open.michigan

Author(s): Brenda Gunderson, Ph.D., 2012

Attribution Key

for more information see: http://open.umich.edu/wiki/AttributionPolicy

Use + Share + Adapt

{ Content the copyright holder, author, or law permits you to use, share and adapt. }

PD-GOV **Public Domain – Government**: Works that are produced by the U.S. Government. (17 USC § 105)

PD-EXP **Public Domain – Expired**: Works that are no longer protected due to an expired copyright term.

PD-SELF **Public Domain – Self Dedicated**: Works that a copyright holder has dedicated to the public domain.

(cc) ZERO **Creative Commons – Zero Waiver**

(cc) BY **Creative Commons – Attribution License**

(cc) BY-SA **Creative Commons – Attribution Share Alike License**

(cc) BY-NC **Creative Commons – Attribution Noncommercial License**

(cc) BY-NC-SA **Creative Commons – Attribution Noncommercial Share Alike License**

GNU-FDL **GNU – Free Documentation License**

Make Your Own Assessment

{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

PD-INEL **Public Domain – Ineligible**: Works that are ineligible for copyright protection in the U.S. (17 USC § 102(b)) *laws in your jurisdiction may differ

{ Content Open.Michigan has used under a Fair Use determination. }

FAIR USE **Fair Use**: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (17 USC § 107) *laws in your jurisdiction may differ

Our determination **DOES NOT** mean that all uses of this 3rd-party content are Fair Uses and we **DO NOT** guarantee that your use of the content is Fair.

To use this content you should **do your own independent analysis** to determine whether or not your use will be Fair.

Statistics 350 Help Card

Summary Measures

Sample Mean

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{\sum x_i}{n}$$

Sample Standard Deviation

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{\sum x_i^{\,2} - n\bar{x}^2}{n-1}}$$

Probability Rules

- **Complement rule**

  $P(A^C) = 1 - P(A)$
- **Addition rule**

  General: $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$

  For independent events:

  $P(A \text{ or } B) = P(A) + P(B) - P(A)P(B)$

  For mutually exclusive events: $P(A \text{ or } B) = P(A) + P(B)$
- **Multiplication rule**

  General: $P(A \text{ and } B) = P(A)P(B \mid A)$

  For independent events: $P(A \text{ and } B) = P(A)P(B)$

  For mutually exclusive events: $P(A \text{ and } B) = 0$
- **Conditional Probability**

  General: $P(A \mid B) = \dfrac{P(A \text{ and } B)}{P(B)}$

  For independent events: $P(A \mid B) = P(A)$

  For mutually exclusive events: $P(A \mid B) = 0$

Discrete Random Variables

Mean

$$E(X) = \mu = \sum x_i p_i = x_1 p_1 + x_2 p_2 + \cdots + x_k p_k$$

Standard Deviation

$$s.d.(X) = \sigma = \sqrt{\sum (x_i - \mu)^2 p_i} = \sqrt{\sum \left(x_i^2 p_i\right) - \mu^2}$$

Binomial Random Variables

$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

where $\dbinom{n}{k} = \dfrac{n!}{k!(n-k)!}$

Mean

$$E(X) = \mu_X = np$$

Standard Deviation

$$s.d.(X) = \sigma_X = \sqrt{np(1-p)}$$

Normal Random Variables

- $z - \text{score} = \dfrac{\text{observation} - \text{mean}}{\text{standard deviation}} = \dfrac{x - \mu}{\sigma}$
- Percentile: $x = z\sigma + \mu$
- If X has the $N(\mu, \sigma)$ distribution, then the variable

  $Z = \dfrac{X - \mu}{\sigma}$ has the $N(0,1)$ distribution.

Normal Approximation to the Binomial Distribution

If X has the *B(n, p)* distribution and the sample size n is large enough (namely $np \geq 10$ and $n(1-p) \geq 10$), then X is approximately $N\left(np, \sqrt{np(1-p)}\right)$.

Sample Proportions

$$\hat{p} = \frac{x}{n}$$

Mean

$$E(\hat{p}) = \mu_{\hat{p}} = p$$

Standard Deviation

$$\text{s.d.}(\hat{p}) = \sigma_{\hat{p}} = \sqrt{\frac{p(1-p)}{n}}$$

Sampling Distribution of $\hat{p}$

If the sample size n is large enough (namely, $np \geq 10$ and $n(1-p) \geq 10$)

then $\hat{p}$ is *approximately* $N\left(p, \sqrt{\dfrac{p(1-p)}{n}}\right)$.

Sample Means

Mean

$$E(\bar{X}) = \mu_{\bar{X}} = \mu$$

Standard Deviation

$$s.d.(\bar{X}) = \sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$

Sampling Distribution of $\bar{X}$

If X has the $N(\mu, \sigma)$ distribution, then $\bar{X}$ is

$$N\left(\mu_{\bar{X}}, \sigma_{\bar{X}}\right) \Leftrightarrow N\left(\mu, \frac{\sigma}{\sqrt{n}}\right).$$

If X follows *any* distribution with mean μ and standard deviation σ and n is large,

then $\bar{X}$ is *approximately* $N\left(\mu, \dfrac{\sigma}{\sqrt{n}}\right)$.

This last result is **Central Limit Theorem**

.

Population Proportion

Parameter p

Statistic $\hat{p}$

Standard Error

$$\text{s.e.}(\hat{p}) = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

Confidence Interval

$$\hat{p} \pm z^* \text{s.e.}(\hat{p})$$

Conservative Confidence Interval

$$\hat{p} \pm \frac{z^*}{2\sqrt{n}}$$

Large-Sample *z*-Test

$$z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$$

Sample Size

$$n = \left(\frac{z^*}{2m}\right)^2$$

Two Population Proportions

Parameter $p_1 - p_2$

Statistic $\hat{p}_1 - \hat{p}_2$

Standard Error

$$\text{s.e.}(\hat{p}_1 - \hat{p}_2) = \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

Confidence Interval

$$(\hat{p}_1 - \hat{p}_2) \pm z^* \text{s.e.}(\hat{p}_1 - \hat{p}_2)$$

Large-Sample *z*-Test

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where $\hat{p} = \frac{n_1\hat{p}_1 + n_2\hat{p}_2}{n_1 + n_2}$

Population Mean

Parameter μ

Statistic $\bar{x}$

Standard Error

$$\text{s.e.}(\bar{x}) = \frac{s}{\sqrt{n}}$$

Confidence Interval

$$\bar{x} \pm t^* \text{s.e.}(\bar{x}) \qquad \text{df} = n - 1$$

Paired Confidence Interval

$$\bar{d} \pm t^* \text{s.e.}(\bar{d}) \qquad \text{df} = n - 1$$

One-Sample *t*-Test

$$t = \frac{\bar{x} - \mu_0}{\text{s.e.}(\bar{x})} = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} \qquad \text{df} = n - 1$$

Paired *t*-Test

$$t = \frac{\bar{d} - 0}{\text{s.e.}(\bar{d})} = \frac{\bar{d}}{s_d/\sqrt{n}} \qquad \text{df} = n - 1$$

Two Population Means

General

Parameter $\mu_1 - \mu_2$

Statistic $\bar{x}_1 - \bar{x}_2$

Standard Error

$$\text{s.e.}(\bar{x}_1 - \bar{x}_2) = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

Confidence Interval

$$(\bar{x}_1 - \bar{x}_2) \pm t^*(\text{s.e.}(\bar{x}_1 - \bar{x}_2)) \qquad \text{df} = \min(n_1 - 1, n_2 - 1)$$

Two-Sample *t*-Test

$$t = \frac{\bar{x}_1 - \bar{x}_2 - 0}{\text{s.e.}(\bar{x}_1 - \bar{x}_2)} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad \text{df} = \min(n_1 - 1, n_2 - 1)$$

Pooled

Parameter $\mu_1 - \mu_2$

Statistic $\bar{x}_1 - \bar{x}_2$

Standard Error

$$\text{pooled s.e.}(\bar{x}_1 - \bar{x}_2) = s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

where $s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$

Confidence Interval

$$(\bar{x}_1 - \bar{x}_2) \pm t^*(\text{pooled s.e.}(\bar{x}_1 - \bar{x}_2)) \qquad \text{df} = n_1 + n_2 - 2$$

Pooled Two-Sample *t*-Test

$$t = \frac{\bar{x}_1 - \bar{x}_2 - 0}{\text{pooled s.e.}(\bar{x}_1 - \bar{x}_2)} = \frac{\bar{x}_1 - \bar{x}_2}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad \text{df} = n_1 + n_2 - 2$$

One-Way ANOVA

SS Groups = SSG = $\sum_{\text{groups}} n_i(\bar{x}_i - \bar{x})^2$

MS Groups = MSG = $\frac{\text{SSG}}{k-1}$

SS Error = SSE = $\sum_{\text{groups}} (n_i - 1)s_i^2$

MS Error = MSE = $s_p^2 = \frac{\text{SSE}}{N-k}$

SS Total = SSTO = $\sum_{\text{values}} (x_{ij} - \bar{x})^2$

$F = \frac{\text{MS Groups}}{\text{MS Error}}$

Confidence Interval $\bar{x}_i \pm t^* \frac{s_p}{\sqrt{n_i}}$ df = $N - k$

ANOVA Table

Source	**SS**	**DF**	**MS**	***F***
Groups	SS Groups	$k - 1$	MS Groups	F
Error	SS Error	$N - k$	MS Error	
Total	SSTO	$N - 1$		

Under H_0, the F statistic follows an $F(k - 1, N - k)$ distribution.

Regression

Linear Regression Model

Population Version:

Mean: $\mu_Y(x) = E(Y) = \beta_0 + \beta_1 x$

Individual: $y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$

where ε_i is $N(0, \sigma)$

Sample Version:

Mean: $\hat{y} = b_0 + b_1 x$

Individual: $y_i = b_0 + b_1 x_i + e_i$

Standard Error of the Sample Slope

$$\text{s.e.}(b_1) = \frac{s}{\sqrt{S_{XX}}} = \frac{s}{\sqrt{\sum (x-\bar{x})^2}}$$

Confidence Interval for β_1

$b_1 \pm t^* \text{s.e.}(b_1)$ df = $n - 2$

***t*-Test for β_1**

To test $H_0 : \beta_1 = 0$

$$t = \frac{b_1 - 0}{\text{s.e.}(b_1)}$$ df = $n - 2$

or $$F = \frac{MSREG}{MSE}$$ df = 1, $n - 2$

Parameter Estimators

$$b_1 = \frac{S_{XY}}{S_{XX}} = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sum (x-\bar{x})^2} = \frac{\sum (x-\bar{x})y}{\sum (x-\bar{x})^2}$$

$b_0 = \bar{y} - b_1 \bar{x}$

Confidence Interval for the Mean Response

$\hat{y} \pm t^* \text{s.e.(fit)}$ df = $n - 2$

where $\text{s.e.(fit)} = s\sqrt{\frac{1}{n} + \frac{(x-\bar{x})^2}{S_{XX}}}$

Residuals

$e = y - \hat{y} =$ observed y – predicted y

Prediction Interval for an Individual Response

$\hat{y} \pm t^* \text{s.e.(pred)}$ df = $n - 2$

where $\text{s.e.(pred)} = \sqrt{s^2 + (\text{s.e.(fit)})^2}$

Correlation and its square

$$r = \frac{S_{XY}}{\sqrt{S_{XX} S_{YY}}}$$

$$r^2 = \frac{SSTO - SSE}{SSTO} = \frac{SSREG}{SSTO}$$

where $SSTO = S_{YY} = \sum (y-\bar{y})^2$

Standard Error of the Sample Intercept

$$\text{s.e.}(b_0) = s\sqrt{\frac{1}{n} + \frac{\bar{x}^2}{S_{XX}}}$$

Confidence Interval for β_0

$b_0 \pm t^* \text{s.e.}(b_0)$ df = $n - 2$

Estimate of σ

$s = \sqrt{MSE} = \sqrt{\frac{SSE}{n-2}}$ where $SSE = \sum (y-\hat{y})^2 = \sum e^2$

***t*-Test for β_0**

To test $H_0 : \beta_0 = 0$

$$t = \frac{b_0 - 0}{\text{s.e.}(b_0)}$$ df = $n - 2$

Chi-Square Tests

Test of Independence & Test of Homogeneity

Expected Count

$$E = \text{expected} = \frac{\text{row total} \times \text{column total}}{\text{total } n}$$

Test Statistic

$$\text{X}^2 = \sum \frac{(O-E)^2}{E} = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

df = $(r - 1)(c - 1)$

Test for Goodness of Fit

Expected Count

$E_i = \text{expected} = np_{i0}$

Test Statistic

$$\text{X}^2 = \sum \frac{(O-E)^2}{E} = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

df = $k - 1$

If Y follows a $\chi^2(df)$ distribution, then E(Y) = df and Var(Y) = 2(df).

TABLE A.1 Standard Normal Probabilities

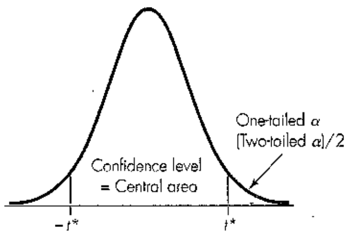
Table entry for *z* is the area to the left of *z*

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998

In the Extreme

z	*Probability*
−3.09	.001
−3.72	.0001
−4.26	.00001
−4.75	.000001
−5.20	.0000001
−5.61	.00000001
−6.00	.000000001
3.09	.999
3.72	.9999
4.26	.99999
4.75	.999999
5.20	.9999999
5.61	.99999999
6.00	.999999999

Table A.2 t^* Multipliers for Confidence Intervals and Rejection Region Critical Values



	Confidence Level						
df	.80	.90	.95	.98	.99	.998	.999
1	3.08	6.31	12.71	31.82	63.66	318.31	636.62
2	1.89	2.92	4.30	6.96	9.92	22.33	31.60
3	1.64	2.35	3.18	4.54	5.84	10.21	12.92
4	1.53	2.13	2.78	3.75	4.60	7.17	8.61
5	1.48	2.02	2.57	3.36	4.03	5.89	6.87
6	1.44	1.94	2.45	3.14	3.71	5.21	5.96
7	1.41	1.89	2.36	3.00	3.50	4.79	5.41
8	1.40	1.86	2.31	2.90	3.36	4.50	5.04
9	1.38	1.83	2.26	2.82	3.25	4.30	4.78
10	1.37	1.81	2.23	2.76	3.17	4.14	4.59
11	1.36	1.80	2.20	2.72	3.11	4.02	4.44
12	1.36	1.78	2.18	2.68	3.05	3.93	4.32
13	1.35	1.77	2.16	2.65	3.01	3.85	4.22
14	1.35	1.76	2.14	2.62	2.98	3.79	4.14
15	1.34	1.75	2.13	2.60	2.95	3.73	4.07
16	1.34	1.75	2.12	2.58	2.92	3.69	4.01
17	1.33	1.74	2.11	2.57	2.90	3.65	3.97
18	1.33	1.73	2.10	2.55	2.88	3.61	3.92
19	1.33	1.73	2.09	2.54	2.86	3.58	3.88
20	1.33	1.72	2.09	2.53	2.85	3.55	3.85
21	1.32	1.72	2.08	2.52	2.83	3.53	3.82
22	1.32	1.72	2.07	2.51	2.82	3.50	3.79
23	1.32	1.71	2.07	2.50	2.81	3.48	3.77
24	1.32	1.71	2.06	2.49	2.80	3.47	3.75
25	1.32	1.71	2.06	2.49	2.79	3.45	3.73
26	1.31	1.71	2.06	2.48	2.78	3.43	3.71
27	1.31	1.70	2.05	2.47	2.77	3.42	3.69
28	1.31	1.70	2.05	2.47	2.76	3.41	3.67
29	1.31	1.70	2.05	2.46	2.76	3.40	3.66
30	1.31	1.70	2.04	2.46	2.75	3.39	3.65
40	1.30	1.68	2.02	2.42	2.70	3.31	3.55
50	1.30	1.68	2.01	2.40	2.68	3.26	3.50
60	1.30	1.67	2.00	2.39	2.66	3.23	3.46
70	1.29	1.67	1.99	2.38	2.65	3.21	3.44
80	1.29	1.66	1.99	2.37	2.64	3.20	3.42
90	1.29	1.66	1.99	2.37	2.63	3.18	3.40
100	1.29	1.66	1.98	2.36	2.63	3.17	3.39
1000	1.282	1.646	1.962	2.330	2.581	3.098	3.300
Infinite	1.281	1.645	1.960	2.326	2.576	3.090	3.291
Two-tailed α	.20	.10	.05	.02	.01	.002	.001
One-tailed α	.10	.05	.025	.01	.005	.001	.0005

Note that the t-distribution with infinite df is the standard normal distribution.

TABLE A.3 ▩ One-Sided p-Values for Significance Tests Based on a t-Statistic

- A p-value in the table is the area to the right of t.
- Double the value if the alternative hypothesis is two-sided (not equal).

	Absolute Value of t-Statistic							
df	1.28	1.50	1.65	1.80	2.00	2.33	2.58	3.00
1	0.211	0.187	0.173	0.161	0.148	0.129	0.118	0.102
2	0.164	0.136	0.120	0.107	0.092	0.073	0.062	0.048
3	0.145	0.115	0.099	0.085	0.070	0.051	0.041	0.029
4	0.135	0.104	0.087	0.073	0.058	0.040	0.031	0.020
5	0.128	0.097	0.080	0.066	0.051	0.034	0.025	0.015
6	0.124	0.092	0.075	0.061	0.046	0.029	0.021	0.012
7	0.121	0.089	0.071	0.057	0.043	0.026	0.018	0.010
8	0.118	0.086	0.069	0.055	0.040	0.024	0.016	0.009
9	0.116	0.084	0.067	0.053	0.038	0.022	0.015	0.007
10	0.115	0.082	0.065	0.051	0.037	0.021	0.014	0.007
11	0.113	0.081	0.064	0.050	0.035	0.020	0.013	0.006
12	0.112	0.080	0.062	0.049	0.034	0.019	0.012	0.006
13	0.111	0.079	0.061	0.048	0.033	0.018	0.011	0.005
14	0.111	0.078	0.061	0.047	0.033	0.018	0.011	0.005
15	0.110	0.077	0.060	0.046	0.032	0.017	0.010	0.004
16	0.109	0.077	0.059	0.045	0.031	0.017	0.010	0.004
17	0.109	0.076	0.059	0.045	0.031	0.016	0.010	0.004
18	0.108	0.075	0.058	0.044	0.030	0.016	0.009	0.004
19	0.108	0.075	0.058	0.044	0.030	0.015	0.009	0.004
20	0.108	0.075	0.057	0.043	0.030	0.015	0.009	0.004
21	0.107	0.074	0.057	0.043	0.029	0.015	0.009	0.003
22	0.107	0.074	0.057	0.043	0.029	0.015	0.009	0.003
23	0.107	0.074	0.056	0.042	0.029	0.014	0.008	0.003
24	0.106	0.073	0.056	0.042	0.028	0.014	0.008	0.003
25	0.106	0.073	0.056	0.042	0.028	0.014	0.008	0.003
26	0.106	0.073	0.055	0.042	0.028	0.014	0.008	0.003
27	0.106	0.073	0.055	0.042	0.028	0.014	0.008	0.003
28	0.106	0.072	0.055	0.041	0.028	0.014	0.008	0.003
29	0.105	0.072	0.055	0.041	0.027	0.013	0.008	0.003
30	0.105	0.072	0.055	0.041	0.027	0.013	0.008	0.003
40	0.104	0.071	0.053	0.040	0.026	0.012	0.007	0.002
50	0.103	0.070	0.053	0.039	0.025	0.012	0.006	0.002
60	0.103	0.069	0.052	0.038	0.025	0.012	0.006	0.002
70	0.102	0.069	0.052	0.038	0.025	0.011	0.006	0.002
80	0.102	0.069	0.051	0.038	0.024	0.011	0.006	0.002
90	0.102	0.069	0.051	0.038	0.024	0.011	0.006	0.002
100	0.102	0.068	0.051	0.037	0.024	0.011	0.006	0.002
1000	0.100	0.067	0.050	0.036	0.023	0.010	0.005	0.001
Infinite	0.1003	0.0668	0.0495	0.0359	0.0228	0.0099	0.0049	0.0013

Note that the t-distribution with infinite df is the standard normal distribution.

TABLE A.5 ▩ Chi-square Distribution

	p = Area to Right of Chi-square Value								
df	*0.50*	*0.25*	*0.10*	*0.075*	*0.05*	*0.025*	*0.01*	*0.005*	*0.001*
1	0.45	1.32	2.71	3.17	3.84	5.02	6.63	7.88	10.83
2	1.39	2.77	4.61	5.18	5.99	7.38	9.21	10.60	13.82
3	2.37	4.11	6.25	6.90	7.81	9.35	11.34	12.84	16.27
4	3.36	5.39	7.78	8.50	9.49	11.14	13.28	14.86	18.47
5	4.35	6.63	9.24	10.01	11.07	12.83	15.09	16.75	20.51
6	5.35	7.84	10.64	11.47	12.59	14.45	16.81	18.55	22.46
7	6.35	9.04	12.02	12.88	14.07	16.01	18.48	20.28	24.32
8	7.34	10.22	13.36	14.27	15.51	17.53	20.09	21.95	26.12
9	8.34	11.39	14.68	15.63	16.92	19.02	21.67	23.59	27.88
10	9.34	12.55	15.99	16.97	18.31	20.48	23.21	25.19	29.59
11	10.34	13.70	17.28	18.29	19.68	21.92	24.73	26.76	31.26
12	11.34	14.85	18.55	19.60	21.03	23.34	26.22	28.30	32.91
13	12.34	15.98	19.81	20.90	22.36	24.74	27.69	29.82	34.53
14	13.34	17.12	21.06	22.18	23.68	26.12	29.14	31.32	36.12
15	14.34	18.25	22.31	23.45	25.00	27.49	30.58	32.80	37.70
16	15.34	19.37	23.54	24.72	26.30	28.85	32.00	34.27	39.25
17	16.34	20.49	24.77	25.97	27.59	30.19	33.41	35.72	40.79
18	17.34	21.60	25.99	27.22	28.87	31.53	34.81	37.16	42.31
19	18.34	22.72	27.20	28.46	30.14	32.85	36.19	38.58	43.82
20	19.34	23.83	28.41	29.69	31.41	34.17	37.57	40.00	45.31
21	20.34	24.93	29.62	30.92	32.67	35.48	38.93	41.40	46.80
22	21.34	26.04	30.81	32.14	33.92	36.78	40.29	42.80	48.27
23	22.34	27.14	32.01	33.36	35.17	38.08	41.64	44.18	49.73
24	23.34	28.24	33.20	34.57	36.42	39.36	42.98	45.56	51.18
25	24.34	29.34	34.38	35.78	37.65	40.65	44.31	46.93	52.62
26	25.34	30.43	35.56	36.98	38.89	41.92	45.64	48.29	54.05
27	26.34	31.53	36.74	38.18	40.11	43.19	46.96	49.65	55.48
28	27.34	32.62	37.92	39.38	41.34	44.46	48.28	50.99	56.89
29	28.34	33.71	39.09	40.57	42.56	45.72	49.59	52.34	58.30
30	29.34	34.80	40.26	41.76	43.77	46.98	50.89	53.67	59.70

ISBN-13: 978-0-495-11811-4
ISBN-10: 0-495-11811-7
90000>
9 780495 118114