TABLE XVI
Sample size for two-sided nonparametric tolerance limits

δ \ $1-\alpha$	0.50	0.70	0.90	0.95	0.99	0.995
0.995	336	488	777	947	1,325	1,483
0.99	168	244	388	473	662	740
0.95	34	49	77	93	130	146
0.90	17	24	38	46	64	72
0.85	11	16	25	30	42	47
0.80	9	12	18	22	31	34
0.75	7	10	15	18	24	27
0.70	6	8	12	14	20	22
0.60	4	6	9	10	14	16
0.50	3	5	7	8	11	12

APPENDIX B

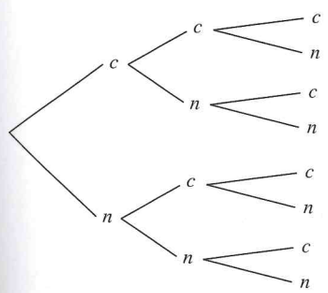
ANSWERS TO SELECTED PROBLEMS

Section 1.1

1. .3; relative frequency
3. .25; classical

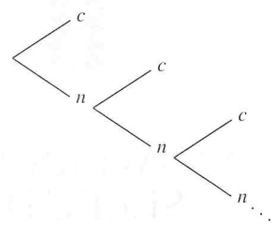
Section 1.2

5. (*a*)



(*b*) {*ccc, ccn, cnc, cnn, ncc, ncn, nnc, nnn*}
(*c*) $A_1 = \{ccc, ccn, cnc, cnn, ncc, ncn, nnc\}$
$A_2 = \{ccc\}$
$A_3 = \{nnn\}$
(*d*) no; yes; yes; no
(*e*) no; the eight sample points are not equally likely

7. (*a*)



(*b*) no
(*c*) {*c, nc, nnc, nnnc,* . . . }; the list cannot be completed
(*d*) {*c, nc, nnc, nnnc*} = *A*
(*e*) A_1 = contact is made on the first try = {*c*}
A_2 = contact is made on the second try = {*nc*}

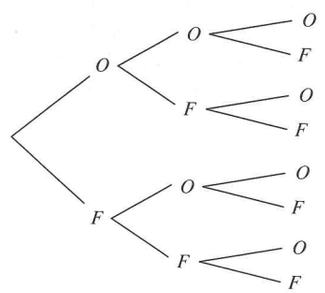
Section 1.3

9. (*a*) 362,880
(*b*) 720
(*c*) 210
(*d*) 30
(*e*) 120
(*f*) 720
11. (*a*) 72
(*b*) 36
13. (*a*) 32
(*b*) 16
(*c*) 4
(*d*) 1
15. (*a*) 5! = 120
(*b*) 48
17. (*a*) 126
(*b*) 56
(*c*) 56
(*d*) 1
19. 21
21. (*a*) 60,480
(*b*) 30,240
23. (*a*) 20!/5!5!5!3!2! = 117,327,450,200
(*b*) 20!/18!2! = 190
25. 12!/3!3!3!3! = 369,600

27. (*a*) $\binom{3}{2} = 3$: {*yyn, yny, nyy*}; or 3!/2!1! = 3
(*b*) $2^{10} = 1024$; $\binom{10}{7}$; or 10!/7!3! = 120

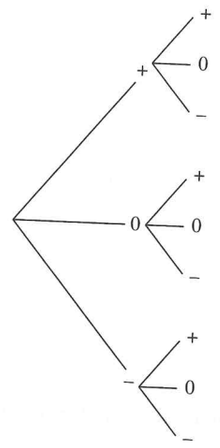
CHAPTER 1 review exercises

28. 7; 15
29. (*a*) 44
(*b*) 11
(*c*) 11/44
30. $\binom{25}{10} = 3{,}268{,}760$; $\binom{5}{3}\binom{20}{7} = 775{,}200$
31. $\binom{6}{3}\binom{4}{0}\Big/\binom{10}{3} = 1/6$; no, something that occurs by chance with probability 1/6 is not unusually rare
32. (*a*) $(26^5)10 = 118{,}813{,}760$
(*b*) $\left(\frac{5!}{3!2!}\right)5 = 50$
(*c*) 1/50
33. 2^{16}; $2^{16} - 1$
34. 15/28
35. (*a*)



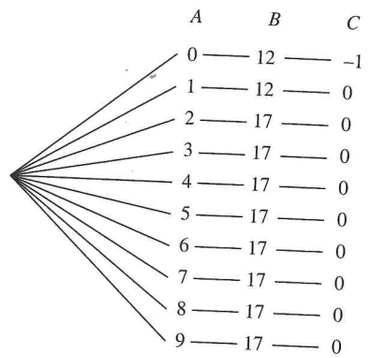
(*b*) {*OOO, OOF, OFO, OFF, FOO, FOF, FFO, FFF*}
(*c*) *A* = {*OOO, OOF, OFO, OFF, FOO, FOF, FFO*}
B = {*OOO, OOF, OFO, OFF*}
C = {*FFF*}
D = ∅
(*d*) no; yes; yes
(*e*) impossible event
(*f*) 1/8

36. (*a*)



(*b*) $\{++, +0, +-, 0+, 00, 0-, -+, -0, --\}$
(*c*) $A = \{-+, -0, --\}$
$B = \{++, 00, --\}$
$C = \{+0, +-, 0-\}$
(*d*) no; yes
(*e*) The first item selected is not of inferior quality, and both items are of the same quality ($A' \cap B = \{++, 00\}$); the first item selected is of inferior quality, but the items are not of the same quality ($A \cap B' = \{-+, -0\}$); the first item selected is not of inferior quality, and the two items are not of the same quality ($A' \cap B' = \{0+, 0-, +0, +-\}$); the first item selected is of inferior quality, the quality of the first does not exceed that of the second, and the items are of the same quality ($A \cap C' \cap B = \{--\}$)
(*f*) The argument is invalid because the nine outcomes are not equally likely.

37. (*a*)



(*b*) $\{(0, 12, -1), (1, 12, 0), (2, 17, 0), (3, 17, 0), (4, 17, 0), (5, 17, 0), (6, 17, 0), (7, 17, 0), (8, 17, 0), (9, 17, 0)\}$
(*c*) yes
(*d*) 5/10
(*e*) 1/10
(*f*) 9/10
(*g*) 1

38. $180!/\underbrace{5!5!5!\ldots5!}_{36 \text{ terms}}$

Section 2.1

1. 12/13
3. .45; .13; .46
5. .58; .28; .1
7. .4
9. .42; .46
11. .004

Section 2.2

13. (*a*) 30/58
(*b*) 28/58
(*c*) Theorem 2.1.2
(*d*) 10/42
(*e*) no; exposure to the lethal dose should increase the probability of death
15. 5/35; 35/40
17. (*a*) 1/5
(*b*) 1/80
(*c*) .04
(*d*) 4/20
(*e*) .84

Section 2.3

19. no; $P[A_1 \cap A_2] = .2 \neq P[A_1]P[A_2]$
21. $(.29)^2 \doteq .15$
23. (*a*) .21
(*b*) 21/23
25. .085
27. .0144(.67) + .0012(.33) = .010044
29. no; $P[B|T] \neq P[B]$
31. .931

Section 2.4

35. .85(.10)/[.85(.10) + .04(.90)] = .7025
37. .9999

CHAPTER 2 review exercises

38. (*a*) .85
(*b*) .15
(*c*) 5/20
(*d*) 5/10
39. (*a*) 1/2
(*b*) 1/8
40. .3529; .2353; .2647; .1471
41. .24; .6; .16
42. (*a*) .5
(*b*) .35
(*c*) .50
(*d*) 1/3
(*e*) 35/85
43. (*a*) .0008
(*b*) .0002
(*c*) .2
44. $(.99)^3(.01) = .00970299$; $.01 + .99(.01) + (.99)^2(.01) + (.99)^3(.01)$

Section 3.1

1. not discrete
3. discrete
5. not discrete

Section 3.2

7. (*a*) .01
(*b*)

x	0	1	2	3	4	5
$F(x)$	.7	.9	.95	.98	.99	1.00

(*c*) .98; .1
(*d*) .03
9. (*a*)

x	0	1	2	3
$f(x)$	$(.1)^3$	$3(.9)(.1)^2$	$3(.9)^2(.1)$	$(.9)^3$

(*b*) $k(x) = \dfrac{3!}{x!(3-x)!}$
(*c*)

x	0	1	2	3
$F(x)$	.001	.028	.271	1.00

(*d*) .999
(*e*) .028
11. (*a*)

x	0	1	2	3	4
$f(x)$	16/31	8/31	4/31	2/31	1/31

(*b*) $F(x) = 0$ for any $x < 0$
(*c*) $F(x) = 1$ for any $x > 4$
13. The sum of probabilities is the sum of numbers greater than or equal to 0.

Section 3.3

15. (*a*) 4.96; 26.34
(*b*) 1.7384; 1.3185
(*c*) holes per bit
17. $1/.7 = 10/7$; $1/p$
21. (*a*) 11
(*b*) −17
(*c*) 16
(*d*) 4
(*e*) 64
(*f*) 8
(*g*) 208
(*h*) 640
(*i*) 0; 1
(*j*) 0; 1
(*k*) $E\left[\dfrac{X-\mu}{\sigma}\right] = 0$ and $\text{Var}\left[\dfrac{X-\mu}{\sigma}\right] = 1$
23. (*e*) 163/60 = 2.7167
(*f*) 2.7007
(*g*) $E[X_{100}] = 94.7953$

Section 3.4

25. (*a*) success is selecting an unacceptable lot; .05
(*b*) $f(x) = (.95)^{x-1}(.05)$
(*c*) $m_x(t) = \dfrac{.05e^t}{1 - .95e^t}$

(*d*) 20; 780; 380; 19.4936
(*e*) .9025
(*f*) .9025

27. $F(x) = 1 - (.95)^x$ for x, a positive integer; .142625

31. (*b*) 24/5
(*c*) $(1/5)e^{4t} + (4/5)e^{5t}$
(*e*) 116/5
(*g*) 4/25; 2/5

33. (*a*) Experiment consists of a series of samples, each resulting in an average that is too low or an average that is not too low.
P[success] = .025 is the same for each sample.
X is of the form, the number of trials needed until the first success is obtained

(*b*) $m_X(t) = \dfrac{.025e^t}{1 - .975e^t}, \; t < \ln .975$

(*c*) 40

35. (*a*) $e - 1$

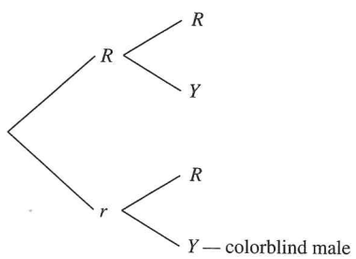
(*b*) $m_X(t) = \dfrac{(e-1)(e^{t-1})}{1 - e^{t-1}}$

(*c*) $E[X] = \dfrac{e^{-1}(e-1)}{(1-e^{-1})^2} = \dfrac{e}{e-1}$

Section 3.5

37. 2; .6778; yes, $P[X \geq 5] = .0328$

39. (*a*) $p = 1/4$



(*b*) 1.25; .1035

41. (*a*) .3758
(*b*) $(.3758)^5$

43. (*a*) $m_X(t) = (pe^t + q)^n$

45. (*a*) X = number of successes in one trial

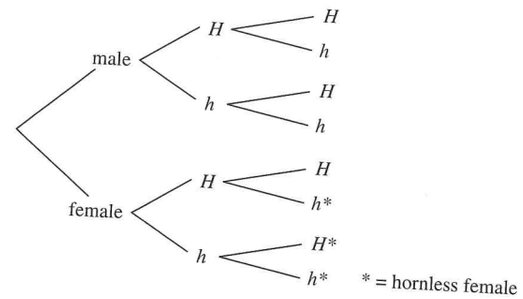
$$f(x) = \binom{1}{x} p^x q^{1-x} \qquad x = 0,1$$

(*b*) $f(x) = p^x q^{1-x} \qquad x = 0, 1$

(*c*) $m_X(t) = pe^t + q$
(*d*) p; pq
(*e*) .14

47. .02852

53.



when $r = 2$ and $p = 3/8$,

$E[X] = 16/3$; no; $P[X \leq 5] \doteq .6185$

Section 3.7

55. $x = 0, 1, 2, 3$; 15/20; $5\left(\dfrac{3}{20}\right)\left(\dfrac{17}{20}\right)\left(\dfrac{15}{19}\right) = .5033$

57. (*a*) $f(x) = \dfrac{\binom{3}{x}\binom{17}{5-x}}{\binom{20}{5}} \qquad x = 0, 1, 2, 3$

(*b*) .75; .5033
(*c*) .3991
(*d*) .6009

59. (*a*) $f(x) = \dfrac{\binom{600}{x}\binom{2400}{20-x}}{\binom{3000}{20}} \qquad x = 0, 1, 2, \ldots, 20$

(*b*) $4; 20\left(\dfrac{600}{3000}\right)\left(\dfrac{2400}{3000}\right)\left(\dfrac{2980}{2999}\right)$

(*c*) $\displaystyle\sum_{x=0}^{3} \frac{\binom{600}{x}\binom{2400}{20-x}}{\binom{3000}{20}}$

(*d*) .4114

Section 3.8

59. (*a*) 10
(*b*) 10
(*c*) $\sqrt{10}$
(*d*) $f(x) = \dfrac{e^{-10}10^x}{x!}$ $x = 0, 1, 2, \ldots$
(*e*) .029
(*f*) .010
(*g*) .019
(*h*) .99
(*i*) .448

63. .010

65. yes; $P[X > 10] = .043$

67. yes; $P[X < 2] = .04$

71. $(.0247)^5 = .00000000919$

CHAPTER 3 review exercises

75. .118; .882

76. (*a*) 5/4; 15/16
(*b*) $(3/4)^5$
(*c*) $(3/4)^{10}$

77. (*a*) X is binomial with $n = 100$ and $p = .1$; $E[X] = 10$
(*b*) Poisson
(*c*) $P[X \geq 17] \doteq .027$

78. $P[X \leq 6] \doteq .4662$

79. 5; 61/125; 64/125

80. 35/210; 105/210

81. $(999/1000)^{12,000} \doteq e^{-12}12^0/0! \doteq .000006; .999994$

82. yes; $P[X \geq 5] = .0127$

83. (*b*) 36/14; 98/14
(*c*) $m_X(t) = (e^t + 4e^{2t} + 9e^{3t})/14$
(*e*) 76/196; $\sqrt{76/196}$

84. $F(x) = 1 - \left(\dfrac{12}{13}\right)^x$ x a positive integer;

$$P[X \geq 3] = 1 - P[X \leq 2] = 1 - F(2) = \left(\frac{12}{13}\right)^2$$

85. (*a*) binomial, $n = 10$, $p = .8$
(*b*) Poisson, $k = 5$
(*c*) point binomial, $p = .3$ or binomial, $n = 1$, $p = .3$
(*d*) geometric, $p = .6$
(*e*) negative binomial, $n = 5$, $p = .3$
(*f*) Poisson, $k = 1$

86. (*a*) 8; 1.6; $\sqrt{1.6}$
(*b*) 5; 5; $\sqrt{5}$
(*c*) .3; .21; $\sqrt{.21}$
(*d*) 10/6; 10/9; $\sqrt{10/9}$
(*e*) 50/3; $5(.7)/(.3)^2 = 38.89$; $\sqrt{38.89}$
(*f*) 1; 1; 1

87. (*a*) $f(x) = (.99)^{x-1}(.01)$ $x = 1, 2, 3, \ldots$
(*b*) 100
(*c*) $F(x) = 1 - .99^x$ x a positive integer
(*d*) $P[X \leq 90] = 1 - (.99)^{90} \doteq .595$

Section 4.1

1. (*a*) 1/6
(*b*) 11/48
(*c*) 0
(*d*) 11/48

3. (*b*) $1 - e^{-.7} = .5034; .4966; 0$
(*c*) yes, $P[1 \leq X \leq 2] = e^{-.1} - e^{-.2} \doteq .086$

5. (*d*) .5
(*e*) equal; probabilities are constant or "uniform" over intervals of equal lengths

9. (*a*)

$$F(x) = \begin{cases} 0 & x < 2 \\ x^2/12 - 1/3 & 2 \leq x \leq 4 \\ 1 & x > 4 \end{cases}$$

(*c*) yes; yes; 0; 1; yes
(*d*) $\dfrac{dF(x)}{dx} = f(x)$

11. (*a*)

$$F(x) = \begin{cases} 0 & x < 0 \\ x/2\pi & 0 \leq x < 2\pi \\ 1 & x \geq 2\pi \end{cases}$$

(*b*) yes; yes; 0; 1; yes
(*c*) $\dfrac{dF(x)}{dx} = f(x)$

13.

$$F(x) = \begin{cases} 0 & x < 25 \\ (\ln x - \ln 25)/\ln 2 & 25 \leq x \leq 50 \\ 1 & x > 50 \end{cases}$$

Section 4.2

15. (*a*) 56/18
(*b*) 10
(*c*) 104/324; $\sqrt{104/324}$
17. (*a*) $m_X(t) = (1 - 10t)^{-1}$ $t < 1/10$
(*b*) 10 minutes
(*c*) 100; 10 minutes
19. π; $\pi^2/3$; $\pi/\sqrt{3}$
21. 10; 10; X
23. (*b*) $F(x) = \frac{25}{24} - \frac{25}{6}x^{-2}$, $2 < x < 10$; .78125
(*c*) 1.033
(*d*) 5.364; 4.297

Section 4.3

25. (*a*) 2
(*b*) 5040
(*c*) 96
(*d*) 1
27. (*a*) 1; 2; 6; 24; 120
(*b*) $\Gamma(n) = (n-1)!$ $n > 1$
(*c*) yes, $\Gamma(1) = 1 = 0!$
(*d*) 14!
29. (*a*) $f(x) = (1/128)x^2e^{-x/4}$ $x > 0$
(*b*) $m_X(t) = (1 - 4t)^{-3}$ $t < 1/4$
(*c*) 12; 48; $\sqrt{48}$
33. $m_X(t) = (1 - \beta t)^{-1}$ $t < 1/\beta$; β; β^2
35. .8647
37. (*a*) $e^{-.25} \doteq .779$
(*b*) $e^{-7/12}/e^{-4/12} = e^{-3/12}$; same as (*a*)

Section 4.4

39. (*a*) .9418
(*b*) .9418
(*c*) 0
(*d*) .0582
(*e*) .8543
(*f*) 1.28
(*g*) −1.28
(*h*) 1.96
(*i*) 1.645
41. (*a*) .9544
(*b*) 1.24%
(*c*) 128 parsecs
(*d*) $m_X(t) = e^{5000t^2}$

43. (*a*) .9525
(*b*) 5.065

Section 4.5

49. $P[-2\sigma < X - \mu < 2\sigma] = .95$
51. (*a*) no
(*b*) $P[|X - \mu| < .5\sigma] \geq -3$, $P[|X - \mu| < 1\sigma] \geq 0$,
$P[|X - \mu| < .2\sigma] \geq .75$, $P[|X - \mu| < 3\sigma] \geq .89$; $k = 2$

Section 4.6

53. (*a*) yes; .9956
(*b*) .0668
55. (*a*) yes
(*b*) 37.5
(*c*) .0322
(*d*) .0392
57. .9484; .8413

Section 4.7

59. (*a*) random factors
(*b*) $R(t) = e^{-.02t}$
(*c*) $R(20) = .6703$
(*d*) $f(x) = .02e^{-.02x}$ $x > 0$
(*e*) exponential
(*f*) 50; 2500
(*g*) .5488
65. (*a*) .9974; .96
(*b*) .8812
(*c*) .9996
(*d*) .8988
(*e*) III: .9964, V: .999999; .9537
67. 3

Section 4.8

71. $f_Y(y) = (2 - y)e^{-(2-y)}$ $y \leq 2$
73. $f_F(x) = 5/54$ $59 < x < 69.8$

CHAPTER 4 review exercises

82. (*a*) 1/18
(*b*) 0; 5.4
(*c*) 5.4; $\sqrt{5.4}$
(*d*) 35/54; 9/54; 26/54

(*e*)

$$F(x) = \begin{cases} 0 & x < -3 \\ (x^3 + 27)/54 & -3 \le x \le 3 \\ 1 & x > 3 \end{cases}$$

83. $\Gamma(11) = 10! = 3{,}628{,}800$

84. (*a*) $\alpha = 9$ and $\beta = 2$
(*b*) .01; .10; .725 (chi-squared with 18 degrees of freedom)

85. (*a*) $f(x) = \dfrac{1}{\sqrt{2\pi}\,(5)} \exp\left[-\dfrac{1}{2}\left(\dfrac{x-15}{5}\right)^2\right]$
(*b*) .0082
(*c*) no; $P[10 \le X \le 20] \doteq .68$ by the normal probability rule
(*d*) yes; $P[X \ge 30] = .0013$

86. .7904; $e^{-6.25(6)}$; .042

87. (*a*) 24
(*b*) 122
(*c*) 152
(*d*) 67
(*e*) 4

89. (*a*) $f(x) = (2/5)x^{-4/5}e^{-2x^{1/5}}$
(*b*) 3.75 years
(*c*) $R(t) = e^{-2t^{1/5}}$
(*d*) .1005
(*e*) 2/5
(*f*) $\rho(t)$ is decreasing, so most failures are attributed to early burnout of defective modems

90. 8; .2912; no; $P[X \le 5] \doteq .1788$

91. $f(x) = (3/2)x^2 + x, \qquad 0 \le x \le 1$

92. (*b*) 2; 6; 2

93. .4892

94. (*a*) normal, $\mu = 3$, $\sigma^2 = 16$
(*b*) gamma, $\alpha = 7$, $\beta = 3$
(*c*) chi-squared with 24 degrees of freedom
(*d*) uniform, $a = 1$, $b = 3$
(*e*) standard normal
(*f*) exponential, $\beta = 7$
(*g*) normal, $\mu = 3$, $\sigma^2 = 1$

95. (*a*) 3; 16
(*b*) 21; 63
(*c*) 24; 48
(*d*) 1; 4/2
(*e*) 0; 1
(*f*) 7; 49
(*g*) 3; 1

Section 5.1

1. (*a*) .005
(*b*) .03
(*c*) .98
(*d*) .045

3. (*b*) $f_X(x) = f_Y(y) = 1/n \qquad x, y = 1, 2, 3, \ldots, n$
(*c*) yes

5. (*a*) .4
(*b*) .429
(*d*) .121
(*e*) .22
(*f*) no

7. (*a*) .707
(*b*) .031
(*c*) .242

9. (*b*) .423
(*c*) .577
(*d*) .153
(*e*) $f_X(x) = 1 \qquad 0 < x < 1$
$f_Y(y) = -\ln y \qquad 0 < y < 1$
(*f*) .5
(*g*) .597
(*h*) no

11. (*a*) .005
(*b*) .0625
(*c*) .25
(*d*) $f_X(x) = .2 - .005x \qquad 20 < x < 40$
$f_Y(y) = .005y - .1 \qquad 20 < y < 40$
(*e*) .5625
(*f*) .25
(*g*) no

13. $f(x_1, x_2, \ldots, x_n) \ge 0$

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\cdots\int_{-\infty}^{\infty} f(x_1, x_2, \ldots, x_n)\, dx_1\, dx_2 \ldots dx_n = 1$$

$$P[a_1 \le X_1 \le b_1, a_2 \le X_2 \le b_2, \ldots, a_n \le X_n \le b_n]$$
$$= \int_{a_n}^{b_n}\int_{a_{n-1}}^{b_{n-1}}\cdots\int_{a_1}^{b_1} f(x_1, x_2, \ldots, x_n)\, dx_1\, dx_2 \ldots dx_n$$

Section 5.2

15. (*a*) negative
(*b*) 60/35; 80/35; 120/35; $-600/35^2$

17. 0

19. (*a*) 30.96; 28.99; 897.84; .3096
(*b*) 1.97; average difference in the inside and outside pressures

21. 1/2; 1/4; 1/6; 1/24

23. (*a*) positive
(*b*) 26.67; 33.33; 900; 11.09
(*c*) 6.66

Section 5.3

29. (*a*) negative; -1
(*b*) 120/35; 200/35; -1

31. 959.76; 841.67; 1.24; 1.25; .24

33. 1/3; 1/9; 1/12; 7/144; .655

37. 0

Section 5.4

39. (*a*) 31.99
(*b*) 28.5

41. (*a*) $\mu_{X|y} = \sum_{x=y}^{n} x \dfrac{1}{n-y+1} + \dfrac{n+y}{2}$; yes
(*b*) 7
(*c*) $\mu_{Y|x} = \sum_{y=1}^{x} \dfrac{y}{x} = \dfrac{x+1}{2}$; yes
(*d*) 5/2

43. (*a*) $\mu_{X|y} = (y + 20)/2$; yes
(*b*) \$25.00
(*c*) $\mu_{Y|x} = (40 + x)/2$; yes
(*d*) \$37.50

Section 5.5

45. (*a*) yes; $x = \dfrac{3u - v}{5}$, $y = \dfrac{2v - u}{5}$
(*b*) 1/5

47. $f_{UV}(u, v) = 1/10,\ 0 < u < 4,\ 0 < v < 7$

53. (*a*) $f_U(u) = \begin{cases} (1/6)(\ln 3 - \ln u/2) & 0 < u < 6 \\ 3/4 & 0 < u < 2/3 \end{cases}$
(*b*) $f_U(u) = 1/3u^2 \quad 2/3 \le u < \infty$

CHAPTER 5 review exercises

54. (*b*) 8/18
(*c*) $P[Y \le 1/2 \text{ and } Y \le X \le Y + 1/4] = 11/96$

(*d*) $f_X(x) = 4x^3 \quad 0 < x < 1$; 4/5; 2/3
(*e*) $f_Y(y) = 4y(1 - y^2) \quad 0 < y < 1$; 8/15; 1/3
(*f*) no
(*g*) $f_{X|y} = 2x/(1 - y^2), \quad 0 < y < x < 1$
(*h*) $P[X \le 3/4 | y = 1/6] = 11/20$
(*i*) $\mu_{X|y} = 2(1 + y + y^2)/3(1 + y)$; no
(*j*) 43/63 (about 41 minutes after the system is activated)
(*k*) positive; .493

55. $f_X(x) = xe^{-x} \quad x > 0$; $f_Y(y) = ye^{-y} \quad y > 0$; yes; 0

56. (*a*) .356
(*b*) 3.279
(*c*)

x	0	1	2	3	
$f_X(x)$	.210	.298	.277	.215	$\mu_X = 1.497;\ \sigma_X^2 = 1.1$

y	1	2	3	4	
$f_Y(y)$	.267	.397	.302	.034	$\mu_Y = 2.103;\ \sigma_Y^2 = .694$

(*d*) .688
(*e*) .1308; .1497; yes

57. (*a*) $f_{XY}(x, y) = \left(\dfrac{e^{-5}5^x}{x!}\right)\left(\dfrac{e^{-3}3^y}{y!}\right) \quad x = 0, 1, 2, \ldots \quad y = 0, 1, 2, \ldots$
(*b*) .0572
(*c*) 0
(*d*) $f_{X|y} = \dfrac{e^{-5}5^x}{x!} \quad x = 0, 1, 2, \ldots$

Section 6.1

1. yes; set of all days from past, present, and future

3. no

5. yes; the 50,000 workers affected

Section 6.2

7. (*a*) 58.8
(*b*) 8.5
(*c*) 16.25
(*d*) 16.25 to 24.75
24.75 to 33.25
33.25 to 41.75
41.75 to 50.25
50.25 to 58.75
58.75 to 67.25
67.25 to 75.75

9. (*a*)

0	2							
0	5	7						
1	1	2	2	3	4	4	4	4
1	5	5	6	6	7	9		
2	0	1	1	2	3			
2	5	6	8	9				
3	0	0	1					
3	7	7						
4	0	1						
4	5							
5	1							
5	8							

(*b*) yes; right

11. (*d*)

Category	Boundaries	Frequency	Relative frequency	Relative cumulative frequency
1	.45 to 1.25	7	7/50	7/50
2	1.25 to 2.05	15	15/50	22/50
3	2.05 to 2.85	15	15/50	37/50
4	2.85 to 3.65	8	8/50	45/50
5	3.65 to 4.45	3	3/50	48/50
6	4.45 to 5.25	2	2/50	50/50

the gamma distribution might be appropriate

13. (*a*) $P[X < p_{25/100}] \leq 25/100$ and $P[X \leq p_{25/100}] \geq 25/100$
(*b*) 8
(*c*) $-\ln .75 \doteq .288$

15. (*a*) approximately .044
(*b*) approximately 7.7
(*c*) approximately 2.2

Section 6.3

17. (*a*) group I 3; 3
group II 3; 2.5
(*b*) 4, 4
(*c*) group I 1.5; 1.2
group II 2.91; 1.7
(*d*) yes

19. .8; 1.07

21. 7.94; 1.221; 1.11

23. (*a*) $\bar{x} = 2.31, \tilde{x} = 2.05$
(*b*) $s = 1.29, s^2 = 1.6745$
(*c*) $\bar{x}$, $\tilde{x}$, s are measured in minutes; s^2 is unitless

25. (*a*) yes
(*b*) 1.86
(*c*) 1.975

Section 6.4

27. (*b*) 1.34σ

29. (*a*)

1	1							
1	5	8						
2	4	3						
2	6	5	7	9				
3	2	0						
3	6	9	5	7	8	7	5	
4	0	0	2					
4	7	9						
5	0	1						
5	6							
6	0							

(*b*) $\tilde{x} = 3.65$ $q_1 = 2.65$ $q_3 = 4.10$ $iqr = 1.45$ $f_1 = .475$ $f_2 = 6.275$ no outliers

(*c*)

2	0							
4								
4	2	3						
4	5	4						
4	6	7	6					
4	9	8						
5	0	1	0					
5	2	2	3	2	3			
5	4	4						
5	6							
5	8	9						
7	8							

(*d*) $\tilde{x} = 5.05$ $q_1 = 4.6$ $q_3 = 5.35$ $iqr = .75$ $f_1 = 3.475$ $f_3 = 6.475$ $F_1 = 2.35$ $F_3 = 7.6$
2 is an extreme outlier; 7.8 is an extreme outlier

(*e*)

3	9							
4	2	4	3	1				
4	5	7	9	8	7	6	8	
5	0	1	1	2	0	4		
5	9	6						
6	1							
6								

58 has a misplaced decimal and should read 5.8; $\bar{x} = 7.29$ (using bad point); $\bar{x} = 4.91$ (using corrected point)

CHAPTER 6 review exercises

26. (*a*) Poisson
(*b*) 1.9; 3.36; 1.8; 1
(*c*) no
(*d*) 6.24; 1.852; 1.36; 6.3

31. (*a*) range = 5.73

Category	Boundaries	Frequency	Relative frequency	Relative cumulative frequency
1	.235 to 1.195	2	2/50	2/50
2	1.195 to 2.155	18	18/50	20/50
3	2.155 to 3.115	13	13/50	33/50
4	3.115 to 4.075	7	7/50	40/50
5	4.075 to 5.035	7	7/50	47/50
6	5.035 to 5.995	3	3/50	50/50

(*b*) 2.788; 1.8594; 1.364
(*c*) approximately 2.644; about 16%
(*d*) *p;* 3/50; 3/50
(*e*) $p(1-p)$; (3/50)(47/50) = .0564; .0576; no; .0576
(*f*) $\sigma_{\bar{X}} \doteq .955$

32. (*a*)

1	1
1	3
1	5
1	
1	9 8
2	1 0
2	2 2 2 3 3
2	5 5 5 5 4 5 4 4 5 5 4
2	6 7 7 6 7 7 6
2	9 8 8
3	0
3	
3	
3	
3	

(*b*) $\tilde{x} = 25$ $iqr = 4$ $F_1 = 10$
$q_1 = 22$ $f_1 = 16$ $F_3 = 38$
$q_3 = 26$ $f_3 = 32$
the values 11, 13, 14, and 15 are flagged as outliers
(*c*) there is a left skew; gamma; no; outliers are flagged, assuming normality

(*d*)

3	
3	3
3	5 5
3	6 7 7 6 6 6 7 7
3	8 8 9 9 8 9 8 9 9
4	0 0 0 0 0 1 1
4	2 3 3
4	5 5
4	6 6
4	

yes

(*e*) $\tilde{x} = 3.9$ $f_1 = 3.1$ no outliers
$q_1 = 3.7$ $f_3 = 4.7$
$q_3 = 4.1$ $F_1 = 2.5$
$iqr = .4$ $F_3 = 5.3$

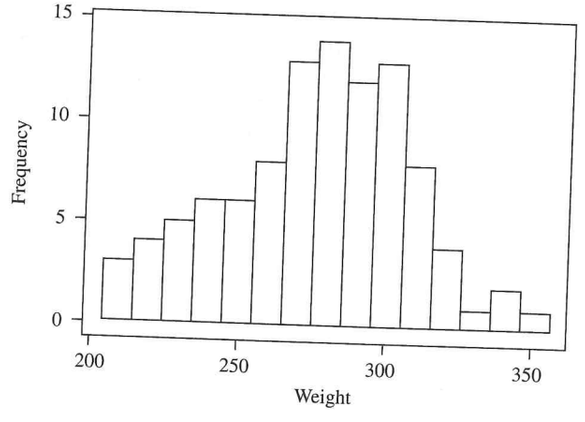
33. (*a*)

15	0
16	0 0
17	0 0 0 0 0 0
18	0 0 0 0 0
19	0 0 0
20	0 0
21	0
22	0

yes

(*b*) $\bar{x} = 18.0$; $\tilde{x} = 18$
(*c*) $s = 1.7$; $s^2 = 2.95$ (from TI83)
(*d*) $q_1 = 17$, $q_3 = 19$, $iqr = q_3 - q_1 = 2$
The TI83 and MINITAB give these same results.

34. (*a*) 275.87, 30.57
(*b*)



(*c*) yes
(*d*) 250; 295; 275
(*e*) TI83 results: $q_1 = 255.85, q_3 = 298.25, \tilde{x} = 277.85$
MINITAB results: $q_1 = 255.63, q_3 = 298.28, \tilde{x} = 277.85$

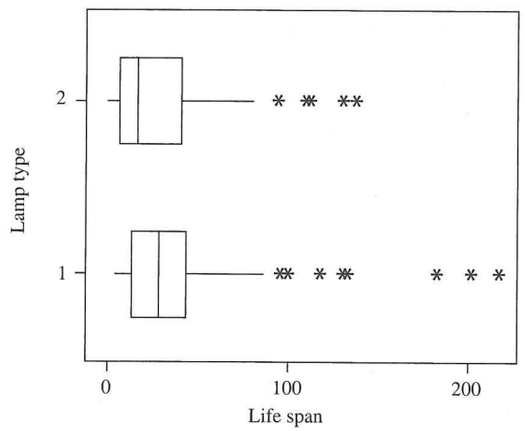
35. (*a*) The distributions of life span for both lamp types are skewed to the right

(*b*)

Variable	Lamp type	Mean	Median	StDev	Variance
Life span	1	38.38	28.78	40.48	20.07
	2	28.97	17.14	30.22	913.25

mean > median

(*c*)



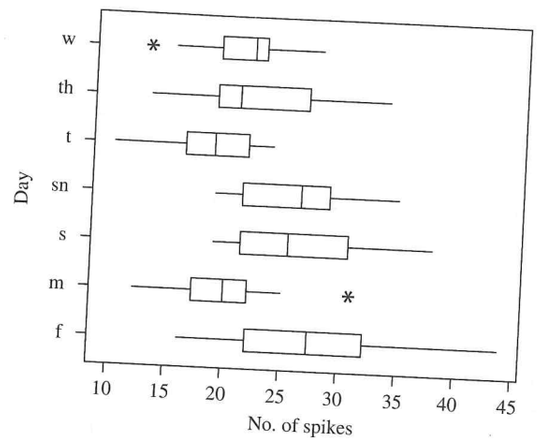
(*d*)

Variable	Lamp type	Mean	Median	StDev	Variance
Life span	1	28.92	23.02	22.04	485.76
	2	25.04	15.28	23.61	557.43

36. (*a*)

Day	Mean	Median	StDev	Min	Max	Q_1	Q_3
sn	25.9	25.5	5.39	1.21	19	21.25	30.75
m	20	20	4.255	12	31	17.25	22
t	18.55	19	4.032	10	24	16.25	21.75
w	21.15	22	3.76	13	28	19.25	23
th	22.4	21	5.35	13	34	19	27
f	27.45	27.5	6.44	16	44	22	32.25

(*b*)



Section 7.1

1. 8; 5/20
3. (*a*) 5.25
(*b*) 5.25
(*c*) 5.25/9
5. (*b*) .44
7. (*a*) 9.7
(*b*) 3.57
(*c*) 19.4
(*d*) 1.9; no
9. (*b*) .817; no, the sample sizes are very different
(*d*) .708
13. (*a*)

16	0	3	2	0	2	3	1	2	4	3
16	5	7	8	7	9					
17	0	2	3							
17	6	9	8							
18	0									
18	5									
19										
19	6									

skewed right

(*b*) $\tilde{x} = 167$ $f_1 = 148$
$q_1 = 163$ $f_3 = 188$
$q_3 = 173$ $F_1 = 133$
$iqr = 10$ $F_3 = 203$
196 is flagged; the distribution is not bell-shaped, so the "outlier" is probably not unusual

(*c*) $\bar{x} = 169.0$ (169.04)
$s^2 = 81.54$

Section 7.2

15. .67
17. $\overline{X}$; $\overline{X}/s$
19. $M_2 - M_1^2$; no
21. $\hat{\beta} = \bar{x} = 169$; $\hat{\sigma}^2 = M_2 - M_1^2 = 24/25(s^2) = 78.28$
23. $1/\overline{X}$
25. $\hat{\sigma}^2 = \dfrac{(1 - 1/\bar{x})}{(1/\bar{x})^2}$
27. (*a*)

31	9
32	0 1 2
32	5 6 7 8
33	0 0 1 3 4 2 4
33	9 8 5 7 8 9 8 6 7
34	0 3 1 1
34	9
35	0

(*b*) 333.8; 60.85
(*c*) 62.94
29. 333.8; 60.85
31. $\overline{X}$; no
33. (*a*) $\overline{X}/2$
(*b*) $\overline{X} = 2\hat{\beta}$; yes
(*c*) 35.25
(*d*) 70.5
35. .1

Section 7.3

37. (*a*) normal; $\mu = 2$, $\sigma^2 = 9$
(*b*) normal; $\mu = 0$, $\sigma^2 = 16$
(*c*) geometric, $p = .25$
(*d*) binomial, $n = 5$, $p = .5$
(*e*) Poisson, $k = 6$
(*f*) gamma, $\alpha = 5$, $\beta = 3$
(*g*) chi-squared, $\gamma = 16$
(*h*) exponential, $\beta = .5$

Section 7.4

47. (*a*) .643
(*b*) .643 ± .0039

(*c*) shorter; .643 ± .0033
(*d*) longer; .643 ± .0052
49. (*a*) no, X is discrete
(*b*) 2.8
(*c*) 2.8 ± .2036; Central Limit Theorem
(*d*) no; 3.0 lies in this interval—it has not been ruled out as a possible value for μ

CHAPTER 7 review exercises

51. (*b*) $\dfrac{1 + \theta}{\theta + 2}$
(*c*) $(1 - 2\overline{X})/(\overline{X} - 1)$
(*d*) $-52/76 \doteq -.6842$
(*e*) $-1 - n/\ln \Pi x_i$
(*f*) $-.3836$; no
52. (*a*) $\theta/2$
(*b*) $2\overline{X}$; yes
(*c*) 2.06
53. (*a*) normal with mean μ and variance 4/16
(*b*) 42.883
(*c*) 42.883 ± .98; no, 42.2 lies in the confidence interval
54. (*a*) \$3.698
(*b*) .0487
(*c*) .221; no
(*d*) .0438; no
55. (*a*) point binomial with probability of success p
(*b*) normal with mean p and variance $p(1 - p)/n$
(*c*) .05
56. (*a*) 7.1
(*b*) normal with mean μ and variance 25/36
(*c*) 7.1 ± 1.9
(*d*) yes; 10 lies outside the 99% confidence interval
57. (*a*) $m_X(t) = e^{15t + 16(t^2/2)}$
$m_Y(t) = e^{1.5t + .25(t^2/2)}$
(*b*) $m_T(t) = e^{16.5t + 16.25(t^2/2)}$
(*c*) T is normally distributed with mean 16.5 minutes and variance 16.25
(*d*) .1922
58. (*a*) $m_Y(t) = (1 - 3t)^{-500}$
(*b*) gamma with $\alpha = 500$ and $\beta = 3$
(*c*) $m_{\overline{X}}(t) = m_Y(t/100) = [1 - (3/100)t]^{-500}$
(*d*) gamma with $\alpha = 500$ and $\beta = 3/100$
(*e*) .0681
59. (*a*) gamma with $\alpha = 2$ and $\beta = \theta$
(*b*) 2θ

(*c*) $\bar{X}/2$
(*d*) $\bar{X}/2$; no
(*e*) 1.55
(*f*) yes

60. (*a*) standard normal
(*b*) X_1^2
(*c*) X_{10}^2; $\bar{y} \sim$ normal; $\mu = \frac{\lambda s}{n}$; $\sigma^2 = \frac{\lambda s}{n^2}$

62. (*a*)

x	1	2	3	4	5	6
$f(x)$	1/6	1/6	1/6	1/6	1/6	1/6

$$E[X] = 3.5$$
$$E[X^2] = 91/6$$
$$\sigma^2 = 35/12 = 2.92$$

(*b*) $E[\bar{X}] = 3.5$; Var $\bar{X} = 2.92/20 = .146$
(*c*) bell
(*d*) 3.5
(*e*) .146
(*f*) 24

63. (*a*) 1274.14
(*b*) 1274.14
(*c*) yes
(*d*) .4562

Section 8.1

1. (*b*) .0129
(*c*) [.0082, .0234]
(*d*) [.091, .153]
(*e*) yes; .2 is not in the confidence interval

3. (*b*) 2.455
(*c*) [1.322, 5.699]
(*d*) [1.15, 2.39], reduce the confidence

5. (*b*) .00000375
(*c*) [0, .00000573]; [0, .00239]
(*d*) yes; σ appears to be at most .00239

7. [5.49, 11.83]

Section 8.2

9. (*a*) 1.86
(*b*) −1.86
(*c*) −2.179

(*d*) 2.179
(*e*) 1.645
(*f*) 1.645
(*g*) 1.708
(*h*) 2.060
(*i*) 1.753
(*j*) 1.325
(*k*) 1.746
(*l*) 1.310

11. (*a*) 1.2896; .0000123; .0035
(*b*) 1.2896 ± .0016
(*c*) no, 1.29 is contained in the confidence interval

13. (*a*) 2.35; .89
(*b*) 2.35 ± .45
(*c*) yes, we are 99% confident that the new mean time is at most 2.80 seconds

15. (*a*)

2	9
3	8 5 9
4	2 1 7 8
5	1 3 5 6 7 5
6	1 8 1 0 2 5 7 3
7	9 7 3 2
8	1 0
9	2
10	0

(*b*) $\tilde{x} = 605$ $f_1 = 120$ no outliers
$q_1 = 480$ $f_3 = 1080$
$q_3 = 720$
$iqr = 240$

(*c*) $\bar{x} = 602.3$; $s = 169.1$; 602.3 ± 85.1
(*d*) lower the confidence

17. $[37.11, \infty)$

19. (*b*) 385
(*c*) 153

Section 8.3

21. (*a*) H_0: $\mu \geq .08$
H_1: $\mu < .08$
(*b*) We shall conclude that the average percentage of metal in household wastes has been reduced when, in fact, it has not been reduced.
(*c*) We shall be unable to detect the fact that the mean percentage of metal in household waste has been reduced.
(*d*) We have a 5% chance of having committed a Type I error.

23. (*a*) We shall conclude that the model is not credible when, in fact, it is a valid model.

(*b*) We shall be unable to detect the fact that the proposed model is not credible.

25. (*a*) $C = \{10, 11, 12, 13, 14, 15\}$, $\alpha = .0338$
(*b*) yes; Type I

27. (*a*) H_0: $p \leq .5$
H_1: $p > .5$
(*b*) 7.5
(*c*) .0592
(*d*) .7827; .4845; .1642; .0127
(*e*) .2173; 5155; 8358; 9873
(*f*) yes; Type I
(*g*) no; Type II

29. .0065; .0003; 0; 0; yes

Section 8.4

31. (*a*) H_0: $\mu \leq .05$
H_1: $\mu > .05$
(*b*) We shall assume that the percentage titanium exceeds 5% when, in fact, it does not; we shall be unable to detect a situation in which the percentage titanium exceeds 5%.
(*c*) .1056; debatable, a P value of .1056 might be considered small by some and large by others

33. (*a*) H_0: $p \leq .15$
H_1: $p > .15$
(*b*) .1335; no, this probability is not unusually small; Type II

Section 8.5

35. (*a*) -1.711
(*b*) -1.282
(*c*) 2.093
(*d*) 2.602
(*e*) ± 1.729
(*f*) ± 2.045

37. (*a*) H_0: $\mu = .12$
H_1: $\mu > .12$
(*b*) 2.462
(*c*) yes, $t = 2.738$
(*d*) that X is at least approximately normal

39. (*a*) H_0: $\mu = 2.5$
H_1: $\mu < 2.5$
(*b*) $t = -3.5$; $.001 < P < .005$; yes, P seems to be small; at least approximate normality
(*c*) conclude that the mean noise level is below 2.5 db; we shall assume that the new product reduces noise when, in fact, it does not

41. (*a*) H_0: $\mu = 4.8$
H_1: $\mu < 4.8$
(*b*) $t = -2.828$; $.001 < P < .005$; yes

43. (*a*) H_1: $\mu < 5$
(*b*) $t = -3.47$; $.001 < P < .005$; reject H_0
(*c*) yes, because $P < .05$
(*d*) probably not since $\bar{x} = 4.28$; there is still a large accumulation there

45. H_1: $\mu < 7$, $P = .27$, no

Section 8.6

47. (*a*) unable to reject H_0
(*b*) $t = 1.154$, critical points $= \pm 2.145$; unable to reject H_0
(*c*) $\chi^2 = 17.81$, critical point $= 23.7$, unable to reject H_0

49. (*a*) unable to reject H_0
(*b*) $t = 1.22$, critical point $= 1.729$, unable to reject H_0
(*c*) $\chi^2 = 9.297$, critical point $= 11.7$, reject H_0; yes

Section 8.7

51. (*a*) yes, .0037
(*b*) yes, .0207
(*c*) yes, .0207
(*d*) yes, .0107
(*e*) no, .0547
(*f*) yes, .0074
(*g*) yes, .0352

53. no, $P = .3770$

55. (*a*) 110/4
(*b*) yes, $|W_-| = 8.5$, critical point $= 11$

57. (*a*) 100(101)/4
(*b*) 100(101)(201)/24
(*c*) H_0: $M = 2$
H_1: $M > 2$
(*d*) $P \doteq .0007$, yes

CHAPTER 8 review exercises

58. (*a*) 44
(*b*) no
(*c*) 3.10; .1213; .348, no
(*d*) $\chi^2_{.95} \doteq 33.65$; [.08998, .1766]; [.298, .418]
$\chi^2_{.05} \doteq 66.05$
(*e*) $3.10 \pm .082$

59. (*a*) H_0: $\mu = 3$
H_1: $\mu < 3$
(*c*) 13
(*d*) $t_{95} = -1.753$; $t \doteq -3.71$; reject H_0; yes, the product should be marketed

60. (*a*) H_0: $p \leq .5$
H_1: $p > .5$
(*b*) $C = \{15, 16, 17, 18, 19, 20\}$
(*c*) no; Type II
(*d*) .8744; .5836; .1958; .0113
(*e*) .1256; .4164; .8042; .9887

61. yes; $t = -2.69$; $.005 < P < .01$

62. $.10 < P < .25$

63. (*a*)

−.3	0
−.2	0 0 0 0
−.1	0 0 0 0 0 0 0 0
0	0 0 0 0 0 0 0 0 0 0 0
.1	0 0 0 0 0 0
.2	0 0 0 0
.3	0
.4	
.5	
.6	
.7	
.8	0

yes; .8 looks like an outlier

(*b*) $\tilde{x} = 0$ $f_1 = -.4$
$q_1 = -.1$ $f_3 = .4$
$q_3 = .1$ $F_1 = -.7$
$iqr = .2$ $F_3 = .7$
.8 is an extreme outlier

(*c*) $\bar{x} = -.008$; $s = .198$; $-.008 \pm .066$

64. (*a*) The number of trials is at most 3000; in a geometric setting there is no a priori number of trials.
(*b*) 20
(*c*) exceed
(*d*) 59; $P[X \geq 59] = 0.51$; see Sec. 3.4
(*e*) no; Type II; we think that the system will not crash when, in fact, it will
(*f*) reject H_0 and conclude that the system will crash; Type I; we shall stop the system unnecessarily

65. (*b*) $8.1 \pm .8$
(*c*) [4.36, 10.56]
(*d*) 3.3 ± 10.7; [.80, 3.17]; [.90, 1.8]
(*e*) no
(*f*) no

66. (*a*) H_1: hollow arrows are faster than those made of solid aluminum
H_1: $\mu < 0$
(*b*) H_0: hollow arrows are no faster than those made of solid aluminum
H_0: $\mu = 0$
(*c*) $\bar{x} = -20.41$; $s = .89$; negative sign means that the time with the hollow arrow was better than that with the solid arrow
(*d*) $t = -102.5$; $P < .0005$

67. (*a*) **e**:

0	6
1	4 5 9
2	3 4 4 6 6 6 7 9 9
3	0 1 2 4 5 6 6 6 9 9 9
4	0 2 3 4 4 4 6 6 6 6 6 7 7 7 8 8
5	1 1 2 2 2 3 3 3 4 9 9
6	0 0 1 2 2 3 4 5 6 6 8 9 9
7	1 1 4 4 5 8
8	0 0 1
9	6

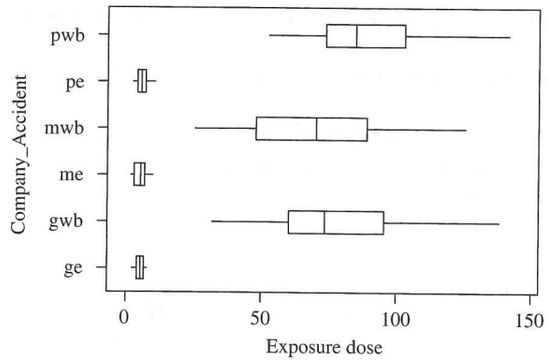
wb:

2	4 8
3	1 9 9
4	0 5 5 9
5	0 0 1 2 3 6 8 8 9
6	3 4 6 7 7 7 8 8 9
7	0 0 1 1 3 4 5 5 6
8	0 0 1 1 1 2 3 3 3 4 5 6 8 9
9	2 4 4 5 5 5 5 6 6 7 8 8 9
10	2 3 3 5 6
11	2 3 8 9
12	5
13	7
14	1

(*b*) **e**: [4.615, 5.359]
wb: [74.112, 83.608]
absolutely; the confidence intervals do not come close to overlapping

(*c*)

Company/Accident	*N*	**Mean**	**Median**	**StDev**
ge	25	4.782	4.790	1.527
gwb	25	77.750	73.250	24.450
me	25	4.829	4.750	2.195
mwb	25	69.370	70.200	25.820
pe	25	5.352	5.180	2.046
pwb	25	89.460	84.600	20.120



The differences are obviously due to the differences among accident types.

Section 9.1

1. (*a*) .9
(*b*) .9 ± .069
(*c*) 609
3. (*a*) .6 ± .025
(*b*) .9 ± .019
5. 1068
7. 6766
9. (*a*) $1 - 2\hat{p}$
(*b*) 1/2
(*c*) − 2
(*d*) 1/4

Section 9.2

11. (*a*) H_0: $p = .99$
H_1: $p > .99$
(*b*) $z = .57$; no, $P = .2843$
(*c*) We are unable to show that the new network is compatible with more than 99% of the equipment already in use.
13. (*a*) H_0: $p = .6$
H_1: $p > .6$
(*b*) 1.645
(*c*) $z = .842$, no; Type II
(*d*) We shall not be able to show that more than 60% of the business offices in the United States have a mainframe when, in fact, this is true.
15. (*a*) ± 1.96
(*b*) $z = 1.38$, no; Type II

Section 9.3

17. (*a*) .356, .489, −.133
(*b*) −.133 ± .062
(*c*) yes, 0 is not contained in the confidence interval
19. (*a*) .31, .40, −.09
(*b*) −.09 ± .079
(*c*) yes, 0 is not contained in the confidence interval
23. 1527
25. 542

Section 9.4

27. (*a*) H_0: $p_1 = p_2$
H_1: $p_1 < p_2$
(*b*) −1.28
(*c*) .0015, .0025, −.001; $\hat{p} = .002$, $z = -.71$, no
29. (*a*) H_0: $p_1 = p_2$
H_1: $p_1 > p_2$
(*b*) $\hat{p} = .334$, $z = 12.35$, yes, $P \doteq 0$

CHAPTER 9 review exercises

33. (*a*) 533
(*b*) .21; .21 ± .034
34. (*a*) H_0: $p = .5$
H_1: $p > .5$
(*b*) $z = .2828$; no, $P \doteq .39$
35. (*a*) H_0: $p = .5$
H_1: $p > .5$
(*b*) 1.645
(*c*) no; the observed value of the test statistic is 1.00
36. (*a*) − .02
(*b*) − .02 ± .047
(*c*) no; 0 lies in the interval
(*d*) no; $n \doteq 2229$, using $\hat{p}_1 = .02$ and $\hat{p}_2 = .04$ as prior estimates
37. H_0: $p_1 = p_2$
H_1: $p_1 > p_2$
where p_1 denotes the proportion of customers reordering during the current year; $\hat{p} = .6$, $z = 1.87$, yes, $P = .0307$
38. (*a*) H_0: $p_1 - p_2 = .1$
H_1: $p_1 = p_2 > .1$
(*b*) 1.645
(*c*) $z = .25$; no, Type II
39. (*a*) .2 ± .078
(*b*) 75,000 ± 29,400
(*c*) 1537

40. (*a*) .25
(*b*) .25 ± .003
(*c*) [2468, 2532]

Section 10.1

1. 4.2; 2; 2.2
3. 8.008; 7.609; .399

Section 10.2

5. (*a*) .9
(*b*) 2.416
(*c*) .05
(*d*) 1.841
(*e*) .05
(*f*) 5.803
7. (*a*) $f = 5$, upper critical point = 2.725, reject H_0
(*b*) $f = 2$, upper critical point = 2.308, unable to reject H_0
(*c*) $f = 1.36$, upper critical point = 1.352, reject H_0
9. (*a*) H_0: $\sigma_1^2 = \sigma_2^2$
H_1: $\sigma_1^2 < \sigma_2^2$
(*b*) $f = .9151$; $P = .4485$; fail to reject H_0
11. $P = .7213$; no; no

Section 10.3

13. (*a*) $s_1^2 = .034$, $s_2^2 = .0525$, $f = 1.54$, upper critical point = 2.147, unable to reject H_0
(*b*) .0433
(*c*) − .67 ± .14
(*d*) yes, the confidence interval does not contain 0
15. (*a*) $f = 1.23$, upper critical point = 2.086, unable to reject H_0
(*b*) 7.93
(*c*) 7.88 ± 3.18
(*d*) yes, 0 is not in the interval
17. no; $f = 1.79$, $P = .421$
19. (*a*) yes, $f = 1.599$, $P = .2598$
(*b*) [.42 and 20.36]; night hours
(*c*) 99%; decrease confidence level

Section 10.4

21. (*a*) H_0: $\mu_1 = \mu_2$ μ_1 = mean level for children
H_1: $\mu_1 > \mu_2$

(*b*) $f = 119.01$, upper critical point ($\alpha = .2$) = 1.348, do not pool
(*c*) $t = 20.00$, $\gamma = 123$, reject H_0: $P < .0005$; conclude that the average strontium level in children is higher than that in adults
23. (*a*) H_0: $\mu_1 = \mu_2$
H_1: $\mu_1 > \mu_2$ (premium > regular)
(*b*) $t = 1.583$, reject H_0, $.05 < P < .1$
(*c*) conclude that the average mileage using premium gasoline is higher than that using regular gasoline
25. (*a*) H_0: $\mu_1 = \mu_2$
H_1: $\mu_1 < \mu_2$ (acrylic < butyl)
(*b*) $f = 2.75$, critical point ($\alpha = .1$) = 1.972, do not pool
(*c*) $t = -5.88$, $\gamma = 24$, reject H_0, $P < .0005$; conclude that the average tensile strength for butyl coating is higher than that for acrylic coatings
27. [−.3116, −.1664]; yes, all values in the interval are negative
29. (*a*) $f = 3.32$, critical point ($\alpha = .10$) = 1.984, do not pool
(*b*) 2.8 ± 1.94, $\gamma = 37$
(*c*) yes, 0 is not in the interval

Section 10.5

31. (*b*) − .412, 1.14
(*c*) − .412 ± .723, no, the confidence interval contains 0, so the results are inconclusive
33. .04 ± .585; no, 0 lies in the interval
35. H_0: $\mu_X = \mu_Y$ $t = 3.04$, reject H_0: $.0005 < P < .005$
H_1: $\mu_X > \mu_Y$ X = travel lane

Section 10.6

37. H_0: $M_I = M_P$, $W_m = 101.5$, upper critical point = 98; reject H_0
H_1: $M_I < M_P$
39. $W_m = 20$, critical point = 22, reject H_0
41. (*a*) 6600
(*b*) 110000
(*c*) $z = -1.999$, $P = .0228$, yes
43. $|W_-| = 7$, can reject at $\alpha = .05$ level (critical point = 11); no, $P[Q_- \le 3] = .1719$, the sign test ignores the magnitude of the differences involved

CHAPTER 10 review exercises

45. (*a*) H_0: $\mu_1 = \mu_2$ where μ_1 = mean temperature setting required by
H_1: $\mu_1 < \mu_2$ using the computerized system
H_0: $\sigma_1^2 = \sigma_2^2$ where σ_1^2 = variance in temperature settings required
H_1: $\sigma_1^2 < \sigma_2^2$ by using the computerized system

(*b*) $s_2^2/s_1^2 = 25$; reject H_0: $\sigma_1^2 = \sigma_2^2$; $P < .05$; do not pool; $\gamma \doteq 25$; $t = -8.73$; reject H_0: $\mu_1 = \mu_2$; $P < .0005$; yes, both claims are supported

46. (*a*) H_0: $\mu_1 - \mu_2 = 15$ where μ_1 = mean amount of dross obtained by using
H_1: $\mu_1 - \mu_2 > 15$ the old method

(*b*) $s_1^2/s_2^2 = 25$; reject H_0: $\sigma_1^2 = \sigma_2^2$; $P < .10$; do not pool; $\gamma \doteq 9$; $t = 4.96$; reject H_0; $P < .0005$; yes, it appears that the new process will be profitable

47. (*a*) yes

(*b*) 2.6 ± 1.0; yes, the confidence interval consists entirely of positive values

48. $s_1^2/s_2^2 = 1.14$; pool; 900 ± 58.2; yes, the confidence interval consists of positive values

49. yes, $t \doteq 7.56$; $P < .0005$

50. (*a*) $\bar{d} = -14.43$

(*b*) $-14.43 \pm .40$; $s_d = .72$

(*c*) yes; 0 is not contained in the confidence interval

51. (*a*)

A		R	
$\tilde{x} = 130$	$f_1 = 90.25$	$\tilde{x} = 253$	$f_1 = 188.5$
$q_1 = 119.5$	$f_2 = 168.25$	$q_1 = 238$	$f_3 = 320.5$
$q_3 = 139$	$F_1 = 61$	$q_3 = 271$	$F_1 = 139$
$iqr = 19.5$	$F_3 = 197.5$	$iqr = 33$	$F_3 = 370$

12.4 and 200 are extreme extreme outliers; 170 is a mild outlier

516 is an extreme outlier

(*b*) $f = 8.83$; upper critical point 1.908; reject at .20 level; conclude that $\sigma_A^2 \neq \sigma_R^2$

(*c*) $(267.4 - 133.9) \pm 2.093\sqrt{4448.89/17 + 503.83/19}$; $df \doteq 19$

(*d*) yes, the confidence interval is negative

52. (*a*)

15	1							
16	2	9						
17	2	5	6	4				
18	9	8	1	3				
19	8	5	7	9	8	2	3	
20	0	6	1	5	4	1	2	7
21	2	1	8	1	4	3		
22	6	1	1	4				
23	0	6	3					
24	1	9						
25	0							

nonsmokers

15	1	7	3	0	2	9	
16	8	1	0	3			
17	7	2	9				
18	1	0	3				
19	4	9	9				
20	5						
21	2	3	6				
22	8	4	1				
23	2	1	8	0			
24	3	1	1	9	8		
25	8	7	1	2	2	0	1

smokers

(*b*) yes; there is a difference in shape, and also variability may be different

(*c*) use the Wilcoxon rank-sum test to test location

53.

1	2								
1	8	9	7	9	5	7			
2	0	1	2	0	4	3	1	3	3
2	9	7	8	5	9	7	6	5	5
3	1	3	0	2	1	4			
3	8								

bank

3	4										
3	7	9	7								
4	3	2	0	0	1						
4	7	9	8								
5	1	4	2	0	1	3	2	1	2	0	
5	9	7	9	8							
6	4	3	2								
6	9										

other

a two-sample t test should apply; $f = 2.19$; variances are unequal ($\alpha = .10$); $t = -13.17$; $df \doteq 50$

54. (*a*) Site 1: 17; Site 2: 13

(*b*) 28

(*c*) 26

(*d*) yes; 17 is not too different from 13 AND $s_1 \approx s_2$

(*e*) two-tailed

(*f*) $P = .058$

(*g*) no; $P > .05$; yes, since $P < .01$

55. (*a*) 1: observed value of test statistic
2: P value for two-tailed test
3: standard deviation of the difference $X - Y$, s_d
4: Mean difference, $\bar{d}$
5: Standard error of the mean difference, $s_{\bar{d}} = s_d/\sqrt{n}$

(*b*) yes; yes

Section 11.2

7. (*b*) $\hat{\mu}_{Y|x} = 0.2177 + 0.0957x$

(*c*) 5.004 for both estimates

(*d*) increase $.1914 \times 10^8$ Btu

(*e*) decrease $.1914 \times 10^8$ Btu

9. (*b*) $\hat{\mu}_{Y|x} = -.1064 + 33.5178x$

(*d*) .8995

(*e*) .8995

(*f*) yes, yes, no

15. .1814

Section 11.3

17. significant ($P < .001$)

19. $t = 4.025$, significant at $\alpha = .01$

21. significant ($P < .001$)

23. $\hat{\mu}_{Y|x} = 14.491 + 1.498x$

25. $t = 1.197$, not significant

27. $\hat{\mu}_{Y|x=15} = 89.588$ (Regression not significant.)

29. (*a*) $\hat{\mu}_{Y|x} = 911.667 - 49.667x$
(*b*) $t = -19.431$, significant at $P < .0001$
(*c*) no
31. $\hat{\sigma}^2 = .0109$
33. (*b*) $\hat{\mu}_{Y|x} = 6.375 + 2.943x$
(*c*) 41.987
(*d*) $t = 6.378$, significant at .0002

Section 11.4

35. (*a*) $f = .392$, not significant at $\alpha = .05$
(*b*) yes
37. (*a*) $\hat{\mu}_{Y|x} = 2.1111 + .3167x$
(*b*) 13.194
41. $f = 4.725$, $P < .025$

Section 11.6

47. (*b*) $\hat{\rho} = .887$
49. $.657 \le \rho \le .966$
51. (*b*) $\hat{\rho} = .586$
(*c*) $-.068 \le \rho \le .888$
57. 96.9%
59. $R^2 \doteq 0$

CHAPTER 11 review exercises

60. (*b*) $\hat{\mu}_{Y|x} = 145.667 + 6.20x$
61. (*a*) no, $f = 27.91$, significant at $\alpha = .05$
(*b*) yes
62. $\hat{\mu}_{Y|x} = 99.383 - .0052x$
63. significant at $\alpha < .001$
64. $R^2 = .967$
65. $99.1603 \le \beta_0 \le 99.6057$
66. $-.00602 \le \beta_1 \le -.00431$
67. $\hat{\mu}_{Y|x} = .8233 - .0589x$
68. $t = -9.264$, significant at $P < .0001$
69. (*a*) $\hat{\mu}_{Y|x=3.25} = .6318$; $(\hat{Y}|x = 3.25) = .6318$
(*b*) $.6121 \le \mu_{Y|x=3.25} \le .6516$
(*c*) $.5703 \le (Y|x = 3.25) \le .6933$
70. (*b*) $\hat{\rho} = -.959$
71. significant at $P < .0001$
72. $-.866 \le \rho \le -.988$
73. (*a*) $t = .889$, $P > .20$
(*b*) $t = 2.179$, $P < .05$

75. (*a*) $\hat{\rho} = .989$
(*b*) $.953 \le \rho \le .997$
(*c*) significant; yes
(*d*) 97.86%
A coefficient of determination of .9786 implies that 97.86% of the variance in the dependent variable Y is explained by the linear regression model.
78. (*a*) As pH increases to 4.0, weight loss decreases.
(*b*) $r = .7259$
(*c*) $t = 4.22$; $P < .001$; there is a significant correlation between pH and weight loss
(*d*) [.392, .891]
79. (*a*) no, the relationship is not linear
(*b*) yes
(*c*) fit a quadratic or other nonlinear model
80. (*a*) $\hat{\mu}_{Y|x} = 6.97 - 0.120x$
(*b*) $t = -14.96$; $P \doteq 0 < .05$; reject H_0
(*c*) 8.77
(*d*) [8.36, 9.18]
81. (*a*) $\hat{\mu}_{Y|x} = -5.94 + 0.0973x$
(*b*) $t = 9.85$; $P \doteq 0 < .05$; reject H_0
(*c*) 2.817
(*d*) [0, 9.2]

Section 12.2

11. (*a*) $X' = \begin{bmatrix} 1 & 1 & 1 & \cdots & 1 & 1 \\ 1.35 & 1.90 & 1.70 & & 1.85 & 1.40 \end{bmatrix}$

(*b*) $X'X = \begin{bmatrix} 10 & 16.75 \\ 16.75 & 28.6375 \end{bmatrix}$

(*c*) $X'\mathbf{y} = \begin{bmatrix} 170 \\ 282.405 \end{bmatrix}$

(*d*) $\begin{bmatrix} 10 & 16.75 \\ 16.75 & 28.6375 \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \end{bmatrix} = \begin{bmatrix} 170 \\ 282.405 \end{bmatrix}$

(*e*) $(X'X)^{-1} = \begin{bmatrix} 4.92688 & -2.88172 \\ -2.88172 & 1.72043 \end{bmatrix}$

(*f*) $\hat{\boldsymbol{\beta}} = \begin{bmatrix} 23.7576 \\ -4.0344 \end{bmatrix}$, results agree with Example 11.3.3

13. (*a*) $\hat{\mu}_{Y|x} = 42.921 - 28.625x + 4.640x^2$
(*b*) $\hat{\mu}_{Y|x=2.5} = .358$

15. $X = \begin{bmatrix} 1 & x_{11} & x_{11}^2 & x_{21} \\ 1 & x_{12} & x_{12}^2 & x_{22} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & x_{18} & x_{18}^2 & x_{28} \end{bmatrix}$

Section 12.3

19. (*a*) $E[C\mathbf{Y}] = \begin{bmatrix} 35 \\ 75 \end{bmatrix}$

(*b*) Var $\mathbf{Y} = \begin{bmatrix} 6 & 0 \\ 0 & 6 \end{bmatrix}$

(*c*) Var $C\mathbf{Y} = \begin{bmatrix} 72 & 102 \\ 102 & 300 \end{bmatrix}$

25. $s^2 = \dfrac{S_{yy} - \text{SSR}}{n-2} = 1.002714$

Var $\hat{\beta}_0 = (2.3)(1.002714) = 2.30624$
Var $\hat{\beta}_1 = (.05342857)(1.002714) = .0535737$
Var $\hat{\beta}_2 = (.00005714286)(1.002714) = .000057298$

Section 12.4

27. $-4.6162 \le \beta_1 \le -3.7038$; yes, since CI excludes zero
$-.02046 \le \beta_2 \le -.00934$; yes, since CI excludes zero

29. $17.6605 \le \mu_{Y|x_1=1.5,\,x_2=40} \le 18.1675$
$17.5383 \le Y|x_1 = 1.5,\, x_2 = 40 \le 18.2897$

31. $9.265 \le \mu_{Y|x=50} \le 10.007$
$7.766 \le Y|x = 50 \le 11.506$

33. $5.445 \le \mu_{Y|x_1=12,\,x_2=40,\,x_3=20} \le 47.301$

35. $-8.666 \le \beta_0 \le 12.590$

Section 12.5

37. $\hat{\mu}_{Y|x} = 4.143 + 7.107x$

39. $\hat{\mu}_{Y|x} = -4.571 + 12.917x - .726x^2$

41. $33.735 \le \mu_{Y|x=4.8} \le 42.780$

45. $\hat{\mu}_{Y|x_1,x_2} = .805 + .245x_1 + .264x_2$

47. $\hat{\rho} = .9517$

49. $f = 18.705$, $P \doteq .0035$, reject H_0; yes

51. $f = 32.2762$, $P \doteq .0003$, reject H_0

Section 12.6

53. (*a*) $X = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1.5 & 1 & 1.5 \\ 1 & 2 & 1 & 2 \\ 1 & 2.5 & 1 & 2.5 \\ 1 & 3 & 1 & 3 \\ 1 & 3.5 & 1 & 3.5 \\ 1 & 4 & 1 & 4 \\ 1 & 4.5 & 1 & 4.5 \\ 1 & 5 & 1 & 5 \\ 1 & 1 & 0 & 0 \\ 1 & 2 & 0 & 0 \\ 1 & 2.5 & 0 & 0 \\ 1 & 3 & 0 & 0 \\ 1 & 4 & 0 & 0 \\ 1 & 5 & 0 & 0 \end{bmatrix}$

(*b*) $\hat{\mu}_{Y|x_1,x_2} = .470 - .084x_1 + .354x_2 + .025x_1x_2$
(*c*) $\hat{\beta}_3 = .0248$
(*d*) $f = 4.9506$, $P = .0479$, reject H_0 at $\alpha = .05$; regression lines for the two furnaces have different slopes

55. (*a*) *A:* $Y = \beta_0 + \beta_1 x_1 + \text{E}$
B: $Y = (\beta_0 + \beta_2) + (\beta_1 + \beta_4)x_1 + \text{E}$
C: $Y = (\beta_0 + \beta_3) + (\beta_1 + \beta_5)x_1 + \text{E}$
(*b*) H_0: $\beta_4 = \beta_5 = 0$
(*c*) H_0: $\beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$; 4 and $n - 6$

CHAPTER 12 review exercises

67. $\hat{\mu}_{Y|x_1} = 154.5 + .5095x_1$

68. $164.163 \le \mu_{Y|x_1=45} \le 190.695$

69. $\hat{\mu}_{Y|x_1} = 96.333 + .6333x_2$

72. $\hat{\mu}_{Y|x_1,x_2} = 78.5 + .510x_1 + .633x_2$

73. Reduced model

74. $R^2 = 34.65$; $\hat{\rho} = .5886$

75. 164.69

76. $153.688 \le \mu_{Y|x_1,x_2} \le 182.027$

77. (*a*) $\hat{y} = 19.7 + 1.35x$
(*b*) $P = .723$; no

78. diff = 12.2 + 0.0704 time

79. diff = 8.0 + 0.0704 time + 1.22 ph

80. $f = .132$; $P = .72$; reduced model is sufficient

81. $R^2 = .489$; $f = 27.75$; $P < .05$; there is a significant linear relationship

Section 13.1

5. (*a*) $f = 4.95$, $P = .0174$, significant at $\alpha = .05$
(*b*) no
(*c*) no

Section 13.2

7. $f_{4,35} = 216.34$, $P < .001$
9. $b = 23.187$ with 3 df, significant at $\alpha < .005$
not reasonable to assume homogeneity of variances; use a nonparametric test
11. $b = .354$, not significant

Section 13.3

13. (*a*) $\alpha' \leq .1426, .0333$
(*b*) $\alpha' \leq .5367, .0067$
(*c*) $\alpha' \leq .9006, .0022$
17. (*a*) 3
(*b*) .05
(*c*) $\mu_1 \neq \mu_2$
21. $\mu_1 \neq \mu_2$, $\mu_1 \neq \mu_3$, $\mu_2 \neq \mu_3$ at $\alpha = .01$

Section 13.4

25. (*a*) $SS_{L_1} = \dfrac{[\bar{Y}_{1\cdot} - (1/3)(\bar{Y}_{2\cdot} + \bar{Y}_{3\cdot} + \bar{Y}_{4\cdot})]^2}{(1 + 1/9 + 1/9 + 1/9)/n}$

$$SS_{L_2} = \frac{(\bar{Y}_{1\cdot} - \bar{Y}_{2\cdot})^2}{(1+1)/n}$$

(*e*) $SS_{L_1} = \dfrac{(\bar{Y}_{1\cdot} - \bar{Y}_{2\cdot} + \bar{Y}_{3\cdot} - \bar{Y}_{4\cdot})^2}{(1+1+1+1)/n}$

$$SS_{L_2} = \frac{(\bar{Y}_{1\cdot} - \bar{Y}_{3\cdot})^2}{(1+1)/n}$$

(*f*) $SS_{L_1} = \dfrac{(\bar{Y}_{1\cdot} - \bar{Y}_{2\cdot} + \bar{Y}_{3\cdot} - \bar{Y}_{4\cdot})^2}{1/5 + 1/5 + 1/10 + 1/10}$

$$SS_{L_2} = \frac{(\bar{Y}_{1\cdot} - \bar{Y}_{3\cdot})^2}{1/5 + 1/10}$$

27. $f_{1,36} = 114.11$, $P < .05$, reject H_0
$f_{1,36} = 8.9246$, $P < .05$, reject H_0
29. 60 51.333 50 44.333 38.667

Section 13.5

33. (*a*) blocking is effective
(*b*) blocking is effective
(*c*) blocking is not effective
(*d*) blocking is not effective
(*e*) designs are equivalent
35. $f_{3,21} = 3.37$, significant at $\alpha = .05$
37. 6; .017
39. yes
41. $\widehat{RE} = 12.47$, blocking is highly desirable

Section 13.6

47. $SS_{Tot} = \sum_i \sum_j \sum_k (Y_{ikj} - \bar{Y}_{\cdots})^2$

$$SS_{Rows} = r \sum_{j=1}^{r} (\bar{Y}_{\cdot j\cdot} - \bar{Y}_{\cdots})^2$$

$$SS_{Col} = r \sum_{k=1}^{r} (\bar{Y}_{\cdot\cdot k} - \bar{Y}_{\cdots})^2$$

49. $f_{2,2} = 8.75$, $P \doteq .1026$, rejection of H_0 is debatable

Section 13.8

51. $\mathbf{Y} = \begin{bmatrix} Y_{11} \\ Y_{12} \\ Y_{21} \\ Y_{22} \\ Y_{31} \\ Y_{32} \end{bmatrix}$, $\boldsymbol{\alpha} = \begin{bmatrix} \mu \\ \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix}$, $X = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 \end{bmatrix}$, $\mathbf{E} = \begin{bmatrix} \mathbf{E}_{11} \\ \mathbf{E}_{12} \\ \mathbf{E}_{21} \\ \mathbf{E}_{22} \\ \mathbf{E}_{31} \\ \mathbf{E}_{32} \end{bmatrix}$,

$$X'X = \begin{bmatrix} 6 & 2 & 2 & 2 \\ 2 & 2 & 0 & 0 \\ 2 & 0 & 2 & 0 \\ 2 & 0 & 0 & 2 \end{bmatrix}$$

$X'X$ has no inverse, since the first column is the sum of the last three columns.

Section 13.9

53. (*a*) $H = 9.05$, not significant at $\alpha = .05$ ($P \doteq .06$)
(*b*) $f = 3.30$, significant at $\alpha = .05$ ($P \doteq .026$)
55. $S = 3.4$ with 4 df; not significant

CHAPTER 13 review exercises

58. (*a*)

Source	Df	*SS*	*MS*
CO_2 level	4	11,274.32	2818.50
Error	45	1,248.04	27.73
Corrected total	49	12,522.36	

(*b*) yes, $f = 101.63$

59. $b = 1.07$, not significant; yes

60. (*b*)

Source	df	*SS*	*MS*	*F*	EMS
Treatment	2	110.6	55.3	3.0	$\sigma^2 + 10\sigma^2_{\text{Tr}}$
Error	27	497.7	18.433		σ^2
Total	29	608.3			

$f = 3.0$ with 2 and 27 df; not significant at $\alpha = .05$

(*c*) due to error, 83.3%; due to treatments, 16.7%

61. (*a*) $f = 79.9$, significant at $\alpha < .0001$

(*b*) yes

(*c*) all three are significantly different

(*d*) all three are significantly different

63. $f = 579.61$, $P \doteq 0$

Section 14.1

3. $Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \text{E}_{ijk}$

7. $P \leq .0001$, significant

9. no, interaction is not significant

11. $Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \text{E}_{ijk}$

13. $P \doteq .064$, significant at $\alpha = .10$

15. E_2 and 3 months

Section 14.2

21. $SS_{\text{Tot}} = SS_A + SS_B + SS_C + SS_{AB} + SS_{AC} + SS_{BC} + SS_{ABC} + SS_E$

23.

Source of variation	Degrees of freedom (*DF*)	Sum of squares (*SS*)	Mean square (*MS*)	*F*	*P* value
Treatment	23	21100.99	917.43	8.36	.0001
A	2	10296.36	5148.18	46.88	.0001
B	3	7586.38	2528.79	23.03	.0001
C	1	1974.01	1974.01	17.98	.0001
AB	6	735.42	122.57	1.12	.3671
AC	2	6.03	3.01	.03	.9729
BC	3	25.49	8.50	.08	.9719
ABC	6	477.31	79.55	.72	.6320
Error	48	5270.67	109.81		
Total	71	26371.65			

Note: All *SS*, *MS*, and *F* statistics have been rounded to two places from SAS output.

Section 14.3

25. H_0: $\sigma^2_{AB} = 0$, $F = MS_{AB}/MS_E$
H_0^{I}: $\sigma^2_A = 0$, $F = MS_A/MS_E$
H_0^{II}: $\mu_{.1.} = \mu_{.2.} = \cdots = \mu_{.b.}$, $F = MS_B/MS_{AB}$
H_0^{III}: $\sigma^2_{\text{Tr}} = 0$, $F = MS_{\text{Tr}}/MS_E$

Section 14.4

27. (*a*) *a*: 13
b: 11
ab: 17

(*c*) *B* high: slope = 3
B low: slope = 3

29. Any value of β_{12} satisfying $\beta_{12} > 2$ or $\beta_{12} < -2$

31. *A*: H_0^{I}: $\beta_1 = 0, f_{1,4} = 1.59$; $P \doteq .2764$
B: H_0^{II}: $\beta_2 = 0, f_{1,4} = 3.76$, $P \doteq .1244$

33. (*a*) $2^4 = 16$

(*b*)

	Effects								
Treatment combination	x_1 *A*	x_2 *B*	x_3 *C*	x_4 *D*	Treatment combination	x_1 *A*	x_2 *B*	x_3 *C*	x_4 *D*
(1)	−	−	−	−	*bc*	−	+	+	−
a	+	−	−	−	*bd*	−	+	−	+
b	−	+	−	−	*cd*	−	−	+	+
c	−	−	+	−	*abc*	+	+	+	−
d	−	−	−	+	*abd*	+	+	−	+
ab	+	+	−	−	*acd*	+	−	+	+
ac	+	−	+	−	*bcd*	−	+	+	+
ad	+	−	−	+	*abcd*	+	+	+	+

(*c*) $$SS_A = \frac{1}{2^4 n}[-(1) + a - b - c - d + ab + ac + ad - bc - bd - cd + abc + abd + acd - bcd + abcd]^2$$

$$SS_B = \frac{1}{2^4 n}[-(1) - a + b - c - d + ab - ac - ad + bc + bd - cd + abc + abd - acd + bcd + abcd]^2$$

$$SS_C = \frac{1}{2^4 n}[-(1) - a - b + c - d - ab + ac - ad + bc - bd + cd + abc - abd + acd + bcd + abcd]^2$$

$$SS_D = \frac{1}{2^4 n}[-(1) - a - b - c + d - ab - ac + ad - bc + bd + cd - abc + abd + acd + bcd + abcd]^2$$

Section 14.5

37. (*a*) *AB*
(*b*) *AB, ABC, C*
(*c*) *ABCD, ABC, BCD, D, A, AD, BC*

39. (*a*) $L_1 = z_1 + z_2$ and $L_2 = z_3 + z_4$

Treatment combination	L_1 (mod 2)	L_2 (mod 2)	Block
(1)	0	0	1
a	1	0	2
b	1	0	2
c	0	1	3
d	0	1	3
ab	0	0	1
ac	1	1	4
ad	1	1	4
bc	1	1	4
bd	1	1	4
cd	0	0	1
abc	0	1	3
abd	0	1	3
acd	1	0	2
bcd	1	0	2
abcd	0	0	1

(*b*) *ABCD;* block 1
(*c*)

Source	Degrees of freedom (*DF*)
Blocks	3
A	1
B	1
C	1
D	1
Error	8
Total	15

Section 14.6

41. $-(1) - a + b - c + ab - ac + bc + abc;\ -a + b - c + abc;\ AC$

43. (*a*)

Block 1	Block 2	Block 3	Block 4
(1)	*d*	*c*	*a*
ab	*e*	*f*	*b*
cf	*ac*	*ad*	*cd*
de	*af*	*ae*	*ce*
acd	*bc*	*bd*	*df*
ace	*bf*	*be*	*ef*
adf	*abd*	*abc*	*acf*
aef	*abe*	*abf*	*ade*
bcd	*cdf*	*cde*	*bcf*
bce	*cef*	*def*	*bde*
bdf	*acde*	*acdf*	*abcd*
bef	*adef*	*acef*	*abce*
abcf	*bcde*	*bcdf*	*abdf*
abde	*bdef*	*bcef*	*abef*
cdef	*abcdf*	*abcde*	*acdef*
abcdef	*abcef*	*abdef*	*bcdef*

(*b*)

Source	Degrees of freedom (*DF*)
A	1
B	1
C	1
D	1
E	1
F	1
Error	9
Total	15

(*c*)

$$A \equiv BDE \equiv BCF \equiv ACDEF$$
$$B \equiv ADE \equiv ACF \equiv DEF$$
$$C \equiv ABCDE \equiv ABF \equiv CEF$$
$$D \equiv ABE \equiv ABCDF \equiv CDF$$
$$E \equiv ABD \equiv ABCEF \equiv CDE$$

CHAPTER 14 review exercises

45.

(1)	*a*	*e*	*b*
bc	*be*	*ab*	*c*
bd	*ce*	*ac*	*d*
cd	*de*	*ad*	*ae*
abe	*abc*	*bce*	*bcd*
ace	*abd*	*bde*	*abce*
ade	*acd*	*cde*	*abde*
abcde	*bcde*	*abcd*	*acde*

(*a*) *ABCD, BCDE, AE*

(*b*)

Source of variation	Degrees of freedon (*DF*)
Blocks	3
A	1
B	1
C	1
D	1
E	1
AB	1
AC	1
AD	1
BC	1
BD	1
BE	1
CD	1
CE	1
DE	1
Error	14
Total	31

(*c*) no, there would be no error term/no error degrees of freedom

46. (*b*) no, error degrees of freedom is 0
(*c*) no, error degrees of freedom is 0
(*d*) yes
(*e*) 3

47. (*a*) $\mu_{Y|x_1,x_2} = \beta_0 + \beta_1 x_1 + \beta_2 x_2$

$$(b)\ X = \begin{bmatrix} 1 & -1 & -1 \\ 1 & -1 & -1 \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & 1 & -1 \\ \cdot & 1 & -1 \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & -1 & 1 \\ \cdot & -1 & 1 \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & 1 & 1 \\ \cdot & 1 & 1 \\ \cdot & \cdot & \cdot \\ 1 & \cdot & \cdot \\ 1 & \cdot & \cdot \end{bmatrix}$$

$$(c)\ X'X = \begin{bmatrix} 2^2n & 0 & 0 \\ 0 & 2^2n & 0 \\ 0 & 0 & 2^2n \end{bmatrix}$$

$$(d)\ X'Y = \begin{bmatrix} (1) + a + b + ab \\ -(1) + a - b - ab \\ -(1) - a + b + ab \end{bmatrix}$$

$$(e)\ \hat{\beta} = \begin{bmatrix} [(1) + a + b + ab]/2^2n \\ [-(1) + a - b + ab]/2^2n \\ [-(1) - a + b + ab]/2^2n \end{bmatrix}$$

$(f)\ \text{SSR} = [-(1) + a - b + ab]^2/2^2n + [-(1) - a + b + ab]^2/2^2n$

$(g)\ \text{SSE}_r = S_{yy} - [-(1) + a - b + ab]^2/2^2n$
$-[-(1) - a + b + ab]^2/2^2n$

$\text{SSE}_f = S_{yy} - [-(1) + a - b + ab]^2/2^2n$
$-[-(1) - a + b + ab]^2/2^2n - [(1) - a - b + ab]^2/2^2n$

$(h)\ \text{SSE}_r - \text{SS}_f = [(1) - a - b + ab]^2/2^2n$

48. $(a)\ Y_{ijkl} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \gamma_k$
$+ (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + \text{E}_{ijkl}$

(b)

Source of variation	Degrees of freedom
A	4
B	3
C	2
AB	12
AC	8
BC	6
Error	24
Total	59

49. (a) (1), *ab, ac, ad, ae, bc, bd, be, cd, ce, de, abcd, abce, abde, acde, bcde*
(b)

Source of variation	Degrees of freedom
A	1
B	1
C	1
D	1
E	1
Error	10
Total	15

50. $(a)\ B \equiv AC \equiv BCD \equiv AD$
$C \equiv AB \equiv D \equiv ABCD$
$D \equiv ABCD \equiv C \equiv AB$

(b) no, the main effect C is aliased with the main effect D

Section 15.1

1. 60, 45, 30, 15; yes, these seem to differ quite a bit from the expected numbers
3. 10; questionable, the observed values are not drastically different from those expected

Section 15.2

5. $\chi^2 = 22.66$; reject H_0, $P < .005$ based on the X^2_4 distribution

Section 15.3

9. $\chi^2 = 4.57$; reject H_0, $.025 < P < .05$ based on the X^2_1 distribution
11. $\chi^2 = 8.84$; reject H_0, $.025 < P < .05$ based on the X^2_3 distribution

Section 15.4

13. $\chi^2 = 3.95$; reject H_0, critical point = 3.84

15. H_0: $p_{11} = p_{21} = p_{31}$
$p_{12} = p_{22} = p_{32}$
$p_{13} = p_{23} = p_{33}$
$p_{14} = p_{24} = p_{34}$
$\chi^2 = 14.72$; reject H_0, $.01 < P < .025$ based on the X_6^2 distribution

17. $\chi^2 = 16.03$; reject H_0; $P < .005$

19. $\chi^2 = 43.65$; reject H_0; $P < .005$

CHAPTER 15 review exercises

23. H_0: $p_{11} = p_{21}$; $\chi^2 = .709$; no, $.25 < P < .50$

24. yes; $\chi^2 \doteq 16.04$; $P < .005$

25. yes; $\chi^2 \doteq 34.05$; $P < .005$

26. no; $\chi^2 \doteq .69$; $.25 < P < .5$

27. (*a*) 175; 87.5; 87.5
(*b*) no; $\chi^2 \doteq .77$; $.50 < P < .75$

Section 16.1

2. $P = .0028$; ARL $\doteq$ 360 minutes; no; every 5 minutes

4. (*b*) .0026
(*c*) 384.6
(*d*) 384.1
(*e*) 6.30
(*f*) 6.30 hours; 3.15 hours; 1.575 hours

Section 16.2

6. (*a*) $\bar{X}$: LCL = 23.116, UCL = 25.884
$\bar{R}$: LCL = 0, UCL = 5.074
(*b*) $\bar{X}$: LCL = .04346, UCL = .04654
$\bar{R}$: LCL = .00112, UCL = .00888
(*c*) $\bar{X}$: LCL = 7.084, UCL = 10.216
$\bar{R}$: LCL = 0, UCL = 4.9067

Section 16.3

11. (*a*) $\bar{p} = .0195$, $\hat{\sigma}_P = .009777$
(*b*) LCL = 0, UCL = .0488
(*c*) All sample points are within control limits. If they were not, one would delete points outside the limits and recompute limits with reduced data set.

13. (*a*) normal
(*b*) λ

Section 16.4

15. (*a*) (11.5166, 12.2834)
(*b*) (11.4916, 12.3084)
(*c*) (11.2996, 12.5004)
(*d*) [11.854, 11.946]
(*e*) In (*a*) and (*b*) we are 95% sure and 99% sure, respectively, that 90% of the population is in the given interval; in (*c*) we are 95% sure that 99% of the population lies in the interval; in (*d*) we are 95% sure that the population mean lies in the given interval.

17. about 90%

Section 16.5

19. (*a*) $\Pi = 0$, $P_{acc} = 1$
$\Pi = .05$, $P_{acc} = .7358$
$\Pi = .1$, $P_{acc} = .3917$
$\Pi = .15$, $P_{acc} = .1756$
(*b*) producer risk = .2642
consumer risk = .1756

Section 16.6

21. (*b*) .6454
(*c*) .8623 for $\Pi = .1$, .1666 for $\Pi = .4$, .0123 for $\Pi = .6$
(*d*) .3546