

# Formulas and Tables

for *Essentials of Statistics*, by Mario F. Triola

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<p><b>Ch. 2: Descriptive Statistics</b></p> $\bar{x} = \frac{\Sigma x}{n} \quad \text{Mean}$ $\bar{x} = \frac{\Sigma f \cdot x}{\Sigma f} \quad \text{Mean (frequency table)}$ $s = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n - 1}} \quad \text{Standard deviation}$ $s = \sqrt{\frac{n(\Sigma x^2) - (\Sigma x)^2}{n(n - 1)}} \quad \text{Standard deviation (shortcut)}$ $s = \sqrt{\frac{n[\Sigma (f \cdot x^2)] - [\Sigma (f \cdot x)]^2}{n(n - 1)}} \quad \text{Standard deviation (frequency table)}$ <p>variance = <math>s^2</math></p>	<p><b>Ch. 6: Confidence Intervals (one population)</b></p> $\bar{x} - E < \mu < \bar{x} + E \quad \text{Mean}$ <p>where <math>E = z_{\alpha/2} \frac{\sigma}{\sqrt{n}}</math> (<math>\sigma</math> known or <math>n &gt; 30</math>)</p> <p>or <math>E = t_{\alpha/2} \frac{s}{\sqrt{n}}</math> (<math>\sigma</math> unknown and <math>n \leq 30</math>)</p> <hr/> $\hat{p} - E < p < \hat{p} + E \quad \text{Proportion}$ <p>where <math>E = z_{\alpha/2} \sqrt{\frac{\hat{p}\hat{q}}{n}}</math></p> <hr/> $\frac{(n - 1)s^2}{\chi_R^2} < \sigma^2 < \frac{(n - 1)s^2}{\chi_L^2} \quad \text{Variance}$
<p><b>Ch. 3: Probability</b></p> <p><math>P(A \text{ or } B) = P(A) + P(B)</math> if <math>A, B</math> are mutually exclusive</p> <p><math>P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)</math> if <math>A, B</math> are not mutually exclusive</p> <p><math>P(A \text{ and } B) = P(A) \cdot P(B)</math> if <math>A, B</math> are independent</p> <p><math>P(A \text{ and } B) = P(A) \cdot P(B A)</math> if <math>A, B</math> are dependent</p> <p><math>P(\bar{A}) = 1 - P(A)</math> Rule of complements</p> ${}_nP_r = \frac{n!}{(n - r)!} \quad \text{Permutations (no elements alike)}$ $\frac{n!}{n_1! n_2! \dots n_k!} \quad \text{Permutations } (n_1 \text{ alike, } \dots)$ ${}_nC_r = \frac{n!}{(n - r)! r!} \quad \text{Combinations}$	<p><b>Ch. 6: Sample Size Determination</b></p> $n = \left[ \frac{z_{\alpha/2} \sigma}{E} \right]^2 \quad \text{Mean}$ $n = \frac{[z_{\alpha/2}]^2 \cdot 0.25}{E^2} \quad \text{Proportion}$ $n = \frac{[z_{\alpha/2}]^2 \hat{p}\hat{q}}{E^2} \quad \text{Proportion } (\hat{p} \text{ and } \hat{q} \text{ are known})$
<p><b>Ch. 4: Probability Distributions</b></p> $\mu = \Sigma x \cdot P(x) \quad \text{Mean (prob. dist.)}$ $\sigma = \sqrt{[\Sigma x^2 \cdot P(x)] - \mu^2} \quad \text{Standard deviation (prob. dist.)}$ $P(x) = \frac{n!}{(n - x)! x!} \cdot p^x \cdot q^{n-x} \quad \text{Binomial probability}$ $\mu = n \cdot p \quad \text{Mean (binomial)}$ $\sigma^2 = n \cdot p \cdot q \quad \text{Variance (binomial)}$ $\sigma = \sqrt{n \cdot p \cdot q} \quad \text{Standard deviation (binomial)}$	<p><b>Ch. 7: Test Statistics (one population)</b></p> $z = \frac{\bar{x} - \mu}{\sigma/\sqrt{n}} \quad \text{Mean—one population } (\sigma \text{ known or } n > 30)$ $t = \frac{\bar{x} - \mu}{s/\sqrt{n}} \quad \text{Mean—one population } (\sigma \text{ unknown and } n \leq 30)$ $z = \frac{\hat{p} - p}{\sqrt{\frac{pq}{n}}} \quad \text{Proportion—one population}$ $\chi^2 = \frac{(n - 1)s^2}{\sigma^2} \quad \text{Standard deviation or variance—one population}$
<p><b>Ch. 5: Normal Distribution</b></p> $z = \frac{x - \bar{x}}{s} \text{ or } \frac{x - \mu}{\sigma} \quad \text{Standard score}$ $\mu_{\bar{x}} = \mu \quad \text{Central limit theorem}$ $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \quad \text{Central limit theorem (Standard error)}$	<p><b>Ch. 8: Test Statistics (two populations)</b></p> $z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad \text{Two means—independent } (\sigma_1, \sigma_2 \text{ known or } n_1 > 30 \text{ and } n_2 > 30)$ <hr/> $t = \frac{\bar{d} - \mu_d}{s_d/\sqrt{n}} \quad \text{Two means—matched pairs } (df = n - 1)$ <hr/> $z = \frac{(\hat{p}_1 - \hat{p}_2) - (p_1 - p_2)}{\sqrt{\frac{\hat{p}\hat{q}}{n_1} + \frac{\hat{p}\hat{q}}{n_2}}} \quad \text{Two proportions}$

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Ch. 8: Confidence Intervals (two populations)	Ch. 10: Multinomial and Contingency Tables
$(\bar{x}_1 - \bar{x}_2) - E < (\mu_1 - \mu_2) < (\bar{x}_1 - \bar{x}_2) + E \quad (\text{Indep.})$ <p>where <math>E = z_{\alpha/2} \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}</math> ←</p> <p><math>(\sigma_1, \sigma_2 \text{ known or } n_1 &gt; 30 \text{ and } n_2 &gt; 30)</math> —</p> <hr/> $\bar{d} - E < \mu_d < \bar{d} + E \quad (\text{Matched Pairs})$ <p>where <math>E = t_{\alpha/2} \frac{s_d}{\sqrt{n}}</math> (df = n - 1)</p> <hr/> $(\hat{p}_1 - \hat{p}_2) - E < (p_1 - p_2) < (\hat{p}_1 - \hat{p}_2) + E$ <p>where <math>E = z_{\alpha/2} \sqrt{\frac{\hat{p}_1 \hat{q}_1}{n_1} + \frac{\hat{p}_2 \hat{q}_2}{n_2}}</math></p>	$\chi^2 = \sum \frac{(O - E)^2}{E} \quad \begin{array}{l} \text{Multinomial} \\ (\text{df} = k - 1) \end{array}$ $\chi^2 = \sum \frac{(O - E)^2}{E} \quad \begin{array}{l} \text{Contingency table} \\ [\text{df} = (r - 1)(c - 1)] \end{array}$ <p>where <math>E = \frac{(\text{row total})(\text{column total})}{(\text{grand total})}</math></p>
Ch. 9: Linear Correlation/Regression	Ch. 10: One-Way Analysis of a Variance
$\text{Correlation } r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2} \sqrt{n(\sum y^2) - (\sum y)^2}}$ <hr/> $b_1 = \frac{n \sum xy - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$ $b_0 = \bar{y} - b_1 \bar{x} \text{ or } b_0 = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2}$ $\hat{y} = b_0 + b_1 x \quad \text{Estimated eq. of regression line}$ <hr/> $r^2 = \frac{\text{explained variation}}{\text{total variation}}$ $s_e = \sqrt{\frac{\sum (y - \hat{y})^2}{n - 2}} \text{ or } \sqrt{\frac{\sum y^2 - b_0 \sum y - b_1 \sum xy}{n - 2}}$ <hr/> $\hat{y} - E < y < \hat{y} + E$ <p>where <math>E = t_{\alpha/2} s_e \sqrt{1 + \frac{1}{n} + \frac{n(x_0 - \bar{x})^2}{n(\sum x^2) - (\sum x)^2}}</math></p> <hr/> $r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)} \quad \text{Rank correlation}$ <p>(critical value for <math>n &gt; 30</math>: <math>\frac{\pm z}{\sqrt{n - 1}}</math>)</p>	$F = \frac{ns_{\bar{x}}^2}{s_p^2} \quad \begin{array}{l} k \text{ samples each of size } n \\ (\text{num. df} = k - 1; \text{den. df} = k(n - 1)) \end{array}$ $F = \frac{\text{MS}(\text{treatment})}{\text{MS}(\text{error})} \quad \begin{array}{l} \leftarrow \text{df} = k - 1 \\ \leftarrow \text{df} = N - k \end{array}$ $\text{MS}(\text{treatment}) = \frac{\text{SS}(\text{treatment})}{k - 1}$ $\text{MS}(\text{error}) = \frac{\text{SS}(\text{error})}{N - k} \quad \text{MS}(\text{total}) = \frac{\text{SS}(\text{total})}{N - 1}$ $\text{SS}(\text{treatment}) = n_1(\bar{x}_1 - \bar{\bar{x}})^2 + \dots + n_k(\bar{x}_k - \bar{\bar{x}})^2$ $\text{SS}(\text{error}) = (n_1 - 1)s_1^2 + \dots + (n_k - 1)s_k^2$ $\text{SS}(\text{total}) = \sum (x - \bar{\bar{x}})^2$ $\text{SS}(\text{total}) = \text{SS}(\text{treatment}) + \text{SS}(\text{error})$

# SUMMARY OF CHAPTER 5 TO CHAPTER 8

## SCSI 2143 PROBABILITY & STATISTICAL DATA ANALYSIS

CHAPTER	TOPICS	H <sub>0</sub> & H <sub>1</sub>	TEST STATISTICS / FORMULA
5 (P1) Point and Interval Estimator	Confidence Interval	-	$\hat{p} \pm (z_{cv}) \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$ $\bar{x} \pm (z_{cv}) \left( \frac{\sigma}{\sqrt{n}} \right)$ $s \pm (t_{cv}) \left( \frac{s}{\sqrt{n}} \right)$
5 (P2) Hypothesis Testing 1-sample	Test for Proportion	$H_0: p = \text{value}$ $H_1: p \neq \text{value}$ $H_1: p < \text{value}$ $H_1: p > \text{value}$	$z = \frac{\hat{p} - p}{\sqrt{\frac{pq}{n}}}$
	Test for Mean	$H_0: \mu = \text{value}$ $H_1: \mu \neq \text{value}$ $H_1: \mu < \text{value}$ $H_1: \mu > \text{value}$	$\sigma^2 \text{ known}$ $z = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$ $\sigma^2 \text{ unknown and } n \leq 30$ $t = \frac{\bar{x} - \mu}{s / \sqrt{n}}$ $\sigma^2 \text{ unknown and } n > 30$ $z = \frac{\bar{x} - \mu}{s / \sqrt{n}}$
	Test for Variance / Standard Deviation	$H_0: \sigma = \text{value}$ $H_1: \sigma \neq \text{value}$ $H_1: \sigma < \text{value}$ $H_1: \sigma > \text{value}$	$\chi^2 = \frac{(n-1)s^2}{\sigma^2}$

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$1 - \alpha$	$\alpha$	$\alpha / 2$	$z_{\alpha/2}$
.90	.10	.05	$z_{.05} = 1.645$
.95	.05	.025	$z_{.025} = 1.96$
.98	.02	.01	$z_{.01} = 2.33$
.99	.01	.005	$z_{.005} = 2.575$

# SUMMARY OF CHAPTER 5 TO CHAPTER 8

## SCSI 2143 PROBABILITY & STATISTICAL DATA ANALYSIS

CHAPTER	TOPICS	H <sub>0</sub> & H <sub>1</sub>	TEST STATISTICS / FORMULA
5 (P3) Hypothesis Testing 2- Sample	Test for 2-Propotions	$H_0: p_1 = p_2$ $H_1: p_1 \neq p_2$ $H_1: p_1 < p_2$ $H_1: p_1 > p_2$	$\bar{p} = \frac{x_1 + x_2}{n_1 + n_2}$ $z = \frac{(\hat{p} - \bar{p}) - (p_1 - p_2)}{\sqrt{\frac{\bar{p}\bar{q}}{n_1} + \frac{\bar{p}\bar{q}}{n_2}}}$
	Test on Difference Between 2-Mean	$H_0: \mu_1 - \mu_2 = \Delta_0$ $H_1: \mu_1 \neq \mu_2$ $H_1: \mu_1 > \mu_2$ $H_1: \mu_1 < \mu_2$	<p><math>\sigma_1^2</math> and <math>\sigma_2^2</math> known</p> $z = \frac{\bar{X}_1 - \bar{X}_2 - \Delta_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$ <p><math>\sigma_1^2</math> and <math>\sigma_2^2</math> unknown</p> <p>Case 1: <math>\sigma_1^2 = \sigma_2^2</math></p> $S_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$ $t = \frac{\bar{X}_1 - \bar{X}_2 - \Delta_0}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$ <p><math>\sigma_1^2</math> and <math>\sigma_2^2</math> unknown</p> <p>Case 2: <math>\sigma_1^2 \neq \sigma_2^2</math></p> $t = \frac{\bar{X}_1 - \bar{X}_2 - \Delta_0}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$ $v = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\left(\frac{s_1^2/n_1}{n_1 - 1} + \frac{s_2^2/n_2}{n_2 - 1}\right)^2}$

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# SUMMARY OF CHAPTER 5 TO CHAPTER 8

## SCSI 2143 PROBABILITY & STATISTICAL DATA ANALYSIS

CHAPTER	TOPICS	H <sub>0</sub> & H <sub>1</sub>	TEST STATISTICS / FORMULA
5 (P3) Hypothesis Testing 2-Sample	Test on Difference Between 2-Variance / Standard Deviation	$H_0: \sigma_1 = \sigma_2$ $H_1: \sigma_1 \neq \sigma_2$ $H_1: \sigma_1 > \sigma_2$ $H_1: \sigma_1 < \sigma_2$	$F = \frac{S_1^2}{S_2^2}$
	Test on 2-Dependent Samples (Matched Pair)	$H_0: \mu_D = 0$ $H_1: \mu_D \neq 0$ $H_1: \mu_D > 0$ $H_1: \mu_D < 0$	$s_D = \sqrt{\frac{\sum D^2 - \frac{(\sum D)^2}{n}}{n-1}}$ $t = \frac{\bar{D} - \mu_D}{\frac{s_D}{\sqrt{n}}}$
6 Chi-Square & Cont. Table	1-Way Contingency	<b>Equal Frequencies</b> $H_0: p_1 = p_2 = \dots = p_k$ $H_1: \text{at least one } p \text{ is different}$	$E = \frac{n}{k}$
		<b>Unequal Frequencies</b> $H_0: p_1 = p_2 = \dots = p_k \text{ as claimed}$ $H_1: \text{at least one } p \text{ is different}$	$E = np$
	2-way Contingency	$H_0: \text{Variables are independent}$ $H_1: \text{Variables are dependent}$	$E = \frac{(i^{\text{th}} \text{ Row Total})(j^{\text{th}} \text{ Column Total})}{\text{Total Sample Size}}$ $\chi^2 = \sum \frac{(O_{i,j} - E_{i,j})^2}{E_{i,j}}$

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# SUMMARY OF CHAPTER 5 TO CHAPTER 8

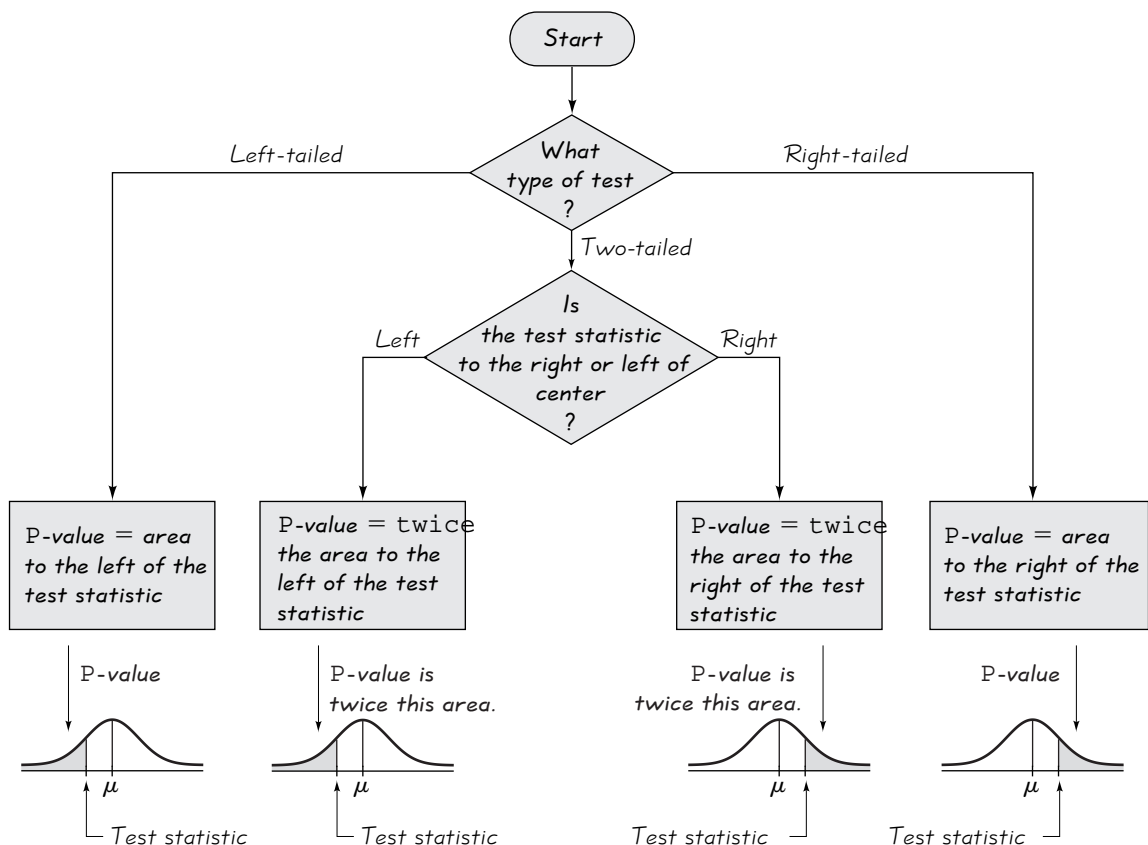
## SCSI 2143 PROBABILITY & STATISTICAL DATA ANALYSIS

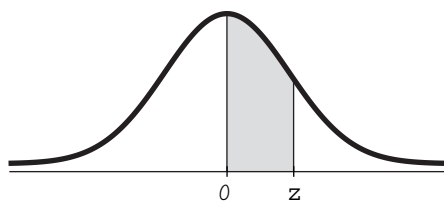
CHAPTER	TOPICS	H <sub>0</sub> & H <sub>1</sub>	TEST STATISTICS / FORMULA
7 (P1)	Correlation		<p><b>Both Interval/Ratio Data</b></p> $r = \frac{\sum xy - \frac{(\sum x \sum y)}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$ <p><b>Both Ordinal Data</b></p> $r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$
		<p><math>H_0: \rho = 0</math> (no correlation)</p> <p><math>H_1: \rho \neq 0</math> (correlation exists)</p>	$t = \frac{r}{\sqrt{\frac{1 - r^2}{n - 2}}}$
7 (P2)	Regression		$\hat{y} = b_0 + b_1x$ $b_1 = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}}$ $b_0 = \bar{y} - b_1\bar{x}$
		<p><math>H_0: \beta_1 = 0</math></p> <p><math>H_1: \beta_1 \neq 0</math></p>	$t = \frac{b_1 - \beta_1}{s_{b_1}}$
8 ANOVA	1-way ANOVA with Equal Sample Sizes	<p><math>H_0: \mu_1 = \mu_2 = \mu_3 = \dots = \mu_n</math></p> <p><math>H_1: \text{At least one mean is different}</math></p>	$F = \frac{ns_{\bar{x}}^2}{s_p^2}$ <p>Numerator = <math>k - 1</math></p> <p>Denominator = <math>k(n - 1)</math></p>

# HYPOTHESIS TESTING

1. Identify the specific claim or hypothesis to be tested and put it in symbolic form.
  2. Give the symbolic form that must be true when the original claim is false.
  3. Of the two symbolic expressions obtained so far, let the null hypothesis  $H_0$  be the one that contains the condition of equality;  $H_1$  is the other statement.
  4. Select the significance level  $\alpha$  based on the seriousness of a type I error. Make  $\alpha$  small if the consequences of rejecting a true  $H_0$  are severe. The values of 0.05 and 0.01 are very common.
  5. Identify the statistic that is relevant to this test, and identify its sampling distribution.
  6. Determine the test statistic and either the  $P$ -value or the critical values, and the critical region. Draw a graph.
  7. Reject  $H_0$ : Test statistic is in the critical region or  $P\text{-value} \leq \alpha$ . Fail to reject  $H_0$ : Test statistic is not in the critical region or  $P\text{-value} > \alpha$ .
  8. Restate this previous conclusion in simple, nontechnical terms.
- 

## FINDING P-VALUES





**TABLE A-2** Standard Normal ( $z$ ) Distribution

$z$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	*.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	↑.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	*.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	↑.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.10 and higher	.4999									

NOTE: For values of  $z$  above 3.09, use 0.4999 for the area.

\*Use these common values that result from interpolation:

$z$ score	Area
1.645	0.4500
2.575	0.4950

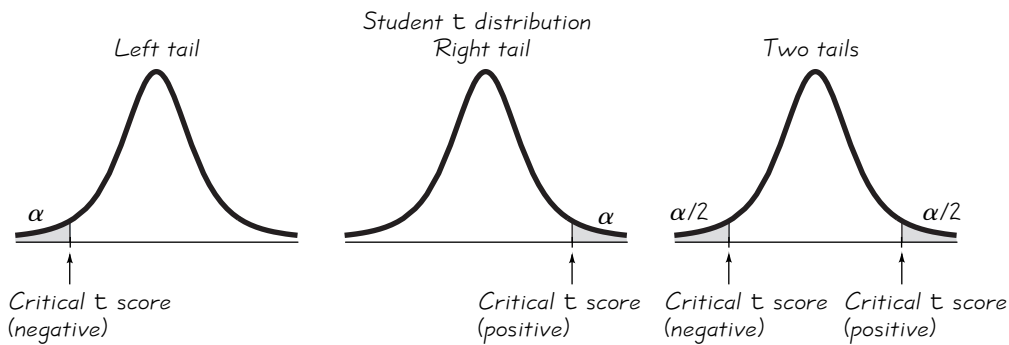
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**STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.**

<b>Z</b>	<b>.00</b>	<b>.01</b>	<b>.02</b>	<b>.03</b>	<b>.04</b>	<b>.05</b>	<b>.06</b>	<b>.07</b>	<b>.08</b>	<b>.09</b>
<b>-3.9</b>	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
<b>-3.8</b>	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
<b>-3.7</b>	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
<b>-3.6</b>	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
<b>-3.5</b>	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
<b>-3.4</b>	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
<b>-3.3</b>	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
<b>-3.2</b>	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
<b>-3.1</b>	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
<b>-3.0</b>	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
<b>-2.9</b>	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
<b>-2.8</b>	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
<b>-2.7</b>	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
<b>-2.6</b>	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
<b>-2.5</b>	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
<b>-2.4</b>	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
<b>-2.3</b>	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
<b>-2.2</b>	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
<b>-2.1</b>	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
<b>-2.0</b>	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
<b>-1.9</b>	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
<b>-1.8</b>	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
<b>-1.7</b>	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
<b>-1.6</b>	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
<b>-1.5</b>	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
<b>-1.4</b>	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
<b>-1.3</b>	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
<b>-1.2</b>	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
<b>-1.1</b>	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
<b>-1.0</b>	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786
<b>-0.9</b>	.18406	.18141	.17879	.17619	.17361	.17106	.16853	.16602	.16354	.16109
<b>-0.8</b>	.21186	.20897	.20611	.20327	.20045	.19766	.19489	.19215	.18943	.18673
<b>-0.7</b>	.24196	.23885	.23576	.23270	.22965	.22663	.22363	.22065	.21770	.21476
<b>-0.6</b>	.27425	.27093	.26763	.26435	.26109	.25785	.25463	.25143	.24825	.24510
<b>-0.5</b>	.30854	.30503	.30153	.29806	.29460	.29116	.28774	.28434	.28096	.27760
<b>-0.4</b>	.34458	.34090	.33724	.33360	.32997	.32636	.32276	.31918	.31561	.31207
<b>-0.3</b>	.38209	.37828	.37448	.37070	.36693	.36317	.35942	.35569	.35197	.34827
<b>-0.2</b>	.42074	.41683	.41294	.40905	.40517	.40129	.39743	.39358	.38974	.38591
<b>-0.1</b>	.46017	.45620	.45224	.44828	.44433	.44038	.43644	.43251	.42858	.42465
<b>-0.0</b>	.50000	.49601	.49202	.48803	.48405	.48006	.47608	.47210	.46812	.46414





**TABLE A-3** t Distribution

Degrees of Freedom	$\alpha$					
	.005	.01	.025	.05	.10	.25
	(one tail) .01 (two tails)	(one tail) .02 (two tails)	(one tail) .05 (two tails)	(one tail) .10 (two tails)	(one tail) .20 (two tails)	(one tail) .50 (two tails)
1	63.657	31.821	12.706	6.314	3.078	1.000
2	9.925	6.965	4.303	2.920	1.886	.816
3	5.841	4.541	3.182	2.353	1.638	.765
4	4.604	3.747	2.776	2.132	1.533	.741
5	4.032	3.365	2.571	2.015	1.476	.727
6	3.707	3.143	2.447	1.943	1.440	.718
7	3.500	2.998	2.365	1.895	1.415	.711
8	3.355	2.896	2.306	1.860	1.397	.706
9	3.250	2.821	2.262	1.833	1.383	.703
10	3.169	2.764	2.228	1.812	1.372	.700
11	3.106	2.718	2.201	1.796	1.363	.697
12	3.054	2.681	2.179	1.782	1.356	.696
13	3.012	2.650	2.160	1.771	1.350	.694
14	2.977	2.625	2.145	1.761	1.345	.692
15	2.947	2.602	2.132	1.753	1.341	.691
16	2.921	2.584	2.120	1.746	1.337	.690
17	2.898	2.567	2.110	1.740	1.333	.689
18	2.878	2.552	2.101	1.734	1.330	.688
19	2.861	2.540	2.093	1.729	1.328	.688
20	2.845	2.528	2.086	1.725	1.325	.687
21	2.831	2.518	2.080	1.721	1.323	.686
22	2.819	2.508	2.074	1.717	1.321	.686
23	2.807	2.500	2.069	1.714	1.320	.685
24	2.797	2.492	2.064	1.711	1.318	.685
25	2.787	2.485	2.060	1.708	1.316	.684
26	2.779	2.479	2.056	1.706	1.315	.684
27	2.771	2.473	2.052	1.703	1.314	.684
28	2.763	2.467	2.048	1.701	1.313	.683
29	2.756	2.462	2.045	1.699	1.311	.683
Large (z)	2.575	2.326	1.960	1.645	1.282	.675

**Formulas and Tables**  
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TABLE A-4		Chi-Square ( $\chi^2$ ) Distribution								
Degrees of Freedom	Area to the Right of the Critical Value									
	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	—	—	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	18.549	21.026	23.337	26.217	28.299
13	3.565	4.107	5.009	5.892	7.042	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	23.542	26.296	28.845	32.000	34.267
17	5.697	6.408	7.564	8.672	10.085	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.390	10.865	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	27.204	30.144	32.852	36.191	38.582
20	7.434	8.260	9.591	10.851	12.443	28.412	31.410	34.170	37.566	39.997
21	8.034	8.897	10.283	11.591	13.240	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.042	30.813	33.924	36.781	40.289	42.796
23	9.260	10.196	11.689	13.091	14.848	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	33.196	36.415	39.364	42.980	45.559
25	10.520	11.524	13.120	14.611	16.473	34.382	37.652	40.646	44.314	46.928
26	11.160	12.198	13.844	15.379	17.292	35.563	38.885	41.923	45.642	48.290
27	11.808	12.879	14.573	16.151	18.114	36.741	40.113	43.194	46.963	49.645
28	12.461	13.565	15.308	16.928	18.939	37.916	41.337	44.461	48.278	50.993
29	13.121	14.257	16.047	17.708	19.768	39.087	42.557	45.722	49.588	52.336
30	13.787	14.954	16.791	18.493	20.599	40.256	43.773	46.979	50.892	53.672
40	20.707	22.164	24.433	26.509	29.051	51.805	55.758	59.342	63.691	66.766
50	27.991	29.707	32.357	34.764	37.689	63.167	67.505	71.420	76.154	79.490
60	35.534	37.485	40.482	43.188	46.459	74.397	79.082	83.298	88.379	91.952
70	43.275	45.442	48.758	51.739	55.329	85.527	90.531	95.023	100.425	104.215
80	51.172	53.540	57.153	60.391	64.278	96.578	101.879	106.629	112.329	116.321
90	59.196	61.754	65.647	69.126	73.291	107.565	113.145	118.136	124.116	128.299
100	67.328	70.065	74.222	77.929	82.358	118.498	124.342	129.561	135.807	140.169

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# Formulas and Tables

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## Linear Correlation (Section 9-2)

**TABLE A-5**  
Critical Values of the Pearson  
Correlation Coefficient  $r$

$n$	$\alpha = .05$	$\alpha = .01$
4	.950	.999
5	.878	.959
6	.811	.917
7	.754	.875
8	.707	.834
9	.666	.798
10	.632	.765
11	.602	.735
12	.576	.708
13	.553	.684
14	.532	.661
15	.514	.641
16	.497	.623
17	.482	.606
18	.468	.590
19	.456	.575
20	.444	.561
25	.396	.505
30	.361	.463
35	.335	.430
40	.312	.402
45	.294	.378
50	.279	.361
60	.254	.330
70	.236	.305
80	.220	.286
90	.207	.269
100	.196	.256

NOTE: To test  $H_0: \rho = 0$  against  $H_1: \rho \neq 0$ , reject  $H_0$  if the absolute value of  $r$  is greater than the critical value in the table.

## Rank Correlation (Section 9-5)

**TABLE A-6**  
Critical Values of Spearman's  
Rank Correlation Coefficient  $r_s$

$n$	$\alpha = 0.05$	$\alpha = 0.01$
5	—	—
6	.886	—
7	.786	—
8	.738	.881
9	.683	.833
10	.648	.794
11	.623	.818
12	.591	.780
13	.566	.745
14	.545	.716
15	.525	.689
16	.507	.666
17	.490	.645
18	.476	.625
19	.462	.608
20	.450	.591
21	.438	.576
22	.428	.562
23	.418	.549
24	.409	.537
25	.400	.526
26	.392	.515
27	.385	.505
28	.377	.496
29	.370	.487
30	.364	.478

## HYPOTHESIS TEST: WORDING OF FINAL CONCLUSION

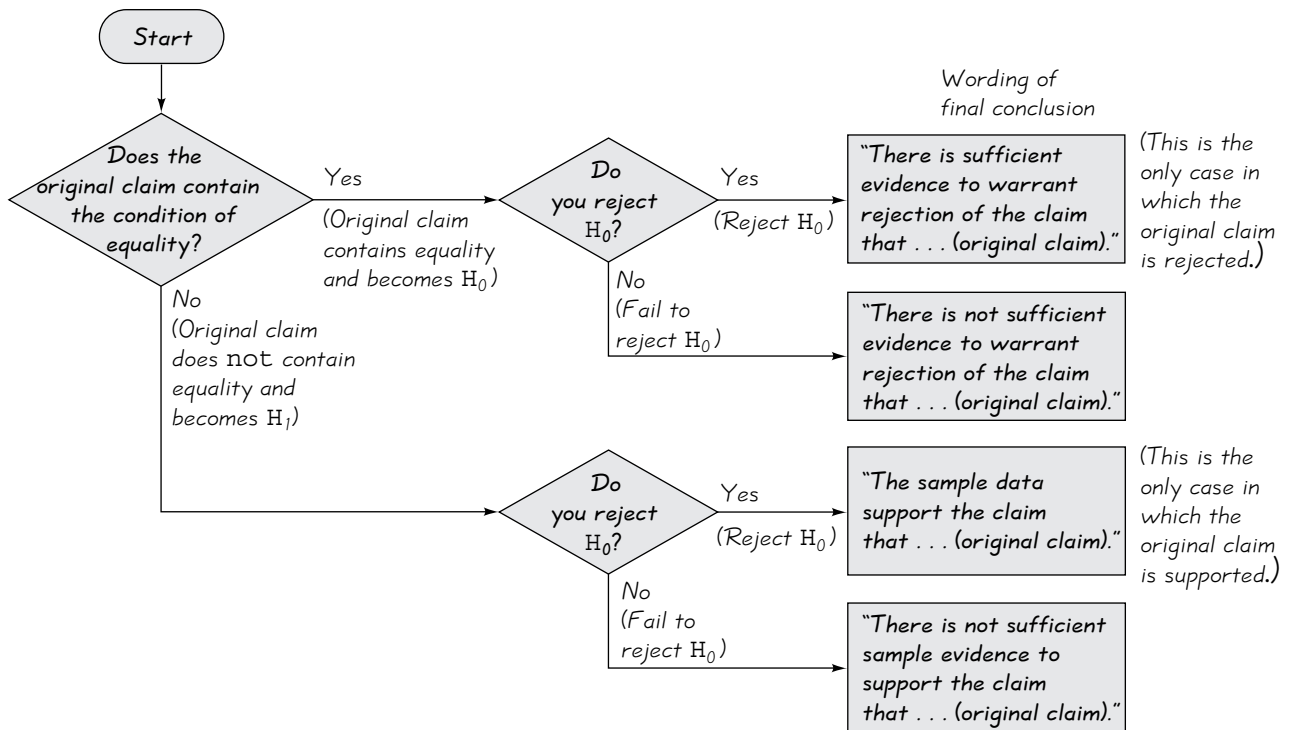
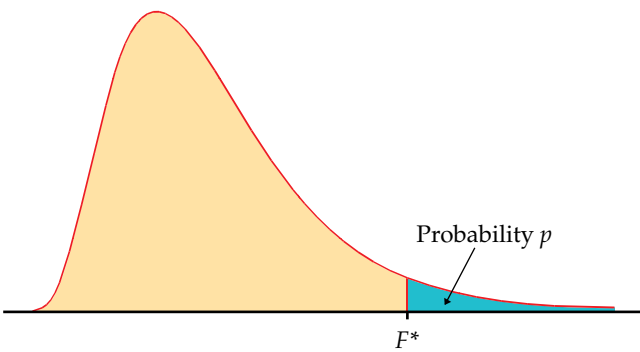


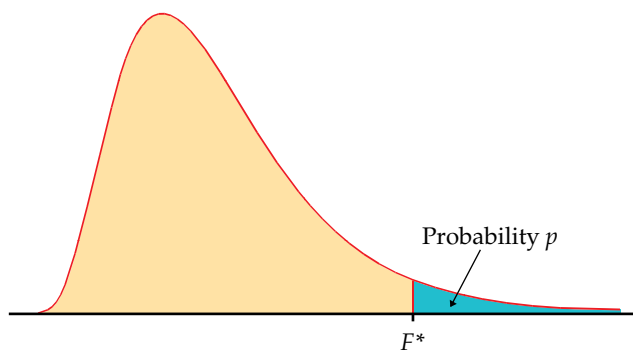
Table entry for  $p$  is the critical value  $F^*$  with probability  $p$  lying to its right.



**TABLE E**  
*F* critical values

		Degrees of freedom in the numerator								
<i>p</i>		1	2	3	4	5	6	7	8	9
Degrees of freedom in the denominator	1	.100	39.86	49.50	53.59	55.83	57.24	58.20	58.91	59.44
		.050	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88
		.025	647.79	799.50	864.16	899.58	921.85	937.11	948.22	956.66
		.010	4052.2	4999.5	5403.4	5624.6	5763.6	5859.0	5928.4	5981.1
		.001	405284	500000	540379	562500	576405	585937	592873	598144
	2	.100	8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37
		.050	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37
		.025	38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.37
		.010	98.50	99.00	99.17	99.25	99.30	99.33	99.36	99.37
		.001	998.50	999.00	999.17	999.25	999.30	999.33	999.36	999.37
	3	.100	5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25
		.050	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85
		.025	17.44	16.04	15.44	15.10	14.88	14.73	14.62	14.54
		.010	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49
		.001	167.03	148.50	141.11	137.10	134.58	132.85	131.58	130.62
	4	.100	4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95
		.050	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04
		.025	12.22	10.65	9.98	9.60	9.36	9.20	9.07	8.98
		.010	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80
		.001	74.14	61.25	56.18	53.44	51.71	50.53	49.66	49.00
	5	.100	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34
		.050	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82
		.025	10.01	8.43	7.76	7.39	7.15	6.98	6.85	6.76
		.010	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29
		.001	47.18	37.12	33.20	31.09	29.75	28.83	28.16	27.65
	6	.100	3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98
		.050	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15
		.025	8.81	7.26	6.60	6.23	5.99	5.82	5.70	5.60
		.010	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10
		.001	35.51	27.00	23.70	21.92	20.80	20.03	19.46	19.03
	7	.100	3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75
		.050	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73
		.025	8.07	6.54	5.89	5.52	5.29	5.12	4.99	4.90
		.010	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84
		.001	29.25	21.69	18.77	17.20	16.21	15.52	15.02	14.63

Table entry for  $p$  is the critical value  $F^*$  with probability  $p$  lying to its right.

**TABLE E****F critical values (continued)**

Degrees of freedom in the numerator										
10	12	15	20	25	30	40	50	60	120	1000
60.19	60.71	61.22	61.74	62.05	62.26	62.53	62.69	62.79	63.06	63.30
241.88	243.91	245.95	248.01	249.26	250.10	251.14	251.77	252.20	253.25	254.19
968.63	976.71	984.87	993.10	998.08	1001.4	1005.6	1008.1	1009.8	1014.0	1017.7
6055.8	6106.3	6157.3	6208.7	6239.8	6260.6	6286.8	6302.5	6313.0	6339.4	6362.7
605621	610668	615764	620908	624017	626099	628712	630285	631337	633972	636301
9.39	9.41	9.42	9.44	9.45	9.46	9.47	9.47	9.47	9.48	9.49
19.40	19.41	19.43	19.45	19.46	19.46	19.47	19.48	19.48	19.49	19.49
39.40	39.41	39.43	39.45	39.46	39.46	39.47	39.48	39.48	39.49	39.50
99.40	99.42	99.43	99.45	99.46	99.47	99.47	99.48	99.48	99.49	99.50
999.40	999.42	999.43	999.45	999.46	999.47	999.47	999.48	999.48	999.49	999.50
5.23	5.22	5.20	5.18	5.17	5.17	5.16	5.15	5.15	5.14	5.13
8.79	8.74	8.70	8.66	8.63	8.62	8.59	8.58	8.57	8.55	8.53
14.42	14.34	14.25	14.17	14.12	14.08	14.04	14.01	13.99	13.95	13.91
27.23	27.05	26.87	26.69	26.58	26.50	26.41	26.35	26.32	26.22	26.14
129.25	128.32	127.37	126.42	125.84	125.45	124.96	124.66	124.47	123.97	123.53
3.92	3.90	3.87	3.84	3.83	3.82	3.80	3.80	3.79	3.78	3.76
5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.70	5.69	5.66	5.63
8.84	8.75	8.66	8.56	8.50	8.46	8.41	8.38	8.36	8.31	8.26
14.55	14.37	14.20	14.02	13.91	13.84	13.75	13.69	13.65	13.56	13.47
48.05	47.41	46.76	46.10	45.70	45.43	45.09	44.88	44.75	44.40	44.09
3.30	3.27	3.24	3.21	3.19	3.17	3.16	3.15	3.14	3.12	3.11
4.74	4.68	4.62	4.56	4.52	4.50	4.46	4.44	4.43	4.40	4.37
6.62	6.52	6.43	6.33	6.27	6.23	6.18	6.14	6.12	6.07	6.02
10.05	9.89	9.72	9.55	9.45	9.38	9.29	9.24	9.20	9.11	9.03
26.92	26.42	25.91	25.39	25.08	24.87	24.60	24.44	24.33	24.06	23.82
2.94	2.90	2.87	2.84	2.81	2.80	2.78	2.77	2.76	2.74	2.72
4.06	4.00	3.94	3.87	3.83	3.81	3.77	3.75	3.74	3.70	3.67
5.46	5.37	5.27	5.17	5.11	5.07	5.01	4.98	4.96	4.90	4.86
7.87	7.72	7.56	7.40	7.30	7.23	7.14	7.09	7.06	6.97	6.89
18.41	17.99	17.56	17.12	16.85	16.67	16.44	16.31	16.21	15.98	15.77
2.70	2.67	2.63	2.59	2.57	2.56	2.54	2.52	2.51	2.49	2.47
3.64	3.57	3.51	3.44	3.40	3.38	3.34	3.32	3.30	3.27	3.23
4.76	4.67	4.57	4.47	4.40	4.36	4.31	4.28	4.25	4.20	4.15
6.62	6.47	6.31	6.16	6.06	5.99	5.91	5.86	5.82	5.74	5.66
14.08	13.71	13.32	12.93	12.69	12.53	12.33	12.20	12.12	11.91	11.72

(Continued)



**TABLE E***F* critical values (continued)

		Degrees of freedom in the numerator								
<i>p</i>		1	2	3	4	5	6	7	8	9
Degrees of freedom in the denominator	8	.100	3.46	3.11	2.92	2.81	2.73	2.67	2.59	2.56
		.050	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.39
		.025	7.57	6.06	5.42	5.05	4.82	4.65	4.43	4.36
		.010	11.26	8.65	7.59	7.01	6.63	6.37	6.03	5.91
		.001	25.41	18.49	15.83	14.39	13.48	12.86	12.05	11.77
	9	.100	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.44
		.050	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.18
		.025	7.21	5.71	5.08	4.72	4.48	4.32	4.20	4.03
		.010	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.35
		.001	22.86	16.39	13.90	12.56	11.71	11.13	10.70	10.11
	10	.100	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.35
		.050	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.02
		.025	6.94	5.46	4.83	4.47	4.24	4.07	3.95	3.78
		.010	10.04	7.56	6.55	5.99	5.64	5.39	5.20	4.94
		.001	21.04	14.91	12.55	11.28	10.48	9.93	9.52	8.96
	11	.100	3.23	2.86	2.66	2.54	2.45	2.39	2.34	2.27
		.050	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.90
		.025	6.72	5.26	4.63	4.28	4.04	3.88	3.76	3.59
		.010	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.63
		.001	19.69	13.81	11.56	10.35	9.58	9.05	8.66	8.12
	12	.100	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.21
		.050	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.80
		.025	6.55	5.10	4.47	4.12	3.89	3.73	3.61	3.44
		.010	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.39
		.001	18.64	12.97	10.80	9.63	8.89	8.38	8.00	7.48
	13	.100	3.14	2.76	2.56	2.43	2.35	2.28	2.23	2.16
		.050	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77
		.025	6.41	4.97	4.35	4.00	3.77	3.60	3.48	3.31
		.010	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.19
		.001	17.82	12.31	10.21	9.07	8.35	7.86	7.49	6.98
	14	.100	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.12
		.050	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.65
		.025	6.30	4.86	4.24	3.89	3.66	3.50	3.38	3.21
		.010	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.03
		.001	17.14	11.78	9.73	8.62	7.92	7.44	7.08	6.58
	15	.100	3.07	2.70	2.49	2.36	2.27	2.21	2.16	2.09
		.050	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64
		.025	6.20	4.77	4.15	3.80	3.58	3.41	3.29	3.12
		.010	8.68	6.36	5.42	4.89	4.56	4.32	4.14	3.89
		.001	16.59	11.34	9.34	8.25	7.57	7.09	6.74	6.26
	16	.100	3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.06
		.050	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.54
		.025	6.12	4.69	4.08	3.73	3.50	3.34	3.22	3.05
		.010	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.78
		.001	16.12	10.97	9.01	7.94	7.27	6.80	6.46	5.98
	17	.100	3.03	2.64	2.44	2.31	2.22	2.15	2.10	2.03
		.050	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.49
		.025	6.04	4.62	4.01	3.66	3.44	3.28	3.16	2.98
		.010	8.40	6.11	5.19	4.67	4.34	4.10	3.93	3.68
		.001	15.72	10.66	8.73	7.68	7.02	6.56	6.22	5.75

**TABLE E****F critical values (continued)**

Degrees of freedom in the numerator										
10	12	15	20	25	30	40	50	60	120	1000
2.54	2.50	2.46	2.42	2.40	2.38	2.36	2.35	2.34	2.32	2.30
3.35	3.28	3.22	3.15	3.11	3.08	3.04	3.02	3.01	2.97	2.93
4.30	4.20	4.10	4.00	3.94	3.89	3.84	3.81	3.78	3.73	3.68
5.81	5.67	5.52	5.36	5.26	5.20	5.12	5.07	5.03	4.95	4.87
11.54	11.19	10.84	10.48	10.26	10.11	9.92	9.80	9.73	9.53	9.36
2.42	2.38	2.34	2.30	2.27	2.25	2.23	2.22	2.21	2.18	2.16
3.14	3.07	3.01	2.94	2.89	2.86	2.83	2.80	2.79	2.75	2.71
3.96	3.87	3.77	3.67	3.60	3.56	3.51	3.47	3.45	3.39	3.34
5.26	5.11	4.96	4.81	4.71	4.65	4.57	4.52	4.48	4.40	4.32
9.89	9.57	9.24	8.90	8.69	8.55	8.37	8.26	8.19	8.00	7.84
2.32	2.28	2.24	2.20	2.17	2.16	2.13	2.12	2.11	2.08	2.06
2.98	2.91	2.85	2.77	2.73	2.70	2.66	2.64	2.62	2.58	2.54
3.72	3.62	3.52	3.42	3.35	3.31	3.26	3.22	3.20	3.14	3.09
4.85	4.71	4.56	4.41	4.31	4.25	4.17	4.12	4.08	4.00	3.92
8.75	8.45	8.13	7.80	7.60	7.47	7.30	7.19	7.12	6.94	6.78
2.25	2.21	2.17	2.12	2.10	2.08	2.05	2.04	2.03	2.00	1.98
2.85	2.79	2.72	2.65	2.60	2.57	2.53	2.51	2.49	2.45	2.41
3.53	3.43	3.33	3.23	3.16	3.12	3.06	3.03	3.00	2.94	2.89
4.54	4.40	4.25	4.10	4.01	3.94	3.86	3.81	3.78	3.69	3.61
7.92	7.63	7.32	7.01	6.81	6.68	6.52	6.42	6.35	6.18	6.02
2.19	2.15	2.10	2.06	2.03	2.01	1.99	1.97	1.96	1.93	1.91
2.75	2.69	2.62	2.54	2.50	2.47	2.43	2.40	2.38	2.34	2.30
3.37	3.28	3.18	3.07	3.01	2.96	2.91	2.87	2.85	2.79	2.73
4.30	4.16	4.01	3.86	3.76	3.70	3.62	3.57	3.54	3.45	3.37
7.29	7.00	6.71	6.40	6.22	6.09	5.93	5.83	5.76	5.59	5.44
2.14	2.10	2.05	2.01	1.98	1.96	1.93	1.92	1.90	1.88	1.85
2.67	2.60	2.53	2.46	2.41	2.38	2.34	2.31	2.30	2.25	2.21
3.25	3.15	3.05	2.95	2.88	2.84	2.78	2.74	2.72	2.66	2.60
4.10	3.96	3.82	3.66	3.57	3.51	3.43	3.38	3.34	3.25	3.18
6.80	6.52	6.23	5.93	5.75	5.63	5.47	5.37	5.30	5.14	4.99
2.10	2.05	2.01	1.96	1.93	1.91	1.89	1.87	1.86	1.83	1.80
2.60	2.53	2.46	2.39	2.34	2.31	2.27	2.24	2.22	2.18	2.14
3.15	3.05	2.95	2.84	2.78	2.73	2.67	2.64	2.61	2.55	2.50
3.94	3.80	3.66	3.51	3.41	3.35	3.27	3.22	3.18	3.09	3.02
6.40	6.13	5.85	5.56	5.38	5.25	5.10	5.00	4.94	4.77	4.62
2.06	2.02	1.97	1.92	1.89	1.87	1.85	1.83	1.82	1.79	1.76
2.54	2.48	2.40	2.33	2.28	2.25	2.20	2.18	2.16	2.11	2.07
3.06	2.96	2.86	2.76	2.69	2.64	2.59	2.55	2.52	2.46	2.40
3.80	3.67	3.52	3.37	3.28	3.21	3.13	3.08	3.05	2.96	2.88
6.08	5.81	5.54	5.25	5.07	4.95	4.80	4.70	4.64	4.47	4.33
2.03	1.99	1.94	1.89	1.86	1.84	1.81	1.79	1.78	1.75	1.72
2.49	2.42	2.35	2.28	2.23	2.19	2.15	2.12	2.11	2.06	2.02
2.99	2.89	2.79	2.68	2.61	2.57	2.51	2.47	2.45	2.38	2.32
3.69	3.55	3.41	3.26	3.16	3.10	3.02	2.97	2.93	2.84	2.76
5.81	5.55	5.27	4.99	4.82	4.70	4.54	4.45	4.39	4.23	4.08
2.00	1.96	1.91	1.86	1.83	1.81	1.78	1.76	1.75	1.72	1.69
2.45	2.38	2.31	2.23	2.18	2.15	2.10	2.08	2.06	2.01	1.97
2.92	2.82	2.72	2.62	2.55	2.50	2.44	2.41	2.38	2.32	2.26
3.59	3.46	3.31	3.16	3.07	3.00	2.92	2.87	2.83	2.75	2.66
5.58	5.32	5.05	4.78	4.60	4.48	4.33	4.24	4.18	4.02	3.87

(Continued)

**TABLE E**

*F* critical values (continued)

		Degrees of freedom in the numerator								
<i>p</i>		1	2	3	4	5	6	7	8	9
Degrees of freedom in the denominator	18	.100	3.01	2.62	2.42	2.29	2.20	2.13	2.08	2.04
		.050	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51
		.025	5.98	4.56	3.95	3.61	3.38	3.22	3.10	3.01
		.010	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71
		.001	15.38	10.39	8.49	7.46	6.81	6.35	6.02	5.76
	19	.100	2.99	2.61	2.40	2.27	2.18	2.11	2.06	2.02
		.050	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48
		.025	5.92	4.51	3.90	3.56	3.33	3.17	3.05	2.96
		.010	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63
		.001	15.08	10.16	8.28	7.27	6.62	6.18	5.85	5.59
	20	.100	2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00
		.050	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45
		.025	5.87	4.46	3.86	3.51	3.29	3.13	3.01	2.91
		.010	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56
		.001	14.82	9.95	8.10	7.10	6.46	6.02	5.69	5.44
	21	.100	2.96	2.57	2.36	2.23	2.14	2.08	2.02	1.98
		.050	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42
		.025	5.83	4.42	3.82	3.48	3.25	3.09	2.97	2.87
		.010	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51
		.001	14.59	9.77	7.94	6.95	6.32	5.88	5.56	5.31
	22	.100	2.95	2.56	2.35	2.22	2.13	2.06	2.01	1.97
		.050	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40
		.025	5.79	4.38	3.78	3.44	3.22	3.05	2.93	2.84
		.010	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45
		.001	14.38	9.61	7.80	6.81	6.19	5.76	5.44	5.19
	23	.100	2.94	2.55	2.34	2.21	2.11	2.05	1.99	1.95
		.050	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37
		.025	5.75	4.35	3.75	3.41	3.18	3.02	2.90	2.81
		.010	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41
		.001	14.20	9.47	7.67	6.70	6.08	5.65	5.33	5.09
	24	.100	2.93	2.54	2.33	2.19	2.10	2.04	1.98	1.94
		.050	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36
		.025	5.72	4.32	3.72	3.38	3.15	2.99	2.87	2.78
		.010	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36
		.001	14.03	9.34	7.55	6.59	5.98	5.55	5.23	4.99
	25	.100	2.92	2.53	2.32	2.18	2.09	2.02	1.97	1.93
		.050	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34
		.025	5.69	4.29	3.69	3.35	3.13	2.97	2.85	2.75
		.010	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32
		.001	13.88	9.22	7.45	6.49	5.89	5.46	5.15	4.91
	26	.100	2.91	2.52	2.31	2.17	2.08	2.01	1.96	1.92
		.050	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32
		.025	5.66	4.27	3.67	3.33	3.10	2.94	2.82	2.73
		.010	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29
		.001	13.74	9.12	7.36	6.41	5.80	5.38	5.07	4.83
	27	.100	2.90	2.51	2.30	2.17	2.07	2.00	1.95	1.91
		.050	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31
		.025	5.63	4.24	3.65	3.31	3.08	2.92	2.80	2.71
		.010	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26
		.001	13.61	9.02	7.27	6.33	5.73	5.31	5.00	4.76

**TABLE E****F critical values (continued)**

Degrees of freedom in the numerator										
10	12	15	20	25	30	40	50	60	120	1000
1.98	1.93	1.89	1.84	1.80	1.78	1.75	1.74	1.72	1.69	1.66
2.41	2.34	2.27	2.19	2.14	2.11	2.06	2.04	2.02	1.97	1.92
2.87	2.77	2.67	2.56	2.49	2.44	2.38	2.35	2.32	2.26	2.20
3.51	3.37	3.23	3.08	2.98	2.92	2.84	2.78	2.75	2.66	2.58
5.39	5.13	4.87	4.59	4.42	4.30	4.15	4.06	4.00	3.84	3.69
1.96	1.91	1.86	1.81	1.78	1.76	1.73	1.71	1.70	1.67	1.64
2.38	2.31	2.23	2.16	2.11	2.07	2.03	2.00	1.98	1.93	1.88
2.82	2.72	2.62	2.51	2.44	2.39	2.33	2.30	2.27	2.20	2.14
3.43	3.30	3.15	3.00	2.91	2.84	2.76	2.71	2.67	2.58	2.50
5.22	4.97	4.70	4.43	4.26	4.14	3.99	3.90	3.84	3.68	3.53
1.94	1.89	1.84	1.79	1.76	1.74	1.71	1.69	1.68	1.64	1.61
2.35	2.28	2.20	2.12	2.07	2.04	1.99	1.97	1.95	1.90	1.85
2.77	2.68	2.57	2.46	2.40	2.35	2.29	2.25	2.22	2.16	2.09
3.37	3.23	3.09	2.94	2.84	2.78	2.69	2.64	2.61	2.52	2.43
5.08	4.82	4.56	4.29	4.12	4.00	3.86	3.77	3.70	3.54	3.40
1.92	1.87	1.83	1.78	1.74	1.72	1.69	1.67	1.66	1.62	1.59
2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.94	1.92	1.87	1.82
2.73	2.64	2.53	2.42	2.36	2.31	2.25	2.21	2.18	2.11	2.05
3.31	3.17	3.03	2.88	2.79	2.72	2.64	2.58	2.55	2.46	2.37
4.95	4.70	4.44	4.17	4.00	3.88	3.74	3.64	3.58	3.42	3.28
1.90	1.86	1.81	1.76	1.73	1.70	1.67	1.65	1.64	1.60	1.57
2.30	2.23	2.15	2.07	2.02	1.98	1.94	1.91	1.89	1.84	1.79
2.70	2.60	2.50	2.39	2.32	2.27	2.21	2.17	2.14	2.08	2.01
3.26	3.12	2.98	2.83	2.73	2.67	2.58	2.53	2.50	2.40	2.32
4.83	4.58	4.33	4.06	3.89	3.78	3.63	3.54	3.48	3.32	3.17
1.89	1.84	1.80	1.74	1.71	1.69	1.66	1.64	1.62	1.59	1.55
2.27	2.20	2.13	2.05	2.00	1.96	1.91	1.88	1.86	1.81	1.76
2.67	2.57	2.47	2.36	2.29	2.24	2.18	2.14	2.11	2.04	1.98
3.21	3.07	2.93	2.78	2.69	2.62	2.54	2.48	2.45	2.35	2.27
4.73	4.48	4.23	3.96	3.79	3.68	3.53	3.44	3.38	3.22	3.08
1.88	1.83	1.78	1.73	1.70	1.67	1.64	1.62	1.61	1.57	1.54
2.25	2.18	2.11	2.03	1.97	1.94	1.89	1.86	1.84	1.79	1.74
2.64	2.54	2.44	2.33	2.26	2.21	2.15	2.11	2.08	2.01	1.94
3.17	3.03	2.89	2.74	2.64	2.58	2.49	2.44	2.40	2.31	2.22
4.64	4.39	4.14	3.87	3.71	3.59	3.45	3.36	3.29	3.14	2.99
1.87	1.82	1.77	1.72	1.68	1.66	1.63	1.61	1.59	1.56	1.52
2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.84	1.82	1.77	1.72
2.61	2.51	2.41	2.30	2.23	2.18	2.12	2.08	2.05	1.98	1.91
3.13	2.99	2.85	2.70	2.60	2.54	2.45	2.40	2.36	2.27	2.18
4.56	4.31	4.06	3.79	3.63	3.52	3.37	3.28	3.22	3.06	2.91
1.86	1.81	1.76	1.71	1.67	1.65	1.61	1.59	1.58	1.54	1.51
2.22	2.15	2.07	1.99	1.94	1.90	1.85	1.82	1.80	1.75	1.70
2.59	2.49	2.39	2.28	2.21	2.16	2.09	2.05	2.03	1.95	1.89
3.09	2.96	2.81	2.66	2.57	2.50	2.42	2.36	2.33	2.23	2.14
4.48	4.24	3.99	3.72	3.56	3.44	3.30	3.21	3.15	2.99	2.84
1.85	1.80	1.75	1.70	1.66	1.64	1.60	1.58	1.57	1.53	1.50
2.20	2.13	2.06	1.97	1.92	1.88	1.84	1.81	1.79	1.73	1.68
2.57	2.47	2.36	2.25	2.18	2.13	2.07	2.03	2.00	1.93	1.86
3.06	2.93	2.78	2.63	2.54	2.47	2.38	2.33	2.29	2.20	2.11
4.41	4.17	3.92	3.66	3.49	3.38	3.23	3.14	3.08	2.92	2.78

(Continued)

TABLE E

F critical values (continued)

		Degrees of freedom in the numerator								
p		1	2	3	4	5	6	7	8	9
Degrees of freedom in the denominator	28	.100	2.89	2.50	2.29	2.16	2.06	2.00	1.94	1.87
		.050	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29
		.025	5.61	4.22	3.63	3.29	3.06	2.90	2.78	2.69
		.010	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23
		.001	13.50	8.93	7.19	6.25	5.66	5.24	4.93	4.50
	29	.100	2.89	2.50	2.28	2.15	2.06	1.99	1.93	1.86
		.050	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28
		.025	5.59	4.20	3.61	3.27	3.04	2.88	2.76	2.67
		.010	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20
		.001	13.39	8.85	7.12	6.19	5.59	5.18	4.87	4.45
	30	.100	2.88	2.49	2.28	2.14	2.05	1.98	1.93	1.85
		.050	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27
		.025	5.57	4.18	3.59	3.25	3.03	2.87	2.75	2.65
		.010	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17
		.001	13.29	8.77	7.05	6.12	5.53	5.12	4.82	4.39
	40	.100	2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.79
		.050	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18
		.025	5.42	4.05	3.46	3.13	2.90	2.74	2.62	2.53
		.010	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99
		.001	12.61	8.25	6.59	5.70	5.13	4.73	4.44	4.02
	50	.100	2.81	2.41	2.20	2.06	1.97	1.90	1.84	1.76
		.050	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13
		.025	5.34	3.97	3.39	3.05	2.83	2.67	2.55	2.46
		.010	7.17	5.06	4.20	3.72	3.41	3.19	3.02	2.89
		.001	12.22	7.96	6.34	5.46	4.90	4.51	4.22	3.82
	60	.100	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77
		.050	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10
		.025	5.29	3.93	3.34	3.01	2.79	2.63	2.51	2.41
		.010	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82
		.001	11.97	7.77	6.17	5.31	4.76	4.37	4.09	3.69
	100	.100	2.76	2.36	2.14	2.00	1.91	1.83	1.78	1.73
		.050	3.94	3.09	2.70	2.46	2.31	2.19	2.10	2.03
		.025	5.18	3.83	3.25	2.92	2.70	2.54	2.42	2.32
		.010	6.90	4.82	3.98	3.51	3.21	2.99	2.82	2.69
		.001	11.50	7.41	5.86	5.02	4.48	4.11	3.83	3.61
	200	.100	2.73	2.33	2.11	1.97	1.88	1.80	1.75	1.70
		.050	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98
		.025	5.10	3.76	3.18	2.85	2.63	2.47	2.35	2.26
		.010	6.76	4.71	3.88	3.41	3.11	2.89	2.73	2.60
		.001	11.15	7.15	5.63	4.81	4.29	3.92	3.65	3.43
	1000	.100	2.71	2.31	2.09	1.95	1.85	1.78	1.72	1.68
		.050	3.85	3.00	2.61	2.38	2.22	2.11	2.02	1.95
		.025	5.04	3.70	3.13	2.80	2.58	2.42	2.30	2.20
		.010	6.66	4.63	3.80	3.34	3.04	2.82	2.66	2.53
		.001	10.89	6.96	5.46	4.65	4.14	3.78	3.51	3.30

**TABLE E****F critical values (continued)**

Degrees of freedom in the numerator										
10	12	15	20	25	30	40	50	60	120	1000
1.84	1.79	1.74	1.69	1.65	1.63	1.59	1.57	1.56	1.52	1.48
2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.79	1.77	1.71	1.66
2.55	2.45	2.34	2.23	2.16	2.11	2.05	2.01	1.98	1.91	1.84
3.03	2.90	2.75	2.60	2.51	2.44	2.35	2.30	2.26	2.17	2.08
4.35	4.11	3.86	3.60	3.43	3.32	3.18	3.09	3.02	2.86	2.72
1.83	1.78	1.73	1.68	1.64	1.62	1.58	1.56	1.55	1.51	1.47
2.18	2.10	2.03	1.94	1.89	1.85	1.81	1.77	1.75	1.70	1.65
2.53	2.43	2.32	2.21	2.14	2.09	2.03	1.99	1.96	1.89	1.82
3.00	2.87	2.73	2.57	2.48	2.41	2.33	2.27	2.23	2.14	2.05
4.29	4.05	3.80	3.54	3.38	3.27	3.12	3.03	2.97	2.81	2.66
1.82	1.77	1.72	1.67	1.63	1.61	1.57	1.55	1.54	1.50	1.46
2.16	2.09	2.01	1.93	1.88	1.84	1.79	1.76	1.74	1.68	1.63
2.51	2.41	2.31	2.20	2.12	2.07	2.01	1.97	1.94	1.87	1.80
2.98	2.84	2.70	2.55	2.45	2.39	2.30	2.25	2.21	2.11	2.02
4.24	4.00	3.75	3.49	3.33	3.22	3.07	2.98	2.92	2.76	2.61
1.76	1.71	1.66	1.61	1.57	1.54	1.51	1.48	1.47	1.42	1.38
2.08	2.00	1.92	1.84	1.78	1.74	1.69	1.66	1.64	1.58	1.52
2.39	2.29	2.18	2.07	1.99	1.94	1.88	1.83	1.80	1.72	1.65
2.80	2.66	2.52	2.37	2.27	2.20	2.11	2.06	2.02	1.92	1.82
3.87	3.64	3.40	3.14	2.98	2.87	2.73	2.64	2.57	2.41	2.25
1.73	1.68	1.63	1.57	1.53	1.50	1.46	1.44	1.42	1.38	1.33
2.03	1.95	1.87	1.78	1.73	1.69	1.63	1.60	1.58	1.51	1.45
2.32	2.22	2.11	1.99	1.92	1.87	1.80	1.75	1.72	1.64	1.56
2.70	2.56	2.42	2.27	2.17	2.10	2.01	1.95	1.91	1.80	1.70
3.67	3.44	3.20	2.95	2.79	2.68	2.53	2.44	2.38	2.21	2.05
1.71	1.66	1.60	1.54	1.50	1.48	1.44	1.41	1.40	1.35	1.30
1.99	1.92	1.84	1.75	1.69	1.65	1.59	1.56	1.53	1.47	1.40
2.27	2.17	2.06	1.94	1.87	1.82	1.74	1.70	1.67	1.58	1.49
2.63	2.50	2.35	2.20	2.10	2.03	1.94	1.88	1.84	1.73	1.62
3.54	3.32	3.08	2.83	2.67	2.55	2.41	2.32	2.25	2.08	1.92
1.66	1.61	1.56	1.49	1.45	1.42	1.38	1.35	1.34	1.28	1.22
1.93	1.85	1.77	1.68	1.62	1.57	1.52	1.48	1.45	1.38	1.30
2.18	2.08	1.97	1.85	1.77	1.71	1.64	1.59	1.56	1.46	1.36
2.50	2.37	2.22	2.07	1.97	1.89	1.80	1.74	1.69	1.57	1.45
3.30	3.07	2.84	2.59	2.43	2.32	2.17	2.08	2.01	1.83	1.64
1.63	1.58	1.52	1.46	1.41	1.38	1.34	1.31	1.29	1.23	1.16
1.88	1.80	1.72	1.62	1.56	1.52	1.46	1.41	1.39	1.30	1.21
2.11	2.01	1.90	1.78	1.70	1.64	1.56	1.51	1.47	1.37	1.25
2.41	2.27	2.13	1.97	1.87	1.79	1.69	1.63	1.58	1.45	1.30
3.12	2.90	2.67	2.42	2.26	2.15	2.00	1.90	1.83	1.64	1.43
1.61	1.55	1.49	1.43	1.38	1.35	1.30	1.27	1.25	1.18	1.08
1.84	1.76	1.68	1.58	1.52	1.47	1.41	1.36	1.33	1.24	1.11
2.06	1.96	1.85	1.72	1.64	1.58	1.50	1.45	1.41	1.29	1.13
2.34	2.20	2.06	1.90	1.79	1.72	1.61	1.54	1.50	1.35	1.16
2.99	2.77	2.54	2.30	2.14	2.02	1.87	1.77	1.69	1.49	1.22