, 336–339
Gosset, W.S., 6	multiple linear regression and, 409–411, 410t
Grand mean, 462–463, 469	of multiple population means, 446–447
Graunt, John, 4–5, 4t, 5t	of probability distribution of sample,
Grouped data, 14–17, 14t, 15f, 15t, 16f, 18t	489–499, 493t, 498f
	of regression parameters
H	α, 376–377
	β , 370–371
Halley, Edmund, 5	of regression to mean, 373–374
Hardy's lemma, 36	robustness of, 311
Hazard rate, 245, 589	of row and column interaction, 469–476,
Hazard rate functions, 589–592	475t, 476f
Hill, A.B., 17 Histograms, 14t, 15f, 16–17, 18t	significance levels, 298–299
normal, 31–33, 31f, 32f, 34f	for two-way analysis of variance, 464–468, 467t, 468f
Hypergeometric random variables, 156–160	for variance of normal population,
Bernoulli random variables and, 157–158	327–329
binomial random variables and, 158–160,	32/ 32)
225–226	I .
mean and variance of, 157–158	
Hypothesis testing, 297–339	Independence, tests of
in Bernoulli populations, 329–336	in contingency tables, 501–505
of equality of m population distributions,	in contingency tables having fixed marginal
508–509	totals, 505–510, 506f
of equality of means of two normal	Independent events, 75–79, 78f
populations, 318-326, 319t, 321f, 323f,	Independent increment assumption, 181
325t	Independent random variables, 101–104
case of known variance, 318-320, 319t	central limit theorem for, 210–219,
case of unknown and equal variance,	226–227
324–325, 325t	moment generating functions of, 127–128
case of unknown variance, 320–324, 321f,	sample mean and variance distribution with,
323f	222
paired <i>t</i> -test, 325–326	sample mean distribution with, 2, 15
of equality of population means, 446,	signed rank test and, 526–527
448–459, 452t, 453f, 456t	Independent variable. See Input variable
of equality of variance of two normal	Indicator random variable, 90–91 covariance of, 125–126
populations, 328–329	
of independence in contingency tables,	expectation for, 109 variance of, 119–120
501–505	
of independence in contingency tables having fixed marginal totals, 505–510, 506f	Individual moment generating functions, 127–128
incu marginar totals, 303-310, 3001	12/-120

Individual probability mass function, joint and,	L
96–99, 98t	Laplace, Pierre-Simon, 5-6
Inferential statistics	Least squares estimators, 385
history of, 6–7	distribution of, 361–367, 368f, 369f
probability models and, 2-3	in multiple linear regression, 400–408,
Inheritance, regression to mean and, 372-375,	413–414
373f, 374f	in polynomial regression, 397–399
Input variable, 357–358	of regression parameters, 359–361, 361f,
variation in response to, 382-384, 390-396,	362f
395f	for Weibull distribution in life testing,
Interaction, two-way analysis of variance with,	610–612
446, 469–476, 475t, 476f	weighted, 390-396, 395f
Intersection	Left-end inclusion convention, 15
of sample space, 55	Level of significance. See Significance level
in Venn diagram, 56–57, 56f, 57f	Levels, in two-way analysis of variance, 460
Interval estimates, 235, 247–260	Life distributions, estimation of, 245–247
confidence interval for normal mean with	Life testing, 589–612
unknown variance, 252–258, 256f	exponential distribution in, 592–606, 598f
confidence interval for variance of normal	Bayesian approach, 604–606
distribution, 259–260, 260t	sequential testing, 598-602, 604f
hypothesis testing v., 310	simulation testing with stopping at r th
prediction, 257–258	failure, 592–598
for unknown mean, 247–252	simulation testing with stopping by fixed
Inverse transformation method, 639–641	time, 602–604
<i>i</i> th order statistic, 594	hazard rate functions, 589–592
T. Control of the Con	introduction, 589
Taine annual since and ability discribed in	two-sample problem, 606–608
Joint cumulative probability distribution	Weibull distribution in, 608–612, 609f
function, 96, 103–104 Joint density	Likelihood function, 236–237
conditional densities and, 107	Line graph, 10, 10t, 11f
random numbers and, 166–168	Linear regression equation, 357–358. See also
Joint density function, 236–237, 242, 244	Multiple linear regression
Joint probability density function, 99–101	assessment of, 384–386, 385–386f
Joint probability mass function	Linearity, transforming to, 387–390, 388f, 389f, 389t, 390t
conditional probability mass function and,	Logarithms, for transforming to linearity,
106	387–390, 388f, 389f, 389t, 390t
individual and, 96-99, 98t, 99t	Logistic regression function, 416, 418f
Jointly continuous, 99, 102–103	Logistic regression models, for binary output
Jointly distributed random variables, 95–107,	data, 416–419, 418f
98t, 99t	Logistics distribution, of random variables,
conditional distributions, 104-107	196–197
independent, 101–104	Logistics random variable, 197
-	Logit, 419
K	Lognormal distribution, 243
Kolmogorov's law of fragmentation, 243	Lower confidence interval
Kolmogorov–Smirnov goodness of fit test, for	for difference in means of two normal
continuous data, 510-514, 511f	distributions, 260–264, 261–262f, 267t
Kolmogorov-Smirnov test statistic, 510-514,	for normal mean with unknown variance,
511f	255–257, 256f
Kruskal–Wallis test, 540	for unknown mean, 249–251

for unknown probability, 272t	for exponentially weighted moving-average,
for variance of normal distribution, 260t	575
Lower control limits	grand, 462–463, 469
for exponentially weighted moving-average, 576–578, 578f	of hypergeometric random variables, 157–158
for fraction defective, 566-567	of least squares estimators, 362–364
for mean control charts, 555-557, 556f	for moving-average, 572
for moving-average, 572–573, 573t, 574f for number of defects, 568–570	normal, confidence intervals for, 252–258, 256f
for variance control charts, 563–564, 564f	of normal population, hypothesis testing concerning, 299–317, 301f, 301f, 311t, 313f, 316f, 317t
M	case of known variance, 299–311, 301f,
Mann-Whitney test. See Rank sum test	304f, 311t
Marginal probability mass function, 98	case of unknown variance, 311–317, 313f,
Markov's inequality, random variables and,	316f, 317t
128–131	of normal random variables, 169–170
Mass function. See Probability mass function	permutation tests and, 634
Matrix notation for multiple linear regression, 401–403	of Poisson distribution, hypothesis testing for, 336–339
for polynomial regression, 400	Poisson distribution with unknown value of,
Maximum likelihood estimators, 235-247, 284,	goodness of fit tests for, 499-501
500	population, 208–209, 209f
of Bernoulli parameter, 237–240	regression to, 372–376, 373f, 374f, 375t,
of difference in means of two normal	376f
distributions, 260	testing equality of means of two normal
evaluation of, 277–278	populations, 318-326, 319t, 321f, 323f,
for exponential distribution in life testing,	325t
593–594, 602–604	case of known variance, 318-320, 319t
least squares estimators as, 365–366	case of unknown and equal variance,
for life distributions, 245–247	324–325, 325t
in logistic regression models, 418	case of unknown variance, 320-324, 321f,
for mean of exponential distribution, 272	323f
of normal population, 242–244	paired <i>t</i> -test, 325–326
of Poisson parameter, 240–241	of uniform distribution, 244–245
in sequential testing for exponential	of uniform random variables, 162
distribution in life testing, 599, 601	unknown
for Weibull distribution in life testing, 608–610	confidence intervals for normal mean with unknown variance, 252–258, 256f
weighted least squares estimators as, 392	control charts for, 557-562, 559t
Mean. See also Population means; Sample mean	estimates of, 247–252
of Bernoulli random variable, confidence	Mean control chart, 554–562, 556f, 564f
interval for, 268–272, 272t	case of unknown, 557–562, 559t
of chi-square random variable, 192	Mean life, maximum likelihood estimator of,
confidence interval estimators of mean	603–604
response, 377–379, 411–413	Mean response
estimation of difference in means of two	estimation of, 411–413
normal distributions, 260–268,	statistical inferences concerning, 377–379
262–263f, 266–267f, 268t	Mean square error
of exponential distribution, confidence	bootstrap method and, 627–628
interval for, 272–273	of point estimators, 273–279

M. Jing San to San 522 524 5246	00 P
Median, sign test for, 523–524, 524f	90 Percent confidence interval of difference in means of two normal
Memoryless, exponential random variables, 178 Modal values, 22	distributions, 265–268, 266–267f
Models assessment of 384 386 385 386f	for variance of normal distribution, 259–260
Models, assessment of, 384–386, 385–386f	Nonparametric hypothesis tests, 521–545
Moment generating functions	introduction to, 521
chi-square distribution, 188	runs test for randomness, 541–545, 543f
chi-square random variable, 188–190, 190f	sign test, 521–525, 524f
exponential random variables and, 177	signed rank test, 525–531, 526f
gamma distribution and, 186–188	two-sample problem, 531–535, 534f, 538f
normal random variables and, 175	classical approximation and simulation,
of Poisson random variables, 149–150	535–539
of random variables, 127–126	equality of multiple probability
Monte Carlo simulation, 255–257, 256f,	distributions, 539–541
622–623	Nonparametric inference, 207–208
determining runs in, 643–644	Nonrandom sample, 3
Moving-average control charts, 571–573, 573t, 574f	Normal approximations, in permutation tests, 633–637
exponentially weighted, 573-578, 575f, 578f	Normal data sets, 34, 31f, 32f, 34f
Multidimensional integrals, simulation of,	Normal density function, 168, 168f, 188, 189f
255–257, 256f	Normal distribution
Multiple comparisons, of sample means,	confidence interval for variance of, 259–260,
456–458	260t
Multiple linear regression, 400-416, 403t, 404f,	estimation of difference in means of,
405f, 406f, 410t, 413t, 414f, 415f	260–268, 262–263f, 266–267f, 268t
Multiple probability distributions, equality	Normal equations
testing of, 539–541	in multiple linear regression, 401–403
Multiple regression equation, 358	in polynomial regression, 397
Multivariate normal distribution, 404	of regressions, 359–360
Mutually exclusive, in sample space, 55	Normal histograms, 33, 31f, 32f, 34f
	Normal mean, with unknown variance,
N	confidence intervals for, 252–258, 256f
Natural and Political Observations Made upon	Normal populations
the Bills of Mortality, 4–5, 4t, 5t	maximum likelihood estimator of, 242–244
Negatively correlated, 37	mean of
Neyman, Jerzy, 7	hypothesis testing concerning, 299–317,
95 Percent confidence interval	301f, 304f, 311t, 313f, 316f, 317t
of difference in means of two normal	testing equality of means of two normal
distributions, 260–268, 252–253f	populations, 318–326, 319t, 321f, 323f,
for estimating unknown mean, 247–252	325t
for mean of exponential distribution,	sampling distributions from, 220–223
272–273	joint distribution, 221–223
of mean response, 378	sample mean distribution, 221
for normal mean with unknown variance,	variance of, hypothesis testing for, 327–329
253–257, 254f	Normal prior, choosing of, 283–284
for regression parameters, 372	Normal random variables, 168–177, 172f, 176f
for unknown probability, 269–271	chi-square distribution, 188–193, 190f, 192f
95 Percent prediction interval, 416	F-distribution, 195–196, 195f
99 Percent confidence interval	generation of, 642–643
for estimating unknown mean, 250–251	mean and variance of, 169–170
for unknown probability, 271	normal density function, 168, 168f

standard normal distribution and, 171–172, 172f, 175–177, 176f	for normal mean with unknown variance, 255–257, 256f
sums of, 175	for unknown mean, 249-251
t-distribution, 193–195, 193f, 195f	for unknown probability, 272t
Notation	for variance of normal distribution, 260t
dot, in two-way analysis of variance, 461–462	One-sided null hypothesis, sign test and,
for least squares estimators, 366	524–525
matrix	One-sided t-tests, for mean of normal
in multiple linear regression, 401-403	population with unknown variance,
for polynomial regression, 400	314–317, 316f
Null hypothesis, 298	One-sided upper confidence interval
permutation tests and, 631–633	for difference in means of two normal
Number of defect control charts, 567–570, 569t	distributions, 261, 265-268, 266-267f
0	for normal mean with unknown variance, 254–255
	for unknown mean, 249-251
Observational study, 336	for unknown probability, 272t
OC curve. See Operating characteristic curve	for variance of normal distribution, 260t
Odds for success, 419	One-way analysis of variance, 446, 448–459,
Odds of event, 59	452t, 453f, 456t
Ogives, 14t, 16–17, 16f, 18t	multiple comparisons of sample means,
$100(1-\alpha)$ Percent confidence interval of	456–458
difference in means of two normal	with unequal sample sizes, 458–459
distributions, 261–265, 268t	Operating characteristic (OC) curve, 303–304,
for estimating unknown mean, 250–251	304f
for exponential distribution in life testing,	for one-sided hypothesis testing for mean of
596	normal population, 307–308
for mean of exponential distribution, 272	Out of control, 553, 555–557, 556f
of mean response, 378	Overlook probabilities, 74
for normal mean with unknown variance,	_
252–258	P
for regression parameters	Paired data sets, 34-36, 34t, 35f
α , 377	sample correlation coefficient and, 37-40,
β , 371–372	39f
in sequential testing for exponential	Paired <i>t</i> -test, 325–326, 523
distribution in life testing, 599–600	Parameter estimation, 235–284
for unknown probability, 269–271	approximate confidence interval for mean of
for variance of normal distribution, 260t	Bernoulli random variable, 268–272,
$100(1 - \alpha)$ Percent confidence region, 263	272t
$100(1 - \alpha)$ Percent prediction interval, 381,	Bayes estimator, 236, 279–284
416	confidence interval for mean of exponential
One-sided Chebyshev's inequality, 29–30	distribution, 272–273
One-sided critical region, 307	of difference in means of two normal
One-sided hypothesis tests	distributions, 260-268, 262-263f,
for mean of normal population, case of	266–267f, 268t
known variance, 306-310	interval estimates, 235, 247-260, 310
for testing equality of means of two normal	introduction, 235–236
populations, 321	of life distributions, 245–247
One-sided lower confidence interval	maximum likelihood estimators, 235-247,
of difference in means of two normal	260, 284
distributions, 260-264, 261-262f, 267t	point estimator evaluation, 273–279

lndex

Parameter estimation (continued) for two-way analysis of variance, 460–463 for Weibull distribution in life testing, 610–612	Population means, 208–209, 209f bootstrap method and, 623–624, 628–630 confidence interval for difference in, 456–458 control charts for, 571–581
Parametric inference, 207–208	cumulative sum, 579–581
Pearson, Egon, 7 The Pareto Distribution, 183–185	exponentially weighted moving-average, 573–578, 575f, 578f
Pearson, Karl, 6, 373, 496	moving-average, 571–573, 573t, 574f
Permutation, 61–63	hypothesis testing of equality of, 446,
Permutation tests, 630–638	448–459, 452t, 453f, 456t
implementation of, 631–632	multiple, hypothesis testing of, 446-447
normal approximations in, 633–637	Population median, sign test for, 523–524, 524f
null hypothesis and, 631–633	Population variance, 208–209
two sample, 637–638	bootstrap method and, 623–625
Pie chart, 12, 13–14f	Populations
Point estimates, 235	definition of, 207
Point estimators	samples and, 3
evaluation of, 273–279	sampling distributions from
for hypothesis testing, 299–300	finite, 223–227
of mean response, 377, 411	normal, 220–223
Point prediction, 413	Positively correlated, 37
Poisson distribution	Posterior density function, 280, 284
hypothesis testing concerning mean of,	Power-function, of hypothesis test, 304
336–339	Prediction interval
with unknown mean, goodness of fit tests for,	confidence interval v., 381
499–501	of future response, 379–381
variance in, 395–396	of response at input level $x0$, 381
Poisson distribution function	of response in multiple linear regression,
computation of, 155–156	411–416, 413t, 414f, 415f
number of defects and, 567–570, 569t	Prior distributions, 279–284, 604–606
Poisson parameters	Probability, 53–79
maximum likelihood estimator of, 240–241	axioms of, 57–59, 59f
testing of relationship between, 337–339	Bayes' formula, 68–75, 69f
Poisson probability mass function, 148–150,	Bernoulli random variables, 141–148
149f, 154–155	binomial random variables, 143–147
Poisson process, exponential random variables	bootstrap method and, 629–630
and, 181–183, 181f	central limit theorem, 210–219, 212–215f,
Poisson random variables, 148–156, 149f	216f
binomial random variables and, 150–153	chi-square distribution and, 187
conditional probability and, 153–154	conditional, 65–68, 66f, 106
moment generating functions of, 149–150	continuous random variable and, 94
probability mass function and, 148–150,	counting and, 60–65
149f, 154–155	of defects, 329–337
Poisson, S.D., 148	distribution function and, 91–92
Polynomial regression, 397–400, 398f, 399f	events, 54–55
Pooled estimator, 266, 321	independent, 75–79, 78f
Population distributions	expectation, 107–111, 111f
empirical distribution and, 624	exponential random variables and, 179–180
equality of, hypothesis testing for,	fraction defective, 565–567
508–509	introduction to, 53–54
signed rank test for, 529-531	overlook, 74

Poisson random variables and, 148-156, 149f	for goodness of fit tests when all parameters
of random variables, 89–90	are specified, 491, 494–499, 498f
rank sum tests, 532–533	for goodness of fit tests when some
sample space, 54–55	parameters are unspecified, 500–501
with equally likely outcomes, 59–65	for hypothesis testing
signed rank test and, 527–529	in Bernoulli populations, 330–333, 335
of uniform random variables, 160–161, 161f	of equality of population means, 452, 453f
unknown, confidence interval for, 268–272,	of mean of normal population, 302,
272t Venn diagram and algebra of events, 56–57,	307–310, 311t, 313, 315–317, 316f,
56f, 57f	317t
Probability density function, 93–94	of mean of Poisson distribution, 337–338
cumulative distribution function and, 94–95,	with multiple linear regression, 411
94f	of regression parameters, β , 370
exponential random variables and, 177	of regression to mean, 374
joint, 99–101	of variance of normal population,
of uniform random variables, 160–161, 161f	327, 329
updated, 280	for Kolmogorov-Smirnov goodness of fit test,
Probability distribution	513
of estimator of mean response, 377–378	for one-sided hypothesis testing for mean of
of sample, goodness of fit tests for, 489–499,	normal population, 307–310
493t, 498f	permutation tests for, 630-638
Probability distribution function	normal approximations in, 633–637
joint cumulative, 96, 103–104	two sample, 637–638
Poisson, 148–156	rank sum test and, 533–535, 534f
of populations, 207	in sequential testing for exponential
random variable and expectation, 111-113	distribution in life testing, 601–602
signed rank test for, 529-531	signed rank test for, 527–529
Probability mass function, 92-93, 93f, 245-247	simulation for approximation of, 496–499,
Bernoulli random variables, 142–144, 143f	498f
binomial random variables, 142-144, 143f	for testing equality of means of two
central limit theorem and, 212–215f	normal populations, 321–324, 323f,
conditional, 105–106	325t, 326
discrete random variables, 92–93, 638–640	in two-way analysis of variance, 467, 467t, 468f, 473–474, 475t, 476f
expectation of, 107–108	1001, 1/3–1/1, 1/70, 1/01
hypergeometric random variables, 156–157	Q
individual and joint, 96–99, 98t	
marginal, 98	Quality control, 553–581
Poisson, 148–150, 149f, 154–155	fraction defective control charts, 565–567
Poisson random variables, 148–150, 149f,	introduction to, 553–554
154–155	mean control chart, 554–562,
Probability models, inferential statistics and,	556f, 564f
2–3 Drahability theory operiories and 5 (number of defect control charts, 567–570, 569t
Probability theory, statistics and, 5–6 Probit model, 419	population mean control charts, 571–581
Pseudo random numbers, 257, 620	cumulative sum, 579–581
<i>p</i> -value	exponentially weighted moving-average,
for determining independence of	573–578, 575f, 578f
characteristics of population member,	moving-average, 571–573, 573t, 574f
504–505	variance control chart, 562–565, 564f

R	Kruskal–Wallis test, 540
Random error, in response to input variable,	probability and, 532–533
357–358, 361	<i>p</i> -value and, 533–535, 534f
Random numbers, 620–623	classical approximation and simulation,
definition of, 163, 163t	535–539, 538f
generation of, 620-622	Rate of distribution, 590
Monte Carlo simulation approach, 622–623	Rayleigh density function, 591
pseudo, 620	Recursive formula, mean control chart and,
use of, 164–166, 166f	559–560, 559t
Random sample, 3, 207, 223	Referents, 334
runs test for, 541–545, 543f	Regression, 357-420
Random variables, 89–92. See also specific	analysis of residuals and assessing models,
random variables	384–386, 385–386f
Bernoulli and binomial, 141–148, 143f,	coefficient of determination and sample
148f	correlation coefficient, 382-384
central limit theorem, 210–219, 212–215f	distribution of least squares estimators,
Chebyshev's inequality, 128–131	361–367, 368f, 369f
continuous, 93–94, 640–643	history of, 6
density function and, 112	introduction, 357–358, 358f
discrete, 91–92, 638–640	least squares estimators of regression
distribution function and, 91–92, 624	parameters, 359–361, 361f, 362f
entropy of, 110	logistic regression models for binary output
expectation of function of, corollary of,	data, 416–420, 418f
114–115	to mean, 372-376, 373f, 374f, 375t, 376f
expected value of sums of, 115–118	multiple linear, 400-416, 402t, 404f, 405f,
exponential, 177–182, 181f, 641–642	406f, 410t, 414f, 415f
gamma distribution of, 186–188, 189f	predicting future responses, 411–416,
generation of, 497, 627, 638–643	413t, 414f, 415f
hypergeometric, 156–160	polynomial, 397-400, 398f, 399f
indicator, 90–91	statistical inferences about regression
jointly distributed, 95–107, 98t	parameters, 367–382, 373f, 374f,
conditional distributions, 104–107	375t, 376f
independent, 101–104	α , 376–377
logistics distribution, 196–197	β, 368–376, 373f, 374f, 375t, 376f
Markov's inequality, 128–130	mean response, 377–379
moment generating functions, 127–128	prediction interval of future response,
normal, 168–177, 172f, 176f, 642–643	379–381
chi-square distribution, 188–193, 190f,	summary of distribution results, 381-382
192f	transforming to linearity, 387–390, 388f,
F-distribution, 195–196, 195f	389f, 389t, 390t
<i>t</i> -distribution, 193–195, 193f, 194f	use of dummy variables, 416–418
Poisson, 148–156, 149f	weighted least squares, 390-396, 395f
probability distribution function and	Regression coefficients, 358, 397
expectation, 111–113	Regression fallacy, 376
types of, 92–95, 93f, 94f	Regression parameters
uniform, 160–168, 161f, 163t, 166f	least squares estimators of, 359–361, 361f,
variance of, 118–120, 162, 169–170, 192,	362f
222, 447–448	statistical inferences about, 367–382, 373f,
variance of a sum of, 123–126	374f, 375t, 376f
weak law of large numbers, 130	α , 376–377
Rank sum test, 521, 531–541, 534f, 538f	β, 368–376, 373f, 374f, 375t, 376f
distribution function of, 531	mean response, 377–379

prediction interval of future response,	Sample percentiles, 24–25
379–381	Sample quartiles, 25–27, 27f
summary of distribution results, 381–382	Sample size, one-way analysis of variance with
Rejection, of hypothesis. See Hypothesis testing	unequal sample sizes, 458-459
Relative frequency tables and graphs, 10–14,	Sample spaces, 54–55
13–14f, 13t, 16	having equally likely outcomes, 59-65
Residuals, 364–366	Sample standard deviation, 24, 219-220
analysis of, 384-386, 385-386f	Sample variance, 22–24, 219–220
in multiple linear regression, 408-409, 411	for normal population, 220
standardized, 385-386, 385-386f	sample mean distribution with, 221–223
Response variable, 357–358	Sampling, 207
prediction interval of future response,	Sampling distributions
379–381	form finite populations, 223–227
in multiple linear regression, 411-416,	form normal populations, 220–223
413t, 414f, 415f	joint distribution, 221–223
variation in, 382–384	sample mean distribution, 221
with input variable, 390-396, 395f	Scatter diagram, 34–36, 36f, 358, 358f, 373,
Robustness, of hypothesis test, 311	385–386, 385–386f, 397
Row factors	Second quartile, 25–27
hypothesis testing for, 464–468, 467t, 468f	Selection, of normal prior, 283–284
in two-way analysis of variance, 460	Sequence of interarrival times, 182
column factor interaction with, 446,	Sequential testing, for exponential distribution
469–476, 475t, 476f	in life testing, 598–602, 598f
deviation from grand mean due to, 462	Sign test, 521–525, 524f
Row sum of squares, 466, 467t	Bernoulli random variables, 522
Run, 541	binomial random variables, 522
Runs test for randomness, 521, 541-542, 543f	one-sided null hypothesis and, 524–525
	paired t -test v., 523
S	for population median, 523–524, 524f
Sample	Signed rank test, 521, 525–531, 526f
definition of, 207	for distribution function, 525, 526f
populations and, 3	for probability distribution function,
Sample 100 <i>p</i> percentile, 24–25	529–531
Sample correlation coefficient, 37–41, 39f	for <i>p</i> -value, 527–529
association v. causation, 40–41	Significance level, 298–299
coefficient of determination and, 382–384	Significance level α test
properties of, 37–38, 41	for determining independence of
Sample mean, 17–20, 22	characteristics of population member,
central limit theorem for, 216–218	503–505
distribution of, with chi-square random	for goodness of fit tests when all parameters
variables, 222	are specified, 496
for exponential random variables, 218–219,	for hypothesis testing
219f	in Bernoulli populations, 329–333
for independent random variables, 2, 15	of equality of population means, 452, 459
multiple comparisons of, 456–458	of mean of normal population, 300–302,
of normal data set, 31	307–309, 311t, 312, 314–316, 317t
for normal population, 220–221	of mean of Poisson distribution, 336–337
population, 208–209, 209f	of regression to mean, 374
sample variance distribution with, 221–223	of variance of normal population, 329
Sample median, 20–22, 31	for Kolmogorov–Smirnov goodness of fit test,
Sample mode, 22	513–514
1	J1J=J17

Significance level α test (continued)	inferential, 2–3
for testing equality of means of two normal	introduction to, 1–7
populations, 318-321, 324-325, 325t	Stem and leaf plots, 16-17, 18t
in two-way analysis of variance, 467, 467t,	of normal data set, 33
472–474, 475t	sample mean and, 21
Simple hypothesis, 298	sample median and, 21
Simple regression equation, 358, 362f, 369f	Subjective interpretation, probability, 53
assessment of, 384-386, 385-386f	Success, odds for, 419
Simulation	Sum of squares
for determination of critical region, 496-499,	column, 467t
498f	error, 465, 467t
of single and multidimensional integrals,	row, 466, 467t
251–253, 256f	between samples, 451-452, 454, 456t, 459
Simulation run, 623	within samples, 450, 454, 456t, 459
in Monte Carlo study, 643–644	in two-way analysis of variance with
Simulation testing, for exponential distribution	interaction, 471–474, 475t
in life testing, 592–598, 602–604	Sum of squares identity, 453-454
Single integrals, simulation of, 255–257, 256f	Sum of squares of residuals, 364-366, 408-409,
Skewed data set, 31, 32f	411
Skewed random variables, 142, 143f	Survival rate, 245–246
Standard deviation	
definition of, 121	T
mean control chart and, 560–561	t-density function, 193, 193f, 252, 253f
variance control chart, 562-563	<i>t</i> -distribution, 193–195, 193f, 292, 2931
Standard logistic, 197	Test statistic
Standard normal distribution, 171–172, 172f,	for determining independence of
175–177, 176f	characteristics of population member,
central limit theorem and, 217	503–505
of mean control chart, 555	for goodness of fit tests when all parameters
t-distribution and, 192–195, 193f, 194f	are specified, 490–492, 494–496
Standard normal random variable, 221	for goodness of fit tests when some
central limit theorem and, 210, 216-217	parameters are unspecified, 500–501
Standardized residuals, 385-386,	for hypothesis testing
385–386f	in Bernoulli populations, 330
Stationary increment assumption, 181-182	of equality of population means, 451–452,
Statistical analysis, 1	455, 456t
Statistical inferences, about regression	of mean of normal population, 302, 307,
parameters, 367–382, 373f, 374f, 375t,	309, 315t, 312–315, 317t
376f	of regression parameters, 370–371
α , 376–377	of regression to mean, 374
β, 368–376, 373f, 374f, 375t, 376f	of variance of normal population, 327, 329
mean response, 377–379	Kolmogorov–Smirnov, 510–514, 511f
prediction interval of future response,	for one-sided hypothesis testing for mean of
379–381	normal population, 307, 309
summary of distribution results, 381-382	for testing equality of means of two normal
Statistical theory, 1	populations, 320–322, 324, 325t, 326
Statistics	for testing independence in contingency
application of, 6–7	tables, 506–507, 506f
definition of, 1, 6–7, 6t, 207–208	in two-way analysis of variance, 467, 467t
descriptive, 1–2	Testing. See Goodness of fit tests; Hypothesis
history of, 3-7, 4t, 5t, 6t	testing; Life testing

T	TT 'C 1' '1 '
Tests of independence in contingency tables, 501–505	Uniform distribution, estimating mean of, 244–245
in contingency tables having fixed marginal totals, 505–510, 506f	Uniform random variables, 160–168, 161f, 163t, 166f
Third quartile, 25–27	mean and variance of, 162
Threshold model, 420	probability density function of,
Ties	160–161, 161f
rank sum test and, 531	random numbers, 166–168
signed rank test and, 530–531	Union
T-method, 456–458	of sample space, 55
Total-time-on-test statistic, 594–595, 604	in Venn diagram, 56–57, 56f, 57f
T-random variable, 264	Unit normal distribution. See Standard normal
Transformation, to linearity, 387-390, 388f,	distribution
389f, 389t, 390t	Unknown mean
Treatment group, 164	confidence intervals for normal mean with
Tree diagram, random numbers and, 166, 166f	unknown variance, 252–257, 256f
t-tests, 311–317, 313f, 316f, 317t	estimates of, 247–252
one-sided, 314–317, 316f	
paired, 325-326	Unknown parameters. See Parameter estimation
p-value of two-sample, 323f	Unknown probability, confidence interval for,
two-sided, 311-313, 313f	268–272, 272t
Two sample permutation tests, 637–638	Unknown variance
Two-sample problem, 521, 531-539, 534f, 538f	confidence intervals for normal mean with,
distribution function of, 531	252–257, 256f
in life testing, 606–608	hypothesis testing for mean of normal
probability and, 532-533	population with, 311–317, 313f,
<i>p</i> -value and, 533–535, 534f	316f, 317t
classical approximation and simulation,	testing equality of means of two normal
535–539, 538f	populations with, 320–325, 321f, 323f,
Two-sided confidence interval, 248, 251	325t
of difference in means of two normal	Updated probability density function, 280
distributions, 261-268, 262-263f,	Upper confidence interval
266–267f	for difference in means of two normal
for normal mean with unknown variance,	distributions, 255, 265–266,
255–257, 256f	266–267f
for unknown probability, 272t	for normal mean with unknown variance,
Two-sided t-tests, for mean of normal	254–255
population with unknown variance,	for unknown mean, 249-251
311–313, 313f	for unknown probability, 272t
Two-way analysis of variance, 446	for variance of normal distribution, 260t
hypothesis testing for, 464–468, 467t, 468f	Upper control limits
with interaction, 446, 469–476, 475t, 476f	for exponentially weighted moving-average,
introduction and parameter estimation,	576–578, 578f
460–463	for fraction defective, 566-567
Type I errors, 298, 300	for mean control charts,
Type II errors, 298, 302–305, 304f	555–557, 556f
	for moving-average, 572–573,
U	573t, 574f
Unbalanced case, in one-way analysis of	for number of defects, 568–570
variance, 459	for variance control charts,
Unbiased estimators, 274–279	563–564, 564f

V	permutation tests and, 634-635
Variance, 118–121. See also Analysis of variance;	population, 208-209
Population variance; Sample variance	of random variables, 118-121, 123-126,
of chi-square random variable, 192, 222,	162, 169–170, 193, 222, 447–448
447–448	in response to input variable, 382–384,
covariance, 121–122	390–396, 395f
definition of, 119	sample, 22–24, 219–220
distribution of, with chi-square random	of a sum of random variables, 124–126
variables, 222	of uniform random variables, 162
estimators of, 447–448	unknown
for one-way analysis of variance, 446,	confidence intervals for normal mean with
448–459, 452t, 453f, 456t	252–257, 256f
in two-way analysis of variance, 464-467	equality of means of two normal
in two-way analysis of variance with	populations with, 320–324, 321f, 323f
interaction, 469–476, 475t, 476f	hypothesis testing for mean of normal
for exponentially weighted moving-average,	population with, 311–317, 313f, 316f,
575–576	317t
of hypergeometric random variables,	unknown and equal, testing equality of
157–158	means of two normal populations with, 324–325, 325t
of independent random variables, 222	Variance control chart, 562–565, 564f
of indicator random variable, 119–121	Venn diagram, 56–57, 56f, 57f
known	probability axioms and, 58–59, 59f
equality of means of two normal	probability axioms and, yo yy, yyr
populations with, 318-320, 319t	NA7
hypothesis testing for mean of normal	W
population with, 299-311, 301f, 304f,	Weak law of large numbers, 130
311t	Weibull density function, 608, 609f
of least squares estimators, 362–364,	Weibull distribution, in life testing, 608–612,
405–407	609f
for moving-average, 572	Weighted average, 19–20
of normal distribution, confidence interval	Weighted least squares estimators, 390–396,
for, 259–260, 259t	395f
of normal population, hypothesis testing for,	Wilcoxon test. See Rank sum test
327–329	Within samples sum of squares, 450, 454, 456t
of normal random variables, 169–170	459